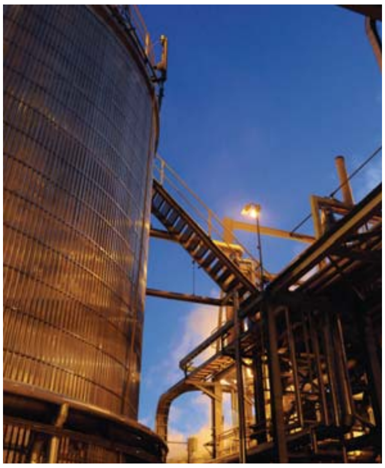

Appendix I

Greenhouse Gas Report

Incitec Pivot Limited

Appendix I

Greenhouse Gas Assessment for Proposed Incitec Pivot Ammonium Nitrate Plant, Kooragang Island.

AUGUST 2012

Prepared for

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Abbreviations

Abbreviation	**Description**
AN	Ammonium Nitrate
CEF	Clean Energy Future
$CO_{2\text{-}e}$	Carbon Dioxide Equivalent
DCCEE	Department of Climate Change and Energy Efficiency
DGRs	Director General Requirements
EEO	Energy Efficiency Opportunities
EIS	Environmental Impact Statement
GHG	Greenhouse Gas
GHGA	Greenhouse Gas Assessment
GWP	Global Warming Potential
HP	High Pressure
IPL	Incitec Pivot Limited
KI	Kooragang Island
ktpa	Kilotonnes per annum
LP	Low Pressure
Mt	Mega-tonne
NA	Nitric Acid
NGER	National Greenhouse and Energy Reporting
NH_3	Ammonia
NSCR	Non Selective Catalytic Reduction
NSW	New South Wales
N_2O	Nitrous Oxide
SCR	Selective Catalytic Reduction

Executive Summary

URS Australia Pty Ltd (URS) has been commissioned by Incitec Pivot Limited (IPL) to undertake a Greenhouse Gas Assessment (GHGA) for the proposed Ammonium Nitrate (AN) facility (the Project). The Project is to be located on IPL's existing property at Kooragang Island (the Site), Newcastle, New South Wales.

A GHG inventory was developed for the construction and operational phases of the Project. The inventory was based on publically available emission factors, information supplied by the proponent and assumptions where necessary. The GHG inventory estimated that during full operation the facility would produce:

- 74,432 t CO_2-e per annum Scope 1 emissions, of which:
    - 42,186 t CO_2-e (approximately 49% of total Scope 1 and 2) would be associated with the release of N_2O,
    - 31,720 t CO_2-e (approximately 36.9% of total Scope 1 and 2) would be associated with the combustion of natural gas; and
    - 526 t CO_2-e (approximately 0.6% of total Scope 1 and 2) would be associated with the combustion of liquid fuels for site vehicles.
- 11,609 t CO_2-e per annum Scope 2 emissions (approximately 13.5% of total Scope 1 and Scope 2 emissions), associated with the purchase of electricity from the grid.

Additionally the assessment estimated that annualised GHG emissions from the Project would contribute:

- approximately 0.02% to the National GHG inventory; and
- approximately 0.06% of the NSW GHG inventory.

The design of the plant has incorporated a number of energy efficiency opportunities and GHG abatement in the form of:

- Heat recovery and process optimisation. The heat generated from the exothermic reactions of the plant would allow the facility to produce steam for heat recovery and for the generation of electricity. It is expected that approximately 7.5 MW of electricity could be produced from excess heat and the auxiliary boiler during steady state operations. This would equate to approximately 51,660 t CO_2-e should this electricity be purchased from the grid, or upwards of 50% of the total Scope 1 emissions estimated for the Project; and
- N_2O abatement through the use of a) the minimisation of N_2O generation in the oxidizer by promoting the desired reaction using a platinum / rhodium catalyst and b) thermal catalytic reduction within the ammonia oxidiser using an N_2O abatement catalyst. The N_2O abatement technologies are capable of reducing N_2O emission by in excess of 90%.

The greenhouse gas emission intensities for the Project were estimated as follows:

- 0.49 kg N_2O / t of 100% nitric acid produced. This equates to 0.15 t CO_2-e / t of nitric acid produced as a result of N_2O released; and
- 1.00 t CO_2-e / t of ammonium nitrate generated[1].

These intensities compared well with published data on plants worldwide and within Australia.

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[1] This intensity also includes an allowance for (upstream) ammonia production to allow for comparisons against other facilities and literature facilities which incorporate ammonia production. IPL do not propose to conduct any ammonia production at the Site.

Introduction

1.1 Background

URS Australia Pty Ltd (URS) has been commissioned by Incitec Pivot Limited (IPL) to undertake a Greenhouse Gas Assessment (GHGA) for the proposed Ammonium Nitrate (AN) facility (the Project). The Project is to be located on IPL's existing property at Kooragang Island (the Site), Newcastle, New South Wales.

The Project consists of a 350 ktpa AN production facility incorporating:

- A 30,000 tonne anhydrous ammonia storage area;
- A 280,000 tonne per annum Nitric Acid (NA) (100% basis)[2] plant;
- A 350,000 tonne per annum 100% AN plant;
- Bulk storage of 5,000 tonnes of Technical Grade AN;
- Bagging facility for Technical Grade AN, including storage of 6,000 tonnes; and
- Auxiliary infrastructure and utilities.

The Project does not include ammonia manufacture, as ammonia would be imported to the Site.

1.2 Assessment Scope

The Director General's Environmental Assessment Requirements (DGRs) for the environmental assessment of the Project outlines that the Environment Impact Statement (EIS) must include an assessment of greenhouse gases associated with the Project including "*a quantitative analysis of the Scope 1 and 2 greenhouse gas emissions of the Project and a qualitative analysis of the impacts of these emissions; details of measures to improve energy efficiency*".

To satisfy the DGRs, and facilitate the consideration of the Project approval in the context of greenhouse gas emissions, the GHGA has included the following:

- Preparation of a greenhouse gas (GHG) inventory incorporating direct (Scope 1) and indirect (Scope 2) emissions;
- A comparison of these emissions against National and State inventories, and other similar facilities; and
- Preparation of a deliverable report outlining:
    - The greenhouse gas emissions associated with the Project;
    - The legislative framework associated with greenhouse gas emissions;
    - The methodology and results of the developed inventory; and
    - A summary of proposed greenhouse gas abatement, energy efficiency measures and other greenhouse gas reduction mechanisms.

The direct (Scope 1) emissions associated with the Project would originate from:

- The release of nitrous oxide (N_2O) formed during NA production processes; and
- Combustion of liquid (i.e. diesel) and natural gas, both during construction and operational phases of the Project.

The formation of N_2O is considered a key area in terms of greenhouse gas emissions, as N_2O has a global warming potential of 310 times that of carbon dioxide.

Scope 2 emissions would be associated with the purchase of electricity from the grid.

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[2] In this report, NA denotes Nitric Acid on a 100% basis.

Greenhouse Gas Policy

2.1 International Policy

The Kyoto Protocol to the United Nations Framework Convention on Climate Change was signed in 1997 and entered into force in 2005. Australia ratified the Kyoto Protocol in December 2007. Its aim is to limit greenhouse gas emissions of countries that ratified the protocol by setting individual mandatory greenhouse gas emission targets in relation to those countries' 1990 greenhouse gas emissions. Australia has committed to meeting its Kyoto Protocol target of 108% of 1990 emissions by 2008-2012.

The Kyoto Protocol sets out three "flexibility mechanisms" to allow greenhouse gas targets to be met:

- The Clean Development Mechanism;
- Join Implementation; and
- International Emissions Trading.

The definitions of the three mechanisms above are complex, but effectively they allow greenhouse gas reductions to be made at the point where the marginal cost of that reduction is the lowest. Essentially, an industrialised country sponsoring a greenhouse gas reduction project in a developing country can claim that reduction towards its Kyoto Protocol target and those greenhouse gas reductions can be traded.

2.2 Australia's Climate Change Policy

The Australian policy on climate change was released in July 2007[3] and sets out the Commonwealth Government's focus on:

- reducing Australia's greenhouse gas emissions;
- adapting to climate change that we cannot avoid; and
- helping to shape a global solution that both protects the planet and advances Australia's long term interests.

This Project will operate in accordance with the following climate change policies: Clean Energy Future (CEF), Energy Efficiency Opportunities (EEO), and National Greenhouse and Energy Reporting (NGER).

Additionally the Clean Energy Legislation Act (CELA) was passed in June 2012. The CELA Act makes amendments to the Clean Energy Act 2011 and related legislation establishing the Government's carbon pricing mechanism. This legislation applies to companies operating large emitting facilities (i.e. over 25,000 tonnes of $CO_{2\text{-}e}$ emissions each year) .

2.2.1 Clean Energy Future

In July 2011, the Australian Government announced the plan for a Clean Energy Future (CEF) which has a focus on four key elements[4]:

- carbon price;
- renewable energy
- energy efficiency; and
- land use.

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[3] Department of the Prime Minister and Cabinet, Australian Government 2007 *Australia's Climate Change Policy*. July 2007.

[4] Outlined within *An overview of the Clean Energy Legislative Package*, available at www.cleanenergyfuture.gov.au

The carbon price mechanism is set to operate in two phases: a fixed price phase commencing July 2012 and a floating price phase commencing July 2015. Carbon permits will be required to be submitted by entities that emit more than 25,000 t CO_2-e. A number of additional programs are included within the clean energy future program, such as:

- Clean Technology Program;
- Steel Transformation Plan; and
- Coal Sector Jobs Package;

The CEF is supported by the National Greenhouse and Energy Reporting Act 2007 (NGER) which establishes a national framework for Australian corporations to report greenhouse gas emissions, reductions, removals and offsets, and energy consumption and production.

2.2.2 National Greenhouse and Energy Reporting Act 2007

The National Greenhouse and Energy Reporting (NGER) Act establishes a national framework for Australian corporations to report Scope 1 and Scope 2 greenhouse gas emissions, reductions, removals and offsets, and energy consumption and production from July 2008. It is designed to provide robust data as a foundation to the CEF.

Since 1 July 2008, corporations have been required to register and report if:

- they control facilities that emit 25 kilotonnes or more of greenhouse gas (CO_2-e), or produce/consume 100 terajoules or more of energy annually; or
- their corporate group emits 125 kilotonnes or more greenhouse gas (CO_2-e), or produces/consumes 500 terajoules or more of energy annually.

Lower thresholds for corporate groups have been phased in, with the final threshold at 50 kt CO_2-e emissions or 200 terajoules of energy production or consumption for a corporate group. Companies must register by 31st August, and report by 31st October, following the financial year in which they meet a threshold.

IPL is defined as a large emitter under the National Greenhouse and Energy Reporting System (NGERS) and has a requirement to report annually on energy and greenhouse gas emissions associated with more than 50 sites throughout Australia[5]. In addition, IPL supply data to the Fertiliser Industry Federation of Australia, and have also participated in the Carbon Disclosure Project since 2009.

2.2.3 Energy Efficiency Opportunities

The Energy Efficiency Opportunities (EEO) legislation[6] came into effect in July 2006 and will continue to run in conjunction with the CEF until at least 2016[7]. The EEO requires large energy users (over 0.5 PJ of energy consumption per year) to participate in the program. The objective of this program is to drive ongoing improvements in energy consumption amongst large users. Businesses are required to identify, evaluate and report publicly on cost effective energy savings opportunities.

Energy Efficiency Opportunities legislation is designed to lead to:

- improved identification and uptake of cost-effective energy efficiency opportunities;

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[5] http://www.incitecpivot.com/energy.cfm, accessed 9th March 2012
[6] Energy Efficiency Opportunities Act 2006
[7] AAR 2011 *Climate Change Focus: Carbon pricing scheme*. Allens Arthur Robinson. 12 July 2011

- improved productivity and reduced greenhouse gas emissions; and
- greater scrutiny of energy use by large energy consumers.

The EEO is incorporated into the National Framework for Energy Efficiency.

2.3 State Policy and Initiatives

A number of policies and schemes have been announced for NSW since 2000. Some of the key policies and schemes are outlined within this section.

2.3.1 NSW Greenhouse and Climate Change Action Plan

In November 2005 the NSW Greenhouse Plan was released. This plan provided a strategic approach to combating climate change in NSW from 2005 to 2008 and beyond. The plan set out actions to reduce greenhouse gas emissions from the NSW Government and to work with stakeholders to reduce greenhouse gas emissions from their activities. The NSW Greenhouse Plan set principals and goals as follows:

- Raise awareness of climate change issues within the boarder community;
- Promote understanding of the likely impacts on NSW, and identify adaptation strategies;
- Limit the growth of greenhouse gas emissions and reduce these emissions in NSW;
- Promote climate change partnerships by Government, individuals, industry, business and community groups;
- Reduce business uncertainties by establishing carbon constraints in order to promote new investment and innovation; and
- Identify strategic areas for cooperative work with other Australia jurisdictions including a national emissions trading scheme.

Recently the NSW2021 plan set the Government’s agenda for climate change in NSW.

2.3.2 NSW Greenhouse Gas Reduction Scheme (GGAS)

The NSW Greenhouse Gas Reduction Scheme (GGAS) was a mandatory greenhouse gas emissions trading scheme aiming to reduce greenhouse gas emissions associated with the production and use of electricity. It was created in 2002 through amendments to the Electricity Supply Act 1995 and the Electricity Supply Regulation 2001, and commenced on 1 January 2003. On 5 April 2012, the Minister for Resources and Energy announced the closure of GGAS, effective 1 July, due to the commencement of the Commonwealth carbon pricing mechanism.

2.3.3 NSW 2021 – A Plan to Make NSW Number One

The NSW 2021 plan sets the Government’s agenda for change in NSW. Key targets noted for the plan, in relation to climate change and greenhouse gas emissions are:

- complete fine scale climate change projections for NSW and make available to local councils and the public by 2014;
- work with government agencies and universities to deliver improved climate projections for NSW and the ACT.

Additionally NSW 2021 includes the following goals:

2 Greenhouse Gas Policy

- 20% renewable energy by 2020;
- Assist business and households to realise annual energy savings of 16,000 GWh by 2020 compared to ‘business as usual’ trends; and
- Support 220,000 low income households to reduce energy use by up to 20% by June 2014.

Furthermore the NSW Government Sustainability Policy sets targets and strategies to improve the Government’s efficiency in use of water, energy and transport. The policy is an important step for the NSW Government to meet a commitment of becoming carbon neutral by 2020.

Inventory Framework

3.1 Reporting Boundaries

In preparing a greenhouse gas report that encompasses an emissions inventory is it important that the reporting boundaries are clearly defined to enable the target audience to clearly understand what activities and/or emissions sources have been covered within the inventory. Reporting boundaries may be:

- **Geographical boundaries**: Geographical boundaries are defined by the physical location of the sources being considered. Legislative requirements often differ between states and territories, hence geographical boundaries are often utilised;
- **Organisational boundaries**: Business operations often differ in their legal and organisational structure hence boundaries are often defined around company activities;
- **Facility boundaries**: Facility boundaries are defined when a program or inventory requires site level reporting; and
- **Emission boundaries**: Emission sources are often defined as one of three ‘scopes’ (Scope 1, Scope 2, and Scope 3) to allow a clear definition of direct and indirect emission sources. The varying scopes are defined below.

The inventory constructed in this assessment has been targeted to include emissions relevant to the scope defined in Section 1.2, as to facilitate the consideration of the Project in the context of greenhouse gas emissions. Specifically, the reporting boundary has defined to include scope 1 and 2 emissions associated with:

- Project-related activities occurring on the site; and
- Off-site sources that are under the operational control of IPL.

3.2 Emission Scopes

3.2.1 Scope 1 Emissions

Scope 1 emissions are often referred to as direct emissions and are as a direct result of the activities undertaken at a particular facility. Typically Scope 1 emissions are directly controlled by the proponent and therefore operating regimes or controls employed by the proponent can directly affect the greenhouse gas emissions from such sources.

The Scope 1 emissions for the construction phase of the Project that have been included are:

- combustion of liquid fuels (i.e. diesel) within transport and construction vehicles. Whilst not under direct control of IPL, these emissions have been included as a separate item for completeness;

The Scope 1 emissions for the operational phase of the Project that have been included are:

- production of N_2O within the nitric acid plant with subsequent release to atmosphere (post abatement);
- combustion of liquid fuels (i.e. diesel) in onsite vehicles and employee vehicles; and
- combustion of gaseous fuels (i.e. natural gas) within steam boilers, flare and other infrastructure at the Site;

IPL would not own or have direct control of import and export vehicles and vessels; hence these emissions have been excluded from the inventory.

3.2.2 Scope 2 Emissions

Scope 2 emissions are often referred to as indirect emissions and cover greenhouse gas emissions from the generation of purchased electricity, steam, heating or cooling consumed by the facility. These utilities are defined as being brought into the organisation boundary, i.e. purchasing electricity from the grid or other external source.

3.2.3 Scope 3 Emissions

Scope 3 emissions are all indirect emissions that are not included in Scope 2. Scope 3 emissions are a consequence of the activities of the facility or entity, but occur at sources or facilities not owned or controlled by the entity. Scope 3 emissions typically include other stages of a products life cycle not covered by other 'scopes' such as use and disposal of a product or service.

Scope 3 emissions have not been included in this assessment.

3.3 Materiality

Materiality is a concept used in accounting and auditing to minimise the time spent verifying data that does not impact a company's accounts or inventory in a material way. The exact materiality threshold that is used in GHG emissions accounting and auditing is subjective and dependant on the context of the site and the features of the inventory. Depending on the context, the materiality threshold can be expressed as a percentage of a company's total inventory, a specific amount of GHG emissions, or a combination of both.

Emissions are assumed to be immaterial if they are likely to account for less than 5% of the overall emissions profile. This materiality threshold has been chosen as a standard measure in GHG inventories.

3.4 Calculation Approach

There are several greenhouse gases generally considered for these types of assessments. They include carbon dioxide, (CO_2), methane (CH_4), and nitrous oxide (N_2O). In order to simplify inventory accounting a unit called carbon dioxide equivalent (CO_2-e) is used. This accounts for the various global warming potential (GWP) of non-CO_2 gases. The global warming potential is a measure of the amount of infrared radiation captured by a gas in comparison to an equivalent mass of CO_2, over a fixed lifetime. Following this convention, the inventory present is expressed as a mass of CO_2-e released.

Inventory Methodology

4.1 General

The emissions inventory has covered both the construction and operation phases of the Project, with emission estimates performed on an annualised basis. IPL have estimated construction to take place over a period of 28 months (i.e. over 3 inventory reporting years), with the remainder of the third inventory year assumed to occur when the facility is in complete operation.

4.2 Operational Processes

4.2.1 Nitrous Oxide from NA Production

The Project includes the production of NA through the catalytic oxidation of ammonia through which inadvertent N_2O emissions are generated. As part of this process, filtered ammonia is mixed with filtered air prior to entering the ammonia oxidation reactor, where the following reactions take place:

Equation 1: $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

Equation 2: $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$

Equation 3: $2NH_3 + 2O_2 \rightarrow N_2O + 3H_2O$

The ammonia oxidiser operates on the principal of limiting the generation of N_2O in the first instance, rather than seeking to reduce it downstream. The oxidation reactor includes three catalysts: platinum-rhodium gauzes, palladium gauzes and an N_2O abatement catalyst. Catalysts work by lowering the activation energy required for a desired reaction, in this case the platinum-rhodium gauze promotes the reaction described in **Equation 1**. The other reactions, described within **Equation 2** and **Equation 3**, are undesirable; however still occur to some extent within the process. Hence some production of N_2O would occur. The downstream N_2O abatement catalyst reduces N_2O to nitrogen and oxygen according to the following reaction:

Equation 4: $N_2O \rightarrow N_2 + ½O_2$

The palladium catalyst seeks to recover any loses of the primary catalyst. This catalyst often referred to as a “getter” or catchment, can recover up to 60 to 80% recovery of the total catalyst losses (IPPC 2007). The newly constructed ammonia oxidiser differs from other retrofitted (with N_2O abatement) by limiting the generation of N_2O in the first instance, rather than reducing any generated N_2O downstream. In addition the plant will employ Selective Catalytic Reduction (SCR) for the reduction of nitrogen oxides (NO and NO_2) formed in the process. The SCR process is not targeted at N_2O.

4.2.2 Nitrous Oxide from AN Production

The NA produced is then neutralised with ammonia to create aqueous AN. The exothermic reaction is described by **Equation 5** below.

Equation 5: $NH_3 + HNO_3 \rightarrow NH_4NO_3$

The AN solution is capable of decomposing to N_2O and other compounds if the temperature reaches above 200°C according to the following reactions:

Equation 6: $NH_4NO_3 \rightarrow N_2O + 2H_2O$

Equation 7: $2NH_4NO_3 \rightarrow 2N_2 + O_2 + 4H_2O$

Equation 5 is the desired reaction, hence cooling water is continually added to the neutralization reactor to release the heat generated and prevent the occurrence of decomposition reactions (**Equations 6 and 7**). Therefore N_2O emissions from AN production are not considered significant. This is consistent with IPPC (2007), which does not identify N_2O emissions as being of significance with respect to AN production.

4.2.3 Fuel Combustion

The Project would involve the combustion of liquid and gaseous fuels which would result in the generation of greenhouse gases. Combustion of natural gas would occur to meet plant energy requirements (i.e. to generate process steam within the steam boiler) whilst the combustion of diesel would occur in construction equipment and transport vehicles.

Additionally the ammonia flare would be required to be maintained in a ‘charged’ state (i.e. pilot flame active) to allow for emergency flaring. Natural gas would be used for this purpose.

4.3 Activity Data

Activity data utilised for establishing the greenhouse gas inventory is summarised in this section. The activity data is based on manufacturer’s information provided to URS and necessary assumptions. In some instances activity data varies depending on the operating parameters of the facility. For the purposes of this assessment start-up is considered the time period in which the entire plant takes to reach steady-state from a cold start. Normal operation is defined as the steady state period of operation where operating parameters will typically remain at a consistent level at 100% capacity. An operating design basis of 96 % has been accounted in developing activity data.

4.3.1 Scope 1 Emissions

The activity data utilised for estimating Scope 1 emissions is as follows:

Nitric Acid Production

The quantity of N_2O released (post-abatement) was established on a manufacturer nominated stack N_2O concentration of 75 ppmv (147 mg/Nm^3) at a nominated flow rate of 110,000 Nm^3/hr. This concentration is an average concentration throughout the catalyst life. Operation was assumed to occur for 8,400 hours per annum[8] for the purposes of determining N_2O production.

Liquid Fuel Combustion

During the construction phase it is estimated that approximately 2,153 kL of diesel fuel would be utilised base on anticipated construction equipment and estimates of equipment usage.

During the operation phase it is estimated that approximately 195 kL of diesel fuel would be utilised per annum for onsite vehicles and employee vehicles.

Natural Gas Combustion

Natural gas use during operation was estimated as follows:

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[8] Plant design basis is 96 %, i.e. 350 days or 8400 hours per annum. It is assumed that N_2O production is consistent through normal operating and start-up periods.

- Natural gas consumption of 1,338 kg/hr for the boiler during normal operation, assumed to occur for 8,400 hours per annum[9];
- Natural gas consumption of 3,185 kg/hr for the boiler during start up, assumed to occur for 36 hours per annum[10] ;and
- 20 kg/hour for the ammonia flare pilot flame, occurring for 8,760 hours per annum.

4.3.2 Scope 2 Emissions

Electricity consumption for the first plant start-up (assumed to be part of the construction phase), was provided as 16 MW hours per day occurring over a 330 day period.

Electricity consumption during operation was calculated on the following basis:

- Operational electricity consumption of 1.3 MW, occurring for 8,400 hours per annum[9]. Whilst the plant will be able to generate enough electricity to be self-sufficient, there may be stages where some import of the grid will occur. Typically 0.7 MW would be imported from the grid, however during ammonia unloading up to 1.3 MW may be required. A steady consumption of 1.3 MW has been conservatively applied; and
- For the remainder of the year 7.5 MW of electricity consumption occurs for 168 hours, and electricity consumption of 4.5 MW occurs for 192 hours[10].

4.4 Emission Factors

Emission factors utilised in the development of the inventory have been adopted from DCCEE (2011a) and are summarised in **Table 4-1**.

Table 4-1 Summary of Adopted Emission Factors

Activity	Emission Factor
Scope 1 Emissions	
Nitrous oxide emissions from NA production	310 t CO_2-e /t
Diesel combustion	2.7 t CO_2-e /kL
Fuel oil combustion	2.9 t CO_2-e /kL
Natural gas combustion	51.3 kg CO_2-e /GJ
Scope 2 Emissions	
Electricity consumption	0.89 kg CO_2-e /kWh

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[9] Plant design basis is 96 %, i.e. 350 days or 8,400 hours per annum.

[10] 7 days assumed where AN plant is running, however no power is being generated, i.e. maximum 7.5 MW required to be imported from the grid. The remaining 8 days assume that the AN plant is shutdown and 4.5 MW for other infrastructure would be required.

Greenhouse Gas Inventory

5.1 Project Emissions

During the construction phase of the Project, greenhouse gas emissions have been estimated at approximately 11 kt CO_2-e. Of the construction emissions estimated, approximately 6 kt CO_2-e would be attributable to combustion of diesel in construction vehicles, not directly controlled by IPL. The remaining 5 kt CO_2-e would be attributable to the purchase of electricity from the grid for the first plant start-up. The construction emissions would occur over a three year period.

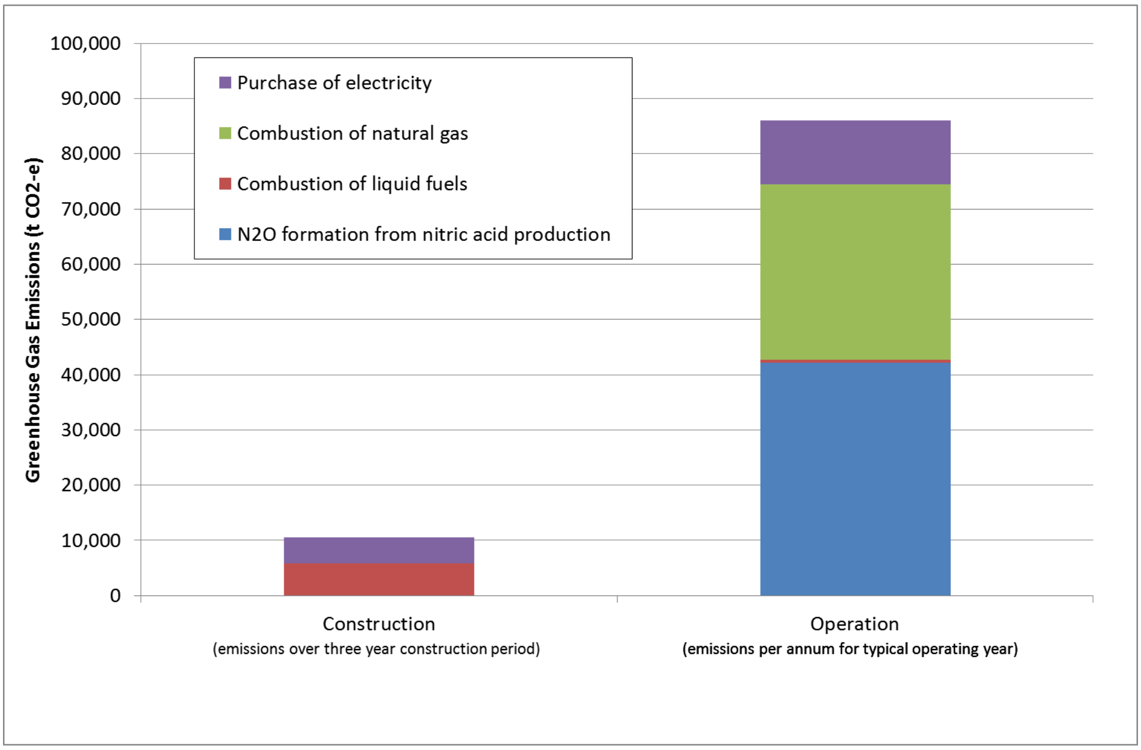
During the operational phase of the Project, greenhouse gas emissions have been estimated at 86 kt CO_2-e per annum. A breakdown of the Scope 1 and 2 emissions is provided in **Table 5-1**. Key emission contributions are associated with nitrous oxide emissions and natural gas combustion, which are estimated to account for approximately 49% and 36.9% of the inventory total (respectively).

Table 5-1 Summary of Scope 1 and 2 Projected Emissions

Activity	Quantity (kt CO_{2-e})	Proportion of Total
Scope 1 Emissions		
N_2O from NA production	42.2	49.0 %
Natural gas combustion	31.7	36.9 %
Liquid fuel combustion	0.5	0.6 %
Scope 2 Emissions		
Electricity consumption	11.6	13.5 %
TOTAL	86	100 %

Figure 5-1 provides a summary of estimated emissions for the construction and operational phases of the Project.

Figure 5-1 Summary of Scope 1 and 2 GHG Emissions



5.2 Comparisons to National and NSW Greenhouse Gas Inventories

The DCCEE publish National and State inventories for greenhouse gas emissions. The national accounts for the year to December 2011 are contained within DCCEE (2011b), and have been referenced for establishing the Project's impact on national inventories. That state accounts for the 2009/10 reporting year are contained within DCCEE (2011c) and have been referenced for establishing the Project's impact on state inventories. **Table 5-2** provides a comparison of the total (Scope 1 and 2) annual emissions from the Project against 2009 State and National inventories. It is estimated that the Project would contribute approximately 0.02% to the National inventories, and approximately 0.06% to the NSW inventory.

Table 5-2 Comparison of Annual Project GHG Emissions Against 2009 State and National Inventories

Boundary	Sector	GHG Quantity ($Mt\ CO_{2-e}$)	Project Contribution
Australia	All	546.3	0.02%
	Industrial processes	32.6	0.26%
NSW	All	152.5	0.06%
	Industrial processes	12.3	0.70%

Table 5-3 provides a comparison of the N_2O annual emissions from the Project against 2009 National N_2O inventories. It is estimated that the Project would contribute less than 0.5% of the N_2O national inventory for all sectors, and approximately 1% of the N_2O national inventory for industrial processes.

Table 5-3 Comparison of Annual Project N_2O Emissions Against 2009 State and National Inventories

Boundary	Sector	N_2O Quantity ($Mt\ CO_{2-e}$)	IPL Contribution
Australia	All	23.3	0.18%
	Industrial processes	3.3	1.28%

Greenhouse Gas Abatement

6.1 Nitrous Oxide Abatement

The abatement of N_2O emissions is a key concern for NA/AN facilities, as N_2O exhibits a global warming potential 310 times that of carbon dioxide, and is released in potentially significant quantities.

US EPA (2010) classifies Nitrous Oxide abatement into three categories, as defined below:

- ***Primary*** - reduces the amount of N_2O formed in the ammonia oxidation step. This can be done by modifying the catalyst used in the oxidation process and/or modifying the operating conditions of this process;
- ***Secondary*** – reduces the N_2O immediately after it is formed in the ammonia oxidation step; and
- ***Tertiary*** – reduces the N_2O by installing a catalytic reactor either upstream or downstream of the tail gas expansion unit following ammonia oxidation.

US EPA (2010) suggests that secondary and tertiary controls are the most commonly applied to NA production. The Project would employ primary and secondary control technologies. The platinum/rhodium catalyst within the ammonia oxidiser will limit the generation of N_2O, and the N_2O abatement catalyst will reduce a large portion of remaining N_2O to nitrogen and oxygen. It is estimated that these technologies would reduce the N_2O emissions by up to 93% below those for an uncontrolled plant. The Project design also incorporates Selective Catalytic Reduction (SCR) downstream of the tail gas expansion unit; however this is in relation to the treatment of NO/NO_2 emissions and not N_2O emissions.

6.2 Energy Efficiency Opportunities

As with many large industrial chemical facilities are number of energy efficiency opportunities exist and are employed within the design of such plants. Energy loss can be minimised in the design of such facilities through a range of energy recovery mechanisms. The design of the IPL facility has incorporated a number of heat and energy recovery process operations, which are described within this section.

6.2.1 Nitric Acid Plant

As detailed in **Section 4.2.1**, NA Production involves a series of exothermic reactions which liberate energy primarily in the form of sensible heat. The oxidation and absorption stages of NA plants typically yield more energy than the total production process consumes, making NA production a net exporter of energy. The following literature provides information on available energy resources in NA plants:

- IPPC (2007) states that the reactions from ammonia to HNO_3 can theoretically release 6.3 GJ/t HNO_3 (100%). Modern duel (medium / high) pressure plants are capable of exporting 2.4 GJ/t 100% HNO_3 as high pressure steam; and
- USEPA (2010)[11] state that 4.5 GJ/t (NA100%) of energy is theoretically available for recovery. However, in practice between 2.3 to 2.8 GJ/t (NA100%) is available for recovery. This can equate to an offset of 0.13 tonnes CO_2-e /t HNO_3, according to US EPA (2010).

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[11] The units within USEPA (2010) have been converted.

The design of the NA plant has incorporated a number of heat recovery mechanisms to utilise this energy. Heat recovery is obtained from two process streams: the low pressure (LP) nitrous gas stream exiting the ammonia oxidiser, and the high pressure (HP) nitrous gas stream which is compressed prior to entering the absorption column.

Heat recovery from the LP nitrous gas occurs through the following means:

- The lower portions of the ammonia oxidation reactor incorporates a steam boiler where 4.7 MPa steam is produced by forced circulation of boiler feed water from the steam drum. The hot exhaust gases from the reactor relay heat for the generation of steam and are hence cooled. Additional coils within the reactor provide additional energy for heating saturated steam from the steam drum.
- A train of shell and tube heat exchangers is utilised post ammonia oxidation for heat recovery. The first of which is the tail gas superheater, where tail gas (from the ammonia oxidiser) is re-heated using heat from tail gas (from operations further downstream), in order for additional steam generation. The recovery boiler then allows for the further generation of steam, which is sent to the steam drum. Remaining residual heat is then obtained in the economizer where boiler feed water is pre-heated and the two tail gas heaters where tail gas is heated to improve energy recovery at other parts of the plant.

Heat recovery from the HP nitrous gas occurs in a dedicated train of shell and tube heat exchangers. The first heat exchanger, the boiler water heater, pre-heats boiler feed water using heat in the HP nitrous gas stream. Tail gas from the adsorption tower is then heated from the HP nitrous gas stream in the tail gas pre-heater. Cooling water is then utilised for cooling the HP nitrous gas stream prior to entering the adsorption column. Additionally heat is recovered from the HP nitrous gas stream at the tail gas expander, post NO_X abatement, and prior to being released to atmosphere.

The high pressure steam (4.7MPa/460°C) is utilised to make low pressure steam which is utilised through the plant, predominantly in the aforementioned heat exchangers. A majority of the high pressure steam is sent to the steam turbine for electricity generation. Approximately 7.5 MW of electricity would be generated on site, with a majority being generated by the excess steam during normal operation. This would equate to approximately 51,660 t CO_2-e[12] should this electricity be purchased from the grid, or 0.18 t CO_2-e/ t HNO_3 (100%). This presents a substantial quantity, upwards of approximately 50% of the direct (Scope 1) emissions associated with typical plant operation.

6.2.2 Ammonium Nitrate Plant

The formation of ammonium nitrate through the neutralisation reaction of nitric acid and ammonia is also an exothermic reaction. Heat is removed through the generation of steam which contains carry over ammonium nitrate mist. The steam is cleaned prior to being utilised at other parts of the plant.

6.3 Best Available Technology

The term Best Available Technology (BAT) is often used to consider the environmental performance of a facility. In this instance a review of BAT in reducing the greenhouse gas emissions of ammonium nitrate plants is provided, with the context of the specific technologies proposed for the Project.

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[12] Assumed 7.5MW at an operating period 8400 hours, with a GHG emission factor of 820 kg $CO_{2\text{-}e}$ / MWh.

For the production of NA, IPPC (2007) describe BAT (in relation to greenhouse gases) as the employment of one or more abatement controls with process optimisation to achieve N_2O emission levels outlined in **Table 6-1**.

Table 6-1 N_2O emission levels associated with the application of BAT for the production of HNO_3 (adopted from IPPC, 2007)

Plant Type[1]	Plant Age	N_2O Emission Level*	
		kg/tonne HNO_3 (100%)	ppmv
M/M, M/H and H/H	New plants	0.12 – 0.6	20 - 100
	Existing plants	0.12 – 1.85	20 - 300

Notes: *These levels relate to the average emission levels achieved in a campaign of the oxidation catalyst.

[1] Defines the operating pressures of each plant stage. Pressures are defined as Medium (M) or High (H)

The proposed NA plant with N_2O abatement should achieve an N_2O emission level of 0.49 kg N_2O / t HNO_3 (100%) at an average concentration of 75 ppmv through the life of the catalyst. This is consistent with the BAT emission levels outlined in **Table 6-1**.

The BAT for the AN stage of the facility (in terms of greenhouse gas minimisation) is typically limited to the optimisation of the neutralisation stage of the process, and thus minimising energy use. The Project achieves this through using energy recovery techniques such as using the heat from the reaction to generate steam. This steam is cleaned prior to being used to evaporate ammonia. This reduces the overall energy use of the facility and thus reduces the need for importing electricity from the grid.

6.4 Benchmarking

Greenhouse gas emissions intensity, or the quantity of greenhouse gases per unit of product, is the key benchmarking parameter for consideration. This section provides a comparison of the greenhouse gas intensities developed for the Project against greenhouse gas intensities for other facilities that are referenced from publicly available literature. Benchmarking against referenced facilities has been conducted for the following:

- Nitric Acid Production (i.e. quantity of greenhouse gases per tonne of 100% nitric acid); and
- Ammonium Nitrate Production (i.e. quantity of greenhouse gases per tonne of ammonium nitrate product).

Detail of this analysis is provided in the following sections.

6.4.1 NA Production

Benchmarking of NA production is based on the net quantity of N_2O released per tonne of 100% nitric acid produced. Emission intensities have been adopted from the following literature:

- IPPC (2007) – intensities for various plant types;
- Wood & Cowie (2004) – intensities for various countries;
- AECOM (2009) – provides GHG emissions for the Orica Kooragang Island ammonium nitrate facility, as part of their recent upgrade. URS estimated intensities from emissions within this report;
- ERM (2010) – provides GHG emissions for the Burrup Nitrates facility in WA. URS estimated intensities from emissions within this report;

- GHD (2009) – provided GHG emissions for the Dampier Nitrogen facility in WA; and
- CSBP (2010) – provides emission intensities for CSBP facility in Kwinana.

These intensities are presented in **Table 6-2** and **Figure 6-1**.

Table 6-2 Benchmarking of Nitric Acid Plant

Description	N_2O Emissions Intensity for NA Production		Source
	kg N_2O / t 100 % NA	t CO_2-e / t NA (100%)	
Norsk Hydro	2.5	0.78	IPPC (2007)
EU Average	6.0	1.86	
EU representative level	7.0	2.17	
Mono M/M plant	4.9	1.52	
Mono M/M plant	6.8	2.11	
Mono M/M plant	7.1	2.20	
Mono M/M plant	5.7	1.77	
Mono M/M plant	3.8	1.18	
Medium pressure plant	1.9	0.59	
Mono H/H plant	0.2	0.06	
Dual L/M plant	4.2	1.29	
Dual M/H plant	7.1	2.20	
Dual M/H plant	7.7	2.39	
Dual M/H plant	9.0	2.79	
Dual M/H plant	0.2	0.06	
Dual M/H plant	7.7	2.39	
Dual M/H plant	9.0	2.79	
Dual M/H plant	5.3	1.64	
Dual M/H plant	7.2	2.23	
Dual M/H plant	1.8	0.56	
Dual M/H plant	1.7	0.53	
Dual M/H plant	2.7	0.82	
Dual M/H plant	1.8	0.56	
Dual H/H plant	0.2	0.06	
USA	5.5	1.71	Wood & Cowie (2004)
Norway – modern, integrated plant	2.0	0.62	
Norway – atmospheric pressure plant	4.5	1.40	
Norway – medium pressure plant	6.8	2.10	
Japan	4.0	1.23	
Canada – without NSCR	8.5	2.64	
Canada – with NSCR	2.0	0.62	
USA – without NSCR	9.5	2.95	
USA – with NSCR	2.0	0.62	
Sweden: Landsrona	7.3	2.25	
Sweden: Koping	9.0	2.80	
Orica KI[1]	2.9	0.90	AECOM (2009)
Burrup Nitrates[2]	0.6	0.19	ERM (2010)
Dampier Nitrogen	1.9	0.59	GHD (2009)
CSBP Kwinana – NA plant 1	6.9	2.14	CSBP (2010)
CSBP Kwinana – NA plant 2	6.5	2.02	
IPL	0.5	0.15	This assessment

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Notes: [1] Calculated from information provided within AECOM (2009). AECOM (2009) reports 544,851 t of CO_2-e from N_2O with a production rate of 605,000 t per annum

[2] Calculated from information provided within ERM (2010). ERM (2010) reports 50,764 t of CO_2-e from N_2O with a production rate of 760 t per day and an up rate of 95 % per annum.

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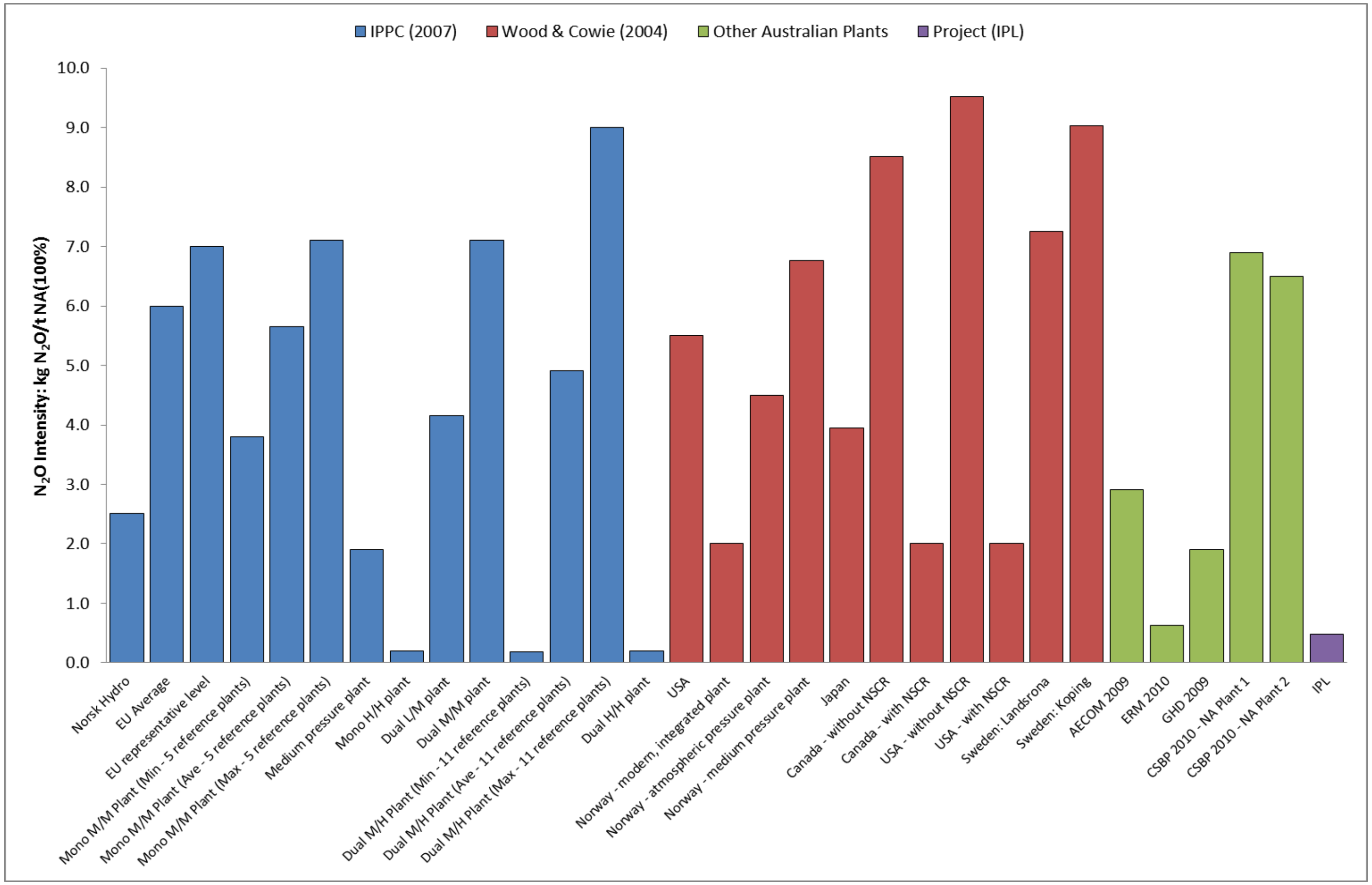
Figure 6-1 Benchmarking of NA Plant in Terms of GHG Intensities



The proposed IPL NA plant performs well when compared with the values cited in the referenced literature. This is expected given that the design of the NA plant incorporates modern process efficiencies and emission controls.

6.4.2 AN Production

The key benchmarking parameter for GHG performance of the Project is GHG emissions per unit of AN produced. The Project's emissions intensity has been estimated based on annualised emissions of 86,041 t, and annual AN production of 350,000 t, equating to approximately 0.25 tCO_2-e/t AN produced.

For the purpose of considering emission intensities in the context of other AN facilities, reference values have been sourced from the following literature:

- Wood & Cowie (2004) – provides emissions intensities for various countries;
- AECOM (2009) – provides GHG emissions for the Orica Kooragang Island ammonium nitrate facility, as part of their recent upgrade. URS established intensities from emissions within this report;
- ERM (2010) – provides GHG emissions intensity for the Burrup Nitrates facility in WA.
- GHD (2009) – provided emissions intensity for the Dampier Nitrogen facility on the Burrup Peninsula, WA; and
- CSBP (2010) – provides emissions intensity for CSBP facility in Kwinana.

These emissions intensities include GHG emissions associated with the production of ammonia (a feedstock to the AN manufacturing process), which is often incorporated within the design of AN facilities. In order to allow the Project's AN production emissions intensity to be considered in the context of the listed references, emissions from the IPL facility have been augmented to include emissions associated with (upstream) manufacture and delivery of ammonia to the Site.

IPPC (2007) provides natural gas consumption ranging between 27.6 to 42.0 GJ/t ammonia produced. This is consistent with the Burrup Fertiliser plant consumption of 32.6 GJ/t of ammonia produced, which is anticipated to be a key source of ammonia to the Project[13]. In the context of an emission factor of 51.33 kg CO_2-e/GJ (DCCEE, 2011a), this equates to an ammonia production emissions intensity of approximately 1.67 tCO_2-e/t ammonia produced. In addition, shipping emissions associated with transport of ammonia to the Site have been estimated at 0.078 tCO_2-e/t ammonia delivered to the Site[14]. Based on ammonia requirements of 0.43 t/t AN produced, upstream ammonia production emissions have been estimated at 0.75 tCO_2-e t AN produced.

When the emissions associated with (upstream) manufacture and delivery of ammonia to the Site are included, (as to allow comparison against the listed references) the augmented emissions intensity of AN production for the Project is estimated at 0. 1.00 tCO_2-e/t AN produced.

Table 6-3 and **Figure 6-2** show the comparison of these values against the listed references.

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[13] WA Minister for the Environment and Heritage Statement No 586, published on 20 February 2002. The Statement suggests approximately 32.6 GJ / tonne of ammonia would be required for the Burrup Facility, which included shipping, transport of product, cooling etc

[14] Based on an average vessel speed of 26.5 km/hr and a return trip distance of 13,000 km, this would equate to 491 hours of travel per delivery. With fuel consumption of 1.083 kL/hour (USEPA, 2000), this would equate to fuel consumption of 531 kL per delivery. In the context of the DCCEE (2011a) emission factor for heavy fuel oil combustion of 73.56 kg CO_2-e/GJ and a heavy fuel oil calorific value of 39.7 GJ/kL (HHV), this equates to 1,552 t CO_2-e of shipping emissions per delivery. Assuming a vessel capacity of 20,000 t, this equates to approximately 78 kg CO_2-e / t ammonia delivered to the Site.

Table 6-3 Benchmarking of Ammonium Nitrate Plant

Description	AN Emissions Intensity t $CO_{2\text{-}e}$ per t AN	Source
European Average	2.46	Wood & Cowie (2004)
European Average	2.28	
Europe Modern Tech.	1.00	
Netherlands	2.38	
United Kingdom	2.19	
Europe	2.25	
Orica KI	1.81	AECOM (2009)
Dampier Nitrogen	1.65	GHD (2009)
Burrup Nitrates	2.28	ERM (2010)
CSBP Kwinana	2.55	CSBP (2010)
IPL*	1.00	This assessment

Note:*Augmented to include emissions associated with (upstream) manufacture and delivery of ammonia to the Site.

Again, the Project performs well in terms of emissions intensity when compared with the referenced values, and is consistent with modern technology values presented.

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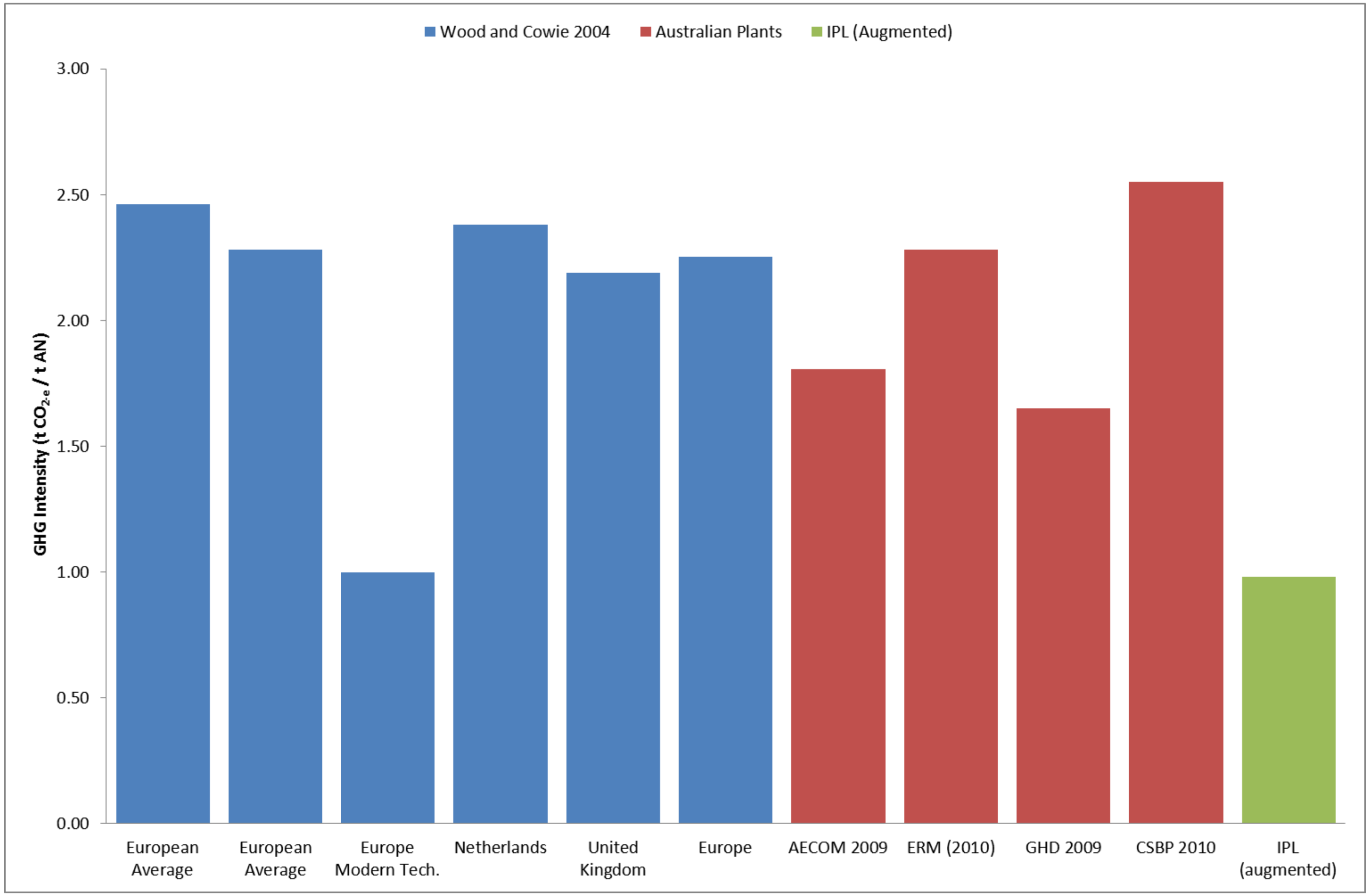
Figure 6-2 Benchmarking of AN Plant in Terms of GHG Intensities



Conclusion

The greenhouse gas inventory developed for the Project estimates that total Scope 1 and Scope 2 emissions would equate to 86,041 t CO_2-e per annum during operation. Of the annual GHG emissions, 49% were estimated to be from N_2O emissions associated with nitric acid production, 36.9% of emissions were estimated to originate from the combustion of natural gas for the production of process heat, whilst 0.6% would be associated with the combustion of liquid fuels. The remainder (13.5%) is estimated to be associated with the consumption of electricity from the grid (Scope 2).

The plant design has incorporated a number of greenhouse reduction mechanisms through N_2O abatement and energy saving opportunities. Most notably the facility would produce steam from the heat generated from exothermic reactions, and would be capable of generating approximately 7.5 MW of electricity. This would equate to approximately 51,660 t CO_2-e should this electricity be purchased from the grid, or upwards of 50% of the total Scope 1 emissions estimated for the Project. A majority of the electricity would be generated from the process heat, however the auxiliary natural gas fired boiler would allow for additional generation.

Being a modern facility the greenhouse gas intensities, in terms of emissions per tonne of NA (100%) and AN, were found to be ideally comparable to best practice, and perform well when compared against literature values for plants within Australia and around the world.

Overall the Project greenhouse gas emissions were found to be minor when compared against current NSW and National inventories. The Project would contribute approximately 0.02% of the National Greenhouse Gas Inventory approximately 0.06%of the NSW Greenhouse Gas Inventory.

References

AECOM (2009) *Greenhouse Gas Assessment Kooragang Island NSW*, prepared for Orica Australia Pty Ltd, April 2009

DCCEE (2011a) *National Greenhouse Accounts Factors,* published by the Australian Government Department of Climate Change and Energy Efficiency July 2011.

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ERM (2010) *Public Environmental Review for Technical Ammonium Nitrate Production Facility,* prepared for Burrup Nitrates Pty Ltd, January 2010

GHD (2009) *Greenhouse Gas Assessment*, prepared for Dampier Nitrogen Pty Ltd, December 2009

IPPC (2007) *Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers,* prepared by European Commission August 2007.

TR (2012) *Effluent and Emission Summary* prepared by Tecnicas Reunidas for proposed IPL KI facility, January 2012.

USEPA (2000) *Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data*, prepared by United States Environmental Protection Agency, Office of Transportation and Air Quality, February 2000.

USEPA (2010) *Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Nitric Acid production Industry,* prepared by the Office of Air Quality Planning and Standards, United States Environmental Protection Agency, December 2010.

Wood and Cowie (2004) *A Review of Greenhouse Gas emission Factors for Fertiliser production*, prepared for IEA Bioenergy, June 2004.

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