Report to:

CAMECO AUSTRALIA PTY LTD
MITSUBISHI DEVELOPMENT PTY LTD

Kintyre Greenhouse Gas Assessment

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GREENHOUSE GAS ASSESSMENT

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1.0 INTRODUCTION

The proposed Cameco Kintyre Project (the Project) would require the consumption of energy, primarily in the form of diesel consumption for the production of electricity, steam and for the mining fleet. This consumption would generate emissions that have been associated with climate change, being so-called greenhouse gases.

This greenhouse gas assessment provides an overview of the proposed operation in the context of its energy usage, provides an introduction to greenhouse gas science, reviews the current state and federal legislative environment and provides discussion of the likely emissions from the proposed project in the context of projected state, Australian and global emissions. A brief discussion of the life-cycle emissions associated with the production and use of uranium is also presented for further context.

Emissions estimates are provided in the various direct (Scope 1) and indirect (Scope 3) categories, and also separates out those emissions reportable under the National Greenhouse and Energy Reporting (NGER) framework.

2.0 PROJECT OVERVIEW

A joint-venture consortium (hereafter Consortium) comprising Cameco Australia Pty Ltd (hereafter Cameco) (70%) and Mitsubishi Development Pty Ltd (hereafter Mitsubishi) (30%) proposes to develop an open pit mine and associated processing facilities at Kintyre in the Shire of East Pilbara of Western Australia, approximately 1,200 km north-northeast of Perth on the edge of the Great Sandy Desert. The proposed Kintyre Uranium Project (the Project) would produce up to approximately 4,400 tonnes of U_3O_8-based uranium oxide concentrate (UOC) per annum (peak annual rate). The open pit mine would consist of a single open pit mine encompassing a number of discrete ore zones. The open pit would ultimately extend approximately 1,000 m north-to-south, 1,500 m east-to-west and would be excavated to a depth of around 250 m. Up to 33 million tonnes (Mt) of overburden and ore would be mined per annum using a combination of selective and bulk open pit mining techniques. Run-of mine (ROM) ore would be stockpiled and subsequently treated in the proposed metallurgical plant, with unmineralised overburden stored in a permanent above-ground Waste Rock Landform (WRL). Below ore-grade uranium overburden (mineralised overburden) would be stockpiled separately from the unmineralised overburden and may be blended with high grade ore to ensure a consistent ore grade for processing.

The metallurgical plant would leach uranium from ore using alkaline reagents and conventional uranium extraction technologies to produce UOC for containerised export via the Port of Adelaide. All tailings generated during the metallurgical processing of the ore would be directed to an above-ground Tailings Management Facility (TMF).

Additional infrastructure would be required to support the mining and metallurgical operations. The main infrastructure components would be:

- pit dewatering infrastructure to maintain dry pit conditions and stable pit slopes
- a process water supply wellfield located in the vicinity of the orebody
- a potable water supply wellfield
- a lined evaporation pond for the disposal of process bleed-water excess to demand
- an electricity supply network using on-site diesel power generation
- buildings, including offices, workshops and warehouses
- an Accommodation Village for a fly-in-fly-out (FIFO) workforce to be used during construction and operations
- an airport for the air transport of personnel
- the upgrade of 60 km of the existing site access road and the construction of a new 30 km road alignment connecting the upgraded Kintyre Road to the existing Telfer Road
- associated infrastructure including haul roads, refuelling facilities, borrow pits, a quarry, waste management facilities, potable water treatment facilities, stormwater management infrastructure, explosives magazine and sewage management facilities.

3.0 GREENHOUSE GAS SCIENCE

Greenhouse gases include gases such as water vapour, carbon dioxide, methane, chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) that absorb and re-emit infra-red radiation (heat), which warm the Earth's surface and contribute to climate change. The greenhouse effect, which is synonymous with climate change and global warming, has been defined as ‘any change in climate over time, whether due to natural variability or as a result of human activity’ (IPCC 2007).

The impact of greenhouse gas emissions on the atmosphere is the combined effect of the radiative properties of the gases (that is, their ability to absorb solar and infra-red radiation) and the time that it takes for those gases to be removed from the atmosphere by natural processes. In order to compare the relative effects of different gases over a particular time period, Global Warming Potentials (GWP) are used, referenced in units of carbon dioxide equivalents (CO_2-e); carbon dioxide is used as the base reference, and has a GWP of 1. There are six major groups of greenhouse gases, which are listed in Table 1. The table also shows the GWP for each of the gases, calculated over a 100-year time scale. The table indicates, for example, that an emission of 1 kg of methane has the same global warming potential as an emission of 21 kg of carbon dioxide: if 1 kg of carbon dioxide is emitted together with 1 kg of methane, the total emission would be valued at 22 kg of CO_2-e.

Table 1. Greenhouse gas categories and indicative global warming potentials[1]

Greenhouse gas	GWP range
Carbon dioxide	1
Methane	21
Nitrous oxide	310
Hydrofluorocarbons (HFC)	150–11,700
Hydrofluoroethers (HFE)	100–500
Perfluorocarbons (PFC)	6,500–23,900

[1] Sourced from National Greenhouse Accounts Factors 2011.

4.0 LEGISLATIVE ENVIRONMENT

4.1 FEDERAL

The primary Australian mechanism for reducing the potential for climate change is based on the Clean Energy Legislative Package which passed into law in November 2011. The package ties together a number of related greenhouse gas abatement and management programmes and introduces a price on carbon designed to promote reductions in greenhouse gas emissions from industry. The carbon price, initially $23 per tonne of CO_2-e emitted (as calculated using the NGER Technical Guidelines methodology), will apply to all enterprises that emit over 25,000 t of CO_2-e per annum, with the money raised being used to provide compensation for households against price rises associated with the carbon price, and for investment into renewable and low-carbon energy sources and greenhouse gas emissions abatement initiatives.

The NGER framework was legislated in 2007 and contains mandatory reporting provisions for companies who, as a corporation, emit over 50,000 t of CO_2-e per annum or demand over 200 terajoules (TJ) of energy or for individual facilities where these emit over 25,000 t of CO_2-e per annum or have an energy demand of greater than 100 TJ, calculated using the associated Technical Guidelines methodology. Aside from supporting the carbon pricing legislation, information from the NGERs reporting is also used in the National Greenhouse Accounts to meet Australia's greenhouse gas reporting obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and to track progress against Australia's target under the Kyoto Protocol.

The *Energy Efficiency Opportunities Act 2006* was developed to improve the method of identifying and evaluating energy efficiency opportunities. Participation in the EEO program is mandatory for corporations that use more than 0.5 petajoules (PJ) of energy per year. The Act requires reporting organisations to submit five year plans that set out proposals for assessing their energy usage and to identify, evaluate and report on cost effective energy saving opportunities.

In terms of greenhouse gas abatement programs facilitated by the Federal Government, the two primary systems are the Renewable Energy Target (RET) scheme, which commenced in 2001, and the Carbon Farming Initiative (CFI). The Australian Government amended the legislation associated with the related RET scheme in mid-2010. This scheme, designed to ensure that 20 percent of Australia's electricity supply is generated from renewable energy sources by 2020, was split into the Large-scale Renewable Energy Scheme (LRET) and the Small-scale Renewable Energy Scheme (SRES) in order to provide greater certainty for people or enterprises developing renewable energy systems.

The CFI allows farmers and land managers to generate carbon credits through increasing the amount of carbon stored in soils and trees on a given area of land that can then be traded to other businesses wanting to offset their own greenhouse gas emissions.

4.2 WESTERN AUSTRALIA

The Western Australian Government had developed a range of measures and policies via its Greenhouse Strategy (2004) and *Making Decisions for the Future: Climate Change* Statement (2007) which were designed to develop a foundation for a carbon pricing scheme in lieu of a national carbon price or trading scheme, and so are of questionable relevance now that the carbon pricing scheme has been legislated. A Climate Change Adaption and Mitigation Strategy is currently being developed to ensure that Western Australian action on climate change targets those areas where a carbon price may not be sufficient to achieve efficient abatement.

5.0 EMISSIONS ESTIMATES

5.1 INTRODUCTION

A description of the assessment methodology and an estimate of the likely emissions associated with the Project are provided in the following section. For the purpose of this greenhouse gas assessment, emissions were broken down by scope in accordance with various international standards for emissions reporting. For the purpose of understanding the potential NGERs liability, emissions were also broken down into NGER-reportable (and thus carbon price-exposed) emissions. Due to significant uncertainty regarding the boundaries associated with life cycle assessments, and to allow comparison of development emissions with other operations and state, federal and global GHG projections, emissions associated with the embedded energy of the materials used to construct the Project were not included in the assessment.

5.2 METHODOLOGY

This section provides a summary of the standards used to undertake GHG emission calculations, sets out the boundaries for the Project, both organisational and operational and describes the data collected, calculation methods employed and the source of energy conversion and emission factors used in quantifying GHG emissions.

5.2.1 STANDARDS

The GHG emission inventory for the Project was prepared in accordance with the following standards:

- ISO 14064-1:2006(E): Greenhouse gases – Specification with guidance at the organisation level for quantification and reporting of greenhouse gas emissions. This is an international standard released by the International Standards Organisation for the development of GHG emission inventories and the reporting of emissions.
- The Greenhouse Gas Protocol - Revised Edition, 2004 (the GHG Protocol), developed by a partnership between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). This is a corporate GHG accounting and reporting standard which has been adopted internationally.
- *National Greenhouse and Energy Reporting (Measurement) Determination 2008.* This document provides detailed guidance on recording data sources and quantifying emissions in order to achieve compliance with Australian NGERS reporting legislation.

ISO 14064-1:2006(E) and the GHG Protocol are complementary in nature and describe the same process for the accounting of GHG emissions and compiling of GHG emission inventories.

The NGERs framework provides a higher level of detail than the GHG Protocol as to how emissions should be calculated by Australian companies, including collating activity data, selecting fuel energy content and emission factors, calculating emissions and estimating uncertainty; as well as minimum standards for data accuracy. This is the primary standard which has been followed in preparing this assessment for the Project.

The *NGER Measurement Determination* does not provide guidance on the calculation of scope 3 emissions. In calculating scope 3 emissions, the following sources are referred to:

- The Greenhouse Gas Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard (WRI and WBCSD, 2011); and
- The National Greenhouse Accounts (NGA) Factors July 2010 (DCCEE, 2010).

5.2.2 ORGANISATIONAL BOUNDARY

The organisational boundary for this assessment has been defined using the Operational Control approach. Section 11 of the *NGER Act* defines Operational Control as follows:

> *A corporate group member has operational control of a facility if it has the authority to introduce and implement any or all of the operating, health and safety and environmental policies for the facility. Only one corporation or group member can have operational control of a facility at a time.*
>
> *If there is uncertainty as to which corporation or member has operational control of a facility, the corporation or member deemed to have operational control will be the one with the greatest authority to introduce and implement operating and environmental policies.*

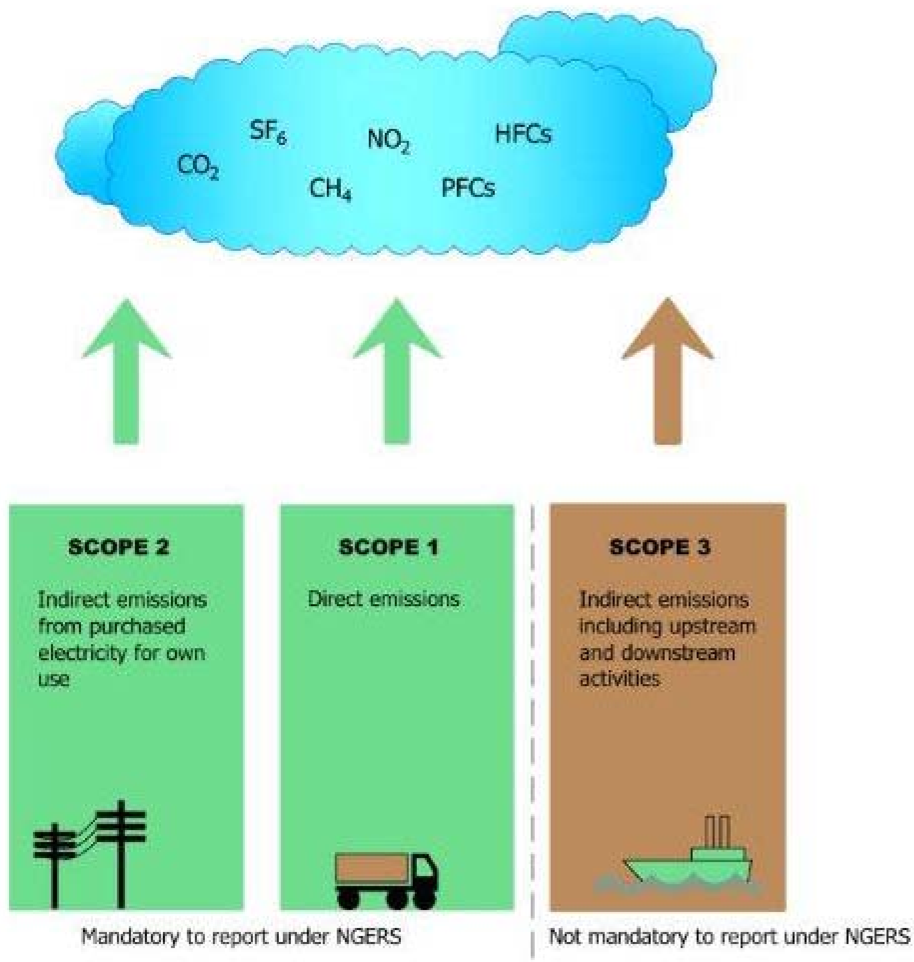
Using this approach, the Consortium will account for all GHG emissions over which it has operational control. It will not account for emissions in which it owns an interest but does not have operational control.

The construction and operation of the Project will rely on a number of contractors. The Consortium will account for emissions associated with its major contractors under its own scope 1 and 2 emissions (as defined below), since it has authority to implement OHS and environmental policies in relation to the activity of these contractors at the Kintyre Project area.

5.2.3 EMISSION SCOPES

Figure 1 shows the relationship between the three emission scopes as defined in the GHG Protocol and used in NGERS reporting. Scope 1 GHG emissions are those emissions from sources owned and controlled by the organisation. Scope 2 emissions are those from purchasing energy (heat or electricity). Scope 3 emissions are all other indirect emissions that occur in the value chain of the reporting company, including upstream and downstream activities.

Figure 1. GHG emission scopes and sources across the value chain



Reporting of Scope 3 emissions by an organisation is voluntary under all of the standards relevant to this assessment (ISO 14064:1-2006, GHG Protocol, NGER Measurement Determination). The consortium has elected to report certain scope 3 emissions which are considered to be of primary interest to the Project stakeholders. In making the decision to include or exclude a certain Scope 3 emission source in the inventory, the criteria presented in Table 2, as specified within WRI and WBCSD (2011), have been taken into account.

Table 2. Criteria for the inclusion of Scope 3 emissions

Criterion	Description
Size	They contribute significantly to the Project's total anticipated downstream or upstream GHG emissions
Influence	There are potential emissions reductions that could be undertaken or influenced by the Consortium
Risk	They contribute to the consortium's risk exposure (e.g. climate change related risks such as financial, regulatory, supply chain, product and technology, compliance/litigation, reputational and physical risks)
Stakeholders	They are deemed critical by key stakeholders (e.g. customers, suppliers, investors or civil society)
Outsourcing	They are outsourced activities previously performed in-house or activities outsourced by the Consortium that are typically performed in-house by other companies in the same industrial sector
Other	They meet additional criteria developed by the Consortium or the industry sector to which the Project belongs

5.2.4 Scope 1 and 2 emission sources

Section 2.2 contains a summary of activities associated with the Kintyre Project, both in the construction and operational phases. Point source GHG emissions from these activities are considered as occurring within Cameco's operational boundary and are therefore categorised as Scope 1 or Scope 2 emissions and need to be reported by Cameco. Table 3 identifies each of the Scope 1 and Scope 2 emissions sources for the Project.

Table 3. Scope 1 and 2 emissions sources

Scope	Source
1	Diesel consumption by mobile fleet
	Stationary energy (electricity) generation
	Explosives
	Metallurgical emissions
	Emissions associated with land-use change (clearing)
2	Nil (electricity will be generated on-site)

5.2.5 SCOPE 3 EMISSION SOURCES

The major scope 3 emission sources to be reported for the Project are identified in Table 4, together with the criteria determining inclusion or exclusion of each of these emission sources in the inventory.

Table 4. Scope 3 emissions sources

Scope	Source	Size	Influence	Risk	Stakeholders	Outsourcing	Other	Include?
3	Product transport diesel (to Australian export port)	Y	Y	N	N	N	N	Y
	Product transport diesel (Bulk sea freight to end user)	N	N	N	N	N	N	N
	Workforce transport	Y	Y	N	N	N	Y	Y
	Further processing of Product	Y	N	Y	Y	N	N	Y
	End use of Product	Y	N	Y	Y	N	N	Y
	Raw materials generation energy	N	N	N	N	N	N	N

5.3 GREENHOUSE GAS EMISSIONS

5.3.1 SCOPE 1 EMISSIONS ESTIMATE

DIESEL CONSUMPTION

Using the diesel demands described in Section 6 (Project Description) of the Environmental Review and Management Programme (ERMP) document, the emissions from the consumption of diesel have been estimated and the results summarised in Table 5.

Table 5. Diesel consumption emissions

Energy demand	Consumption (units)	Energy content (GJ/kL)	Emission factor (kg CO_2-e/GJ)			GHG emission (t CO_2-e/annum)
			CO_2	CH_4	N_2O	
Electricity generation	12.3 (ML/a)	38.6	69.2	0.1	0.2	33,000
Mobile fleet	15.3 (ML/a)	38.6	69.2	0.01	0.6	41,000

EXPLOSIVES

Using the indicative explosive consumptions described in Section 6 of the ERMP, the emissions from the consumption of diesel have been estimated and the results summarised in Table 6.

Table 6. Explosives consumption emissions

Energy demand	Consumption (units)	Emission factor (t/t)	GHG emission (t CO_2-e/annum)
Explosives	10,000 tpa	0.17	1,700

METALLURGICAL EMISSIONS

The dissolution of carbonates during the acid leaching process will result in emissions of CO_2. These emissions have been estimated in accordance with Section 4.2.3 of the NGER Technical Guidelines, which states that emissions from the reaction of carbonates are:

CO_2-e (t) = Raw carbonate (t) x Carbonate Factor, where the Carbonate Factor is:

- 0.396 for calcium carbonate
- 0.522 for magnesium carbonate, and
- 0.453 for dolomite
- Other factors available from the IPCC if the carbonates are of a different form to those described above.

The estimation of metallurgical emissions for the Project is provided in Table 7.

Table 7. Metallurgical process emissions

Carbonate type	Ore throughput (tpa peak)	Carbonate proportion (%)	Amount reacted (%)	GHG emission (t CO_2-e/annum)
Dolomite	600,000	11.4	100	31,000

LAND CLEARING EMISSIONS

An extensive study was undertaken by the Government of Western Australia (Department of Agriculture and Food) in 2010 into the potential for carbon offset enterprises within the Pilbara and Kimberly. This report quantified the carbon stocks on a range of vegetation associations within the Pilbara and Kimberly region, including spinifex grasslands (identified as the Capricorn land system) common to the area around the proposed Project. A summary of the finding of this report for the relevant land system are presented in Table 8.

Table 8. Land use change-related greenhouse gas emission estimate

Carbon pool	Carbon mass (t C per ha)	Greenhouse gas emission (t CO_2-e per ha)
Soil	26.5	97.3
Woody vegetation	17.6	64.6
Herbaceous vegetation	24.3	89.2
Course woody debris	84.3	309.4
Total	**152.7**	**560.5**

Source: WA Department of Agriculture and Food 2010.

Over a 650 ha estimated disturbance footprint, the expected CO_2-e emissions are projected to be around 364,325 t. As the topsoil, incorporating course woody debris, would be stockpiled during operations and subsequently used in rehabilitation activities, and as the Project footprint is expected to be fully rehabilitated and revegetated following decommissioning, these emissions would be offset over the longer term, and thus the above represents a worst-case emissions scenario.

5.3.2 SCOPE 3 EMISSIONS ESTIMATE

PRODUCT TRANSPORT DIESEL

Product transport diesel emissions have been estimated based on a peak UOC production rate of 4,400 tpa, a one-way trip distance of 3,900 km, an average diesel consumption of 2.66 km/L and assuming that 125 drums (at 400 kg per drum) can be transported in one trip. The emissions are summarised in Table 9.

Table 9. Product transport diesel consumption emissions

Energy demand	Consumption (ML/a)	Energy content (GJ/kL)	Emission factor (kg CO_2-e/GJ)	GHG emission (t CO_2-e/annum)
Transport diesel	1.8	38.6	69.81	4,900

WORKFORCE TRANSPORT

Emissions for a fly-in/fly-out workforce were calculated based on information provided by the International Civil Aviation Organisation (ICAO, 2012) and assuming employees transit from Perth to site on a two week-on, two week-off roster (i.e. 26 legs per employee per year). The results of the analysis are summarised in Table 10.

Table 10. Workforce transport consumption emissions

Energy demand	Number of Pax.	Emission factor (kg CO_2-e/Pax/leg)	GHG emission (t CO_2-e/annum)
Aviation Avtur	400	170	1,800

URANIUM LIFE CYCLE EMISSIONS

Studies of nuclear fuel life cycle greenhouse gas emissions have shown that the generation of nuclear electricity produces about 65 g of CO_2-e per KWh of electricity generation (Sovacool 2008; Lenzen 2008). This emissions intensity is about 10 to 15 times less than that of other fossil fuel electricity generation and at the higher end of the range of renewable electricity generation emission intensities.

An extensive analysis of the life cycle greenhouse gas emissions of electricity-generating technologies has been undertaken (Sovacool 2008; Lenzen 2008). These studies indicated the following factors have the greatest influence on life cycle greenhouse gas emissions:

- the grade of the uranium ore mined
- the method of enrichment
- the conversion rate of the nuclear fuel cycle (i.e. the amount of fuel recycling)
- the source (fossil, renewable or nuclear) of electricity used for the enrichment phase and the overall greenhouse gas intensity of the electricity mix in the countries where fuel cycle activities are undertaken.

A high-level assessment of the life cycle greenhouse gas emissions associated with the proposed development was undertaken using available literature to estimate emissions associated with uranium production, use and disposal.

Approximately 9.05 kg of UOC is required to produce 1 kg of nuclear fuel-grade UO_2 (World Nuclear Association 2008), sufficient to generate approximately 360,000 kWh of electricity. Given the nuclear life cycle information presented above, the life cycle greenhouse gas emissions for the UOC produced by the proposed Kintyre development would be around 2.6 t of CO_2-e per kilogram of UOC, with the proposed development accounting for 0.3 t of this.

The actual generation of electricity using uranium generates no GHG emissions however would offset emissions that would otherwise occur should the same amount of electricity be generated using traditional fossil fuel energy mixes. Using the indicative production rates described in Section 6 of the ERMP, the uranium produced by the Project would generate up to 1,150,000 GWh of electricity in a nuclear powerplant. The net greenhouse gas benefit of the Kintyre operation would be around 850 million tonnes of CO_2-e over the life of the operation, if the nuclear electricity generated from Kintyre UOC was otherwise produced using traditional fossil fuel electricity generation (using Western Australia's typical purchased electricity emission factor of 0.80 kg of CO_2-e/kWh.

5.3.3 EMISSION ESTIMATE SUMMARY

Table 11 outlines the NGER-reportable emissions associated with the Project. Table 12 summarises the total GHG emissions from the Project, including potential benefits associated with uranium end use emissions.

Table 11. NGER-reportable Project GHG emissions summary

Energy demand	Greenhouse gas emission (t CO_2-e per annum)
Electricity generation	33,000
Mobile fleet	41,000
Metallurgical emissions	31,000
Total	**105,000**

Table 12. Project GHG emissions summary

Energy demand	Greenhouse gas emission ($t\ CO_2$-e per annum)
Scope 1	
Electricity generation	33,000
Mobile fleet	41,000
Explosives	1,700
Metallurgical emissions	31,000
Sub-total[1]	**106,700**
Scope 3	
Product transport	4,900
Workforce transport	1,800
Uranium life cycle emissions[2]	66,700,000
Uranium end-use emissions[3]	-920,000,000
Sub total	**-853,300,000**
Total	**-853,190,000**

[1] In addition to these annual emissions, there would be a once-off land clearing emission of 364,325 t of CO_2-e. This would be offset as the site is progressively rehabilitated and revegetated.
[2] Excluding mining and UOC production emissions.
[3] The actual emissions associated with the direct generation of nuclear electricity are zero. This number assumes that emissions that would otherwise be generated through fossil fuel-based electricity are offset through nuclear electricity generation.

6.0 STATE, AUSTRALIAN AND GLOBAL CONTEXT

In order to quantify the potential impact of global greenhouse gas emissions, and thus the potential of the Kintyre project to influence climate change, the project's Scope 1 emissions (excluding land use change-related emissions) were compared to projections of Western Australian, Australian and global emissions over the next two decades. The results of this analysis are presented in Table 13.

Table 13. Kintyre greenhouse gas emissions in context

Source	Unit	2010	2020	2030
Western Australia[1]	CO_2-e (Mt)	60.9	80.8	97.7
	Kintyre (%)	0.16	0.12	0.10
Australia[2]	CO_2-e (Mt)	577	690	803
	Kintyre (%)	0.017	0.014	0.012
Global[3]	CO_2-e (Mt)	42,300	53,800	63,600
	Kintyre (%)	Neg.	Neg.	Neg.

[1] Source: ABARE, 2006.
[2] Source: Department of Climate Change and Energy Efficiency, 2010.
[3] Source: ABARE, 2007

As indicated in Table 13, the emission of greenhouse gases associated with the Kintyre project represent only a fraction of a percentage of Western Australian, Australian and global emissions.

7.0 MANAGEMENT MEASURES

With regards to the reduction of greenhouse gas emissions from an operation, management measures can be typically categorised as either demand-side, relating to measures that reduce the on-site demand for energy, and supply-side, relating to measures that reduce the greenhouse gas emissions associated with meeting the site demands. The following sections discuss the management measures that will be undertaken to reduce emissions both demand-side and supply-side.

7.1 DEMAND-SIDE MANAGEMENT

The Project would undertake studies during the detailed design phase with the objective of reducing energy demand for the operation. These studies may include:

- Optimisation of the proposed mining fleet size (number of trucks versus size of trucks) in order to best meet the targets of the mine plan and optimise diesel demand
- Optimisation of mine blasting regimes to reduce the energy required to crush the resultant ore
- Optimisation of the metallurgical process to reduce the electricity and steam requirements, where possible, and thus reduce the site diesel demand
- Incorporation of energy efficiency measures for the accommodation and administration facilities

7.2 SUPPLY-SIDE MANAGEMENT

The Project would undertake studies with the objective of meeting the site's energy needs in manners that reduce the greenhouse gas footprint of the operation, including:

- The use of solar hot water systems and solar photovoltaic systems for the site administration and accommodation facilities
- The use of solar photovoltaic power systems for powering the remote groundwater wells and associated pumping stations
- If available, the use of biodiesel blends in the mining fleet and for the generation of on-site steam and electricity.