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WSN Environmental Solutions

Alternative Waste Technology Facility, Lucas Heights

Greenhouse Gas Emissions Assessment

July 2009

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Abbreviations

AWT	Alternative waste technology
CO_2-e	Carbon dioxide equivalent emissions (emissions of other greenhouse gases are multiplied by their GWP so that their effects can be compared to emissions of carbon dioxide)
DCC	Commonwealth Department of Climate Change
DGR	Director General's Requirements
EF	Emission Factor
G	Giga (billion or $x10^9$)
GHG	Greenhouse Gas
J	Joule
kL	kilolitre
km	kilometre
kWh	kilowatt hour
LCA	Life Cycle Assessment
LHWRC	Lucas Heights Waste and Recycling Centre
M	Mega (million or $x10^6$)
MSW	Municipal solid waste
NGA	National Greenhouse Accounts
PE	Photoelectric
t	tonne
VSD	variable speed driven
WSN	WSN Environmental Solutions, the proponent
y	year

Executive Summary

Methodology

A greenhouse gas assessment of the construction and operation of an alternative waste technology facility at Lucas Heights was conducted in accordance with the general principles of:

- The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard developed by the World Business Council for Sustainable Development; and
- The Commonwealth Department of Climate Change (DCC) National Greenhouse Accounts (NGA) Factors, 2009).

The assessment included scope 1 and 2 emissions from both construction and operation of the facility, including:

- Emissions from fuel use associated with site preparation and construction;
- Operation mobile equipment diesel usage;
- Fuel used for residual waste transport, placement and compaction;
- Emissions from fixed equipment;
- Emissions from the biogas generators (from incomplete combustion, gas escapes); and
- Energy exported (greenhouse reduction).

Results

The project is estimated to produce greenhouse gas emissions of 1,577 t CO_2-e during the construction period or 79 t CO_2-e per annum annualised over the life of the project (assuming a 20 year design life). During operation, the project is estimated to produce a greenhouse gas emission reduction of 3,399 t CO_2-e per annum. The predicted greenhouse intensity is a net reduction of 0.033 t CO_2-e/ t municipal solid waste processed.

Assessment of Impacts

Considering scope 1 and scope 2 emissions (for construction and operation), the project is expected to produce an annual greenhouse gas reduction of 3,320 t CO_2-e. Hence the project would have a positive environmental impact in terms of greenhouse gas and climate change.

1. Introduction

1.1 Background

WSN Environmental Solutions (WSN) is proposing to construct and operate an alternative waste technology (AWT) facility at the Lucas Heights Waste and Recycling Centre (LHWRC), Lucas Heights (referred to as 'the project'). The site is located in the south-eastern corner of the LHWRC, with access to the site off New Illawarra Road to Little Forest Road and falls within the Sutherland Shire local government area.

The project would comprise a mechanical biological treatment plant to process up to 100,000 tonnes per annum of municipal solid waste (MSW) using the patented ArrowBio technology. The technology is similar to that currently being commissioned at WSN's Jacks Gully site (Ecolibrium™ Mixed Waste Facility at the Macarthur Resource Recovery Park) in south west Sydney and would incorporate the following:

- Receival hall;
- Processing building;
- Biological plant;
- Energy generation plant;
- Staff facilities;
- Parking area; and
- Internal road network.

The plant would use material separation technologies to recover recyclable materials from the municipal waste stream and conventional anaerobic digestion to produce stabilised sludge/soil conditioner with market potential and biogas, suitable for electricity generation. It would divert an estimated 70% of the incoming material from landfill.

1.2 Greenhouse Gas Assessment Scope

The scope and methodology for conducting the assessment has been based on the Director-General's Requirements (DGR) of August 22, 2008. The DGR only required assessment of scope 1 and 2 emissions. Scope 3 emissions were excluded.

The purpose of the greenhouse assessment is to calculate the (scope 1 and 2) emissions of the greenhouse gases associated with the project and qualitatively assess the potential impacts of these emissions on the environment. In order to obtain a comprehensive estimate, emission sources were considered associated with:

- Emissions from fuel use associated with site preparation and construction;
- Mobile equipment diesel usage;
- Fuel used for residual waste placement and compaction;
- Emissions from fixed equipment;
- Emissions from the biogas generators (from incomplete combustion, gas escapes); and

- Energy exported (greenhouse reduction).

The emissions from these sources were then aggregated into a single greenhouse gas emissions inventory for the project.

1.3 Methodology

The greenhouse assessment was prepared in accordance with the general principles of:

- The recognised international standard – The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard developed by the World Business Council for Sustainable Development (GHG Protocol); and
- The Commonwealth Department of Climate Change (DCC) National Greenhouse Accounts (NGA) Factors, 2009.

These are considered to represent best practice in Australian greenhouse gas accounting.

1.3.1 Emission Scopes

Emissions are separated into scopes 1, 2 and 3, in accordance with the Greenhouse Gas Protocol for the project. However, only scope 1 and 2 emissions have been considered in the assessment, in accordance with the DGRs for the project. These scopes are defined as follows:

- Scope 1: Direct greenhouse gas emissions from sources falling within the operational boundary of the assessment, from sources that are owned and/or operated by the organisation in question. Scope 1 emissions include direct carbon dioxide emissions from the combustion of stationary or transportation fuels (natural gas, coal, petrol and diesel) in boilers, furnaces, vehicles etc, and fugitive emissions of greenhouse gases from chemical processes, such as wastewater treatment and some product manufacturing.
- Scope 2: Indirect greenhouse gas emissions associated with purchased electricity, heat or steam. These emissions physically occur at the facility where the electricity, heat or steam is generated.
- Scope 3: All other indirect greenhouse gas emissions associated with the activities considered in the assessment. These emissions occur from sources not owned or controlled by the company. Scope 3 emissions include those associated with production of purchased materials, transport and contractor owned vehicles, waste disposal, product usage and the extraction and processing of fuels.

2. Greenhouse Gas Assessment

2.1 Level of Assessment Required

The Department of Planning's Draft Guidelines *Energy and Greenhouse in EIA,* (Guidelines) indicate two possible levels of assessment:

1. Level 1 Assessment – A simplified assessment based on a limited number of energy sources and methane generation potential; and
2. Level 2 Assessment – A more detailed assessment including all Scope 1 and 2 emissions and 'upstream' and 'downstream' scope 3 emissions.

A Level 2 Assessment is required for proposals with projected emissions above a threshold of 15,000 to 20,000 t CO_2-e per annum. Included in this threshold are direct emissions from the project, indirect emissions from the combustion of fuels for the provision of electricity used at the AWT facility and for the transportation of materials and products.

The development will not exceed the Level 1 threshold and therefore a Level 2 assessment is not required.

2.2 Boundary of the Assessment

2.2.1 Life cycle stages for the product

The life cycle stages for the project are:

- Raw materials – products, energy and materials required to produce the construction materials and incoming waste etc;
- Delivery of raw materials such as concrete, tanks, reinforcement steel and delivery of waste during operation;
- Waste processing and electricity generation from biogas – use of utilities such as electricity, fuels, refrigerants, running of gas engines and the generation of waste including solid waste and recycling, wastewater and gaseous emissions from the site;
- Transportation of recyclable materials or stabilised sludge from the AWT facility to points of sale;
- Transportation, placement and compaction of residual wastes from the process at the LHWRC landfill for the period up to the end of 2024;
- Transportation of residual waste from the process to an offsite class 2 landfill from 2025 onwards; and
- Usage – emissions associated with use of process by-products such as recyclables and stabilised sludge.

These life cycle stages are illustrated in Figure 1. The AWT facility operation and residual waste disposal are the only applicable life cycle stages for this assessment, since only scope 1 and 2 emissions need to be considered.

System boundaries and geographic limitations

The system boundary is the inputs and outputs of each of the identified life cycle stages, including transportation.

The assessment covers emissions generated from fuel use associated with site preparation and construction and operation, emissions from fixed equipment and from biogas generators. It also includes emissions associated with energy exported (greenhouse reduction). It does not include:

- Products, energy and materials required to produce construction or raw materials – these are considered Scope 3 emissions;
- Delivery of construction or raw materials to the site (waste would be delivered by council or other contractors to the site) – this is considered a Scope 3 emission;
- The end of life impacts of process products used as a raw material for the manufacture of other by-products – such as recyclable materials extracted from the incoming waste – this is considered a Scope 3 emission;
- Emissions from the transportation of the soil conditioner or recyclable materials offsite for use by customer or for further processing materials – this is considered a Scope 3 emission;
- Emissions from landfill placement and compaction of residual waste from the process at an offsite class 2 landfill from 2025 onwards;
- Emissions associated with use of the process products, such use of recyclable materials extracted from the incoming waste stream – this is considered a Scope 3 emission; and
- Emissions associated with refrigerant leakages from office air conditioning. These are negligible compared to emissions from other sources.

Figure 1 Life Cycle stages for the project

Raw materials & transportation →

Emissions associated with the inputs, outputs and energy use of raw material production and transportation to the AWT facility.

Construction Raw Materials:

- Steel;
- Concrete;
- Water;
- Timber;

Operation Raw Materials:

- Municipal Solid Waste;
- Biological treatment seed organisms.

Construction of the AWT facility →

Emissions associated with the construction of the AWT facility.

Construction equipment:

- Fuel use;
- Electricity for site offices.

AWT facility operation →

Emissions associated with the inputs, outputs and energy usage at the AWT facility.

- Electricity for plant operation (from biogas generators)
- Electricity (excess exported to the grid)
- Mobile equipment
- Biogas generators
- Comingled landfill waste (not including process residual waste)
- Recycled materials (glass, paper, steel, aluminium etc)
- Refrigerant leakages
- Office and support services, including fuel usage and resource consumption.

Product distribution

Emissions associated with the transportation of the recyclable materials from the AWT facility to the various points of sale across Australia.

- Fuel consumption

↓

Product usage

- Diesel (processing and use of recyclable materials)

↓

Disposal

- Transportation of residual waste to landfill
- Placement and compaction of waste at LHWRC landfill (until end of 2024)
- Placement and compaction of waste at offsite Class 2 landfill (from 2025 onwards)

Note: Items printed in BLUE are excluded from the assessment. Details of exclusions are included in Section 2.4.

2.2.2 Aspects of energy use considered

The following aspects of energy use have been considered:

- Energy required for construction of the project - from fuel use of construction equipment and electricity for site offices;
- Energy required for operation of the project including electricity and diesel, as well as fuel use for transfer to, placement and compaction of residual material at the adjacent landfill; and
- Energy exported from combustion of biogas for electricity generation.

2.2.3 Greenhouse gases considered

The greenhouse gases considered in this assessment are:

- Carbon dioxide;
- Nitrous oxides; and
- Methane.

WSN would not use, store or generate any perfluorocarbons or sulphur hexafluoride, and would use only negligible quantities of hydrofluorocarbons for refrigeration. These gases have therefore been excluded.

2.3 Data Collection and Calculation Procedures

Emission factors that are used in the greenhouse footprint calculations are outlined in Appendix A. Where possible, factors have been sourced from the *National Greenhouse Accounts (NGA) Factors,* 2009. If factors have been sourced elsewhere then source references have been provided in Table 1 and Table 2 below.

Wherever possible, estimates with high accuracy were used to calculate greenhouse gas emissions. For example, electricity consumption estimates can be multiplied by the NGA emission factors to calculate greenhouse gas emissions with a high degree of accuracy. When data is unavailable, assumptions and approximations were made in order to obtain a reasonable estimate. For example, fuel consumption for construction equipment was not readily available, and these were estimated based on the best available information from manufacturer's specifications. Recognised standards, such as the World Business Council Greenhouse Gas Protocol, were used to assist in these estimations whenever appropriate.

All energy consumption and emissions data has been converted into quantities of carbon dioxide equivalents, as shown in Appendix A. The emission values have been summed to reach an estimate of the total greenhouse gas emissions over the project lifecycle.

2.4 Exclusions and Assumptions

2.4.1 Exclusions

The life cycle stages, emissions sources and energy consumption that have been omitted from the study are identified below:

- Emissions associated with decommissioning of the AWT facility, including the end of life disposal and vehicles and machinery required for decommissioning. Emissions associated with decommissioning of large processing facilities are typically a very small proportion of the annual operating emissions. Furthermore, once total lifetime emissions are annualised, decommissioning typically accounts for less than 1% of the total emissions.
- Emissions associated with support services for the facility including offsite office activities, marketing and promotional materials, staff business travel and/or visitors travelling to and from the site by any means of transport; and
- Fugitive emissions of refrigerants from refrigeration and air conditioning systems.

The materiality of the omitted emission sources is difficult to accurately establish. However, these emissions are unlikely to be significant compared to the major emission sources, such as electricity consumption. The discrepancies in the total emissions inventory due to the exclusions and limitations of the assessment are therefore anticipated to be non-material.

2.4.2 Assumptions

Assumptions used in estimating the energy use and greenhouse gas emissions for the construction of the AWT facility are listed in Table 1.

Table 1 Construction energy use and greenhouse gas emissions assumptions

Parameter	Data Source and Assumptions
Diesel used in construction equipment	Construction equipment types and durations of use estimated were provided by WSN Environmental Solutions. Diesel consumption was estimated based on equipment type and assumed specifications from manufacturers' websites as 554 kL. Diesel is assumed to have an energy density of 38.6 GJ/kL and emissions factor both from Table 4 of the DCC NGA Factors publication (2009) for fuel combustion emission factors – fuels used for transport energy purposes.
Electricity for site offices	Quantity estimated based on site office requirements as 93.5 MWh over the construction period. Emission Factor from Table 5 of the DCC NGA Factors publication (2009) for NSW (Scope 2).

Assumptions used in estimating the energy use and greenhouse gas emissions during operation are listed in Table 2.

Table 2 Operation energy use and greenhouse gas emissions assumptions

Parameter	Data Source and Assumptions
Net electricity exported to the grid	Quantity of electricity consumed by the AWT facility during operation estimated by Arrow Ecology / WSN as 10,871 MWh/y. Quantity of electricity generated by the AWT facility during operation estimated to be 16,000 MWh/y by WSN. Net electricity exported to the grid = 16,000 – 10,871 = 5,129 MWh/y Emission Factor from Table 5 of the DCC NGA Factors publication (2009) for NSW (Scope 2).
Biogas generators – combustion emissions	Biogas generators are assumed to have an efficiency of 40% based on the Arrow Ecology website. Biogas combusted = 16,000 MWh/y / 0.4 = 40,000 MWh/y Conversion factor 1 GJ = 0.278 MWh from Table 30 of the DCC NGA Factors publication (2009) for energy conversion factors Biogas combusted = 40,000 MWh/y / 0.278 MWh/GJ = 143,885 GJ/y Emission Factor from Table 2 of the DCC NGA Factors publication (2009) (Scope 1). Refer Appendix A.
Diesel in mobile equipment at the AWT facility	Quantity of diesel consumption estimated by Arrow Ecology as 122.76 kL/y Diesel is assumed to have an energy density of 38.6 GJ/kL from Table 4 of the DCC NGA Factors publication (2009) for fuel combustion emission factors – fuels used for transport energy purposes. Emissions factor from Table 4 of the DCC NGA Factors publication (2009) for fuel combustion emission factors – fuels used for transport energy purposes. Refer Appendix A.
Diesel for residual waste transport, placement and compaction	Fuel use for residual waste placement and compaction (to end of 2024 only) is estimated based on data provided by WSN Environmental Solutions to be 1.5 L/t of waste, or 49 kL/y. Fuel use for transport of residual waste to offsite class 2 landfill (7 year period 2025-2031) is estimated based on data provided by WSN Environmental Solutions to be 1.9 km/L. Assume average distance to offsite class 2 landfill = 40 km. Diesel is assumed to have an energy density of 38.6 GJ/kL from Table 4 of the DCC NGA Factors publication (2009) for fuel combustion emission factors – fuels used for transport energy purposes. Emissions factor from Table 4 of the DCC NGA Factors publication (2009) for fuel combustion emission factors – fuels used for transport energy purposes. Refer Appendix A.

3. Greenhouse Assessment Results Analysis

3.1 Scope 1 and Scope 2 Emissions

The scope 1 and scope 2 emissions associated with the construction of the project are listed in Table 3.

Table 3 Construction Scope 1 & Scope 2 Emissions

Emissions Source	Quantity Consumed	Scope 1 Emissions (t CO_2-e)	Scope 2 Emissions (t CO_2-e)
Electricity for site offices	93,479 kWh	-	83
Diesel from construction equipment	554 kL	1,493	-
Sub totals*		**1,493**	**83**
Total construction scope 1 and 2 emissions (t CO_2-e)		**1,577**	

*Note: Figures in table may not sum exactly to total value due to rounding.

The scope 1 and scope 2 emissions associated with the operation of the project are listed in Table 4.

Table 4 Operations Scope 1 & Scope 2 Emissions

Emissions Source	Quantity Consumed Annually	Scope 1 Emissions (t CO_2-e/y)	Scope 2 Emissions (t CO_2-e/y)
Net electricity exported (electricity generated onsite minus electricity consumed for plant operation)	(5,129) MWh		(4,565)
Residual waste management	104 kL	140	
Diesel from mobile equipment	123 kL	331	
Biogas generators	143,885 GJ	695	
Sub totals*		**1,166**	**(4,565)**
Total operations scope 1 and 2 emissions (t CO_2-e)		**(3,399)**	

*Note: Figures in table may not sum exactly to total value due to rounding.

3.2 Greenhouse Emissions Results Summary

The results from the greenhouse assessment are summarised Table 5 below.

The total emissions during construction amount to 1,577 t CO_2-e or 79 t CO_2-e per annum assuming a design life of 20 years. Total annual emissions abatement during operation amounts to 3,399 t CO_2-e. The estimated annual emissions abatement from the project is 3,320 t CO_2-e assuming a design life of 20 years (refer Appendix B for calculations details).

The total annual NSW emissions for 2007 was 160.0 Mt CO_2-e. Hence, the estimated annual emissions abatement from the project would equate to approximately 0.002% of the state's total emissions.

Table 5 Greenhouse assessment summary

Greenhouse indicator	Note	Value	Units
Net annual emissions	1		
◗ Scope 1		1,241	t CO_2-e/y
◗ Scope 2		(4,561)	t CO_2-e/y
Total		**(3,320)**	**t CO_2-e/y**
Greenhouse Intensity of the project (Scopes 1, 2)	2	(0.033)	t CO_2-e/t MSW
Total annual NSW emissions	3	151.6	Mt CO_2-e/y

Notes:

1. See Section 1.3.1 for definitions of reporting scopes. A detailed emissions inventory can be found in Appendix A Annualised emissions calculations details can be found in Appendix B
2. Greenhouse intensity based on annual Scope 1 and 2 emissions (excluding annualised decommissioning emissions)
3. Total annual NSW emissions based on DCC (2009) 'State and Territory Greenhouse Gas Inventories 2007'

Greenhouse Intensity

The emissions intensity for construction and operation of the project is a net reduction of 0.033 t CO_2-e/ t MSW processed, including scope 1 and scope 2 emissions considered in the assessment.

3.3 Assessment of Impacts on the Environment

Considering scope 1 and scope 2 emissions, the project is expected to net an annual greenhouse gas reduction of 3,320 tonnes CO_2-e, which is approximately 0.002% of the state's total emissions in 2007. Hence the project would have a positive environmental impact in terms of greenhouse gas and climate change.

3.4 Mitigation Measures

During operation, the project would consume approximately 10 GWh of electricity annually. This operational electricity requirement is deducted from the 'green' energy that is generated from the biogas in the energy plant that would otherwise be exported to the grid. During the detailed design of the plant, it may be possible to integrate additional energy efficiency measures to reduce consumption of electricity. A discussion of potential measures to maximise energy efficiency are outlined in the following sections.

3.4.1 Lighting

Wide-panel skylights would be considered for installation on the roof of the large waste receival and waste processing buildings. The high-bay lamps serving these two areas would be coupled to appropriate photo-electric switching cells that automatically switches off selected high-bay lighting when suitable levels of natural lighting are available.

A variety of efficient high-bay lighting alternatives, including fluorescent high-bay lamp options, would be considered.

Installation of dedicated task lighting in the alternative waste technology facility may be required to supplement the maintenance light levels provided by high-bay lighting. The use of dedicated task lighting would allow for a reduction in the number of high-bay lights installed for general illumination in this area, and so reduce unnecessary lighting energy consumption. The final lighting design would, however, ensure that the appropriate Australian Standard lighting levels are maintained at all times.

Where feasible and cost-effective energy efficient lamp and lighting control technologies would be considered in all other parts of the facility, and may include:

- Specification of 28W T5 fluorescent lighting (with high-frequency ballasts) in office and near-office areas in place of standard 36W T8 fluorescent lighting;
- Specification of appropriate compact fluorescent lighting in other areas such as bathrooms, hallways and entrance areas;
- The use of occupancy sensors to automatically switch lighting in low-traffic or low-occupancy areas, such as bathrooms, storerooms, communal rooms and individual office areas; and
- Photoelectric (PE) switching cells would be considered in place of timer switches to control security lighting based on available natural light levels.

3.4.2 Compressed air

The use of compressed air would be minimised in the final process design, since up to 90% of the electrical energy input into a compressed air system is dissipated as waste heat. This makes compressed air one of the more inefficient sources of motive power available.

Where compressed air is required as part of the process design, the site final design would consider the use of variable speed driven (VSD) air compressors to supply optimised compressed air needs. VSD air compressor controls are capable of balancing the compressed air supply to meet the required air demand, thereby reducing unnecessary energy wastage in the system.

If multiple compressed air lines are required to supply various components of the process plant, solenoid valves would be considered on individual compressed air lines. This would isolate inactive components and so reduce systematic leakage. Compressed air leakage is a significant issue in industry, and solenoid valves are useful to mitigate against unnecessary air losses and associated energy wastage.

3.4.3 Ventilation

The detailed ventilation design would consider the installation of VSDs on all supply air and exhaust air fan motors, which typically run continuously or for protracted periods. Depending on cost-effectiveness, the site may install VSDs on all supply and exhaust air fan motors rated over 1 kW. Ventilation fan motors serving the waste receival area may benefit from the use of VSD control.

3.4.4 Odour prevention and removal

High-speed roller doors (similar to those at the existing facility at the Macarthur Resource Recovery Park) would be used for each of the waste drop-off bays.

In addition, the energy requirements of various odour control systems would be reviewed during the detailed design stage. The review would consider the cost, efficiency and maintenance trade-offs in order to determine the most suitable system for this situation.

3.4.5 Heating and cooling

The combined administration and control room area would require air-conditioning. The most energy efficient arrangement would be a centralised chilled water system. However this may not be feasible, as the current area may be too small for the application. Energy efficient, inverter-type packaged air-conditioners are therefore likely to be used for heating and cooling in these areas, as well as energy efficient split-system air conditioning units for standalone rooms requiring heating and cooling.

All components of these air-conditioning systems installed outside the building would be located in shady areas, or provided with artificial shading, to improve the efficiency with which heat is rejected from the building. Appropriate room temperature set-points would also be applied when these air-conditioning units are commissioned.

Air-conditioning of the waste receival and waste processing areas would not be energy efficient or cost effective due to the large volume of these areas. Localised cooling, combined with suitable ventilation rates would be used for maintaining worker comfort in these areas.

Passive cooling arrangements to reduce the overall heat load on the buildings are more applicable to this situation. There may be substantial benefits from applying an infra-red reflective paint on part or all of these rooftops to reduce heat gain in these two areas. Similarly, external-shading devices may be considered for exposed walls that receive large amounts of sunlight, particularly on those walls that abut onto air-conditioned parts of the facility, such as the administration and control room areas.

3.4.6 Process efficiency

Energy efficiency would be considered when designing the process control system to ensure suitable control “interlocks” are applied to automatically switch-off unused process components when not required to operate. Such interlocked components might include linked conveyors, pumps, and other motor drives. Installation of VSDs on most process drive motors would also be considered to allow for both fine process control and energy efficient operation of the process plant.

In addition, high efficiency motors would be considered for all motor drive applications across the facility, particularly for motors rated between 22 kW and 45 kW, where efficiency differences between standard motors and high efficiency motors are typically at a maximum.

4. Disclaimer

This report has been prepared at the request of WSN and is for the sole purpose of evaluating the scope 1 and scope 2 greenhouse gas emissions associated with the construction activities and operation of the project.

This report is not for use by any related or third party or for any other project. The information and recommendations are to be read and considered as a whole and the content is not to be used selectively as this may misrepresent the content of the report and provide erroneous project or decision outcomes.

The recommendation, opinions, assessments, analyses and summaries presented in this report are based on preliminary design information, data, assumptions and advice provided by WSN. This information may not reflect the final design and construction and operational activities and where assumptions are identified and recommendations made these need to be verified and tested.

Appendix A

Greenhouse Gas Emissions Inventory

Greenhouse Gas Emissions Calculator Summary

Construction	Value (Q)	Units	Scope 1 Emission Factor (EF)	Scope 2 Emission Factor (EF)	Total Emission Factor (EF)	Units	Source	Method	Scope 1 Emissions (t CO2-e)	Scope 2 Emissions (t CO2-e)	Total Emissions (t CO2-e)	Proportion of Construction Inventory %
Diesel use in construction vehicles	554	kL	2698.14		2698.14	kg CO2-e/kL	NGA Factors June 2009	Q x EF /1000	1,493		1,493	95%
Electricity for site sheds	93,479	kWh		0.89	0.89	kg CO2-e/kWh	NGA Factors June 2009	Q x EF /1000		83	83	5%
Total Construction Emissions									**1,493**	**83**	**1,577**	

Operation	Value (Q)	Units (per year)	Scope 1 Emission Factor (EF)	Scope 2 Emission Factor (EF)	Total Emission Factor (EF)	Units	Source	Method	Scope 1 Emissions (t CO2-e)	Scope 2 Emissions (t CO2-e)	Emissions (t CO2-e/y)	Proportion of Operation Inventory %
Diesel in mobile equipment	123	kL	2698.14		2698.14	kg CO2-e/kL	NGA Factors June 2009	Q x EF / 1000	331		331	6%
Residual waste management	52	kL	2698.14		2698.14	kg CO2-e/kL	NGA Factors June 2009	Q x EF / 1000	140		140	2%
Biogas generators	143,885	GJ	4.83		4.83	kg CO2-e/GJ	NGA Factors June 2009	Q x EF / 1000	695		695	12%
Electricity exported	-5,129,000	kWh		0.89	0.89	kg CO2-e/kWh	NGA Factors June 2009	Q x EF / 1000		-4,565	-4,565	-80%
Total Operational Emissions									**1,166**	**-4,565**	**-3,399**	

Note: additional worksheets are not included in this Appendix, but can be supplied on request

Appendix B

Calculation Details

Calculation Details – Annualised Emissions

Annual emissions from construction

Design life = 20 years

Emissions from construction = 1,577 tCO_2-e

Therefore, annual emissions from construction = 1,577 tCO_2-e / 20 years = 79 tCO_2-e

Total project annual emissions

Annual emissions during operation = -3,399 tCO_2-e

Annual emissions from construction = 79 tCO_2-e

Therefore, total project annual emissions = -3,399 + 79 = -3,320 tCO_2-e.

Total project scope 1 annual emissions

Design life = 20 years

Scope 1 emissions from construction = 1,493 tCO_2-e

Therefore, annual scope 1 emissions from construction = 1,493 tCO_2-e / 20 = 75 tCO_2-e

Annual scope 1 emissions during operation = 1,166 tCO_2-e

Therefore, total project scope 1 annual emission = 75 + 1,166 = 1,241 tCO_2-e

Total project scope 2 annual emissions

Design life = 20 years

Scope 2 emissions from construction = 83 tCO_2-e

Therefore, annual scope 2 emissions from construction = 83 tCO2-e / 20 = 4 tCO_2-e

Annual scope 2 emissions during operation = -4,565 tCO_2-e

Therefore, total project scope 2 annual emissions = 4 - 4565 = -4,561 tCO_2-e

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