10. GREENHOUSE GAS

This chapter describes the supplementary greenhouse gas study undertaken to address changes made to the project description as a result of detailed front-end engineering design (FEED) completed after the Arrow LNG Plant EIS (Coffey Environments, 2012) was finalised and exhibited.

The chapter presents the findings of the supplementary greenhouse gas report completed by PAEHolmes, which is attached as Appendix 3.

10.1 Studies and Assessments Completed for the EIS

This section provides an overview of the greenhouse gas impact assessment completed for the Arrow LNG Plant EIS and describes the main conclusions from the assessment.

PAEHolmes was engaged to conduct the greenhouse gas impact assessment, which is included as Appendix 13 of the EIS. Chapter 20 of the EIS presents the findings of the assessment.

The greenhouse gas impact assessment estimated greenhouse gas emissions that may result from the construction and operation of the Arrow LNG Plant, comprising the LNG facility and its associated marine and mainland infrastructure. The study considered a number of options and alternatives to the proposed plant and infrastructure design, most notably two options for power generation: the all mechanical option (also known as Power Island Mode with gas turbine generators on site producing all plant power) and the all electrical option (also known as Power Import Mode with all site power for LNG compressors and site utilities sourced from the electricity grid).

The greenhouse gas impact assessment for the EIS estimated the project's contribution to national and global carbon emissions in three types of emissions associated with the project: scope 1, scope 2 and scope 3 emissions. Direct scope 1 emissions sources were assumed to include:

- Generation of electricity, where emissions result from fuel combustion in stationary sources, such as gas turbines and diesel electricity generators.
- Transport of materials, waste and employees, where emissions result from fuel combustion in Arrow Energy owned or controlled mobile combustion sources, such as vehicles and vessels.
- Construction activity, where emissions result from fuel combustion in Arrow Energy 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.
- Vegetation clearance.

Indirect scope 2 emissions were assumed to include emissions from electricity procured from third parties. The indirect scope 2 emissions will not occur at the LNG plant site but will occur at the

third-party facility producing electricity. Indirect scope 3 source emissions were assumed to include all other emissions not included in scope 1 and 2 emissions, e.g., emissions associated with fuel production through to the end use of the produced LNG.

A key conclusion of the assessment was that, given the application of appropriate mitigation and management measures, the contribution of the Arrow LNG Plant to global greenhouse gas emissions would be negligible, accounting for less than 0.03% of global emissions under a worst-case scenario.

A number of greenhouse gas commitments were developed based on the expert advice of PAEHolmes. Table 10.1 lists the commitments proposed for abatement of greenhouse gas emissions.

Table 10.1 Greenhouse gas commitments

No.	Commitments
C20.01	Develop and implement a greenhouse gas standard as part of Arrow's HSEMS.
C20.02	Identify and consider measures to reduce emissions intensity and improve the energy efficiency of the different project components throughout the design process.
C20.03	Minimise greenhouse gas emissions through the progressive clearing of areas and implement rehabilitation as soon as practical.

10.2 Study Purpose

The greenhouse gas supplementary report has addressed changes to the project description that have arisen due to the completion of front-end engineering design after the EIS was finalised and exhibited. Those project description changes identified as having the potential to affect the conclusions of the greenhouse gas impact assessment are described below.

The most significant project description change relevant to the greenhouse gas assessment relates to the options being taken forward for power generation. The all electrical option that was modelled as part of the original greenhouse gas impact assessment has been discontinued. The power generation options being taken forward are:

- Base case: all mechanical option. This is the base case that was assessed in the EIS and that was modelled as part of the original greenhouse gas impact assessment.
- Alternate case: mechanical/electrical option (also known as Partial Auxiliary Import Power Mode). This reflects the mechanical/electrical case, which was identified but not fully assessed in the original greenhouse gas impact assessment.

Table 10.2 outlines these and other project description changes that have been identified as having the potential to affect the greenhouse gas emission estimates presented in the original greenhouse gas impact assessment.

Table 10.2 Description of project design changes

Changes to Project Design	Description of Changes
Power generation options	The power generation options have been revised from the arrangement described in the EIS, as follows. **All Mechanical Option** • All the power required will be generated on the LNG plant site. • The refrigerant compressors will be powered by gas turbines, and all the auxiliary electrical power will be provided by gas turbine generators without power import, i.e., no change to the arrangement described in the EIS. For this option, five 30-MW gas turbine generators will be required for trains 1 and 2; and an additional three 30-MW gas turbine generators will be required for trains 3 and 4. • The 10 to 20 MW of power required during the construction phase (site construction activities and camp) will be generated on the construction site by means of diesel engine driven generators. **Mechanical/Electrical Option** • Power imported from the Gladstone North Substation on the mainland will include two (redundant) high-voltage (132-kV) feeders to supply up to 80 MVA installed underground from the Gladstone North Substation to the LNG plant. This will be supplemented on site by three 30-MW gas turbine generators for trains 1 and 2, with an additional three 30-MW gas turbine generators for trains 3 and 4. • The worst-case scenario is assumed to involve one gas turbine generator tripping out while another gas turbine generator is in maintenance. During this scenario, the power import could be as much as approximately 45 MW to meet the power demand for full-capacity LNG production. • Imported power will also be used during the construction phase. Diesel engine generators will be installed on site to supply construction power of some 5 MW during the initial phase of the construction work (first 16 months). After completion of the connection to the electricity grid, the power supply for construction will be taken from the grid, and onsite generation by diesel generators will be terminated. The redundant high-voltage feeders from the mainland will be routed in ducts installed in two horizontal directional drilled bores that will connect the mainland to Curtis Island. • Establishment of the connection is expected to be completed 14 months after final investment decision is taken. Prior to establishment of the connection, diesel generators will provide electrical power to the site. Following establishment of the connection, major electrical users, such as the construction camp and main temporary offices, will be switched over to be powered by electricity from the grid, while smaller, isolated users will continue to be powered by diesel generators based on the relative expense of establishing electrical reticulation to smaller users compared to the savings gained from reduced diesel requirements. Electrical power for commissioning will be sourced from the electricity grid.

Table 10.2 Description of project design changes (cont'd)

Changes to Project Design	Description of Changes
Refinement of activity data for the Arrow LNG plant	• Following front-end engineering design, the projected LNG production rate has been set, for the purposes of greenhouse gas assessment, at an estimated 16.2 Mtpa. For the purposes of the general project description, the LNG plant capacity is reported as being up to 18 Mtpa. Whilst 18 Mtpa is an accurate representation of the production capacity of the LNG plant, the efficiency of the plant will be affected by the predominantly warm ambient temperatures. An actual total production of 16.2 Mtpa is considered to be realistic and remains generally aligned with the production rate modelled for the EIS (16 Mtpa). • Diesel consumption requirements have been refined for construction activities such as dredging volumes and associated diesel consumption, vessel movements and the inclusion of landing craft transport vessels. • Estimates for the transport of materials, waste and employees have been refined.
Revisions in flare design	The flare design has been revised from the arrangement described in the EIS, as follows: • The operational flare is no longer proposed. • All flares will be gas-assisted during turn-down operation. • Three flare stacks will be required for trains 1 and 2 (stage 1) including warm wet, cold dry and storage and loading flares. • An additional cold flare will be required for trains 3 and 4 (stage 2). In addition, a spare flare stack will be provided with the stage 1 development to allow one flare to be taken out of service for maintenance. All flares will be elevated flares, and there will be no liquid disposal burners. The maximum exhaust rate and flare height have been revised for the worst-case scenario associated with the cold dry flare.
Mainland infrastructure	Arrow Energy is currently considering options for the accommodation of the project workforce. For the purpose of the supplementary report to the EIS, the greenhouse gas assessment has assumed that the TWAF remains the worst-case scenario in terms of its contribution to greenhouse gas emissions, and it has been included in the modelling for scope 1 emissions.
Increase in plant availability	Plant availability has increased from 339 days annually to 346.3 days annually (94.8%).
Increase in project footprint (area of disturbance)	The site footprint has increased, which in turn increases the amount of vegetation that needs to be cleared. The worst-case scenario for vegetation clearance has been calculated at 336.7 ha, compared with 318 ha assessed in the EIS.

10.3 Legislative Update

Since the EIS was finalised and exhibited, there have been some changes to government policy that impact on the management of greenhouse gas emissions.

Parties to the Kyoto Protocol have decided to establish a second commitment period under the protocol from 1 January 2013. Further negotiations will occur in 2012 to finalise the emission reduction targets to be adopted by countries that participate in the second commitment period. If Australia participates in the second commitment period, emissions from the Arrow LNG plant will count towards the second commitment period of this protocol.

10.4 Study Method

The greenhouse gas emission estimates established as a part of the greenhouse gas supplementary report reflect the project description changes and updated guidance documentation on greenhouse gas emission techniques. They are based on the most recently published guidance issued by the Australian Government Department of Climate Change and Energy Efficiency. Since the EIS was finalised and exhibited, the following guidance documentation on greenhouse gas emission techniques were updated:

- Australia National Greenhouse Accounts: National Greenhouse Accounts Factors, July 2012 (DCCEE, 2012).
- National Greenhouse and Energy Reporting System Measurement: Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia 2012 (DCCEE, 2012a).

With the exception of the power generation scenarios modelled (all mechanical and mechanical/electrical options), the study methods remained the same as those outlined in the EIS.

10.5 Study Findings

This section describes the key findings of the greenhouse gas supplementary report, including any changes to the impacts outlined in the EIS.

10.5.1 Construction Emissions

The total direct and indirect greenhouse gas emissions (scope 1, scope 2 and scope 3) associated with construction of the project for the all mechanical option have been estimated at approximately 95 kt CO_2-e/annum (excluding one-off vegetation clearing), as described in Table 10.3. This represents an approximate 14% increase when compared to the 83.6 kt CO_2-e/annum that was reported in the EIS. Within the total, scope 1 and 2 construction emissions were reduced due to refinement of diesel consumption data and a change to the emission factor for Queensland electricity usage, respectively. Scope 3 construction emissions were increased due to refinement of activity data allowing additional emission sources to be included in the assessment.

The total direct and indirect greenhouse gas emissions (scope 1, scope 2 and scope 3) associated with construction of the project for the mechanical/electrical option have been estimated at approximately 139 kt CO_2-e/annum (excluding one-off vegetation clearing). The mechanical/electrical option generates more emissions than the all mechanical option as importation of electricity from the grid is more emissions-intensive than onsite power generation using diesel generators.

Both the all mechanical option and the mechanical/electrical options generate fewer emissions than the all electrical option, which has been discontinued. The all electrical option was reported in the EIS as generating approximately 182.4 kt CO_2-e/annum.

Table 10.3 Direct and indirect construction greenhouse gas emissions

Scope	Category	Activity	Total[1] CO_2-e Reported in the EIS[2]	Total[1] Updated CO_2-e [2]
All Mechanical Option				
Scope 1	Fuel combustion	Construction power, dredging equipment and passenger and marine vessels.	59,074	45,800
	Land clearing	Vegetation removal.	(64,032[3])	(67,753[2])
Scope 2	Energy consumption	Electricity consumption at the TWAF.	17,483	16,894
Scope 3	Energy consumption or production	Full fuel cycle (marine vessels, TWAF and construction activities).	7,022	32,322
Overall			**83,579**	**95,017**
Mechanical/Electrical Option				
Scope 1	Fuel combustion	Dredging, passenger and marine vessels, and passenger transport.	NA	19,362
	Land clearing	Vegetation removal.		(67,753[2])
Scope 2	Energy consumption	Electricity consumption for power generation and LNG trains and energy consumption at the TWAF.		80,506
Scope 3	Energy consumption or production	Full fuel cycle (electricity at TWAF, marine vessels, and electricity for construction power).		39,182
Overall				**139,050**

[1] Total CO_2-e emissions (tonnes CO_2-e/annum) include carbon dioxide, methane and nitrous oxide.

[2] Any discrepancy between the sum of the rows in this table and the totals themselves are due to differences in rounding between data sates.

[3] Vegetation removal is only included in Year 1 and is excluded from the overall total.

10.5.2 Operations Emissions

The total direct and indirect greenhouse gas emissions (scope 1, scope 2 and scope 3) associated with operations (excluding start-up flaring) have been estimated to be approximately 59.6 Mt CO_2-e/annum for the all mechanical option, as described in Table 10.4. This represents a reduction of approximately 12% compared to the 67.5 Mt CO_2-e/annum that was reported in the EIS. Scope 1 operational emissions were reduced due to the refinement of data associated with power generation requirements. Scope 3 emissions were reduced due to updated production data. As there is no requirement to source electricity from third parties during operations as a part of this option, Scope 2 emissions remained at zero.

The total direct and indirect greenhouse gas emissions (scope 1, scope 2 and scope 3) associated with operation of the project for the mechanical/electrical option have been estimated to be approximately 59.6 Mt CO_2-e/annum.

The all mechanical and mechanical/electrical options generate approximately 16% and 15% fewer emissions, respectively, than the all electrical option, which was reported in the EIS as being approximately 70.3 Mt CO_2-e/annum. The all electrical option has been discontinued.

Table 10.4 Direct and indirect operations greenhouse gas emissions

Scope	Category	Activity	All Mechanical Option		Mechanical/Electrical Option	
			Total[1] CO_2-e Reported in the EIS	**Total[1] Updated CO_2-e**	**Total[1] CO_2-e Reported in the EIS**	**Total[1] Updated CO_2-e**
Scope 1	Fuel combustion	Stationary engines – power generation for utilities and LNG trains, passenger and marine vessels, and passenger transport.	6,380,431 (97,334[2])	4,684,793 (43,879[2])	NA	4,589,442 (43,384[2])
	Fugitive emissions	Venting from acid gas removal unit, start-up flaring, [2] pilot and maintenance flaring, facility-level fugitives and transmission.				
Scope 2	Energy consumption	Electricity consumption for power generation and LNG trains	0	0		143,189
Scope 3	Energy consumption and production	End use LNG, full fuel cycle (coal seam gas processed), full fuel cycle (marine vessels), and full fuel cycle (operations power and accommodation).	61,117,866	54,919,313		54,874,502
Overall[3]			**67,498,296**	**59,604,106**		**59,607,132**

[1] Total CO_2-e emissions (tonnes CO_2-e/annum) include carbon dioxide, methane and nitrous oxide.

[2] Start-up flaring is only included in Years 1 and 9 and is excluded from the overall total.

[3] Any discrepancy between the sum of the rows in this table and the totals themselves are due to differences in rounding between the two data sets.

10.5.3 Potential Impacts and Management Measures

The scope 1 and scope 2 emissions from operation of the Arrow LNG Plant under the all mechanical and mechanical/electrical options are less emissions-intensive than the all electrical option assessed in the EIS (4 to 4.7 Mt CO_2-e/annum, respectively, compared with 8.2 Mt CO_2-e/annum, excluding start-up flaring). Using the data in Table 10.5, this represents approximately 1% to 1.1% of the Australian Government's 2009 energy sector emissions.

The predicted greenhouse gas CO_2-e emissions for the project are equivalent to 0.016% of 2009 global emissions for the worst-case scenario (most emissions-intensive operational year). This indicates that the Arrow LNG Plant's contribution to global greenhouse gas emissions and climate change is expected to be negligible.

As the estimated greenhouse gas emissions are generally lower than those reported in the EIS (all mechanical option and all electrical option) no changes to the mitigation measures described in the EIS are proposed.

Table 10.5 Estimates of greenhouse gas emissions

Geographic Area	Source Coverage	Time Scale	Emissions per Annum (Mt CO_2-e/annum)
Global[1]	Consumption of fossil fuels	2009	30,086
Australia[2]	Energy sector	2009	420.3
Queensland	Total greenhouse gas emissions including land use, land use change and forestry	2009	155.1
Arrow LNG Plant	Scope 1 operational emissions	All mechanical option	4.6
	Scope 2 operational emissions		0.14
	Total operational emissions		4.7
	Scope 1 operational emissions	Mechanical / electrical option	4.7
	Scope 2 operational emissions		0
	Total operational emissions		4.7

[1] UNSD (2012).
[2] DCCEE (2011).

10.6 Conclusion

The greenhouse gas impact assessment, revised to account for changes in the project description that have been developed as a result of front-end engineering design, indicates the following:

- The all mechanical option and mechanical/electrical option assessed in the supplementary report are estimated to result in lower greenhouse gas emissions than the all electrical option reported in the EIS.
- The refined all mechanical option is estimated to result in higher emissions during construction than the same option reported in the EIS (due to the inclusion of additional emission sources in the revised assessment) and lower greenhouse gas emissions during operation. Overall, the refined all mechanical option is estimated to generate approximately 12% fewer emissions than the same option reported in the EIS.
- The refined all mechanical option is estimated to result in lower greenhouse gas emissions than the mechanical/electrical option, due to the higher emissions-intensity of power sourced from the electricity grid, making the all mechanical option the least emissions-intensive option.

The project description changes generally result in a reduction in greenhouse gas emissions compared with those reported in the EIS. In particular, the decision to discontinue the all electrical option and progress the all mechanical and mechanical/electrical options has resulted in a reduction in greenhouse gas emissions. Given this, the mitigation measures detailed in the EIS are considered to be adequate for managing greenhouse gas emissions.

10.7 Commitments Update

Measures to manage potential greenhouse gas impacts presented in the EIS are unchanged and are included in Attachment 7, Commitments Update.