6

GREENHOUSE GAS

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SUPPLEMENTARY REPORT TO THE EIS

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6 Greenhouse Gas

This chapter summarises the supplementary greenhouse gas (GHG) assessment completed as a result of refinements to the field development plan and conceptual design of the Project. Also described and discussed are updates to the legislative and policy context, emissions estimation methodologies, emission sources and likely impacts. The chapter also reviews the abatement, management and mitigation commitments required by Arrow to minimise GHG emissions released from the Project.

The supplementary GHG assessment is included in the Greenhouse Gas Technical Report (Appendix C) of this SREIS. The study supplements the Greenhouse Gas Technical Report (Appendix I) of the EIS, the main findings of which are summarised in the Greenhouse Gas Emissions chapter (Section 10) of the EIS.

The revised project description is provided in the Project Description chapter (Section 3) of this SREIS, and the revisions with specific relevance to the assessment of GHG emissions are discussed in this chapter. The responses to all submissions are provided in the Submission Responses chapter (Section 21) of this SREIS.

6.1 Summary of Updates to the GHG Assessment

The Project refinements that are applicable to the supplementary GHG assessment are related to changes in major infrastructure components, electrical power supply options and power requirements for Project facilities. The new and updated datasets that have become available since the EIS which have been incorporated into the SREIS assessment include:

- New vehicle transport data;
- Updated estimates of land clearance;
- Specifications for drilling equipment;
- Updated Global Warming Potential (GWP) values; and
- National Greenhouse and Energy Reporting guidance documentation.

Additional information included in the assessment for scientific completeness, in response to stakeholder submissions and resulting from new information in documents listed in Section 6.3.1.2, includes:

- Transport emissions;
- Climate change adaptation; and
- Fugitive emissions.

Table 6-1 provides a summary of the changes that have been made to the EIS assessment as a result of refinements to the project description, the inclusion of updated and new datasets, and supplementary information requested by stakeholders.

Table 6-1 Summary of Key Changes to the EIS

Project Aspect	EIS	SREIS	Basis for Change
Estimated total gas production	7.1 million TJ	5.8 million TJ	Project description refinement.
Estimated maximum annual gas production	189,070 TJ (2046)	283,240 TJ (2027)	Project description refinement.
Number of central gas processing facilities (CGPF)	3	Two with co-located water treatment facilities.	Project description refinement.
Number of field compression facilities (FCF)	10	33	Project description refinement - field radius has been reduced from generally 12 km to 6 km.
Integrated processing facilities (IPF)	4	Removed.	Project description refinement.
Number of vertical production wells	6,625	Approximately 4,000 (up to 12 wells per pad, six vertical production and six lateral wells).	Project description refinement.
Traffic data	Vehicle kilometres travelled (VKT) from EIS traffic model.	Improved estimates of VKT from updated traffic model.	Updated information.
Power supply	Base Case In field power generation based on 10% of the maximum CSG produced to meet 100% of Project needs. Worst Case In field power generation based on 10% of the maximum CSG produced to meet a portion of the Project needs.	Base Case Grid power supply based on connection to existing electricity infrastructure with partial gas-fired power generation at remote wellheads (up to 10% of total number of wells) if required. Temporary Power Supply In field power generation at the facilities using CSG for first two years. Partial gas-fired power generation at remote wellheads if required (up to 10% of total number of wells).	Project description refinement. An assessment was made between the preferred 'Base Case' power option and a temporary power supply option. It was determined that the temporary power supply option was the most conservative option and this is reported.
CGPF power requirement	60 MW maximum power requirement.	44 MW maximum power requirement, including power supplied to water treatment facilities.	Project description refinement.
FCF power requirement (largest)	19 MW	35 MW	Project description refinement.
Production wellhead power requirement	75 kW	20 kW	Project description refinement.
Land clearance	Assessed.	Updated.	Project description refinement.
Drill rig emissions	Not included.	Included (four diesel generators with 1,000 kVA engines).	Updated / new information.

Project Aspect	EIS	SREIS	Basis for Change
Ramp up flaring	Assessed.	Not required.	Project description refinement.
Flaring during well completions and workovers	Not included.	Assessed.	Project description refinement.
Upset condition / operational flaring rates	Based on maximum worst-case rate.	Based on updated maximum worst-case rate.	Project description refinement.
Updated guidance documents	--	See Section 6.3.	Updated information.
New guidance documents	--	For the estimation of fly-in / fly-out (FIFO) and drive-in / drive-out (DIDO) emissions.	New information.
GWP Values	21 for CH_4 and 310 for N_2O.	25 for CH_4 and 298 for N_2O*.	Updated information.
Transport emissions (FIFO and DIDO)	Not included.	Included in updated inventory.	Stakeholder submission.
Climate change	Climate change impact assessment included.	Further detail on adaptation provided.	Stakeholder submission.
Fugitive emissions	Scope 1 emission calculated for facility level production and processing, gas transmission and flaring. Expressed in carbon dioxide equivalent (CO_2-e).	Addition of a description of Arrow's fugitive methane emissions sampling program.	Stakeholder submission.

* The fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) GWP values for methane and nitrous oxide have been used in the emissions inventory update. The National Greenhouse and Energy Reporting (NGER) (Measurement) Amendment Determination 2013 (No. 1) Explanatory Statement (Australian Government, 2011) outlines the intention to adopt these values from 2017 onwards.

Based on the updated project description, two power options were considered in this assessment: grid power supply and temporary power generation.

Grid Power Supply (Preferred Base Case)

The 'base case' involves grid power supply based on connection to existing electricity infrastructure from the start of the Project. Partial gas-fired power generation at remote wellheads (10% of total number of wells) is required from year three. As a long term power supply option, electricity from the grid will generally be supplied to CGPFs from where it will be distributed to FCFs and water transfer stations with further distribution to the wells from the FCFs.

The calculation of Scope 2 emissions from electricity purchased from the grid was based on Arrow's forecast electricity demand for the Project and a conservative assumption that the emissions intensity of Queensland's electricity supply will stay constant into the future.

Temporary Power Generation (Worst Case)

Under this scenario, temporary gas-fired power will be generated at the production facilities in the first two years. Connection to the electricity network is assumed from the third year onwards, with 10% of total number of wells powered locally by gas-fired engines, as it may not be feasible to connect some of the wells to the electrical distribution network.

The methodology for calculation of Scope 1 emissions for temporary power generation was based on Arrow's forecast gas demand for the first two years of the Project.

Selection of Power Option for Reporting

Total Project emissions, for both power options were compared to determine the most conservative scenario. This comparison is presented in Section 3.4.3.2 of the Greenhouse Gas Technical Report (Appendix C) of this SREIS.

Total GHG emissions were estimated to be higher for temporary power generation and so these results are presented as they represent the worst case emissions. However, it should be noted that grid power supply (base case) remains the preferred option. In the event that temporary power generation is not used, the emissions will be lower than those shown in this report.

Potential Decrease in Project Emissions

Australia has committed to reduce national GHG emissions by 5% of 2000 levels by 2020 under the Kyoto Protocol. This represents a 23% reduction below business as usual (Australian Government, 2013g). As energy production is the source of approximately 75% of Australia's total GHG emissions, reducing emissions from this sector will be necessary to meet this commitment. The SREIS has shown that the Project will source electricity from the national grid for the majority of its power needs, which means its Scope 2 GHG emissions are the most significant Project emissions. Therefore, Project emissions will depend on the emissions associated with purchased electricity and therefore on state and federal policies on electricity generation. Emissions from electricity generation across all sectors in Queensland have been decreasing from a peak in 2009. Queensland emissions per unit of electricity generated in 2011 were more than 8% lower than in 2009; this is reflected in the most recent Scope 2 emission factors applied to the Project. If emissions per unit of electricity generated in Queensland continue to fall, Project emissions will be lower than predicted in the SREIS.

6.2 Legislative and Policy Context

6.2.1 International Policy

6.2.1.1 The Kyoto Protocol

The Kyoto Protocol first commitment period ended on 31 December 2012. On 9 December 2012, at the United Nations climate change conference in Doha, it was announced that Australia has agreed to a second commitment period under the Kyoto Protocol. The second commitment period of the Kyoto

Protocol commenced on 1 January 2013 and will end in 2020 in line with the start of the new global agreement. Australia agreed a Kyoto target to reduce its emissions to 5% of 2000 levels by 2020. However, the option to increase the target to up to 25% might be considered, depending on the scale of global action.

6.2.2 Australia's Climate Change Legislation

6.2.2.1 Proposed Repeal of the Carbon Pricing Mechanism

The Greenhouse Gas Emissions chapter (Section 10.1.2.2) of the EIS described the *Clean Energy Act 2011*, which was implemented under the Government's Clean Energy Plan. The Clean Energy Plan incorporated a Carbon Pricing Mechanism (CPM) intended to impose a cap on emissions from covered sectors of the economy. As the Project would exceed emissions of covered sources of 25,000 t of CO_2-e per year, it would create a liability for the proponent under the CPM.

On 14 November 2013, the Senate referred the Clean Energy Legislation (Carbon Tax Repeal) Bill 2013 and related bills to the Environment and Communications Legislation Committee for inquiry and report by December 2013 (Australian Government, 2013a). If the Clean Energy Legislation (Carbon Tax Repeal) Bill 2013 is passed, 2013-2014 would be the last financial year that the carbon price in its current form will apply to liable entities. As the ramp-up phase of the Project is likely to begin in 2017, under this scenario, the proponent would not incur any carbon liability under the *Clean Energy Act 2011*.

The proponent will still be required to report Project emissions under the *National Greenhouse and Energy Reporting Act 2013* (NGER Act) if the CPM is repealed.

6.2.2.2 Energy Efficiency Opportunities

The *Energy Efficiency Opportunities Act 2006* (EEO Act) is described in the Greenhouse Gas Technical Report (Appendix I, Section 2.2.2) of the EIS. The Energy Efficiency Opportunities (EEO) Amendment Regulation 2012, which came into effect in July 2012, have been amended since publication of the EIS.

The amendments expanded the coverage of the EEO program to include new developments and expansion projects from July 2013. The regulation provides specific definitions for a new development or expansion project and defines future energy use as the energy that a new development or expansion will use, on an annual average basis, after commercial operation has commenced. Corporations will be subject to participation thresholds for new projects and those corporations not registered for EEO whose projects meet these thresholds will be required to participate.

As the Project is a new development which may utilise more than 0.5 PJ of energy per financial year, it may be subject to an EEO Program assessment under the EEO Act. As a result, the proponent may be obliged to submit an assessment plan for the Project (Australian Government, 2013b) or seek an exemption on the basis that it can demonstrate systems and processes that meet the intent of the EEO Act.

6.2.2.3 Direct Action Plan

The Australian Government intends to implement a climate change strategy called the Direct Action Plan. The Direct Action Plan will include initiatives to reduce CO_2 emissions by 5% by 2020. A key initiative of the Direct Action Plan is the Emissions Reduction Fund.

The Emissions Reduction Fund would work together with other incentives under the Direct Action Plan and the Renewable Energy Target (under review) so the Project can contribute to Australia's emissions reduction target.

The fund would include the following initiatives:

- The Government will purchase low-cost abatement through reverse auctions or 'abatement buy-back'. The proponent will be incentivised to find the lowest cost approach to reduce emissions as high cost abatement will not be purchased by the Government;
- Incentives for abatement activities across the Australian economy in conjunction with the Carbon Farming Initiative; and
- Community input will be invited on potential sources of low-cost abatement and on key design features such as auctions, baselines and contract arrangements.

The ToR for the Emissions Reduction Fund remain under review at this time (Australian Government, 2013c).

6.2.3 State Policy and Initiatives

Since the EIS, significant changes have been made to state policies and initiatives as described in Sections 6.2.3.1 to 6.2.3.5.

6.2.3.1 Smart Energy Savings Program

Under the Queensland government formed in April 2012, the Smart Energy Savings Program was discontinued to reduce regulatory burden on Queensland businesses. However, this has no effect on the GHG assessment because the Project will be required to report under the EEO Program.

6.2.3.2 Queensland Future Growth Fund

The Queensland Future Growth Fund was created to provide funding for infrastructure and initiatives that would benefit the economy and environmental sustainability of Queensland, such as investment in clean coal technologies. The *Future Growth Fund Act 2006* has been repealed and the fund closed effective from July 2013 (Queensland Treasury and Trade, 2013).

6.2.3.3 Queensland Gas Scheme

Under the ClimateSmart2050 strategy, the Queensland Government announced its intention to transition the Queensland Gas Scheme into a national emissions trading scheme. With the advent of the CPM in July 2012, the Queensland Government reviewed the Queensland Gas Scheme and identified that it would provide an advantage to gas-fired generators and likely duplicate the expected impacts of the CPM.

The Queensland Gas Scheme closed at the end of 2013, therefore there will be no further Gas Electricity Certificate creation or liability. However, administration of the scheme and the registry will continue until the penalty imposition day of 30 June 2014 (DEWS, 2013).

After stakeholder consultation by the Department of Energy and Water Supply, amendments to the *Electricity Act 1994* will be made through the Energy Red Tape Reduction (Amendment and Repeal Bill) 2013 (Queensland Government, 2013).

6.2.3.4 Climate Change Strategy

The climate change strategy ClimateQ: toward a greener Queensland has been replaced by a new approach to managing climate change by the Queensland Government. The Queensland Government has committed to managing the impact of climate change through supporting adaptation measures with the aim of building community resilience, protecting ecosystems and enhancing industry productivity in a cost-effective way (EHP, 2013).

6.2.3.5 Summary of Relevant Policies

A summary of the relevant policies relating to emissions of GHGs and electricity consumption / generation from the Project is presented in Table 6-2.

Table 6-2 GHG Emissions Policies Relevant to the Project

Level	Policy	EIS	SREIS
International	Kyoto Protocol	INDIRECT As the Project is planned to be commissioned after 2013, emissions do not count towards Australia's Kyoto target for the 2008-2012 period.	INDIRECT As the Project is planned to be commissioned after 2013, emissions will count towards Australia's Kyoto target for the 2013-2020 as part of the second commitment period.
Australia	National Greenhouse Energy Reporting	MANDATORY Proponent already participates in NGER and will have to annually report GHG emissions and energy consumption / production associated with the Project.	MANDATORY The assessment has incorporated updates to the NGER Technical Guidelines in the estimation of emissions.
	Energy Efficiency Opportunities Program	MANDATORY It is expected that the Proponent will report energy usage and EEOs associated with the Project.	MANDATORY The EEO Program has been expanded to include new developments and expansion projects. Section 2.2.2.

Level	Policy	EIS	SREIS
	Carbon Price Mechanism	MANDATORY Proponent is a participant in the CPM 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.	PROPOSED Proposed repeal for which 2013-2014 will be the last financial year that the carbon tax will apply.
	Direct Action Plan	--	PROPOSED The potential implications of the proposed Direct Action Plan for the Project are not yet known.
Queensland	Smart Energy Savings Program	NONE Proponent will only have to report energy efficiency data from the Project if it does not do so under the EEO Program.	NONE Discontinued in 2012.
	Queensland Gas Scheme	INDIRECT The Project will not be a direct participant in the trading of Gas Electricity Certificates.	NONE Closed at end of 2013 under the Energy Red Tape Reduction (Amendment and Repeal Bill) 2013.
	Climate Change Strategy	--	INDIRECT The Queensland Government is committed to supporting adaptation and building resilience to climate change in communities and ecosystems.

6.3 Updated Greenhouse Gas Emissions Estimation Methodology

An updated GHG emissions 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. A detailed description of the inventory is provided in the Greenhouse Gas Technical Report (Appendix C) of the SREIS.

The inventory was developed using the methods outlined in the Greenhouse Gas Technical Report (Appendix I, Section 3) of the EIS, with the modifications outlined in Sections 6.3.1 and 6.3.2.

6.3.1 Updated and New Reference Documents

This updated estimate of GHG emissions is based on the latest methodologies, some of which have been updated or introduced since the EIS. A summary of the documents used in the EIS and the SREIS is provided in Section 3.2 of the Greenhouse Gas Technical Report (Appendix C) and is outlined in Sections 6.3.1.1 and 6.3.1.2.

6.3.1.1 Updated Documents

Updated documents include:

- The NGER Technical Guidelines 2013 (Australian Government, 2013d);
- National Greenhouse Accounts Factors 2013 (Australian Government, 2013e); and
- The National Greenhouse and Energy Reporting (Measurement) Determination 2008 as amended – Reporting Year 2012-2013 (Australian Government, 2013f).

6.3.1.2 New Documents

New documents include:

- Technical Guidance for Calculating Scope 3 Emissions (version 1.0), Category 6: Business Travel; The Greenhouse Gas Protocol (WRI and WBCSD, 2013); and
- Climate Leaders: Greenhouse Gas Inventory Protocol Core Module Guidance: Optional Emissions from Commuting, Business Travel and Product Transport (US EPA, 2008).

The new documents were used for the purpose of responding to a submission response requesting the assessment of Scope 3 emissions from FIFO and DIDO staff.

6.3.2 Updated Emission Sources

Project emissions quantified in the updated inventory were estimated for direct (Scope 1) and indirect (Scope 2) emissions and are shown in Table 6-3. Table 6-4 shows the estimated Scope 3 emissions.

Table 6-3 Summary of Scope 1 and Scope 2 Emission Sources

Project Phase	Scope	Source of GHG Emission	EIS	SREIS
Construction, operation and decommissioning	1	Water storage and treatment.	✓	✓
Construction	1	Power generation from generation sets for construction activities.	✓	✓
		Diesel fuel consumption during construction and drilling.	✓	✓
		Vegetation losses as a result of land clearing for the gas well heads, nodes, and gas gathering infrastructure.	✓	✓
		Vertical production well installation.	✓	✓
		Gas and water gathering infrastructure installation.	✓	✓
		Water transmission infrastructure.	✓	✓
		Road construction to production facilities.	✓	✓

Project Phase	Scope	Source of GHG Emission	EIS	SREIS
		Dam construction associated with each water treatment facility.	✓	✓
		Ramp-up flaring.	✓	×
		Accommodation camp construction.	✓	✓
		Diesel combustion from drill rigs.	×	✓
		Flaring during well completions.	×	✓
Operation and maintenance	1	Gas combustion in gas-fired engines for 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 system (high point vents, water dams), gas gathering lines, drilling and fugitive releases associated with each facility.	✓	✓
		Flaring during upset conditions at the facilities.	✓	✓
		Emissions associated with electricity production at Project facilities.	✓	✓
		Power supply to facilities and well heads via distribution lines.	✓	✓
		Flaring during well workovers.	×	✓
	2	Electricity purchased from the grid.	✓	✓
Decommissioning and rehabilitation	1	Earth moving and fuel usage.	✓	✓
		Gathering infrastructure.	✓	✓
		Facility site.	✓	✓

Table 6-4 Summary of Scope 3 Emission Sources

Project Phase	Scope	Source of Greenhouse Gas Emission	EIS	SREIS
Construction, operation and decommissioning	3	End use (consumption of gas).	✓	✓
		Full fuel cycle (diesel).	✓	✓
		Full fuel cycle (electricity).	✓	✓
		Third party infrastructure – CSG transmission to Arrow Liquefied Natural Gas (LNG) plant.	✓	✓
		Third party infrastructure – CSG downstream processing.	✓	✓
		FIFO and DIDO.	×	✓

A description of the updated assumptions and assessment parameters applied in the SREIS are provided in Section 3.4 of the Greenhouse Gas Technical Report (Appendix C).

6.4 Greenhouse Gas Emission Estimates

This section describes the emissions sources, assessment scenarios and estimated emissions for the SREIS and compares them to the EIS.

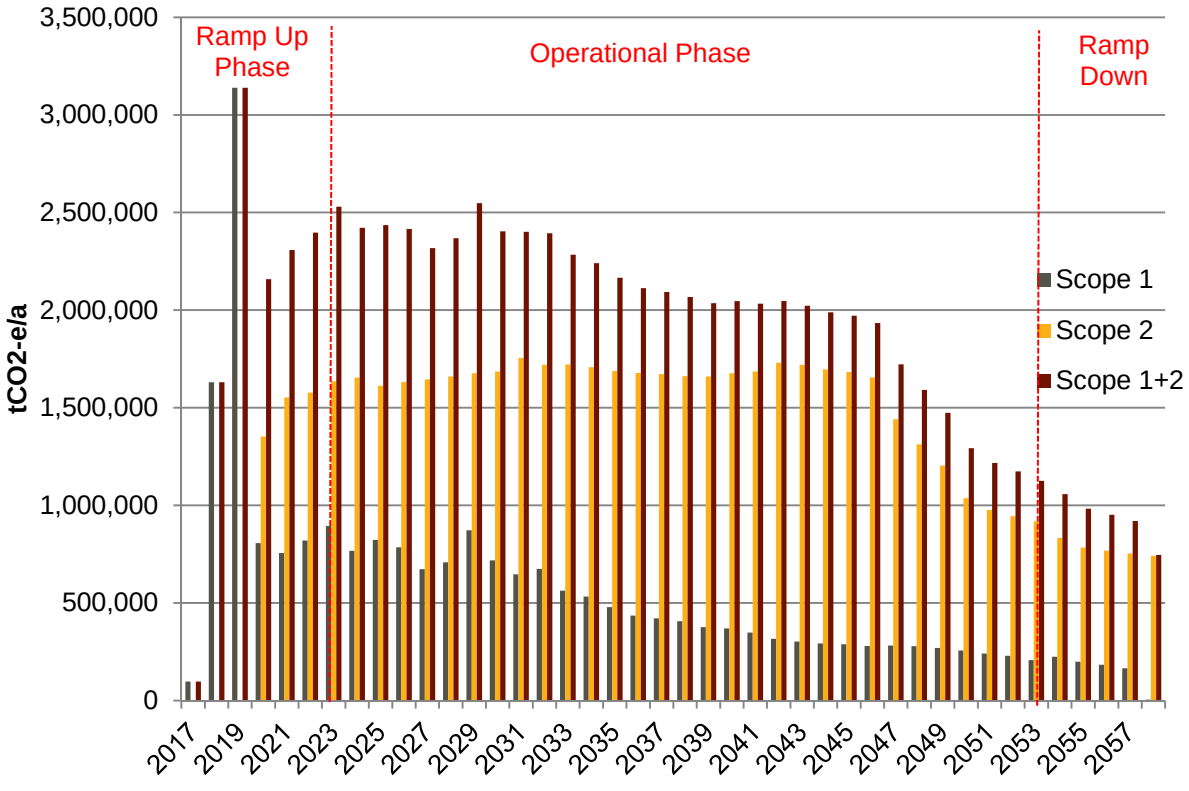
6.4.1 Project Emissions

Project 'direct' (Scope 1) GHG emissions are defined as emissions that occur from within the Project boundary and Project 'indirect' (Scope 2) emissions result from the use of energy products (electricity).

Figure 6-1 shows the estimated Project GHG emissions released for each year of the Project. Figure 6-1 shows that direct Project emissions (Scope 1) in the ramp-up phase are higher than indirect Project (Scope 2) emissions for the first three years of the Project. Total emissions are expected to be highest during the year 2019, assuming the worst case scenario of requiring temporary power generation, and consist entirely of direct (Scope 1) emissions. For the remainder of the Project, the proportion of indirect emissions from the purchase of electricity are greater than the proportion of direct emissions. In the operational phase, the production plateau is expected to last until 2046. From 2046, direct and indirect Project emissions gradually decline to the end of the ramp-down phase. In the EIS, direct emissions were estimated to be greater than indirect emissions for the whole Project.

The inventory updates show that overall Project emissions are likely to reduce by 4% from 82.9 Mt CO_2-e (EIS) to 79.3 Mt CO_2-e (SREIS).

Figure 6-1 Project (Scope 1 and Scope 2) GHG Emissions in t CO_2-e for each Year from 2017 to 2058



6.4.2 Project Emissions (Scope 1 and 2)

Scope 1 and Scope 2 GHG emissions associated with the Project are shown in Table 6-5.

For each period (ramp-up, operation and ramp-down) estimates for the year with the highest emissions are reported.

Table 6-5 Predicted GHG Emissions for Worst-Case Year of Ramp-Up (2019), Operation (2029) and Ramp-down (2054)

Category	Activity	Updated GHG emissions (t CO_2-e)		
		Ramp-up (2019)	**Operation (2029)**	**Ramp-down (2054)**
Scope 1 Emissions	Fuel combustion – gas-fired power generation	1,921,913	34,501	5,143
	Fuel combustion – diesel powered drilling	35,981	14,247	0
	Fuel combustion- diesel used in vehicles for transport and construction energy	12,174	10,930	12,787
	Vegetation clearing	843,026	339,199	0
	Gathering lines	25,474	84,354	17,104
	Fugitive emissions (facility level) - production and processing	140,995	221,808	35,823
	Fugitive emissions - flaring during well completions and workovers, pilot lights and upset conditions flaring	159,411	166,964	153,615
Total Scope 1 Emissions		**3,138,974**	**872,003**	**224,472**
Scope 2 Emissions		0	1,676,080	833,120
Total Scope 2 Emissions		**0**	**1,676,080**	**833,120**
Total (Scope 1 and Scope 2) Emissions		**3,138,974**	**2,548,083**	**1,057,592**

The highest Project emissions were estimated to be 3.1 Mt CO_2-e in the ramp-up phase, which is double the estimate made in the EIS. This is a result of higher gas combustion for power generation under the highly conservative worst case scenario of temporary power generation being required, the inclusion of drilling emissions and an increase in the estimate of vegetation clearance. Indirect (Scope 2) emissions for the worst-case year 2019 were estimated to be zero in the ramp up phase as all power will be provided from combusted gas at Project facilities.

It should be noted that power demand and hence calculated emissions for the possible alternative temporary power generation scenario in 2018 and 2019 are based on a full capacity power demand for each facility, and as such are based on a highly conservative scenario. Through detailed design the installed capacity of any required temporary power generation will be optimised to a much lesser degree than full capacity, which will result in lower emissions. Estimates provided on the full capacity scenario within this report are therefore presented as a highly conservative case that exceeds the

likely worst case emissions for the temporary power demand from the eventual optimised required capacity for the Project.

Annual Project emissions in the operational phase were estimated to be 2.5 Mt CO_2-e which is approximately 20% higher than in the EIS. Scope 1 emissions in the peak operational year were estimated to be approximately one-third of Project emissions. The other two-thirds are Scope 2 emissions from power supplied by the electricity grid. In contrast to the EIS, the majority of Scope 1 emissions are from vegetation clearing and fugitive emissions and not fuel combustion for power generation and drilling because of the switch to grid electricity. The estimate of gas combustion for power generation in the SREIS is 3.5% of the EIS estimate. Scope 2 emissions in the operational phase are 73% higher than the estimate in the EIS due to the increase in the use of grid electricity.

Project emissions for the worst-case year of the ramp-down period 2054 were estimated to be 1.1 Mt CO_2-e, which is 40% lower than the worst-case ramp-down year in the EIS.

6.4.3 Other Indirect Emissions (Scope 3)

Scope 3 emissions are indirect emissions that are a consequence of the activities of an entity that occur outside of the Project boundary, excluding emissions due to electricity consumption. Project Scope 3 emissions include the end-use of produced gas, full fuel cycles of diesel and electricity, the third party infrastructure required to export gas as LNG and workplace travel based on FIFO and DIDO operations.

Table 6-6 shows the Scope 3 emissions associated with the worst case year for each phase of the Project.

Table 6-6 Predicted Worst-Case Annual Scope 3 Greenhouse Gas Emissions during Ramp-Up, Operational and Ramp-Down Period

Activity	Ramp-up (2019) (t CO_2-e)	Operational (2029) (t CO_2-e)	Ramp-down (2054) (t CO_2-e)
End use (consumption of gas)	9,224,474	14,511,673	2,343,719
Full fuel cycle (diesel)	923	829	969
Full fuel cycle (electricity)	0	286,160	142,240
Third party infrastructure – CSG transmission to Arrow LNG plant	6,538	6,538	6,538
Third party infrastructure – CSG downstream processing	1,395,619	2,195,621	354,497
FIFO / DIDO operations	4,649	2,327	2,234
Total Scope 3 Emissions	**10,632,203**	**17,003,148**	**2,850,197**

The annual Scope 3 GHG emissions associated with the ramp-up period have been estimated to be 10.6 Mt CO_2-e for the worst-case year, which is the same as the EIS. For the operational period Scope 3 emissions were estimated to be 17.0 Mt CO_2-e for the worst case year, which is 35% higher than the

EIS. For the ramp-down period Scope 3 emissions were estimated to be 2.9 Mt CO_2-e for the worst case year, which is almost 68% less than the EIS.

The majority of Scope 3 Project emissions are associated with the end use of the produced gas. The expected total gas production is lower for the SREIS reference case than for the EIS reference case, but the peak production rate is higher.

6.4.4 Summary of Emissions

Table 6-7 summarises the estimated Project total GHG emissions during each phase of the Project, including non-Project (Scope 3) emissions.

Table 6-7 Total Greenhouse Gas Emissions Estimated for Each Phase of the Project by Scope

Type	Ramp-up Period (t CO_2-e)		Operational Period (t CO_2-e)		Ramp-Down Period (t CO_2-e)	
	EIS 2016-2022	**SREIS 2017-2023**	**EIS 2023-2056**	**SREIS 2024-2053**	**EIS 2057-2062**	**SREIS 2054-2058**
Project (direct) Scope 1	8,817,223	8,143,317	51,335,961	13,841,885	7,497,589	777,046
Project (indirect) Scope 2	978,432	6,116,380	13,366,019	46,501,380	876,606	3,880,240
Total 1+2	**9,795,655**	**14,259,697**	**64,701,980**	**60,343,265**	**8,374,196**	**4,657,286**
Other (indirect) Scope 3	43,807,678	79,524,884	350,651,846	267,800,894	26,021,718	6,095,394

Table 6-7 shows that:

- In the ramp-up period, Project emissions are significantly higher in the SREIS than the EIS as a result of higher production rates for which the power demand from third year of ramp-up will be met by purchased electricity. This is reflected in the increase in Scope 2 emissions in the SREIS. Ramp up period Scope 3 emissions are almost double the EIS estimate, which is a result of increased gas field production and a subsequent increase in downstream gas combustion;
- In the operational period, direct Project emissions are lower in the SREIS than the EIS as a result of the reduction in fuel consumption for power requirements. Indirect Project emissions are more than three times higher in the SREIS as a result of the use of purchased electricity to meet Project power requirements. The net result of the changes made in the SREIS assessment is to lower operational period Project emissions by approximately 7%. Operational period Scope 3 emissions are 24% lower than the EIS as a result of the reduction in estimated gas production from 7.1 million TJ (EIS) to 5.8 million TJ (SREIS);

- In the ramp-down period, Project Scope 1 and Scope 2 emissions are lower than those estimated in the EIS as a result of lower gas production. SREIS direct Project emissions are approximately 10% of those estimated in the EIS and the indirect Project emissions are more than four times greater as a result of the use of purchased electricity to meet Project power requirements during ramp-down. In the ramp-down period, SREIS Scope 3 emissions are approximately a quarter of those estimated in the EIS; and
- Total other GHG emissions (Scope 3) are lower than predicted in the EIS.

6.5 Impact of Greenhouse Gas Emissions from the Project

6.5.1 Updated Estimate of Potential Impacts

In Table 6-8 emission estimates for worst case year 2019 (3.1 Mt CO_2-e) representing the annual emissions for the Project are compared to global, Australia and Queensland GHG emissions.

Table 6-8 Estimates of Greenhouse Gas Emissions

Geographic Area	Source	Year	Emissions
Global	Consumption of fossil fuels.	2010	31,387 Mt CO_2
Australia	Total (including Land Use, Land Use Change and Forestry (LULUCF) activities).	2011	563.1 Mt CO_2-e
Australia	Energy sector.	2011	422.0 Mt CO_2-e
Queensland	Total (including LULUCF activities).	2011	155.5 Mt CO_2-e
Queensland	Energy sector.	2011	99.5 Mt CO_2-e

Table 6-8 shows Project emissions for worst case year 2019, were estimated to be:

- 0.01% of **global** 2010 fossil fuel consumption emissions;
- 0.6% of **Australian** emissions and 0.7% of emissions from the **Australian energy sector**; and
- 2.0% of the 2011 **Queensland** inventory and 3.1% of the **Queensland energy sector** inventory.

The SREIS emission estimate comparisons against global, Australian and Queensland emissions are similar to the EIS.

The same approach to representing typical GHG emissions for the Project has been applied as used in the EIS. 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. This is particularly pertinent to the SREIS estimates as Scope 1 emissions from the ramp-up phase have been used to represent Project emissions. In worst case ramp-up year 2019, Scope 1 emissions as a result of gas usage are approximately three times the highest emission estimate for the operational phase which occurs in 2023. Furthermore, in 2019 all emissions from vegetation clearance for the Project are included.

Emission factors are used to calculate Scope 2 emissions from the generation of the electricity purchased and consumed by an organisation as kilograms of CO_2-e per unit of electricity consumed. Scope 2 emission factors are dependent on the state, territory or electricity grid in which the production occurs. Each year, the NGER Guidelines are updated to include the latest Scope 2 emission factors, and to reflect changes made to the Measurement Determination. However, emissions per unit of electricity generated across all sectors in Queensland have been decreasing from a peak in 2009. Queensland Scope 2 emission factors in 2011 were more than 8% lower than in 2009 (Australian Government, 2013e). In line with standard industry practice, the current emission factor has been used for the lifetime of the Project. However, the observed trend is expected to continue as action is taken to reduce Australian GHG emissions to achieve the policy objective of a 5% reduction by 2020. As purchased electricity accounts for the majority of Project emissions, actual Scope 2 Project emissions are likely to be significantly lower than estimated here.

A conservative approach was also used to calculate emissions associated with land clearing by applying generic biomass densities and excluding planned rehabilitation. Therefore, the total Project emissions are likely to be lower than those predicted in this assessment. Implementing additional abatement measures may also reduce direct GHG emissions from the Project.

6.5.2 Updated Greenhouse Gas Intensities

The refined project description shows that the Project will be five years shorter than the EIS and production rates will increase during ramp-up and decrease during operation and ramp-down more sharply than the EIS. It can therefore be expected that emissions intensities will be higher at the beginning and end of the Project in the SREIS.

The Project average emissions intensity has been calculated as the sum of upstream Scope 1 emissions (gas combustion for upstream facilities, flaring, fugitive losses, gas gathering system maintenance, land clearance, drilling and vehicle transportation) and Scope 2 emissions from the consumption of electricity.

Table 6-9 presents a comparison between the Project lifecycle average emissions intensities for the EIS and SREIS.

Table 6-9 Comparison of Emissions Intensity

Fuel	Emissions Intensity (kg CO_2-e /GJ)	
	EIS	**SREIS**
Project average	11.7	13.7

Table 6-9 shows in the SREIS the GHG intensity averaged over the Project lifecycle is 13.7 kg CO_2-e/GJ). This is higher than the EIS (11.7 kg CO_2-e/GJ) and can be expected because the reduction in forecast gas production is greater than the predicted reduction in GHG emissions.

However, the following should be noted:

- Conservative assumptions have been used to assess GHG emissions such as, but not limited to, the assessment of emissions from temporary power generation under the full capacity scenario instead of the likely optimised required capacity for the Project; and
- Despite the expected increase in intensity of GHG emissions during the life of the Project after the project description refinements, the inventory update shows that overall Project emissions are likely to reduce from 82.9 (EIS) to 79.0 Mt CO_2-e/yr (SREIS) which is a reduction of 4.3%.

The end-use of gas for electricity production results in much lower GHG emissions than other fossil fuels. The use of gas for energy production (Scope 3 emissions) produces much higher GHG emissions than Project related activities and processes. Hence, electricity sourced from gas has a significant advantage over other fossil fuels with respect to full cycle emissions, which include emissions from the extraction, production and transport of the fuel, and the emissions associated with combustion. For instance, each unit of electricity generated from gas produces approximately 50% lower full-cycle GHG emissions than conventional coal-fired electricity. Recent studies in the Australian context focused on exports of Australian conventional gas, CSG and coal to Asia (refer to the Greenhouse Gas Technical Report (Appendix C) of the SREIS). These studies have concluded generally that LNG has lower overall lifecycle GHG emissions than coal, when power generation technologies of similar efficiency or application are compared. Open cycle gas technology, using LNG from CSG produces 27% less emissions over its life cycle than sub-critical coal fired technology.

6.6 GHG Abatement, Management and Mitigation Measures

The Project is subject to international, national, state and corporate GHG policies with abatement objectives and performance standards. Arrow will comply with all mandatory international, national and state objectives. Arrow remains committed to the mitigation measures described in the EIS Greenhouse Gas Technical Report (Appendix I, Table 6-1) and the climate change adaptation commitments described in the SREIS Greenhouse Gas Technical Report (Appendix C, Section 7). Table 6–10 summarises the commitments presented in the EIS. A single commitment has been slightly amended, as presented in Table 6-11.

Table 6-10 GHG Commitments as Presented in the EIS

No.	Commitment	Change Made
B004	Select equipment with consideration for low emissions to air (NOx, SOx), high energy efficiency and fuel efficiency.	No
B006	Minimise fuel consumption of vehicles by optimising transport logistics.	No
B007	Select gaskets, seals and vehicle exhaust systems that are suitable for the task.	No
B008	Arrow will develop a greenhouse gas management plan that will take into account both biodiversity and economic values of carbon.	No
B009	Consider energy efficiency programs both locally and across the company that contribute to greenhouse gas emission reductions.	No

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No.	Commitment	Change Made
B010	Arrow will participate actively in any government-approved emissions trading scheme.	No
B011	Consider supporting gas industry initiatives that seek to improve technology or processes, such as contributions to or sponsorship of research and development.	No
B012	Consider supporting through corporate community involvement programs the development of energy efficiency initiatives in the areas where Arrow operates.	No
B013	Ensure all engines, machinery equipment and pollution control mechanisms are operated and maintained in accordance with manufacturer's recommendations.	No
B017	Minimise the disturbance footprint and vegetation clearing.	No
B018	The land cleared for construction purposes will be kept to the minimum necessary, especially during the drier months of the year.	No
B021	The cleared areas and stockpiles will be progressively rehabilitated through revegetation and/or mulching.	No
B022	Prevent venting and flaring of gas as far as practicable and where safe to do so, in accordance with the P&G Act.	No
B024	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).	No
B025	Minimise potential fugitive emissions from construction and operation of production wells and gas production infrastructure.	No
B026	Use of low NOx equipment, where practical.	No
B028	Minimisation of emissions from gas dehydration.	No
B029	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.	No
B030	Implementation of a quantifiable monitoring and measuring program.	No
B031	Use of efficient gas and water separation methods on wellheads, gathering and process facilities to minimise fugitive gas release.	No
B032	Commitment to clear areas progressively. Implement rehabilitation as soon as practicable following construction activities.	No
B033	Clear areas progressively and implement rehabilitation as soon as practicable following construction and decommissioning activities.	No
B034	During the decommissioning phase, minimise greenhouse gas emissions by optimising transport logistics and minimising the footprint of disturbance.	No
B035	Assess the energy-efficiency opportunities and estimate greenhouse gas emissions associated with the Project in accordance with regulatory requirements. Calculate annual greenhouse gas emission s required under the *National Greenhouse and Energy Reporting Act 2007* (Cwlth) (NGER Act) and Energy Efficiency Opportunities program, as well as future carbon price mechanisms.	No
B037	Annual greenhouse gas emissions and energy consumption / production from the Project will be reported as required under the NGER Act and Energy Efficiency Opportunities program, as well as future carbon price mechanisms	Yes
B317	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.	No

Table 6-11 Revised Commitment

No.	Commitment
B037	Annual greenhouse gas emissions and energy consumption / production from the Project will be reported as required under the NGER Act and Energy Efficiency Opportunities program.

Arrow has committed to the ongoing measurement and monitoring of the Project's emissions, energy consumption and production through schemes which include:

- NGER Program; and
- EEOs.

As electricity consumption is an important contributor to life cycle emissions, electrical equipment (e.g. motors, pumps and compressors) will be regularly monitored and maintained as part of a comprehensive energy efficiency improvement program for the Project. These measures will be consistent with the EEO Program activities.

Arrow is a direct participant in the CPM. This means that if the Clean Energy Legislation (Carbon Tax Repeal) Bill 2013 is passed, Arrow will not be required to submit permits equivalent to its liability beyond 30 June 2014. However, Arrow will be a participant in the Direct Action Plan and the project will be included in the federal government's program to meet its emission reduction commitments. If the CPM is not repealed, Arrow will continue to acquit liability under the *Clean Energy Act 2011*.

6.7 Conclusion

The project description was developed to inform the Project EIS. Since publication of the EIS for public comment in Q1 2013, Arrow's field development plan and project description have been refined. The emissions inventory for the Project has been updated to reflect these refinements incorporating updated and new guidance documents and Project data sources. These updates and revised estimates of GHG emissions from the construction, operation and decommissioning of the Project have been reported. They are supplemented by new information about the Project in response to stakeholder submissions.

The refinements to the project description and resulting inventory updates show that total Project emissions are likely to be lower than the EIS. However, the refinements have made a significant difference to the source, profile and intensity of GHG emissions through the Project. The refined project description shows that the Project will be five years shorter than the EIS and production rates will increase during ramp-up and decrease during operation and ramp-down more sharply.

Direct Project emissions (Scope 1) in the ramp-up phase are higher than indirect Project (Scope 2) emissions for the first three years of the Project. This is a result of the combustion of gas for facility power generation. The highest year of emissions for the Project is expected to be in the ramp-up phase in 2019 when direct Project emissions are at their highest. For the remainder of the Project, annual indirect emissions are greater than direct emissions because power is predominantly supplied by electricity. It should be noted that power demand and hence calculated emissions for the possible

alternative temporary power generation scenario in 2018 and 2019 are based on a full capacity power demand for each facility, and as such are based on a highly conservative scenario. Through detailed design the installed capacity of any required temporary power generation will be optimised to a much lesser degree than full capacity, which will result in lower emissions. Estimates provided on the full capacity scenario within this report are therefore presented as a highly conservative case that exceeds the likely worst case emissions for the temporary power demand from the eventual optimised required capacity for the Project. In the operational phase, the production plateau is expected to last until 2046.

GHG intensity averaged over the Project is higher in the SREIS than the EIS. This can be expected because the reduction in forecast gas production is greater than the predicted reduction in GHG emissions. However, the following should be also be noted:

- Conservative assumptions have been used to assess GHG emissions such as, but not limited to, the assessment of emissions from temporary power generation under the full capacity scenario instead of the likely optimised required capacity for the Project; and
- Despite the expected increase in intensity of GHG emissions during the life of the Project after the project description refinements, the inventory update shows that overall Project emissions are likely to reduce by 4.3%.

Although the 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. Hence, electricity sourced from gas has a significant advantage over other fossil fuels with respect to full cycle emissions, which include emissions from the extraction, production and transport of the fuel, and the emissions associated with combustion. In the EIS, it was shown that each unit of electricity generated from gas produces approximately 50% lower total (full-cycle) GHG emissions than conventional coal-fired electricity. Recent studies in the Australian context focused on exports of Australian conventional gas, CSG and coal to Asia. These studies have concluded generally that LNG has lower overall lifecycle GHG emissions than coal, when power generation technologies of similar efficiency or application are compared. Open cycle gas technology using LNG from CSG produces 27% less emissions over its life cycle than sub-critical coal fired technology.

In the ramp up period, other indirect emissions (Scope 3) are significantly higher than the EIS, where increased production rates result in an increase of downstream processing requirements and subsequently the end use of the gas. In the operational period, other indirect emissions are higher in the EIS than the SREIS which corresponds to the reduction in gas production from 7.1 million TJ (EIS) to 5.8 million TJ (SREIS), and the reduction in emissions from downstream processing and end use. Production in the operational phase of the SREIS is expected to be lower than the EIS. Similarly, in the ramp-down period SREIS Scope 3 emissions are approximately a quarter of those estimated in the EIS as a result of lower estimated gas production.

Australia has committed to reducing national GHG emissions by 5% of 2000 levels by 2020 under the Kyoto Protocol. This represents a 23% reduction below business as usual. As energy production is the source of approximately 75% of Australia's total GHG emissions, reducing emissions from this sector will be necessary to meet this commitment. The Project will now source electricity from the national grid for the majority of its power needs, which means its Scope 2 GHG emissions are the most significant Project emissions. Therefore, these emissions depend on state and federal electricity

generation policies. Emissions from electricity generation across all sectors in Queensland have been decreasing from a peak in 2009. If emissions per unit of electricity generated in Queensland continue to fall, Project emissions will be lower than predicted in the SREIS.

It has been shown that end-use of gas for electricity production results in much lower GHG emissions than other fossil fuels. The use of gas for energy production (Scope 3 emissions) produces much higher GHG emissions than Project Scope 1 and Scope 2 emissions. Hence, electricity sourced from gas has a significant advantage over other fossil fuels with respect to full cycle emissions (Scopes 1, 2 and 3), which include emissions from the extraction, production and transport of the fuel, and the emissions associated with combustion. For instance, each unit of electricity generated from gas produces approximately 50% lower full-cycle GHG emissions than conventional coal-fired electricity. Recent studies in the Australian context focused on exports to Asia of Australian conventional gas, CSG and coal (refer to the Greenhouse Gas Technical Report (Appendix C) of the SREIS). These studies have concluded that LNG has lower overall lifecycle GHG emissions than coal, when power generation technologies of similar efficiency or application are compared. Open cycle gas technology, using LNG from CSG produces 27% less emissions over its life cycle than sub-critical coal fired technology.

The Project is subject to international, national, state and corporate GHG policies with abatement objectives and performance standards. Arrow will comply with all mandatory international, national and, state objectives. The Project will therefore be consistent with Australia's current policy to reduce GHG emissions. Arrow remains committed to the mitigation measures described in the EIS Greenhouse Gas Technical Report and new climate change adaptation commitments described in the SREIS Greenhouse Gas Technical Report (Appendix C). It is considered that the mitigation measures applied for the EIS are still appropriate to address identified impacts.