10. GREENHOUSE GAS EMISSIONS

Gases that trap heat in the atmosphere are often referred to as greenhouse gases. Greenhouse gases emitted to the atmosphere can be naturally occurring (e.g., carbon dioxide, methane and nitrous oxide) and can also be produced solely through human activities (e.g., fluorinated gases). Greenhouse gases play a role in the process known as the greenhouse effect, which keeps the earth warm enough to sustain life, as we currently know it.

This chapter provides an inventory of expected project greenhouse gas emissions. An environmental protection objective has been developed and the mitigation and management measures to achieve the objective identified. For the detailed findings of the project's greenhouse gas emissions and abatement measures, refer to Appendix D, Greenhouse Gas Impact Assessment.

10.1 Legislative Context

Applicable international, national and state regulatory framework specific to greenhouse gas emissions is described below.

10.1.1 International Framework

The Intergovernmental Panel on Climate Change (IPCC) is a panel established in 1988 by the World Meteorological Organisation and the United Nations Environment Programme to provide independent scientific advice on climate change. The panel was asked to prepare, based on available scientific information, a report on all aspects relevant to climate change and its impacts and to formulate realistic response strategies. This first assessment report of the IPCC served as the basis for negotiating the United Nations Framework Convention on Climate Change (UNFCCC) (IPCC, 2004).

Since the UNFCCC entered into force in 1994, the IPCC remains the pivotal source for scientific and technical information relevant to climate change and greenhouse gas emissions.

The Kyoto Protocol entered into force on 16 February 2005. The Kyoto Protocol builds upon the UNFCCC by committing to individual, legally binding targets to limit or reduce greenhouse gas emissions. Annex I Parties included countries that were members of the Organisation for Economic Co-operation and Development in 1992, plus countries with economies in transition such as Russia. The Kyoto Protocol applies to greenhouse gases, including carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride.

The emission reduction targets were calculated based on a party's domestic emission greenhouse gas inventories (which included the land use change and forestry clearing, transportation and stationary energy sectors). Domestic inventories require approval by the Kyoto Enforcement Branch. The Kyoto Protocol required developed countries to meet national targets for greenhouse gas emissions over a five-year period between 2008 and 2012.

Ratification came into force for Australia on 11 March 2008. Under the protocol, developed countries are legally required to take domestic action to reduce greenhouse gas emissions and each developed country's target was negotiated and agreed. Australia's national target is to achieve an average of 108% of 1990 emissions for the five years of the first commitment period (2008 to 2012). Any new sources that begin emitting during this period will contribute to Australia's Kyoto target. The Kyoto Protocol requires Australia to implement a range of monitoring

and reporting commitments. Specifically, Australia is required to report its annual greenhouse gas emissions every year during the 2008 to 2012 commitment period.

An international framework for mitigating the impacts of climate change past the Kyoto period was discussed at the fifteenth United Nations Conference of Parties, Copenhagen, in December 2009. It concluded with an agreement that the global temperature rise should be capped through significant emission reductions by all countries; however, no legally binding agreement was ratified.

10.1.2 Australian Legislation and Policies

National Greenhouse and Energy Reporting Act 2007. The National Greenhouse and Energy Reporting Act (NGER Act) establishes a national system for reporting greenhouse gas emissions, and establishes triggers for corporate- and facility-reporting thresholds for greenhouse gas emissions, energy consumption or energy production. Based on the findings of this EIS, annual greenhouse gas emissions from the project will trigger the NGER Act facility-reporting threshold. Therefore, Arrow will be required to report greenhouse gas emissions and energy consumption or production from the project.

Energy Efficiency Opportunities Act 2006. The Energy Efficiency Opportunities program is designed to improve the energy efficiency of large businesses. Participation is mandatory for corporations that use more than 0.5 PJ of energy. Arrow will trigger the 0.5-PJ energy-consumption threshold and, as such, will be required to report under the Energy Efficiency Opportunities program.

Australian National Policy. On the 8 November 2011 the Australian Parliament passed laws to put a price on greenhouse emissions as part of a comprehensive package of reforms referred to as the Clean Energy Legislation. A key element of this legislation is the introduction of a carbon pricing mechanism from 1 July 2012. Covered sectors will be required to hold permits for each tonne of greenhouse emissions released, which initially will be purchased from the government and later traded in a market based mechanism. Arrow will be covered under this legislation and required to hold permits equal to its greenhouse emissions.

The next Australian Federal election must be held by 30 November 2013 and could result in a change in government. Under the Australian Liberal Party's proposed Direct Action Plan, a baseline and credit approach would reward businesses that reduce their emissions below their 'baseline' levels by offering the abatement for sale to the government. Businesses that remain at their baseline level would not be penalised. Financial penalties have been proposed for businesses that exceed their baseline emission levels. Under the Direct Action Plan, carbon dioxide abatement would be achieved through bio-sequestration (LPA, 2010).

10.1.3 Queensland Strategies and Schemes

The Queensland Government's climate change mitigation strategy is presented in ClimateQ: Toward a Greener Queensland (DERM, 2009b). It is a consolidation and update to previous governments' strategies such as ClimateSmart 2050 and the ClimateSmart Adaptation Plan 2007-12.

ClimateQ outlines a commitment to reduce Queensland's greenhouse gas emissions by 60% by 2050, in line with the Australian Government's long-term target. This is proposed to be achieved through a variety of short-, medium- and long-term strategies, such as improving energy efficiency, reducing the emissions intensity of the Queensland energy sector, mode switching and fuel efficiency in the transport sector, reduction of land clearing and carbon sequestration.

Under the Queensland Gas Scheme (Qld Govt., 2010a) Queensland electricity retailers and large electricity users will be required to source a portion of their electricity from gas-fired generation at rates of 15% by 2010 and 18% by 2020.

The government administers targets through tradeable gas electricity certificates. Accredited gas-fired power stations earn tradeable gas electricity certificates for each megawatt-hour of electricity produced. Electricity retailers and large consumers must purchase and surrender gas electricity certificates equivalent to the proportion of electricity that must be generated by gas under the Queensland Gas Scheme. Since 2005, the average price of gas electricity certificates has been $16, and the scheme has generated $158 million through gas electricity certificates sales, making gas-fired power generation economically competitive with coal (DME, 2008).

Natural gas has been identified as a key transitional fuel source while renewable energy and clean coal technologies are developed. The Queensland Government's rationale for increasing electricity sourced from natural gas is that, in comparison to coal-fired generation, natural gas produces approximately half the emissions per unit of electricity generated.

10.1.4 Arrow's Greenhouse Gas Standards

Arrow recognises the need to reduce anthropogenic greenhouse emissions and is developing a greenhouse gas standard as part of its integrated health, safety and environmental management system (HSEMS). The environmental component of the HSEMS focuses on potential environmental impacts and integrates the environmental risks into the overall management plans to reduce the risk of potential impacts. Management measures will include reducing the greenhouse intensity of operations, complying with relevant legislation, setting and implementing targets and preparedness for carbon constraints.

10.2 Assessment Methods

The most abundant greenhouse gases in the earth's atmosphere include water vapour, carbon dioxide, methane, nitrous oxide and ozone. For the purpose of the greenhouse gas assessment, estimated carbon dioxide, methane and nitrous oxide emissions from the project have been calculated in the form of carbon dioxide equivalents (CO_2-e). Calculations were based on gas production estimates, and estimates of point source and fugitive emissions. Emissions of ozone have been assessed in Chapter 9, Air Quality.

The Greenhouse Gas Protocol (DCCEE, 2008) categorises the sources of greenhouse gas emissions into three 'scopes' (Scope 1, Scope 2 and Scope 3) for greenhouse gas accounting and reporting purposes. This terminology has been adopted in Australian greenhouse reporting and measurement methods and has been employed in this assessment. For inventory purposes, the scopes comprised:

- Scope 1 emissions, which are also known as direct emissions. Scope 1 emissions will principally result from the following project activities:
  - Generation of electricity where emissions result from combustion of fuels in stationary sources.
  - Transport of materials, waste and employees, where emissions result from the combustion of fuels in Arrow-owned or controlled mobile combustion sources such as buses and cars.
  - Construction activity, where emissions result from fuel combustion in Arrow-owned or controlled industrial vehicles and equipment, such as excavators, graders, truck-mounted drilling rigs and land-clearing equipment.

  - Planned or unplanned releases of gas from venting or flaring.
  - Fugitive emissions from equipment.
- Scope 2 emissions, also known as indirect emissions, include amongst other indirect sources, the procurement of electricity for the Surat Gas Project.
- Scope 3 emissions are associated with fuel cycles (diesel and electricity consumption from the grid), the end-use of produced gas and third-party infrastructure required to export the gas as liquefied natural gas (LNG).

Methods for estimating Scope 1 and Scope 2 emissions were consistent with those described in the Greenhouse and Energy Reporting Determination 2008 (DCCEE, 2008) and the National Greenhouse and Energy Reporting System Measurement Technical Guidelines 2010 (DCCEE, 2010b). Methods for estimating Scope 3 emissions were consistent with the National Greenhouse Accounts Factors (DCCEE, 2010a).

The base case scenario for activities associated with the construction, operation and decommissioning phases of the project is integrated power generation. However, an alternative power supply option is electricity from the grid where wells and production facilities are in proximity to existing supply networks, that are conducive to this arrangement. For the purposes of estimating Scope 2 emissions from project activities, a worst-case scenario that includes electricity supplied from the grid for 20% of the production wells in operation was assessed.

Scope 2 (indirect) emissions considered in preparation of the inventory included emissions that result from the generation of purchased electricity. Emissions that physically occur at the electricity-generating facility, as opposed to the facility that uses the electricity, form the basis of this inclusion.

Note that the greenhouse gas emissions released from the production of electricity in the proposed infrastructure are classified as Scope 1 emissions in this assessment (since the power generation is under the control of Arrow). However, electricity purchased from the grid during construction or operation will have associated Scope 2 emissions.

Scope 3 emissions (which arise from sources not owned or controlled by Arrow) that were quantified in the assessment included emissions associated with fuel cycles, electricity consumption from the grid and the end-use of produced gas.

A conservative estimate of annual greenhouse emissions in carbon dioxide equivalents was calculated for each phase of the project based on the year when the highest greenhouse emissions are expected during construction (2019), operations (2030) and decommissioning (2040).

10.3 Existing Environment and Environmental Values

This section provides a description of the existing environment in relation to greenhouse gases and provides a summary of environmental values.

10.3.1 Existing Environment

Australia's greenhouse gas emissions increased by 9.3% between 1990 and 2007. The largest increase was in the energy sector, with emissions increasing by 42.5% between 1990 and 2007. In particular, the stationary energy subsector (which includes emissions associated with non-transport fuel combustion) increased by 49.5% (96.6 Mt CO_2-e) between 1990 and 2007

(DCCEE, 2009). The largest contribution to stationary energy comes from electricity generation (68.4%). Emissions from the Surat Gas Project will be categorised as part of the energy sector.

Queensland has the highest per capita emissions of all Australian states. Queensland's net greenhouse gas emissions increased by 8.9% (15.2 Mt CO_2-e) between 1990 and 2007. The stationary energy sector contributes the most to Queensland's emissions. Factors supporting growth in the stationary energy sector include increasing residential electricity demand and the export of Queensland's generated electricity to other Australian states (DERM, 2009b).

The existing air quality environment is described in Chapter 9, Air Quality. Regional air quality meets Environmental Protection Policy (Air) objectives for all pollutants assessed.

10.3.2 Environmental Value

Greenhouse gases are an essential component of the earth's climate, as we know it. The earth's climate sustains life and maintains the diversity of ecosystems.

10.4 Issues and Potential Impacts

This section outlines emission sources and provides an estimation of impacts.

10.4.1 Emission Sources

Scope 1 emissions associated with proposed project activities and considered in this assessment are detailed in Table 10.1.

Scope 2 emissions include indirect emissions the premises that generates the electricity, rather than the facility that uses the electricity. Electricity purchased from the grid during construction and operations was assessed as part of the Scope 2 emissions estimate.

Table 10.1 Equipment and activities associated with Scope 1 emissions

Project Phase	Project Activity	Source of Greenhouse Gas Emissions
Construction	Production well installation	Ramp-up flaring associated with well installation. Industrial vehicles or generator fuel usage.
	Land clearing	Clearing of vegetation.
	Gas and water gathering systems installation	Earthmoving and construction equipment (fuel usage).
	High-pressure pipeline construction	
	Road construction to production facilities	
	Dam construction	
	Production facility and temporary workers accommodation facilities construction	

Table 10.1 Equipment and activities associated with Scope 1 emissions (cont'd)

Project Phase	Project Activity	Source of Greenhouse Gas Emissions
Operations	Power generation	Gas processing and compression, water transport and treatment and field development.
	Production well operation and maintenance (including well repairs)	Diesel consumption in light and heavy vehicles.
	Gas and water gathering system operation and maintenance	• Diesel consumption in light and heavy vehicles. • Fugitive emissions through the water gathering system (high point vents, coal seam water dams). • Fugitive emissions through the coal seam gas gathering line (compressor blow downs, maintenance of pipelines, leakage, accidents).
	Production facility operation and maintenance	• Diesel consumption in light and heavy vehicles. • Flaring which includes: – Pilot flaring under normal operating conditions. – Flaring due to upset conditions. – Fugitive emissions associated with gas compression, dehydration and other types of equipment associated with each facility.
Decommissioning	Power generation	Earthmoving equipment and fuel usage.
	Production well decommissioning and rehabilitation	
	Gathering infrastructure decommissioning and rehabilitation	
	Facility site decommissioning and rehabilitation	

Scope 3 emissions are defined as those emissions that occur as a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Scope 3 emission sources considered in the assessment are presented in Table 10.2.

Table 10.2 Equipment and activities associated with Scope 3 emissions

Source of Greenhouse Gas Emissions	Key Variables which Influence Total Emissions
Fuel cycles of diesel (indirect emissions due to extraction, production and transport of fuel consumed).	Amount of fuel used.
Electricity consumption from the grid (fuel transport, distribution losses).	Amount of electricity consumed.
Gas end use (domestic or export).	Amount of gas produced.
Third party infrastructure to export the gas as LNG.	• Length of transmission pipeline to transport coal seam gas to Arrow LNG Plant. • Amount of gas to be processed at Arrow LNG.

Scope 3 emissions do not include emissions associated with LNG product shipping and emissions generated in construction materials manufacturing processes. It is difficult to quantify these emissions due to the number of unknown variables involved (e.g., the destination of the ships or the origin of the construction material).

The Greenhouse Gas Protocol (DCCEE, 2008) allows optional reporting of Scope 3 emissions. If an organisation believes that Scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with Scope 1 and Scope 2 emissions. However, the Greenhouse Gas Protocol notes that reporting Scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations or products difficult (due to reporting being voluntary). The protocol also recognises that compliance regimes are more likely to focus on the 'point of release' of emissions (i.e., direct emissions) or indirect emissions from the purchase of electricity.

10.4.2 Estimation of Impacts

Greenhouse gas emissions as CO_2 equivalents were estimated for each phase of the project, as shown in Table 10.3. The year shown for each project phase is the worst-case year, expected to generate the highest greenhouse gas emissions.

Table 10.3 Project greenhouse gas emissions by project phase and scope

Project Phase	Year	Scope 1 (t CO_2-e/annum)	Scope 2 (t CO_2-e/annum)	Scope 3 (t CO_2-e/annum)	Total (t CO_2-e/annum)
Ramp-up period (2014 to 2019)	2019	2,361,663	216,467	18,413,406	20,991,536
Operational period (2020 to 2039)	2030	2,807,044	678,053	23,095,897	26,580,994
Ramp-down period (2040 to 2047)	2040	2,619,118	305,229	20,316,199	23,240,546

Scope 3 emissions are not directly attributable to the project due to third party influences and crossover between differing project boundaries. Scope 1 and 2 emissions are more directly attributable to the project and are shown in Figure 10.1. These emissions increase over the ramp-up phase to peak and form a plateau during the operational phase, before decreasing again during project ramp-down.

Project greenhouse gas emissions as CO_2 equivalents are expressed as a percentage of global, Australian and Queensland greenhouse gas emissions in Table 10.4. The aggregate Scope 1 and Scope 2 emissions from the project associated with the worst-case scenario for each project phase were calculated. The project's predicted greenhouse gas carbon dioxide equivalent emissions were equivalent to 0.012% of global 2007 emissions for the worst-case operational year.

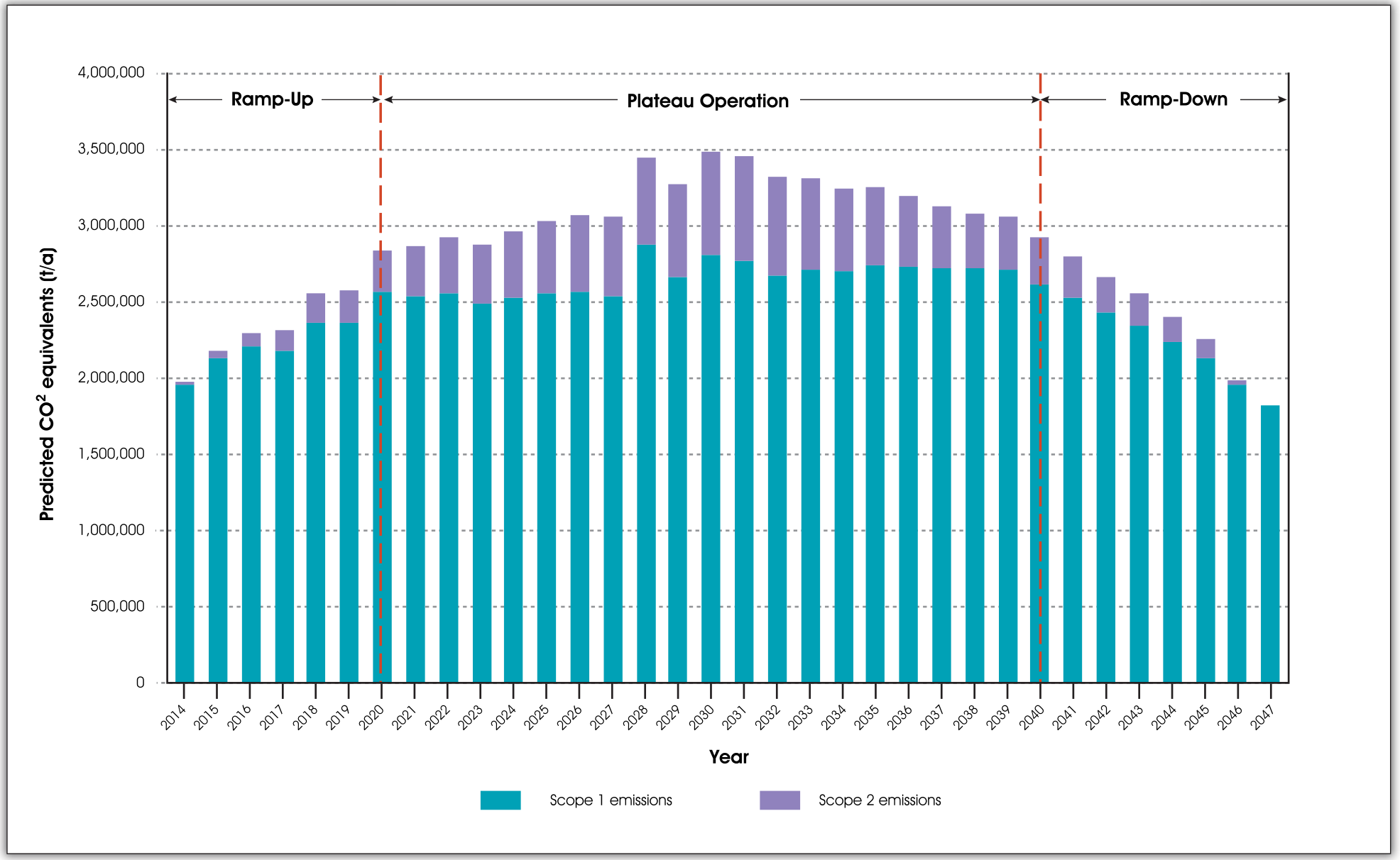
Table 10.4 Estimates of greenhouse gas emissions

Source	Emissions Per Annum (Mt CO_2-e/annum)	Surat Gas Project Contribution		
		Scope 1 (%)	Scope 2 (%)	Scope 1 & 2 (%)
Global[a]	29,335.0	0.010	0.002	0.012
Australia[b] (Energy Sector)	408.2	0.688	0.166	0.854
Queensland[c]	181.6	1.546	0.373	1.92

a. UNSD (2011) - Millennium Development Goals indicators: carbon dioxide emissions (CO_2), thousand metric tonnes of CO_2 (collected by the Carbon Dioxide Information Analysis Centre).

b. Section 2, DCCEE (2009) - Energy sector includes stationary energy, transport and fugitive emissions.

c. DCCEE (2009) - Emissions including land use change.



	coffey environments	Job No: 7040	Arrow Energy	arrow energy go further	Scope 1 and Scope 2 greenhouse gas emissions for the Surat Gas Project	Figure No: 10.1
		File Name: 7040_04_F10.01_GL	Surat Gas Project			

10.5 Environmental Protection Objective

The environmental protection objective for the project is to minimise greenhouse gas emissions.

10.6 Avoidance, Mitigation and Management Measures

Mitigation and management measures have been proposed to achieve the environmental protection objective.

10.6.1 Planning and Design

During the planning and design phase of the project, Arrow will make provisions during procurement of equipment and field development that will assist with minimising greenhouse gas emissions through the decision to:

- Select gaskets, seals and vehicle exhaust systems that are suitable for the task. [C005]
- Minimise the disturbance footprint and vegetation clearing. [C020]

10.6.2 Construction

During the construction phase, minimise greenhouse gas emissions through selection of equipment and the commitment to clear areas progressively. Implement rehabilitation as soon as practicable following construction activities. [C021]

10.6.3 Operations

To minimise greenhouse gas emissions during project operations, Arrow will:

- Optimise gas-engine operation to minimise duration of operation at low-efficiency levels that may result in increased emissions. [C018]
- Ensure all engines, machinery equipment and pollution control mechanisms are operated and maintained in accordance with manufacturers' recommendations. [C011]
- Minimise fuel consumption of vehicles by optimising transport logistics. [C004]
- Prevent venting and flaring of gas as far as practicable and where safe to do so. [C016]

Arrow will develop a greenhouse gas management plan that will take into account both biodiversity and economic values of carbon. [C006] The low carbon dioxide content in the coal seam gas precludes the capture and sequestration of carbon dioxide.

Arrow is committed to reducing emissions through the support of greenhouse mitigation programs. Arrow will consider:

- Energy efficiency programs both locally and across the company that contribute to greenhouse gas emission reductions. [C007]
- Supporting gas industry initiatives that seek to improve technology or processes, such as contributions or sponsorship of research and development. [C022]
- Supporting through corporate community involvement programs the development of energy efficiency initiatives in the areas where Arrow operates. [C010]

Arrow will participate actively in any government-approved emissions trading scheme. [C008]

10.6.4 Decommissioning

During the decommissioning phase, minimise greenhouse gas emissions by optimising transport logistics and minimising the footprint of disturbance. [C023]

10.7 Residual Impacts

The avoidance, mitigation and management measures outlined above will reduce the intensity of greenhouse emissions from the project.

10.8 Inspection and Monitoring

Arrow will assess the energy-efficiency opportunities and estimate greenhouse emissions associated with the project in accordance with regulatory requirements. Annual greenhouse gas emissions from the project will be calculated as required under the NGER Act and Energy Efficiency Opportunities program, as well as future carbon price mechanisms. [C512]