Perdaman Urea Project

Greenhouse Gas Assessment

Final Report

Version 1

Prepared for Perdaman Chemicals and Fertilisers Pty Ltd

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Name	Position	Signature
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1 INTRODUCTION

1.1 Background

Perdaman Chemicals and Fertilisers Pty Ltd (Perdaman) proposes to establish a Urea Production Plant on the Burrup Peninsula, Western Australia, to be located within the Burrup Strategic Industrial Area approximately 8 km from Dampier and 20 km north-west of Karratha (the Project).

With Air Quality identified as a preliminary key environmental factor for the Project, the significance of Greenhouse Gas (GHG) emissions has been included for assessment. The addition of GHGs to the atmosphere from human activities such as burning of fossil fuels has resulted in increased GHG concentrations in the atmosphere, and according to the best available scientific evidence is the dominant cause of the observed warming of the global climate system.

An assessment of the GHG emissions from the Project has been undertaken to inform the assessment of potential environmental impacts and the proposed management measures with respect to the approval of the Project under the *Environmental Protection Act 1986* (EP Act), and to determine if the Project emissions trigger the reporting threshold under the *National Greenhouse and Energy Reporting Act 2007* (NGER Act).

1.2 Scope of work

GHG emissions from the Project have been assessed in accordance the requirements outlined in the Environmental Scoping Document (ESD) (Cardno, 2019), as presented in Table 1-1.

Table 1-1: Scope of work

EPA objective	To maintain air quality and minimise emissions so that environmental values are protected.
Relevant activities	Operation of the urea plant.
Potential impacts and risks	Air emissions from the proposed urea plant have the potential to contribute to climate change.
Required work	Characterise greenhouse gas emissions (type and quantities) from the Project and estimate the expected direct and indirect greenhouse gas emissions in accordance with the *National Greenhouse and Energy Reporting Act* 2007 (NGER Act), and assess the contribution to regional, state, national, and international greenhouse gas emissions.
	Analyse greenhouse gas intensity (i.e. quantity of carbon dioxide equivalent - CO_2-e generated per tonne of product produced) and compare with published current benchmarked world's best practice for urea production plants, equipment and operations.
	Develop a Greenhouse Gas Management Plan and detail the management and mitigation measures that will be used to reduce greenhouse gas emissions and improve operational efficiency using the mitigation hierarchy, including the management and mitigation measures that can be implemented over time to achieve a long-term reduction in greenhouse gas emissions. Identify and justify the contemporary best practice management and mitigation measures that will be implemented.

EPA objective	To maintain air quality and minimise emissions so that environmental values are protected.
	Predict the extent, severity, and duration of any residual impacts associated with the greenhouse gas emissions from the Project that may be expected after implementing the proposed management and mitigation measures.

Notes:

1. Adapted from Table 3-1 of the ERD (Cardno, 2019) for relevance to GHG emissions.

1.3 Structure of report

This report describes the applied methodology, assumptions, results and conclusions of the GHG assessment completed for the Project. The assessment includes:

- Overview of the regulatory context (Section 2).
- Emission estimates for the Project (Section 3).
- Benchmarking assessment (Section 4).
- Mitigation and management measures (Section 5).
- Summary and conclusions (Section 6).

2 REGULATORY CONTEXT

This GHG assessment has been prepared to inform the assessment of environmental impacts and the proposed management measures with respect to the approval of the Project under the Part IV provisions of the EP Act. Guidance on how GHG emissions are to be considered in the context of the State regulatory environmental impact assessment (EIA) process is currently being updated by the Environmental Protection Authority (EPA), intended to be finalised by the end of the year. The proposed guidance on GHG emissions assessment has been published for consultation purposes and is used as a reference to supplement the requirements outlined in the ESD (Cardno, 2019). The approach used to assess GHG emissions from the Project is consistent with the proposed guidance published by the EPA (2019).

Similarly, a new climate change policy is also being developed to replace Western Australia's previous climate change strategy, Adapting to Our Changing Climate, published in 2012 in the context of a national carbon price which has since been abolished. The new State climate change policy is also due to be released by the end of the year.

Estimates of GHG emissions from the Project have been derived using methods prescribed under the *National Greenhouse and Energy Reporting Act 2007*, described in further detail in Section 3.1. The National Greenhouse and Energy Reporting Scheme (NGERS) establishes a national framework for reporting and disseminating company information about GHG emissions and energy production and consumption. GHG emission data collected through the NGERS is used to meet Australia's international reporting obligations, as well as inform Commonwealth and state and territory government policy formulation, programs and activities.

There are different thresholds that determine which companies have an obligation under the NGER Act that apply to emissions, energy produced, and energy consumed, at both a facility level and across a corporate group. The current facility reporting thresholds are:

- 25,000 tpa CO_2-e or more of GHG (Scope 1 and Scope 2) emissions;
- production of 100 Terajoules (TJ) or more of energy; or
- consumption of 100 TJ or more of energy.

3 GREENHOUSE GAS EMISSIONS

This section outlines the GHG emission estimation process used to develop an expected emission inventory for the Project. It includes direct emissions, also referred to as Scope 1 emissions, from ammonia synthesis, urea production and stationary energy generated onsite. The assessment considered emissions only from the operational phase of the Project. Emissions have been estimated for a single year of operation, based on the proposed nominal production rates for ammonia (1.16 Mtpa) and urea (2.05 Mtpa). The nominal production rates are assumed to be representative over the life of the Project. During the commissioning phase of the Project less GHG emissions are expected to be generated as the production of ammonia and urea is gradually increased to reach the nominal production rates.

Indirect emissions have not been considered for this assessment. Indirect Scope 2 emissions from the consumption of an energy commodity (i.e. purchase of third-party electricity), are not applicable as power for the Project is proposed to be generated onsite. Indirect Scope 3 emissions generated from upstream or downstream activities by suppliers or customers that use a company's products, have not been considered in the assessment as their contribution is expected to be very minor compared with direct emissions.

3.1 Emission sources

GHG emissions from the Project will be primarily generated directly from ammonia synthesis, urea production and stationary energy generated onsite.

The Project will apply the most advanced commercially available ammonia synthesis and urea production technology, provided by well-established companies with a proven track record in the international market. The selection of technology for the Project represents international best practice in terms of energy efficiency and GHG emissions, as demonstrated in the benchmarking assessment undertaken for the Project as part of this assessment (refer to Section 4.3).

Urea is an organic compound with the chemical formula $CO(NH_2)_2$, manufactured via the reaction of ammonia (NH_3) and carbon dioxide (CO_2) at high pressure and temperature. Natural gas from the nearby Woodside LNG plant will be used as feedstock to the process. The stages involved in ammonia synthesis and urea production are outlined below and depicted in the block flow diagram (Figure 3-1). Support utilities include onsite power generation and an air separation plant.

Gas reforming: Natural gas is catalytically reformed with oxygen and steam to form 'syngas', which is purified to a hydrogen rich and CO_2 stream.

Ammonia synthesis: The hydrogen and nitrogen mixture are compressed and reacted (with help of a catalyst) to form ammonia. This chemical reaction releases heat which is recovered as steam which improves the overall process thermal efficiency, and consequently lowers emissions.

Urea synthesis: Ammonia and CO_2 are reacted to form urea (solution) in a two-stage process which involves an ammonium carbamate (NH_2COONH_4) intermediate. The urea solution is concentrated to over 95 per cent.

Urea granulation: The concentrated urea solution is dried and granulated, suitable for storage before being conveyed to Dampier Port.

Power generation: Process power requirements will be met with a high efficiency combined cycle gas turbine (CCGT) that includes cogeneration of steam, and a steam turbine for excess steam. The gas turbine will be operated on natural gas under normal conditions.

Air separation: Air is compressed and separated into nitrogen (N_2) and oxygen (O_2) in a conventional cryogenic air separation unit.

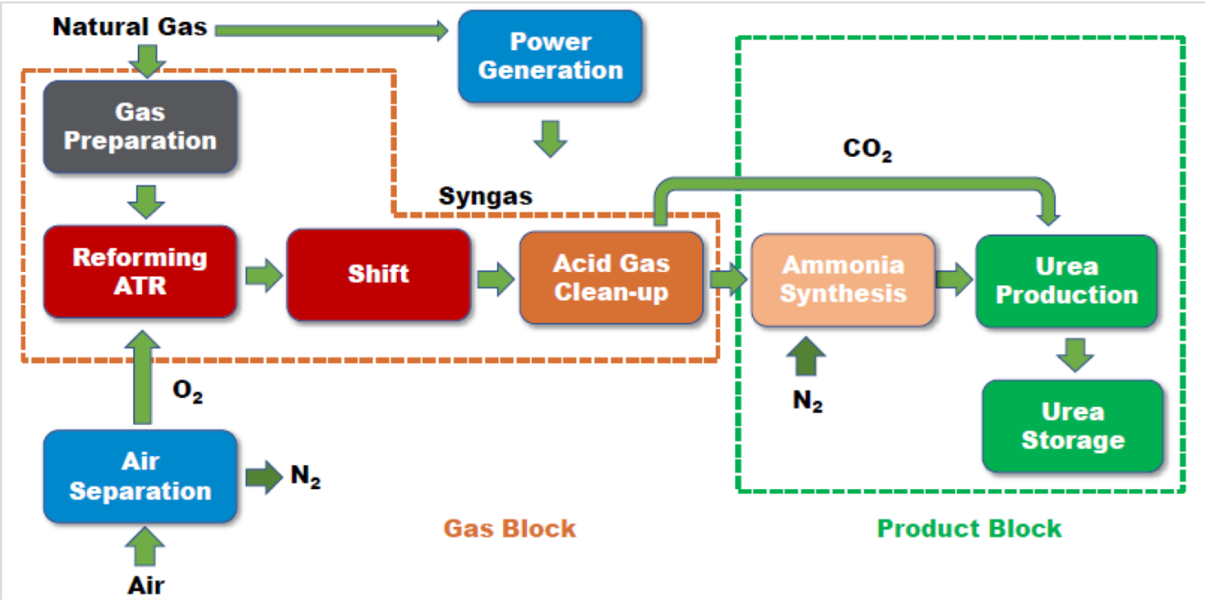

Figure 3-1 Block flow diagram of urea production

The CO_2 generated as a by-product of gas reforming is used as a reagent in the urea synthesis process, and hence accounts for a net reduction in emissions from the Project. An important feature of the Project design is that the production of ammonia is fully balanced to urea, such that no ammonia is produced for export as with typical plants, resulting in complete consumption of CO_2 generated from gas reforming within the urea synthesis process.

Combustion of natural gas for onsite power generation, process heating and steam generation comprise the key stationary energy emission sources. The operation of the flare pilot burner, so in the event of abnormal plant operations emissions containing ammonia and other volatile gases can be safely discharged, is also a minor emission source.

Although minor, the leakage or loss of methane (CH_4) and CO_2 from the gas reforming and urea synthesis process circuits is a direct source of emissions.

The use of heavy vehicles for material handling within the product storage sheds at the Project site and Dampier Port will also be a minor contributor to Project emissions, and therefore has not been considered in the assessment. Urea product is proposed to be transported by conveyor to Dampier Port, operated using power generated onsite.

The key sources that form part of the GHG emissions inventory the Project include:

- Stationary energy sources;
  - combustion of natural gas for onsite power generation.
  - combustion of natural gas for process heating and steam generation.
  - combustion of natural gas for flaring (burner pilots only).

- Process generated sources;
    - CO_2 generated from gas reforming.
    - CO_2 consumed in urea synthesis (i.e. net reduction).
    - minor process gas leakage/loss.

3.2 Emission estimation methods

Emissions from all key sources associated with the Project have been derived using accepted methods of emission estimation. Emissions from the main sources which are gas reforming and stationary energy, have been estimated using methods prescribed under the NGERS. Although leakage or loss of GHG emissions from the process circuits are expected to be minor, estimated emissions have also been derived for these sources using process engineering design information, and provided for use in this assessment.

The GHGs that are reported under the NGERS include CO_2, CH_4, nitrous oxide (N_2O), sulphur hexafluoride (SF_6) and specified kinds of hydro fluorocarbons and perfluorocarbons. CO_2, CH_4 and N_2O are the only GHGs generated from the Project. The current global warming potential values specified under the NGERS are presented in Table 3-1, and are inherent in the CO_2 equivalent (CO_2-e) emissions derived for this assessment.

Table 3-1: Global Warming Potentials (t/CO_2-e)

CO_2	CH_4	N_2O
1	25	298

The NGERS Method 1 emissions factors have been adopted for this assessment, presented in Table 3-2. Method 1 is the National Greenhouse Accounts default method, derived to ensure that consistency is maintained between inventories at company or facility level and the emission estimates presented in the National Greenhouse Accounts. The emission estimation methods are designed for use in estimating facility GHG emissions and provide a suitable basis for comparison to emission inventory data published for Australia. The most current emission factors prescribed under the NGERS have been applied, applicable to the 2017-18 reporting year.

Information on production and consumption data provided for this assessment are presented in Table 3-3, and were used as the basis for the emission estimation.

Table 3-2: Default GHG Emission Factors

Source	Fuel Type	CO_2	CH_4	N_2O	Reference
		kg CO_2-e/GJ [1]			
Primary Steam Reforming	natural gas	51.4	-	-	*NGER (Measurement) Determination 2008* [2] Part 2 of Schedule 1
Stationary Energy	natural gas	51.4	0.1	0.03	

Notes:
1. Relevant oxidation factor (fraction of carbon that is actually oxidised when combustion occurs) incorporated.
2. Compilation No. 10. Compilation Date: 1 July 2018.

Table 3-3: Production and Consumption data used in emission estimation

Type	Parameter	Input	Units
Production/Design	Ammonia production[1]	1,157,310	tpa
	Urea production[2]	2,046,000	tpa
	CO_2 recovered from urea production	1,503,810	tpa
	Combined Cycle Gas Turbine[3]	792,000	MWh/y
Fuel (natural gas) Consumption[4]	Primary steam reforming	101,404	GJ/d
	Combined Cycle Gas Turbine	18,259	GJ/d
	Process heat/steam generation	7,195	GJ/d
	Flaring	126	GJ/d
Leakage/loss	Primary steam reforming	300	kg/y of CH_4
	Urea production	22.7	tpa of CH_4
		35.0	tpa of CO_2

Notes:

1. Nominal capacity of 3,507 tpa ammonia production and assumed equipment availability (330 days/y).
2. Nominal capacity of 6,200 tpa urea production and assumed equipment availability (330 days/y).
3. 100 MW power generating capacity, assumed to operate continuously (330 days/y).
4. Higher Heating Value (HHV) based on Woodside/Dampier Bunbury Pipeline (DBP), using ISO 6976 (1995).

3.3 Project emission estimates

A summary of the estimated annual emissions from the Project are shown in Figure 3-2. Total net GHG emissions for the Project are estimated to be equal to 0.65 Mtpa CO_2-e. Gas reforming is the largest single source of GHG emissions (1.72 Mtpa CO_2-e). Emissions from this source, however, are almost entirely offset through the consumption of CO_2 within the urea production process (-1.50 Mtpa CO_2-e), such that net GHG emissions are estimated to be equal to 0.22 Mtpa CO_2-e, which represents 33% of Project emissions. GHG emissions from stationary energy sources are estimated to be equal to 0.43 Mtpa CO_2-e, which represents 67% of Project emissions.

The total energy demands of the Project can be apportioned as approximately 78% required for ammonia synthesis and 22% for urea synthesis (*Pers comm* J DeBoer [SNC-Lavalin], 11 September 2019). On this basis, ammonia production accounts for 0.51 Mtpa CO_2-e and urea production accounts for 0.14 Mtpa CO_2-e.

The total GHG emissions estimated for the Project triggers the current facility threshold under the NGER Act of 25,000 tpa CO_2-e or more (refer to Section 2), and therefore the proponent will have an obligation to report emissions.

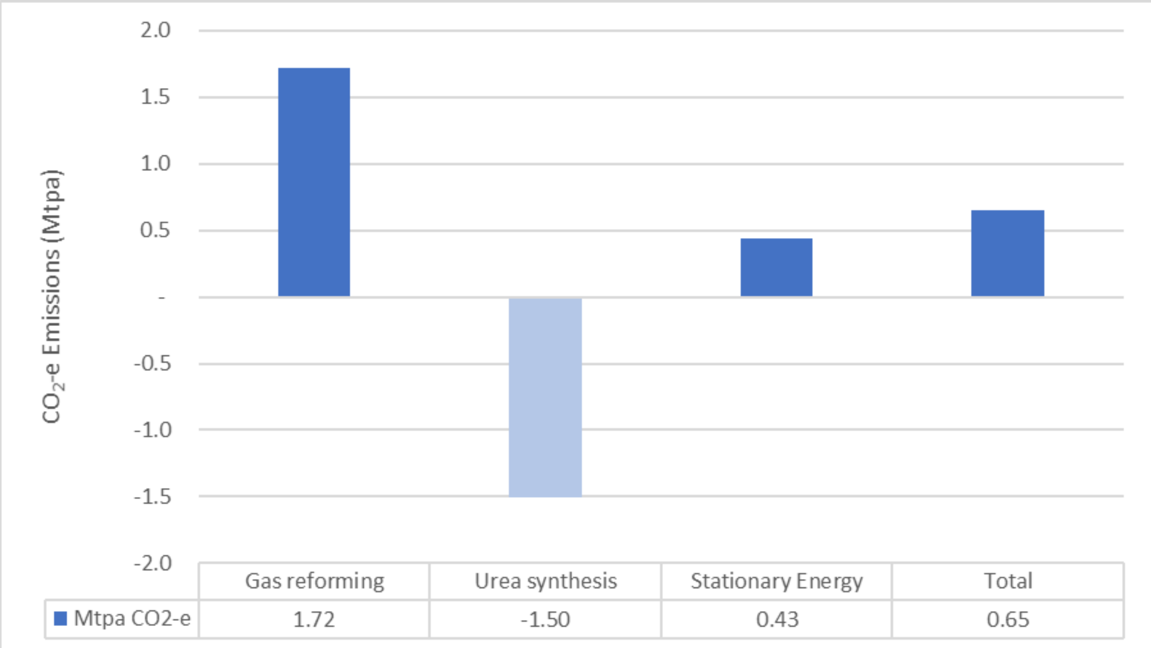

Figure 3-2 Estimated annual GHG emissions

The accuracy of estimating emissions is almost entirely determined by the availability of data to define the amount and energy content of natural gas consumed. The emission estimates are subject to a degree of uncertainty as they are based on estimated consumption data derived from equipment and process engineering design information that is currently available for the Project and will be subject to refinement as the Project proceeds.

Further the NGERS default emission factors have been adopted for this assessment, so adjustment to account for actual CO_2 composition of natural gas supply will also slightly alter the emission estimates.

The estimates are considered suitably representative of Project emissions for the purposes of this assessment.

3.4 Project contribution

To evaluate the extent to which GHG emissions from the Project could contribute to national and state GHG emissions, estimated Project emissions have been compared to the latest available data published in the Australian National Greenhouse Accounts for 2017 (Department of the Environment and Energy, 2019 & 2019a), presented in Table 3-4. The annual net GHG emissions estimated for the Project (0.65 Mt CO_2-e) represents a 0.7% increase on 2017 emission estimates for Western Australia, and a 0.1% increase at a national level.

Table 3-4: Project compared to Australia and Western Australia emissions

Source	Total emissions 2017 (Mt CO_2-e)	Total emissions 2017 (Including Project)	Estimated Project Contribution (%)
Australia	534.7 [1]	535.4	0.1
Western Australia	88.5 [2]	89.2	0.7

Notes:

1. 2017 calendar year.
2. 2017 financial year.

The GHG emissions from the Project have also been assessed in the context of longer-term trends in state and national GHG emissions, presented in Figure 3-3 and Figure 3-4 respectively. As a proportion of national and state GHG emissions, the contribution of the Project is low, but still of significance within the context of an increasing trend in Western Australian emissions and the state's contribution to national GHG emissions.

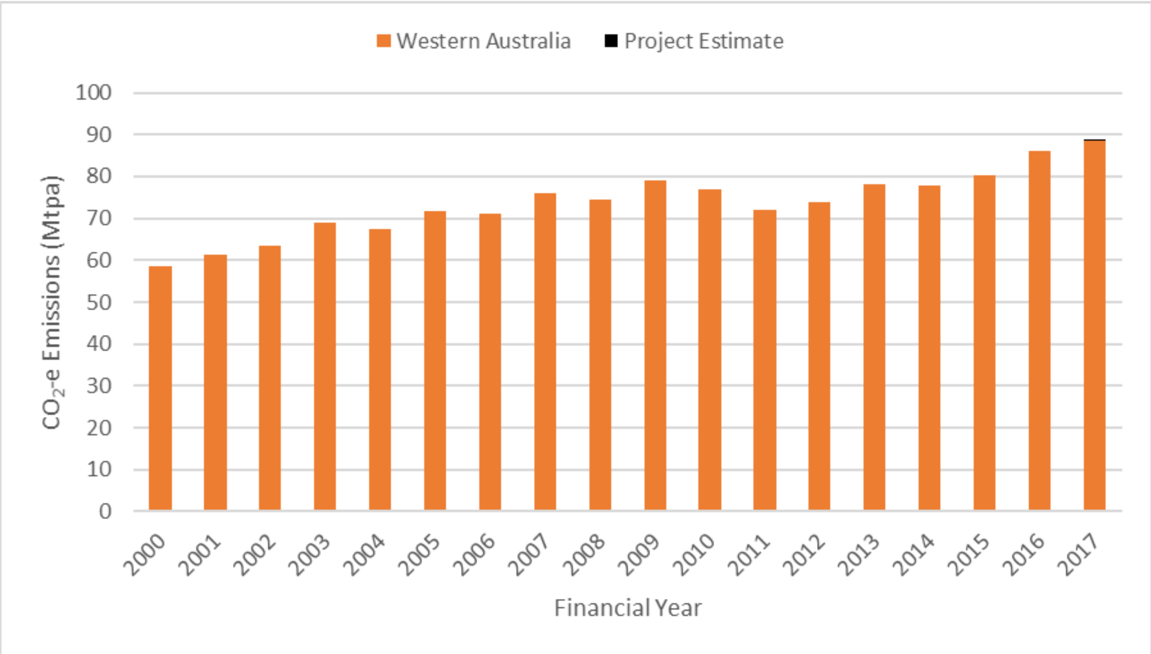

Figure 3-3 Project compared to Western Australia longer-term emissions trend

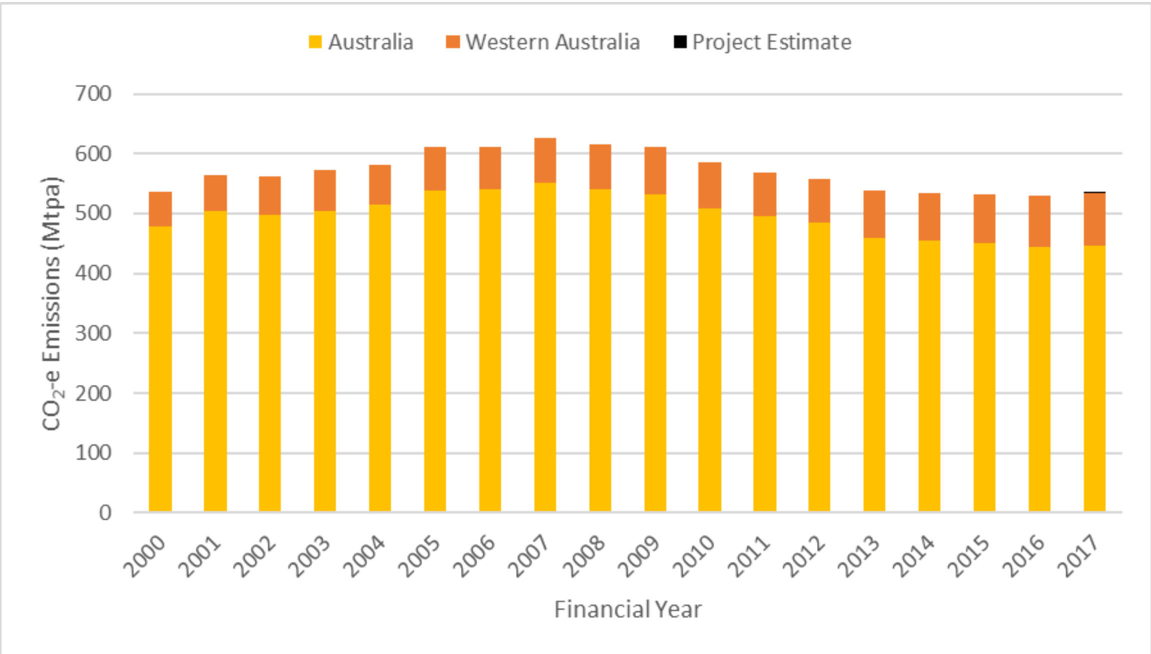

Figure 3-4 Project compared to Australia longer-term emissions trend

It is also important to consider the contribution of the Project to state and national GHG emissions in the context of international urea production markets and Australian urea imports. In recent years Australia has imported on average approximately 2 Mtpa of urea, mostly from the Middle East with smaller volumes imported from China and other countries. Urea imported from the Middle East is typically sourced from older plants (10 to 25 years old) which operate under a low-cost natural gas regime where economic efficiency drivers are less critical, and therefore associated GHG emissions are higher. Similarly, urea imported from China is primarily produced using coal rather than natural gas as feedstock, and is therefore also associated with higher GHG emissions (SNC-Lavalin, 2019).

The Project has the capacity to displace all Australian imports of urea, which would have a net benefit as GHG emissions from the Project represent international best practice and a significant improvement upon urea imported from the Middle East and China. On the basis that the Project displaces all imported urea, Australia's net CO_2 position could be reduced by an estimated 1.1 Mtpa or more (SNC-Lavalin, 2019), which would far outweigh the total GHG emissions estimated for the Project.

4 BENCHMARKING OF PROJECT EMISSIONS

The benchmarking assessment for the Project has been approached in a tiered manner, based upon comparisons to published data on energy efficiency and GHG intensity data for the industry sector, presented in the following subsections.

GHG intensity is often used to benchmark projects against other facilities or relevant industry standards. GHG intensity represents the quantity of GHG emitted per unit of production. For the industrial processes sector this is calculated as CO_2-e/t of product. Energy efficiency is also a common benchmarking measure for the energy sector and other energy intensive industry, calculated as CO_2-e/GJ. International energy efficiency performance benchmarks for ammonia and urea production are reported on the natural gas Lower Heating Value (LHV) basis.

The estimated GHG intensity and energy efficiency of the Project is presented in Section 4.1.

4.1 Project energy efficiency and GHG intensity estimates

The GHG intensity of the Project has been assessed for the ammonia plant alone based on ammonia production (t CO_2-e/t of NH_3), as well as for the Project as a whole based on urea production (CO_2-e/t of urea). The GHG intensity estimated for ammonia production is based on net GHG emissions, including the offset from consumption of CO_2 within the urea production process (refer to Section 3.3). Similarly, the energy efficiency of the Project has been assessed based on ammonia production alone, as well as for the Project as a whole based on urea production. The estimated energy efficiency and GHG intensity of the Project are presented in Table 4-1.

Table 4-1: Estimated energy efficiency and GHG intensity

Parameter	Units	Ammonia plant	Urea production [1]
Production	tpa	1,157,310 (ammonia)	2,046,000 (urea)
Energy [2]	GJ_{LHV}/y	30,887,969	39,599,960
Energy efficiency	GJ_{LHV}/ t NH_3 or urea	26.7	19.4
GHG emissions [3]	Mtpa CO_2-e	0.51	0.65
GHG intensity	t CO_2-e/t NH_3 or urea	0.44	0.32

Notes:

1. Refers to Project as a whole (includes ammonia and urea synthesis).
2. Natural gas consumption presented on LHV basis. LHV:HHV ratio of 0.945 applied (*Pers comm* J De Boer [SNC-Lavalin], 11 September 2019).
3. Stationary energy demands of the Project apportioned as 78% required for ammonia synthesis and 22% for urea synthesis (*Pers comm* J De Boer [SNC-Lavalin], 11 September 2019).

4.2 Feedstock

In ammonia and urea production, the type of feedstock used plays a significant role in the amount of energy that is consumed and GHG emissions produced. The type of process technology used for gas reforming is another key factor. Approximately 70% of all ammonia is produced from natural gas, about 25% from coal and petroleum coke (mainly in China), and the remaining plants from other sources such as naphtha or fuel oil (mainly in India) (SNC-Lavalin, 2019).

Comparison of the Best Available Technology (BAT) processes in terms of energy use and CO_2 emissions in ammonia production for different feedstocks published by the International Fertiliser Industry Association (IFA) (2009) is presented in Table 4-2.

Table 4-2: Comparison of Best Available Technology (BAT) in ammonia production

Energy source [1]	Energy (GT/ t NH_3)	CO_2 emissions (t / t NH_3)	GHG Index
Natural gas	28	1.6	100
Coal	42	3.8	238
Naphtha	35	2.5	153
Heavy fuel oil	38	3.0	188

Notes:

1. Adopted gas reforming process: Steam gas reforming for natural gas and naphtha. Partial oxidation gas reforming for heavy fuel oil and coal.
2. Using natural gas as the reference, this index shows the relative carbon intensity of the different energy sources.

The data presented in Table 4-2 shows that the energy requirement in coal-based plants is significantly higher per tonne of ammonia. These plants also produce some 2.4 times more CO_2 per tonne of ammonia than natural gas plants. As such, the selection of natural gas as feedstock for the Project is considered the most energy efficient and least GHG intensive option.

4.3 International performance benchmarks

The Fertilisers Europe, formerly the European Fertiliser Manufactures Association (EFMA), publication series on Best Available Techniques (BAT) in the European fertiliser industry (Fertilisers Europe, 2000) is adopted as the relevant international environmental performance benchmark for ammonia production (Table 4-3), used to evaluate the energy efficiency of the Project in terms of world's best practice.

This energy efficiency benchmark adopted for ammonia production (28.4 GJ_{LHV}/t NH_3) is comparable to theoretical design efficiencies and the optimum efficiency level for new plant of approximately 28-29 GJ/t NH_3 (IFA, 2009a).

Comparison of the Project metric to this international performance benchmark demonstrates that the Project meets international best practice for energy efficiency in ammonia production.

Table 4-3: International performance benchmark

Parameter	Product	Units	Benchmark [1]	Project
Energy efficiency [2]	ammonia	GJ_{LHV}/t NH_3	28.4 [3]	26.7

Notes:

1. Sourced from Fertilisers Europe (2000).
2. Natural gas consumption reported on Lower Heating Value (LHV) basis.
3. Sum of 24.8 GJ (LHV)/t NH_3 (typical feedstock requirement for modern plants using autothermal reforming) and 3.6 GJ (LHV)/t NH_3 (low end of range given for fuel requirements for autothermal reforming).

The energy demands of urea production are small compared to those of ammonia production and no efficiency benchmark is provided in the relevant the EFMA BAT publication series for urea production (EFMA, 2000a).

4.4 Australian ammonia production

The latest available data published in the Australian National Greenhouse Accounts for the 2017 financial year (2017/18) (Department of the Environment and Energy, 2019) provides production and emissions information from the manufacture of ammonia in Australia reported under the NGERS from 2009 onwards. This data has been used to derive an average GHG intensity for ammonia production in Australia over this time period (Figure 4-1).

The GHG intensity of the Project is a significant improvement on the national average for ammonia production in Australia and will further enhance the reduction in the national average GHG intensity that can be seen in the longer-term trend.

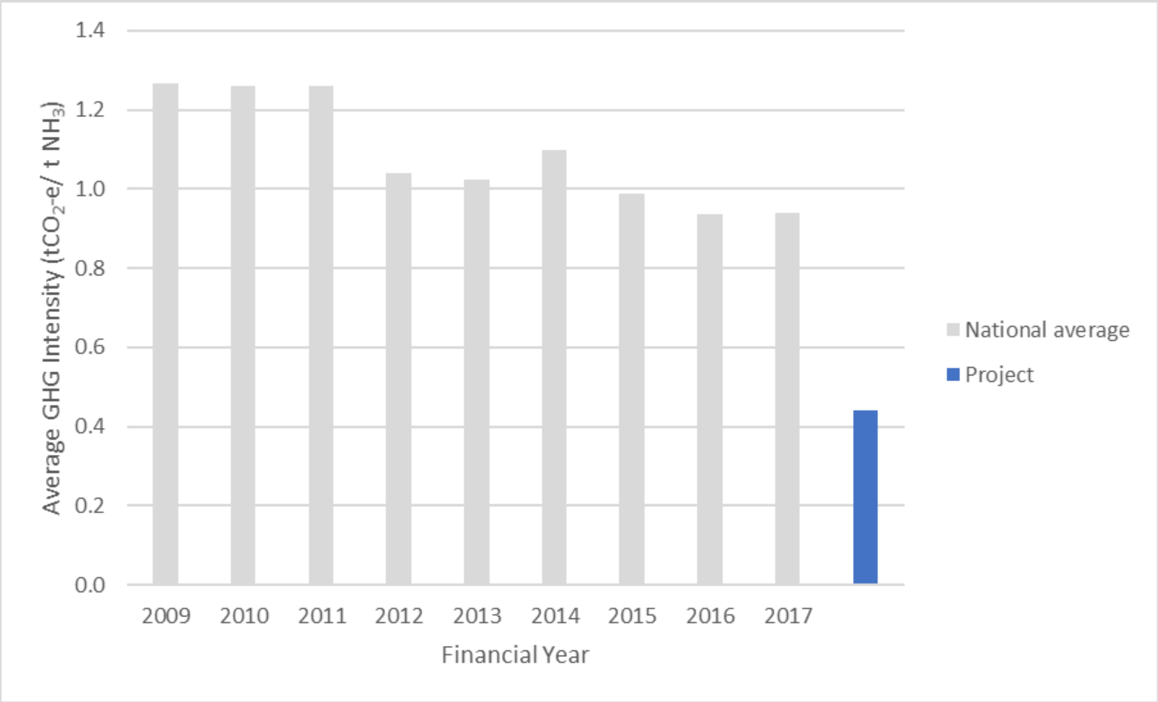

Figure 4-1 National average GHG intensity for ammonia production.

4.5 Approved Western Australian projects

The GHG intensity of the Project has been compared to other comparative ammonia and urea projects in Western Australia that have been granted environmental regulatory approval, summarised in Table 4-4.

The enhanced energy efficiency of the Project is indicated by the lower energy requirement estimated for the Project compared to other projects that have been approved in Western Australia, when considered both on an ammonia production basis and on a urea production basis. Furthermore, there is a more significant improvement in GHG intensity for the Project compared to the Dampier Nitrogen project, also an ammonia-urea plant and hence most suitable for comparison, attributable to the increased net reduction (offset) of CO_2 emissions in the urea synthesis process from 'balanced' ammonia to urea production (refer to Section 5.1).

Table 4-4: Comparison to approved Western Australian projects

Project	Proponent	Location	Products	Energy efficiency	GHG intensity	Reference
Ammonia-Urea Plant	Dampier Nitrogen Pty Ltd (Dampier Nitrogen)[1]	Burrup Peninsula	ammonia urea	29.3 GJ_{LHV}/t NH_3 26.6 GJ_{LHV}/t urea[3]	0.67 t CO_2-e/t urea [3]	EPA (2002)
Ammonia Plant	Yara Pilbara Fertilisers Pty Ltd (Yarra)[2]	Burrup Peninsula	ammonia	29.7 – 29.9 GJ_{LHV}/t NH_3	-	EPA (2001)
Kwinana Ammonia Project	Wesfarmers CSBP Ltd (CSBP)	Kwinana	ammonia	33 – 35 GJ/t NH_3	-	EPA (1998)
Perdaman	Perdaman	Burrup Peninsula	ammonia urea	26.7 GJ_{LHV}/t NH_3 19.4 GJ_{LHV}/t urea	0.32 t CO_2-e/t urea	Section 4.1

Notes:

1. Formerly Plenty River Corporation Ltd.
2. Formerly Burrup Fertilisers Pty Ltd.
3. Calculated from available information. Urea Plant 3,500 tpd nominal capacity. Natural gas 93 TJ/day (Max). Estimated total CO_2-e emissions 841,055 tpa.

4.6 Overall assessment findings

The overall conclusions of the benchmarking of Project emissions are as follows:

- Selection of natural gas as feedstock for the Project is considered the most energy efficient and least GHG intensive option of the alternative feedstocks used for ammonia production.
- The Project meets the international best practice benchmark established by the EFMA (2000) for energy efficiency in ammonia production.
- The GHG intensity of the Project is a significant improvement on the national average for ammonia production in Australia and will further enhance the reduction in the national average GHG intensity that can be seen in the longer-term trends in data published in the Australian National Greenhouse Accounts.
- The enhanced energy efficiency of the Project is indicated by the lower energy requirement estimated for the Project compared to other projects that have been approved in Western Australia.

5 GREENHOUSE GAS MITIGATION AND MANAGEMENT

The GHG mitigation and management framework for the Project has been developed in accordance with the mitigation hierarchy (avoid, reduced, offset):

- avoiding emissions through best practice design and benchmarking
- continuous improvement to reduce emissions over the project life
- offsetting emissions.

Energy efficiency and GHG emission considerations during the design stage of the Project is critical to reducing emissions over the life of the Project, with the most significant opportunities to avoid and reduce emissions associated with technology selection and choice of feedstock (refer to Section 5.1).

There may also be opportunities to further improve energy efficiency and reduce emissions through continuous improvement over the life of the Project, and to develop and implement cost effective GHG emission offset initiatives. The Perdaman Greenhouse Policy (Appendix A) reiterates the company's commitment to increase energy efficiency and reduce GHG emissions and presents the strategy to achieve this.

5.1 Project design

The Project will apply the most advanced commercially available ammonia synthesis and urea production technology, provided by well-established companies with a proven track record in the international market.

The ammonia synthesis technology will be supplied by Haldor Topsøe, using SynCOR Ammonia™ technology. This applies a proprietary method of steam reforming based on oxygen-fired autothermal reforming to reduce the steam/carbon ratio from 3.0 (typical) down to 0.6, resulting in substantial energy savings in gas reforming. The urea production technology will be supplied by Stamicarbon, using an energy enhanced layout that reduces process steam requirements, also resulting in improved energy efficiency.

The CO_2 generated as a by-product of gas reforming is used as a reagent in the urea synthesis process, and hence accounts for a net reduction (offset) in emissions from the Project. An important feature of the Project design is that the production of ammonia is fully 'balanced' to urea, such that no ammonia is produced for export as with typical plants, resulting in complete consumption of CO_2 generated from gas reforming, within the urea synthesis process.

Natural gas from the nearby Woodside LNG plant will be used as feedstock to the process. The use of natural gas ensures the Project will achieve the highest energy efficiency and lowest GHG emissions compared to coal, an alternative feedstock sometimes used in the manufacture of ammonia (refer to Section 4.2). Further, the Project will receive natural gas feedstock with a relatively high methane content, and therefore slightly lower associated GHG emissions.

Various other specific design features will be incorporated into the Project to improved energy efficiency and lower GHG emissions, including (but not limited to):

- autothermal reforming layout to reduce steam demand
- maximised waste heat steam recovery systems
- hydraulic turbine to recover process energy in the Acid Gas Recovery (AGR) unit
- high efficiency pump selection
- low energy reverse osmosis desalination plant
- modern combined cycle power plant with cogeneration mode for start-up
- water cooling rather than air cooling to achieve a better condensing approach temperature and greater stability during hot days
- no continuous flare purging required
- fuel gas containing streams are collected and reused for fired heater duty.

5.2 Continuous improvement

Modern ammonia production technology is rapidly approaching the theoretical minimum energy consumption for ammonia production (IFA, 2009a). The opportunity for further significant improvement in energy efficiency and GHG emissions over the life of the Project is therefore expected to be limited, with continuous improvement focused on attaining optimal equipment performance and reliability. A comprehensive energy efficiency and GHG emissions monitoring and reporting systems will be developed and implemented to track relevant performance metrics over the life of the Project, and to inform decisions on opportunities to implement cost effective measures to improve energy efficiency.

5.3 Carbon offsets

GHG offsets (carbon offsets or carbon credits) are generated from activities that prevent or reduce the release of GHG emissions to the atmosphere or remove GHGs from the atmosphere (i.e. through 'carbon sequestration' in soils, geological reservoirs, forests and vegetation).

The proposed co-location of ammonia-urea production allows for the CO_2 generated as a by-product of gas reforming to be used as a reagent in the urea synthesis process, and hence accounts for a net reduction (offset) in emissions from the Project (refer to Section 5.1). The net reduction is estimated to be 1.5 Mt CO_2-e per annum.

Opportunities to develop and implement cost effective GHG emissions offset initiatives will continue to be evaluated over the life of the Project.

5.4 Monitoring and Reporting

Monitoring and reporting of GHG emissions from the Project will be in accordance with obligations under the NGER Act (refer to Section 3.3). Acknowledging the current restrictions on publication of facility-level data under the NGER Act, relevant GHG emissions data will also be publicly disclosed by Perdaman. The intent of this is to ensure accountability and public transparency on progress made to minimise emissions over the life of the Project and ensure the commitments in relation to emission intensity performance are met.

6 SUMMARY

Perdaman proposes to establish a Urea Production Plant on the Burrup Peninsula, Western Australia. An assessment of the GHG emissions from the Project has been undertaken to inform the assessment of potential environmental impacts and the proposed management measures with respect to the approval of the Project under the EP Act.

Estimates of GHG emissions from the Project have been derived using methods prescribed under the NGERS, including direct (Scope 1) emissions from ammonia synthesis, urea production and station energy generated onsite. Emissions have been estimated for a single year of operation, based on the proposed nominal production rates for ammonia (1.16 Mtpa) and urea (2.05 Mtpa). Indirect (Scope 2) emissions have not been considered for this assessment as the power demands of the Project are proposed to be met through onsite generation. Similarly, indirect (Scope 3) emissions have not been considered as their contribution is expected to be very minor compared with direction emissions.

The Project will apply the most advanced commercially available ammonia synthesis and urea production technology, provided by well-established companies with a proven track record in the international market. The selection of technology for the Project represents international best practice in terms of energy efficiency in ammonia production, as demonstrated in the benchmarking assessment undertaken for the Project.

The CO_2 generated as a by-product of gas reforming is used as a reagent in the urea synthesis process, and hence accounts for a net reduction in emissions from the Project. An important feature of the Project design is that the production of ammonia is fully balanced to urea, such that no ammonia is produced for export as with typical plants, resulting in complete consumption of CO_2 generated from gas reforming within the urea synthesis process.

A summary of the GHG emission metrics estimated for the Project is presented in Table 6-1.

Table 6-1: Estimated GHG emission metrics

Parameter	Units	Ammonia plant	Urea production [1]
GHG emissions	Mtpa CO_2-e	0.51	0.65
Energy efficiency	GJ_{LHV}/ t NH_3 or urea	26.7	19.4
GHG intensity	t CO_2-e/t NH_3 or urea	0.44	0.32

Notes:

1. Refers to Project as a whole (includes ammonia and urea synthesis).

The key findings of the GHG assessment completed for the Project are:

- As a proportion of national and state GHG emissions, the contribution of the Project is low (0.1% and 0.7% respectively), but still of significance within the context of an increasing trend in Western Australian emissions and the state's contribution to national GHG emissions.
- The Project has the capacity to displace all Australian imports of urea, which would have a net benefit (~ 1.1 Mtpa CO_2-e) as GHG emissions from the Project represent international best practice and a significant improvement upon urea imported from the Middle East and China. This would far outweigh the total GHG emissions estimated for the Project.

- The Project represents best practice in terms of energy efficiency and GHG emissions, as demonstrated by the findings of the benchmarking assessment:
    - Natural gas from the nearby Woodside LNG plant will be used as feedstock to the process. The use of natural gas ensures the Project will achieve the highest energy efficient and lowest GHG emissions compared to other alternative feedstocks sometimes used in the manufacture of ammonia.
    - The Project meets the international best practice benchmark established by the EFMA (2000) for energy efficiency in ammonia production.
    - The GHG intensity of the Project is a significant improvement on the national average for ammonia production in Australia and will further enhance the reduction in the national average GHG intensity that can be seen in the longer-term trends in data published in the Australian National Greenhouse Accounts.
    - The enhanced energy efficiency of the Project is indicated by the lower energy requirement estimated for the Project compared to other projects that have been approved in Western Australia.

The GHG mitigation and management framework for the Project has been developed in accordance with the mitigation hierarchy (avoid, reduced, offset). Energy efficiency and GHG emission considerations during the design stage of the Project is critical to reducing emissions over the life of the Project, with the most significant opportunities to avoid and reduce emissions associated with technology selection and choice of feedstock.

A comprehensive energy efficiency and GHG emissions monitoring and reporting systems will be developed and implemented to track relevant energy efficiency performance metrics over the life of the Project, and to inform decisions on opportunities to implement cost effective measures to improve energy efficiency.

The proposed co-location of ammonia-urea production allows for the CO_2 generated as a by-product of gas reforming to be used as a reagent in the urea synthesis process, and hence accounts for a net reduction (offset) in emissions from the Project. The net reduction is estimated to be 1.5 Mt CO_2-e per annum. Opportunities to develop and implement cost effective GHG emissions offset initiatives will continue to be evaluated over the life of the Project.

Monitoring and reporting of GHG emissions from the Project will be in accordance with obligations under the NGERS. Further, acknowledging the current restrictions on publication of facility-level data under the NGERS, relevant GHG emissions data will also be publicly disclosed by Perdaman to ensure accountability and public transparency on progress made to minimise emissions over the life of the Project and ensure the commitments in relation to emission intensity performance are met.

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8 GLOSSARY

Acronym	Definition
BAT	Best Available Techniques
CO_2	Carbon Dioxide
CO_2-e	Carbon Dioxide equivalent
CH_4	Methane
CCGT	Combined cycle gas turbine
EPA	Environmental Protection Authority (WA)
EFMA	European Fertiliser Manufactures Association
ETA	Environmental Technologies& Analytics Pty Ltd
ESD	Environmental Scoping Document
GHG	Greenhouse gas
GJ	Gigajoules
HHV	Higher heating value
IFA	International Fertiliser Industry Association
kg	kilograms
LHV	Lower heating value
Mtpa	Million tonnes per annum
MW	Mega watt
NGERS	National Greenhouse and Energy Reporting Scheme
N_2O	Nitrous oxide
NH_3	Ammonia
tpa	Tonnes per annum
TJ	Terajoules

Appendix A – Perdaman Greenhouse Policy

PERDAMAN

CHEMICALS & FERTILISERS

Greenhouse Policy

Objectives

Perdaman Chemicals and Fertilisers Pty Ltd (PERDAMAN) is committed to demonstrating leadership in minimising the impact of its operations on the natural environment. PERDAMAN aims to increase its energy efficiency and reduce its greenhouse emissions.

Strategy

To maximize the achievement of the above objectives PERDAMAN will:

- Develop and implement cost effective greenhouse emissions reduction initiatives at its sites;
- Develop and implement cost effective greenhouse emissions offset initiatives;
- Measure and report greenhouse emissions at its manufacturing sites;
- Implement cost effective measures to improve energy efficiency at its sites;
- Contribute to research in greenhouse emissions reduction technologies in the clean coal industry;
- Participate in industry and community initiatives to reduce greenhouse emissions; and
- Be proactive in anticipating potential greenhouse issues and in promoting science based climate change awareness

Implementation

All PERDAMAN employees and contractors are responsible for the implementation and maintenance of this policy.

Vikas Rambal
Chairman and Managing Director

Signed on 19 December 2018