HASTINGS
Technology Metals Limited

APPENDIX 6-5

Greenhouse gas emissions assessment

Final Report

Yangibana Rare Earth Project – Greenhouse Gas Emissions Assessment

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Executive summary

Project description

Hastings Technology Metals Limited (Hastings) is seeking environmental approvals for the Yangibana Rare Earth Project (YREP). The project is located approximately 270 kilometres (km) east-northeast of Carnarvon, in the Gascoyne region of Western Australia. The YREP will include open pit mining and processing of mineralised monazite ore, including transport of product to port.

Mining is anticipated to occur over an eight year period. The on-site beneficiation plant will treat up to 1 million tonnes per annum (Mtpa) of mineralised monazite, producing approximately 30,000 tpa of mineral concentrate. The concentrate will pass through a hydrometallurgical process, producing an estimated average of 12,000 tpa of final product. Power for the plant will be supplied from an onsite diesel generation plant.

The objective of this study is to estimate emission of greenhouse gases from the operation of the YREP as currently defined, and to identify where mitigation measures may be required to minimise the impact of the project.

Overview of assessment

For the purpose of the greenhouse gas assessment, the YREP comprises the mine and processing facilities, including power supply, the road network, buildings and support facilities.

The assessment has been undertaken taking into account the general principles and methods contained within:

- the National Greenhouse and Energy Reporting (Measurement) Determination 2008 as amended on 1 July 2016 (CER, 2016a).
- the National Greenhouse and Energy Reporting System Measurement Technical Guidelines 2016 (NGER Technical Guidelines) (CER, 2016b).
- the National Greenhouse and Energy Reporting System Measurement Technical Guidelines 2014 (NGER Technical Guidelines) (CER, 2014)
- the National Greenhouse Accounts Factors (DoEE, 2016).
- The Environmental Protection Bulletin No. 24, (EPA WA, 2015)

The assessment has included the assessment of emissions from the following activities associated with the YREP:

- Onsite power generation using diesel
- Fuel usage in the sulphation bake kilns
- Diesel combustion in vehicles and equipment
- Onsite waste water handling
- Onsite emissions from landfill.

The assessment has considered the following greenhouse gases and their associated global warming potential (GWP), expressed in values of carbon dioxide equivalent (CO_2-e):

- Carbon dioxide (CO_2)
- Methane (CH_3)
- Nitrous oxide (N_2O).

Emissions have been assessed as either Direct (Scope 1) or Indirect (Scope 2), where:

- Scope 1 - Direct emissions from sources owned or controlled by the reporting entity (Hastings), such as fuel use.
- Scope 2 – Indirect emissions from the generation of purchased energy products (eg purchase of electricity from the grid). These are indirect emissions as they arise from sources that are not owned or controlled by the reporting entity (Hastings).

Quantities of fuel and materials were calculated based on information provided by Hastings. Emission factors were sourced from the National Greenhouse Gas Account Factors (DoEE, 2016). When data was unavailable, assumptions and approximations were made in order to obtain a reasonable estimate of activity levels or emission factors.

Key findings of the assessment

The scope 1 emissions associated with the normal operating scenario are about 12,937 tonnes CO_2^{-e} per annum. This is approximately 0.002% of the 2014 Australian emissions. These emissions also represent approximately 0.087% for the mining sector, 0.016% of Western Australia and around 0.003% of the Australian Government's 2030 emissions target. There are no scope 2 emissions associated with the project. The direct emissions from the facility are well below the 25,000 tonnes CO_2^{-e} trigger under the NGER Act.

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1 Introduction

Hastings Technology Metals Limited (Hastings) is seeking environmental approvals for the Yangibana Rare Earth Project (YREP). The project is located approximately 270 kilometres (km) east-northeast of Carnarvon, in the Gascoyne region of Western Australia. The YREP will include open pit mining and processing of mineralised monazite ore, including transport of product to port.

Mining is anticipated to occur over an eight-year period. The on-site beneficiation plant will treat up to 1 million tonnes per annum (Mtpa) of mineralised monazite, producing approximately 30,000 tpa of mineral concentrate. The concentrate will pass through a hydrometallurgical process, producing an estimated average of 12,000 tpa of final product. Power for the plant will be supplied from an onsite diesel power plant.

The objective of this study is to estimate the emission of greenhouse gases from the operation of the YREP as currently defined, and to identify where mitigation measures may be required to minimise the impact of the project.

2 Assessment Approach

For the purposes of the greenhouse gas assessment, the YREP comprises the mine and processing facilities, including power supply, the road network, buildings and support facilities.

The assessment has been undertaken taking into account the general principles and methods contained within:

- the National Greenhouse and Energy Reporting (Measurement) Determination 2008 as amended on 1 July 2016 (CER, 2016a).
- the National Greenhouse and Energy Reporting System Measurement Technical Guidelines 2016 (NGER Technical Guidelines) (CER, 2016b).
- the National Greenhouse and Energy Reporting System Measurement Technical Guidelines 2014 (NGER Technical Guidelines) (CER, 2014).
- the National Greenhouse Accounts Factors (DoEE, 2016).
- Greenhouse gas emissions and consideration of projected climate change impacts in the EIA process, EPA Bulletin No. 24 (WA EPA, 2015).

The report has included the assessment of emissions from the following activities associated with the YREP:

- Onsite power generation using diesel
- Fuel usage in the sulphation bake kilns
- Diesel combustion in vehicles and equipment
- Onsite waste water handling
- Onsite emissions from landfill.

Greenhouse gas emissions associated with construction activities are beyond the scope of this report.

The assessment has considered the following greenhouse gases and their associated global warming potential (GWP):

- Carbon dioxide
- Methane
- Nitrous oxide.

Emissions have been assessed as either Direct (Scope 1) or Indirect (Scope 2), where:

- Scope 1 emissions are greenhouse gas emissions created directly by the reporting entity (Hastings).
- Scope 2 emissions are greenhouse gas emissions created as a result of the generation of electricity, heating, cooling or steam that is purchased and consumed by the reporting entity (Hastings).

Quantities of fuel, materials and waste disposed on site were calculated based on the information provided by Hastings. Emission factors were sourced from the National Greenhouse Accounts Factors ("NGA Factors"). When data was unavailable, assumptions and approximations were made in order to obtain a reasonable estimate of activity levels or emission factors.

3 Greenhouse Gas Emissions

The emission sources considered for this assessment are detailed below:

- Onsite power generation using diesel
- Diesel combustion in vehicles and equipment
- Fuel usage in the sulphation bake kiln
- Onsite waste water handling
- Onsite emissions from landfill.

3.1 Scope 1 Emissions

Direct greenhouse gas emissions occur from sources owned or controlled by the reporting entity. Direct greenhouse gas emissions principally result from the following types of project activities:

- Direct generation of electricity, heat or steam
- Physical or chemical processing
- Transportation of materials, products, waste and employees
- Fugitive emissions.

The Scope 1 emissions identified for the YREP are associated with the following activities

- Diesel power generation
- Diesel used for transport energy purposes
- Diesel used for stationary energy purposes
- Liquefied Natural Gas (LNG) used in acid bake kilns
- Onsite waste water handling
- Landfill waste disposal.

3.1.1 Diesel power generation

Given the remoteness of the YREP, an onsite diesel power generator will be used to meet the energy requirements of the facility. The annual electricity requirement for the site is projected to be 10MW and this will be achieved by 5 units of 2MW power output.

In the future, Hastings also proposes to install solar panels for energy production reducing their dependency on fossil fuels and thereby greenhouse gas emissions from the facility.

An inventory of the annual quantity of diesel used for power generation purposes is provided in Table 2.

Table 2: *Input Data – Power Generation*

Item	Consumption (litres/ hour)	Operating hours per annum	Total Consumption (litres per annum)
Power Station Ancillaries	25	8073	201,825
Emergency Power	60	807	48,420
Total			250,245

Emissions of CO_2, CH_4 and N_2O were estimated using Method 1 (Division 2.4.2, *Method 1- emissions of carbon dioxide, methane and nitrous oxide from liquid fuels other than petroleum based oils or greases* of the *NGER Technical Guidelines, 2016*):

Equation 1

$$E_j = \frac{Q \times EC \times EF_{joxec}}{1000}$$

where:

E_j	=	Estimated emissions of gas type (j) from fuel combustion	(t CO_2-e/yr)
Q	=	Estimated quantity of fuel combusted in the year	(kL/yr)
EC	=	Energy content factor of fuel	(GJ/kL)
EF_{joxec}	=	Emission factor for each gas type (j)	(kg CO_2-e/GJ)

The default energy content and emission factors for diesel were obtained from Table 3 of the National Greenhouse Accounts Factors (hereafter “NGA Factors”) (DoEE, 2016) and are presented in Table 3.

Table 3: *Energy Content and Emissions Factors associated with diesel for stationary energy purposes*

Description	Value	Units
Energy content factor for diesel oil	38.6	GJ/kL
Emission factor for CO_2 - stationary energy purposes	69.9	kg CO2-e/GJ
Emission factor for CH_4 - stationary energy purposes	0.1	kg CO2-e/GJ
Emission factor for N_2O - stationary energy purposes	0.2	kg CO2-e/GJ

3.1.2 Diesel for transport energy purposes

The NGA Factors (DoEE, 2016) state that the fuel used for transport energy purposes include any of the following:

- transport by vehicles registered for road use
- rail transport
- marine navigation

- air transport.

For the YREP this includes the following vehicles

- Landcruiser wagon
- Dual cab units
- Tray top ute
- Troop carrier
- Bus/Troop carrier
- Coach.

An inventory of the quantity of diesel used for transport energy purposes per annum is provided in Table 4.

Table 4: *Input Data – Plant Mobile Equipment- transport energy purposes*

Plant Mobile Equipment	Quantity	Consumption (litres per hour)	Operating hours per annum	Total Consumption (litres per annum)
Land cruiser wagon	2	6	780	9,360
Dual cab units	6	6	780	28,080
Tray top ute	5	6	780	23,400
Troop carrier	1	6	780	4,680
Bus/Troop carrier	n/a	9	832	7,488
Coach	2	50	1460	146,000
Total				219,008

Emissions of CO_2, CH_4 and N_2O were estimated using Method 1 (Division 2.4.2, Method 1- emissions of carbon dioxide, methane and nitrous oxide from liquid fuels other than petroleum based oils or greases of the NGER Technical Guidelines) , **Equation 1**.

The default energy content and emission factors for diesel were obtained from Table 4 of the NGA Factors (DoEE, 2016) and are presented in Table 5.

Table 5: *Energy Content and Emissions Factors associated with diesel for transport energy purposes*

Description	Value	Units
Energy content factor for diesel oil	38.6	GJ/kL
Emission factor for CO_2 - transport energy purposes	69.9	kg CO2-e/GJ
Emission factor for CH_4 - transport energy purposes	0.1	kg CO2-e/GJ
Emission factor for N_2O - transport energy purposes	0.5	kg CO2-e/GJ

3.1.3 Diesel used for stationary equipment

For the YREP, all other equipment that use diesel (non-transport) falls under this category. The equipment inventory and their annual diesel consumption are presented in Table 6.

Table 6: *Input Data – Mining and Plant Mobile Equipment – Stationary energy purposes*

Mining Mobile Equipment	Quantity	Consumption (litres per hour)	Operating hours pa	Total Consumption (litres per annum)
Big trucks	8.8	50	4,037	1,776,280
Little trucks	3	40	4,037	484,440
Loaders	1	20	4,037	80,740
Diggers	2.4	10	4,037	96,888
Bore 1	1	15	8,073	121,095
Bore 2	1	15	8,073	121,095
Tool Carrier	1	8	1,820	14,560
Bob CAT	1	8	1,820	14,560
Crane	1	20	780	15,600
Hiab Truck	1	9	1,092	9,828
Service Truck	1	9	1,092	9,828
Forklift	2	4.6	2,730	25,116
Container Forklift	1	21	2,730	57,330
80t Crane	0.6	40	780	18,720
Total				2,846,080

Emissions of CO_2, CH_4 and N_2O were estimated using Method 1, **Equation 1** described in earlier sections.

The default energy content and emission factors for diesel were obtained from Table 3 of NGA Factors (DoEE, 2016) and are presented in Table 3.

3.1.4 Liquefied Natural Gas (LNG) used in kilns

Liquefied Natural Gas (LNG) is used as a fuel in the sulphate baking kilns. An inventory of the annual quantity of LNG used in the kilns is provided in Table 7.

Table 7: *Input Data – Kilns*

Item	Quantity	Consumption (litres/ hour)	Operating hours per annum	Total Consumption (litres per annum)
Acid Bake Kilns	2	84	8073	1,356,264

Emissions of CO_2, CH_4 and N_2O were estimated using Method 1, **Equation 1**.

The default energy content and emission factors for LNG were obtained from Table 2 of the NGA Factors (DoEE, 2016) and listed in Table 8.

Table 8: *Energy Content and Emissions Factors associated with diesel for stationary energy purposes*

Description	Value	Units
Energy content factor for Liquefied Natural Gas	25.3	GJ/kL
Emission factor for CO_2 - Liquefied Natural Gas	51.4	kg CO2-e/GJ
Emission factor for CH_4 - Liquefied Natural Gas	0.1	kg CO2-e/GJ
Emission factor for N_2O - Liquefied Natural Gas	0.03	kg CO2-e/GJ

3.1.5 Onsite waste water handling

The primary source of waste water is associated with personnel in accommodation facilities. Wastes generated during the processing of ore are disposed in the tailings storage facilities and do not form part of this assessment. The total greenhouse gas emissions from waste water handling involves the following two components:

- Waste water treatment
- Sludge treatment.

Information displayed in Table 9 is used to calculate the amount of waste water generated onsite.

Table 9: *Input Data – Waste water handling*

Item	Value	Unit	Comments
Average consumption during operational phase	70	kL/day	Supplied
No. of personnel (operational phase) [a]	280	person	Calculated

a) Calculated based on a consumption rate of 100L/day for 2.5 personnel in a permanent resident site (EPA VIC, 1997)

The following equation (Equation 2) is used to estimate the CO_2-e emissions that can be expected from treating municipal wastewater. Default values for both chemical oxygen demand and methane emission factors were used. Other parameters are listed in Table 10.

Equation 2

$$GHG\ Emissions\ (t\ CO_2 - e) = \left(\left(\left((COD_w) \times (1 - F_{sl}) - COD_{eff}\right) \times MCF_{ww} \times EF_w\right)\right) + (P \times DC_w \times F_{sl} \times MCF_{sl} \times EF_{SL}) - R$$

where:

P	=	The population served in persons
DC_w	=	The quantity in kilograms of Chemical Oxygen Demand (COD) per capita per year of wastewater. In the event that no waste analysis data is available, a default value of 0.0585 tonnes per person per year can be used
F_{sl}	=	Default fraction of COD removed as sludge. (default value of 0.29)
COD_{eff}	=	The quantity of COD in wastewater discharged in effluent from the treatment plant

$\mathrm{COD_w}$	=	Chemical Oxygen Demand (COD) in tonnes of COD per year which is the product of DCw and population
$\mathrm{MCF_{ww}}$ and MCF_{sl}	=	Fraction of COD anaerobically treated in wastewater (ww) and sludge (sl). Default for anaerobic digestor = 0.8
EF_w	=	Default methane emission factor for wastewater with value of 6.3 tonnes CO2-e/tonne COD (wastewater)
$\mathrm{EF_{SL}}$	=	Default methane emission factor for sludge with value of 6.3 tonnes CO2-e/tonne COD (sludge)
R	=	Recovered methane from wastewater in an inventory year, measured/expressed in tonnes

Table 10: *Emission parameters for Waste Water Handling*

Item	Value	Unit	Comments
CODeff	2	tonnes	Assumed

3.1.6 Waste disposals in Landfill

The primary source of waste for landfill is associated with residents living in the onsite accommodation facilities. Information on the tonnage of solid waste generated for landfill purposes is presented in Table 11. As mentioned previously, emissions from the construction phase are beyond the scope of this assessment.

Table 11: *Input Data – Landfill*

Item	Value	Unit	Comments
Average consumption during operational phase	70	kL/day	Supplied
Density of waste water	1	t/KL of wastewater	Assumed
Solid waste generated (operation phase)	70	t/day	Calculated

To calculate the emissions from the biological treatment of wastes in landfill (composting), reference was made to Method 1, *Biological treatment of solid waste production IPCC 2006 Guidelines for National Greenhouse Gas Inventories Volume 5, Chapter 4*.

Equation 3

$$\mathrm{E_{ij}} = (\mathrm{M}_i \times EF_i) - R$$

where:

$\mathrm{E_i}$	=	Estimated emissions of waste type (i)	(t CO_2-e/yr)
M_i	=	Quantity of waste of type (i)	(t waste)
$\mathrm{EF_i}$	=	Emission factor for each waste type (i)	(t CO_2-e/t waste)
R	=	Amount of methane recovered	(t CO_2-e)

Emission factor was referenced from Section 5.22, Division 5.2.6, of the NGER Technical Guidelines 2014 and is presented in Table 12.

Table 12: *Emissions Factors associated with waste disposal in landfill*

Description	CH_4	N_2O	Units
Emission factor for type of gas and biological treatment: Composting	0.016	0.030	t CO2-e/ t of waste treated

3.1.7 Total Scope 1 Emissions

A summary of the total Scope1 greenhouse gas emissions generated as CO_2–e per annum for the operational phase of the YREP are presented in Table 13.

Table 13: *Annual GHG Emissions – Scope 1*

Item	Emissions of CO_2 (t)	Emissions of CH_4 (t)	Emissions of N_2O (t)	Total Emissions (t CO_2 -e)
Diesel power generation	675.2	1.0	1.9	678.1
Diesel used for stationary energy purposes	7,679.1	11.0	22.0	7,712.1
Diesel used for transport energy purposes	590.9	0.8	4.2	596.0
LNG for Acid Bake Kilns	3,867.8	7.5	2.3	3,877.6
Landfill	-	-	-	1.2
Waste Water Handling	-	-	-	72.5
Total				12,937.4

3.2 Scope 2 Emissions

Scope 2 emissions refer to the indirect emissions resulting from the generation of electricity purchased and consumed by an entity.

As 100% of the project's energy requirements are met by an onsite diesel power generator, there are no Scope 2 emissions associated with the YREP.

3.3 Summary of Greenhouse Gas Emissions

In summary, the operations at YREP is estimated to generate scope 1 emissions of 12,937.4 tonne CO_2-e per annum. There are no scope 2 emissions associated with the facility as currently designed.

4 Assessment of Potential Impact of Emissions

Limited published information was available on the greenhouse gas estimates for a similar mine in the region. Therefore, the project's estimated emissions were compared to the latest published national emissions inventory and industry specific emissions inventory for 2014. This is summarised and presented in Table 14.

The contribution from the YREP to the total greenhouse gas emissions in Australia and Western Australia are 0.002% and 0.016% respectively.

When the greenhouse gas emissions from the YREP are compared to the *Metal ore and non-metallic mineral mining and quarrying industry (ANZSIC code 08-10)*, the emissions from the project represent 0.087% of the emissions from the industry.

Table 14: *Greenhouse Emissions Contribution from the YREP*

Item[a]	Total GHG emissions $MtCO_2$ -e/year	Contribution from Project to GHG Emissions (%)
Australia	523.3	0.002%
Western Australia	83.4	0.016%
Metal ore and non-metallic mineral mining and quarrying (ANZSIC Code 08-10)	14.9	0.087%

a) Australian Greenhouse Emissions Information System, http://ageis.climatechange.gov.au/# , accessed 20 October 2016

5 Potential Mitigation Measures

The annual Scope 1 emissions associated with the YREP are estimated to be approximately, 12,937 tonnes CO2 –e per annum, without mitigation. Diesel used for stationary energy purposes is calculated to be the largest contributor, followed by LNG used in the bake kilns.

5.1 Avoidance of Impacts

The consumption of fuel is a necessary requirement of the Project. Hastings proposes to operate a solar farm reducing the reliance on fossil fuels for onsite power generation, however detailed specification was not available at the time of this assessment. This measure, if implemented, is estimated to reduce the greenhouse gas impact from the facility by 5%.

5.2 Mitigation of Impacts

The most significant greenhouse gas mitigation option for fuel related emissions is likely to be the use of fuel other than diesel/heavy fuel oil.

A small reduction in fuel consumption may be achieved through the use of more efficient plant and vehicles. Newer vehicle and plant models are typically more fuel efficient than older models. The use of more recent vehicles and plant models would need to be part of a wider fuel management strategy that incorporates Project planning, logistics, driver education and maintenance as any fuel reduction due to more efficient models may be outweighed by poor management in other areas.

A reduction in the quantity of transport and logistics activities may reduce the number of vehicles and/or trips required within the project. Optimisation of activities and logistics will reduce the number of trips required, hence associated fuel consumption. Optimisation could be considered during the detailed project design and planning stage.

5.2.1 Recommended for Client Consideration

Implementation of the following greenhouse gas mitigation options are presented for client consideration, offset and minimise greenhouse emissions from the YREP project:

- selection and use of fuel efficient mobile equipment (on-site vehicles) and stationary equipment (generators)
- optimise on-site travelling routes and patterns (logistics and driver awareness)
- implement a preventative maintenance program to ensure engines are operating efficiently
- optimise operations to minimise time of operation at low efficiency levels that may result in elevated greenhouse gas emissions.
- adopt a system of continual improvement in the net greenhouse emissions and emissions intensity, including review, adoption of new technologies and process management, where applicable.

6 References

CER (2014), National Greenhouse and Energy Reporting System Measurement Technical Guidelines for the estimation of greenhouse gas emissions by facilities in Australia, Clean Energy Regulators, Commonwealth of Australia, 2014.

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