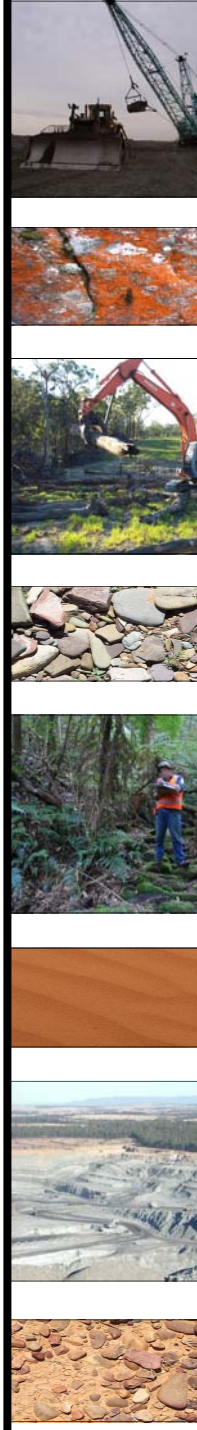
Greenhouse Gas Assessment (SLR, 2011)



APPENDIX 6

global environmental solutions

Ventilation Air Methane Abatement Demonstration Project

Mandalong Mine

Greenhouse Gas Assessment

Report Number 30-2517-R3

30 May 2011

Centennial Mandalong P/L
c/- GSSE
Level 1, 241 Denison St
Broadmeadow NSW 2292

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Ventilation Air Methane Abatement Demonstration Project

Mandalong Mine

Greenhouse Gas Assessment

PREPARED BY:

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
2 Lincoln Street Lane Cove NSW 2066 Australia

(PO Box 176 Lane Cove NSW 1595 Australia)
T: 61 2 9427 8100 F: 61 2 9427 8200
E: sydney@slrconsulting.com www.slrconsulting.com

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TABLE OF CONTENTS

TABLE OF CONTENTS

TABLES

FIGURES

1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR Consulting) has been commissioned by GSS Environmental (GSSE) on behalf of Centennial Mandalong Pty Ltd (Centennial Mandalong) to undertake a greenhouse gas assessment for the proposed Ventilation Air Methane (VAM) Abatement Demonstration Project at Mandalong Mine. Mandalong Mine is an underground long wall mine with development consent approval for 6 Million tonnes per annum (Mtpa) Run of Mine (ROM) coal extraction.

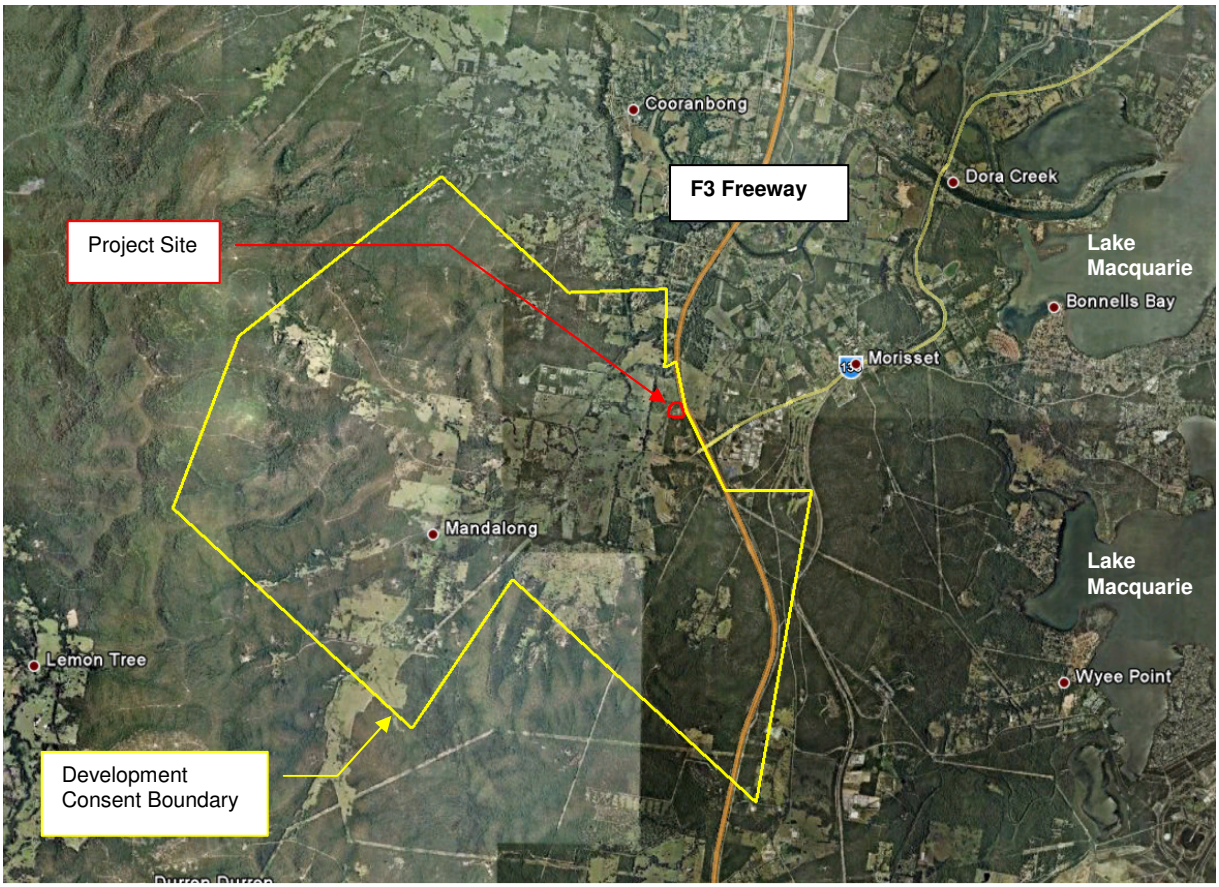
This report presents the Greenhouse Gas Assessment for the project.

1.1 Project Setting

Mandalong Mine site is located near Morisset, approximately 5 km west of Lake Macquarie, in the Newcastle Coalfield of New South Wales. The Project Site, defined as the area in which the VAM Abatement Demonstration Project will be installed, is bound by the F3 Sydney to Newcastle Freeway to the east and Mandalong Road to the south.

Figure 1 illustrates the local setting of the Project Site.

Figure 1 Local Setting of Centennial's Mandalong Mine



1.2 Project Overview

Greenhouse gas (GHG) emissions from the Mandalong Mine are approximately 1 Mt of carbon dioxide equivalent (CO_2-e) (direct emissions) emitted each year. Emissions of greenhouse gas from the Project site are mainly methane and carbon dioxide. Methane has a global warming potential 21 times that of carbon dioxide if released unabated into the atmosphere (IPCC 1996). Methane released from the coal seam consists of high purity methane drainage gas (32% v/v) and high flow rate ventilation air methane (68%v/v - VAM) (GSS Environmental 2011).

Centennial Coal has investigated several options for the abatement of GHG emissions from the Project site. Emissions of high purity methane from coal seam drainage gas can be reduced by gas flares (burning) and gas engines (power generation). The installation of both gas flares and gas engines at Mandalong Mine have previously been approved (Umwelt 2006).

The GHG emissions associated with VAM is more difficult to mitigate. Methane is only flammable in air when the temperature is above 595ºC and the concentration exceeds 5%(v/v) (Cork 2009). The methane concentration in VAM is however only 1%(v/v), making it more difficult to mitigate than the high purity methane extracted from the coal seam and different alternatives for mitigation are currently being researched by the industry.

One abatement technique is to thermally oxidise the methane in a Ventilation Air Methane Regenerative After-Burner (VAM-RAB) unit where the VAM is progressively heated to 700ºC through a series of chequer bricks until it reaches the combustion chamber with a temperature of 1,000ºC. Oxidisation of the methane occurs in the high temperature chamber, with 99.98% of the methane oxidised to carbon dioxide and water vapour. The heat from the air is then transferred back to the chequer bricks before the air is emitted. Centennial Mandalong is seeking approval for the installation and operation of a single VAM-RAB unit without heat recovery or generation capability, as a demonstration project to prove the VAM-RAB technology.

1.3 Summary of Previous Greenhouse Gas Assessments

1.3.1 Mandalong Mine Statement of Environmental Effects (SKM, 2004)

The Mandalong Mine Statement of Environmental Effects (SoEE) evaluated the air quality impact from both construction and operation of the methane drainage plant. Dust emissions during the construction phase were estimated to be of minor impact. The impact of methane emissions from the mine ventilation system were evaluated with the AUSPLUME v5.4 dispersion model (as developed by the Environment Protection Authority (EPA) of Victoria) using meteorological data from the Mannering Park automatic weather station (AWS), located 8 km southeast of Mandalong. No exceedances of the Project goal for methane in the surrounding area were predicted.

1.3.2 Mandalong Mine Statement of Environmental Effects (Umwelt Australia, 2006)

The Mandalong SoEE prepared by Umwelt Australia assessed the proposed installation of enclosed gas flare units. The high purity methane captured in the methane drainage plant was proposed to be flared to reduce greenhouse gas emissions from the mine. The SoEE determined that the flaring of methane would reduce GHG emissions by 433,152 tonnes of CO_2-e per annum representing 72% of Centennial Mandalong's annual methane emissions associated with high purity methane drainage gas.

Construction impacts were assumed to be minor given that the construction area had already been cleared for the construction of the methane drainage plant.

1.3.3 Mandalong Modification to Development Consent Environmental Assessment– Appendix E (Holmes Air Sciences, 2008)

The Modification to Development Consent Air Quality Assessment by Holmes Air Sciences analysed changes in greenhouse gases for the Mandalong mine due to:

- A 2 Mtpa increase in production capacity, allowing for up to 6 Mtpa of ROM coal to be mined; and
- The construction and operation of multiple gas engines with a total power of 12 MW, fuelled by the high purity methane gas captured by the existing methane drainage plant.

The fugitive emissions of methane from the mine have been calculated under Method 1 and Method 4 of the NGERS reporting scheme.

The estimated CO_2-e associated with the modified development consent are summarised in **Table 1**.

Table 1 Summary of Greenhouse Gas Emissions Associated with the 2008 Proposed Modification (t of CO_2-equivalent)

Component Activity/Source	Scope 1	Scope 2	Scope 3	Total
Combustion of 4 Mt of ROM coal in a power station			8,584,880	8,584,880
Combustion of 2 Mt of ROM coal in a power station			4,292,440	4,292,440
Emissions due to electricity required to mine 6 Mt of ROM coal	83,319	1,215		84,534
Emissions due to diesel required to mine 6 Mt of ROM coal	2,723	303		3,026
Emissions of CH_4 due to mining 6 Mt of ROM coal	1,898,459			1,898,459
Emissions of CO_2 due to mining 6 Mt of ROM coal	22,655			22,655
Emissions of greenhouse gas due to the CH_4 that is proposed to be captured and burnt annually assuming it is released without burning (based on 40% capture)	184,674			184,674
Emissions of greenhouse gas equivalent from the burnt CH_4 that is proposed to be captured and used to generate electrical power or flared (based on 40% capture)	24,183			24,183
Emissions that would be liberated by a NSW coal-fired power station producing 12 MW of electrical power for 8,760 hours (i.e. one year)	93,872		18,501	112,373

Taken from Holmes Air Sciences (2008)

The modified development consent was predicted to lead to increased emissions of CO_2-e due to the increase in ROM coal production and associated ventilation air methane emissions. The proposed gas engine would lead to a reduction in greenhouse gas emissions compared to when the methane is liberated unburnt, assuming that 40% of the methane is captured and used to produce 105,120 MWh of electrical energy.

2 GREENHOUSE GAS ASSESSMENT

2.1 Direct and Indirect Emissions (Emission Scopes)

The National Greenhouse Energy and Reporting (Measurement) Technical Guidelines (NGERs) (DCCEE, 2010) provides methods and criteria for the estimation and measurement of greenhouse gas emissions, the production of energy and the consumption of energy from the operation of facilities.

The National Greenhouse Accounts Factors (NGA Factors) (DCCEE, 2010) defines two types of greenhouse gas emissions:

- **Direct emissions** are produced from sources within the boundary of an organisation and as a result of the organisation's activities.
- **Indirect emissions** are emissions generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services), but which are physically produced by the activities of another organisation.

The NGA Factors identifies three 'scopes' of emissions for greenhouse gas accounting and reporting purposes, defined as follows:

- **Scope 1**: Direct (or point-source) emission factors give the kilograms of carbon dioxide equivalent (CO_2-e) emitted per unit of activity at the point of emission release (i.e. fuel use, energy use, manufacturing process activity, mining activity, on-site waste disposal, etc.). These factors are used to calculate scope 1 emissions.
- **Scope 2**: Indirect emission factors are used to calculate scope 2 emissions from the generation of the electricity purchased and consumed by an organisation as kilograms of CO_2-e per unit of electricity consumed. Scope 2 emissions are physically produced by the burning of fuels (coal, natural gas, etc.) at the power station.
- **Scope 3**: Various emission factors can be used to calculate scope 3 emissions. For ease of use, specific 'scope 3' emission factors are reported for organisations that:
  (a) burn fossil fuels: to estimate their indirect emissions attributable to the extraction, production and transport of those fuels; or
  (b) consume purchased electricity: to estimate their indirect emissions from the extraction, production and transport of fuel burned at generation and the indirect emissions attributable to the electricity lost in delivery in the T&D network.

2.2 Greenhouse Gas Calculation Methodology

Quantification of potential emissions from the VAM-RAB has been undertaken in relation to both carbon dioxide (CO_2) and other non-CO_2 greenhouse gas emissions.

For comparative purposes, non-CO_2 greenhouse gases are awarded a "CO_2-equivalence" (CO_2-e) based on their contribution to the enhancement of the greenhouse effect. The CO_2-e of a gas is calculated using an index called the Global Warming Potential (GWP). The GWPs for a variety of non-CO_2 greenhouse gases are contained within the Intergovernmental Panel on Climate Change (IPCC), (1996) document *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*.

The GWPs of relevance to this assessment are:

- Methane (CH_4): GWP of 21 (21 times more effective as a greenhouse gas than CO_2)
- Sulfur hexafluoride (SF_6): GWP of 23,900 (23,900 times more effective as a greenhouse gas than CO_2)

The short-lived gases such as carbon monoxide (CO), nitrogen dioxide (NO_2), and non-methane volatile organic compounds (NMVOCs) vary spatially and it is consequently difficult to quantify their global radiative forcing impacts. For this reason, GWP values are generally not attributed to these gases nor have they been considered further as part of this assessment.

The greenhouse gas emissions associated with the VAM-RAB have been assessed in terms of direct (Scope 1) emission potential, indirect (Scope 2) emission potential and significant upstream/downstream (Scope 3) emission potential.

A summary of the potential Mandalong Mine, Gas Engines, Flares and VAM-RAB greenhouse gas emission sources is provided in **Table 2**.

Table 2 Summary of Potential Mandalong Project (Mine plus Gas Engines, Flares and VAM-RAB) Greenhouse Gas Emissions

Project Component	Direct Emissions	Indirect Emissions	
	Scope 1	**Scope 2**	**Scope 3**
Fugitive Emissions	Emissions from the release of coal seam methane and carbon dioxide as a result of coal extraction activities	N/A	N/A
Diesel	Emissions from the combustion of diesel at Mandalong Mine in both mobile and fixed plant and equipment	N/A	Estimated emissions attributable to the extraction, production and transport of diesel consumed at Mandalong Mine
Liquid petroleum gas	Emissions from the combustion of LPG at Mandalong Mine in both mobile equipment	N/A	N/A
Consumption of sulfur hexafluoride	Consumption of sulfur hexafluoride for gas insulated switchgear and circuit breaker applications	N/A	N/A
Electricity	NA	Emissions associated with the consumption of generated and purchased electricity at Mandalong Mine	Estimated emissions from the extraction, production and transport of fuel burned for the generation of electricity consumed at the Project Site and the electricity lost in delivery in the transmission and distribution network

N/A = Not applicable

2.2.1 Activity Data

Activity data for Scope 1 and 2 emissions associated with a 5.33 Mtpa ROM coal for the 2009/2010 reporting period are taken from the Centennial Mandalong OSCAR Part B report, and are shown in **Table 3 below**. Scope 3 emissions have been determined to have no change and are therefore not shown in the table.

Activity data for the years 2009 and 2010 associated with a 5.03 Mtpa and a 5.33 Mtpa coal ROM coal has been incorporated in the Centennial Mandalong Annual Environmental Management Reports for 2009 and 2010, and is shown in **Table 4** below. Data for 2009 and 2010 have been aggregated to produce a pro-rata emission rate of 1,189,985 t of CO_2-e.

Table 3 Summary of Project Related Activity Data Relevant to GHG Emissions

Activity	Quantity	Unit	Emission Factor (t CO_2-e/unit activity)	NGERS Method	Scope 1 Emissions (t CO_2-e)
Annual ROM production	6	Mt	0.305 t CO_2-e/t ROM	1	1,830,000
Annual electricity consumption	59,155,369	kWh	0.89 kg CO_2-e/kWh	1	52,648
Annual diesel consumption, stationary non transport	775	kL	38.6 GJ/kL 69.5 kg CO_2-e/GJ	1	2,080
Petroleum based greases	10	kL	38.8 GJ/kL 27.9 kg CO_2-e/GJ	1	11
Petroleum based oils	265	kL	38.8 GJ/kL 27.9 kg CO_2-e/GJ	1	287
Annual diesel consumption product, transport by road	1,023	kL	38.6 GJ/kL 69.9 kg CO_2-e/GJ	1	2,760
Sulfur hexafluoride	0.025	t	23,900 t CO_2-e/t 0.005 (default leakage rate)	1	2.99

Table 4 Comparison of Various Calculations of Emissions of Methane (as CO_2-e)

Activity	Quantity (Mtpa)	Scope 1 fugitive emissions (t CO_2-e)	NGERS Method
Projected annual ROM production (Method 1)	6	1,830,000	1
Coal extracted in 2009 (OSCAR)	5.06	1,048,321	4
Coal extracted in 2010 (OSCAR)	5.33	1,012,334	4
Pro rata amount	**6**	**1,189,985**	**4**

3 GREENHOUSE GAS ASSESSMENT

3.1 Scope 1: Direct Emissions

3.1.1 Fugitive Emissions - Coal Bed Methane

The process of coal formation creates significant amounts of methane. Some of this methane remains trapped in the coal until the pressure on the coal is reduced, which occurs during the coal mining process. NGERs technical guidelines provide two methods for measuring emissions from coal mines:

- Method 1 is estimated by multiplying a physical quantity of ROM coal by an emission factor (0.305 of CO_2-e per tonne of coal for gassy underground mines in NSW); and
- Method 4 is based on estimations associated with underground mining operations and involves directly measuring emissions within ventilation shafts and degasification systems.

The information given in **Table 4** above shows a range of values for emissions estimations from the Centennial Mandalong mine given by various reports since 2006. There is some disagreement between these reports on a year to year basis, as discussed below.

The Projected Annual ROM figure for fugitive emissions from the mine is estimated using Method 1 of the NGERs technical guidelines and is as assumed to be 1,830,000 t of CO_2-e.

The NGERs reporting instrument Online System for Comprehensive Activity Reporting (OSCAR) for 2009 and 2010 gives values based on Method 4 estimations (direct measurement), based upon ROM of 5.06 Mtpa and 5.33 Mtpa respectively.

The Mandalong mine had fugitive emissions of methane from coal mining activities of 1,048,321 t CO_2-e for ROM coal of 5.06Mt in the 2009 reporting period and 1,012,334 t CO_2-e for ROM coal production of 5.33Mt in the 2010 reporting period. These emissions rates have been aggregated to produce a pro rata emission rate of 1,189,985 t of CO_2-e emissions for the projected and approved extraction of 6 Mtpa of ROM coal.

As can be seen from the data presented in **Table 4**, the Method 4 estimation (measured) is significantly lower than both the Method 1 (projected figure for underground gassy mines) as estimated from the NGERs technical guidelines and the Holmes report. However, the guidelines state that the measured emissions are to be used for reporting where available. In this case the use of NGERs Method 1 would overestimate emissions by some 640,015 t CO_2-e.

This report has used pro rata figure of 1,189,985 t CO_2e per annum emission rate for the 6 Mt ROM coal license. As discussed previously, approximately 32%(v/v) of the fugitive emissions of the mine is from high purity methane drainage gas and 68%(v/v) is from Ventilation Air Methane. This gives the equivalent emissions of 380,795 t CO_2-e for the high purity methane and 809,190 t CO_2-e for the VAM.

3.1.2 Diesel Usage

Scope 1 greenhouse gas emissions attributable to diesel relate to the use of on-site (stationary) machinery and transport. These are estimated by summing the emissions of the greenhouse gases produced by diesel combustion. The NGA factors states that the amount of fuel used (diesel in this case) is multiplied by its energy content factor (38.6 GJ/kL) and calculated from the aggregate of the emissions factors for carbon dioxide, methane and nitrous oxide (kg CO_2e/GJ). **Table 5** below shows the emissions factors for stationary and transport fuel combustion.

It has been assumed that road transport sources are within direct control of the Proponent and have therefore been calculated as Scope 1 emissions.

Table 5 Diesel Combustion Emission Factors for Stationary Engines and Transport

Activity	Energy Content (GJ/kL)	Emission Factor kg CO_2-e/GJ		
		CO_2	CH_4	N_2O
Stationary	38.6	69.2	0.1	0.2
Transport	38.6	69.2	0.2	0.5

The primary fuel source for the vehicles, plant and equipment operating at the Project site is diesel. Diesel consumption for stationary and mobile equipment for the Project is estimated at 775kL and 1,023kL respectively (OSCAR 2009/2010).

This consumption corresponds to calculated emissions of 2,080 t CO_2-e for stationary plant and 2,760 t CO_2-e for mobile plant to give a combined total of 4,840 t CO_2-e for use of diesel in the 2009-2010 reporting period.

3.1.3 Sulfur Hexafluoride

Sulfur hexafluoride is used in high voltage switch gear due its ability to insulate against high voltage arcing. Sulfur hexafluoride has a global warming potential of 23,900 times that of carbon dioxide. Emissions are estimated using the leakage rate of the gas from equipment multiplied by the stock contained within the equipment. The leakage of sulfur hexafluoride from onsite stock is estimated at 0.025 t in 2009-2010.

Greenhouse gas emissions are assumed to be 3 t CO_2-e / tonne, as reported in Mandalong OSCAR 2010.

3.1.4 Greases and Oils

Greases and oils are used for the lubrication of plant and equipment.

Consumption of petroleum based greases and oils were 10kL and 265kL respectively.

These have an energy content defined as 38.8 GJ/kL and have an emissions factor of 27.9 kg CO_2-e/GJ.

Greenhouse gas emissions are estimated as 11 t CO_2-e for petroleum based grease and 287 t CO_2-e for petroleum based oils in the 2009-2010 reporting period. Cumulatively, these emissions are estimated to contribute 298 t CO_2-e.

3.2 Scope 2: Indirect Emissions

Emissions of GHG result from the consumption of purchased electricity generated at off-site locations.

State emission factors are used because electricity flows between states are significantly constrained by the capacity of the inter-state interconnectors and in some cases there are no interconnections.

Electricity consumption for the Mandalong Project has been calculated as (approximately) 59,155,369 kilowatt-hours (kWh) for the 2009-2010 reporting period.

The emission factor for Scope 2 of 0.89 kg CO_2/kWh represents the consumption of purchased electricity in NSW.

Emissions from Scope 2 electricity consumption are estimated to be 52,648 t CO_2-e.

3.3 Scope 3: Sources Not Included

Scope 1 GHG emissions will reduce as a result of the proposed VAM abatement demonstration project as VAM is thermally oxidised. Scope 2 emissions will increase marginally (refer **Section 4**) as a result of the electrical demand of the VAM-RAB unit. It is considered that emissions of Scope 3 GHG will not be affected by the proposed VAM abatement demonstration project as sources within this scope category, namely those listed below, will remain unchanged:

- Combustion of product coal.
- Transport via road.
- Employee business travel.
- Outsourced activities.

The GHG emissions associated with the above will not be changed by the approval of the plant. All rates of activity of these sources are to remain unchanged and as such have not been assessed within this GHG report.

3.4 Greenhouse Gas Calculation Results (2010 Excluding Modification)

Calculated Scope 1 and Scope 2 emissions of greenhouse gas resulting from the emissions sources outlined above are presented in **Table 6** below.

3.5 Comparison with National and State GHG Emissions

A comparison of the predicted direct Scope 1 emissions (**Table 6** below) of 1,195,126 t CO_2-e against Australia's 2008 net emissions of 576 Mt CO_2-e demonstrates the Mandalong Project would represent approximately 0.21 % of the total annual Australian emissions (DCCEE, 2008).

A comparison of the predicted Scope 1 emissions against NSW emissions in 2008 (164.7Mt CO_2-e) demonstrates that the Mandalong project would represent approximately 0.72% of NSW emissions (DCCEE, 2008).

Table 6 Summary of Scope 1 and Scope 2 GHG Emissions Attributable to Mandalong Mine (2010)

Emission Scope	Emission Source	Activity Data	Emission Factor	Emission (t CO_2-e) per annum
Scope 1	Fugitive methane emissions	6 Mtpa	NGERS Method 4, direct measurement	1,189,985
	Diesel combustion, stationary sources	775 kL	38.6 GJ/kL 69.5 kg CO_2/GJ	2,080
	Diesel combustion, transport	1,023 kL	38.6 GJ/kL 69.9 kg CO_2/GJ	2,760
	Sulfur hexafluoride	0.025 t	23,900t CO_2-e/t	3
	Greases and Oils	275kL	38.8 GJ/kL 27.9 kg CO_2/GJ	298
Total Scope 1				**1,195,126**
Scope 2	Electricity	59,155,369 kWh	0.89 kg CO_2/kWh	52,648
Total Scope 1 and 2				**1,247,774**

4 GREENHOUSE GAS MITIGATION MEASURES

Centennial Mandalong is proposing to reduce the emission of Ventilation Air Methane into the atmosphere by evaluating the potential of a proposed demonstration Regenerative After-Burner unit developed in conjunction with Newcastle based engineering company Corky's Carbon and Combustion.

The VAM-RAB demonstration project is phase one of a potential three phase project. Centennial Mandalong is seeking approval for the installation and operation of a single VAM-RAB unit as a demonstration project to prove the VAM-RAB technology. If successful, phases two and three could see the installation and operation of up to 36 VAM-RAB units at Mandalong, and the integration of VAM-RAB technology with existing and/or approved infrastructure (gas flares and gas engines) to create what is referred to as the Mandalong Greenhouse Abatement Facility (MGAF). A fully developed and integrated MGAF could see the capture and abatement of up to 100 percent of Mandalong's Scope 1 emissions. This report does not include the reductions provided by the use of the high purity methane in gas flares and electricity generation that has previously been assessed and approved, however it is noted that installation of this approved infrastructure would significantly reduce Scope 1 emissions.

Expansion and integration of VAM-RAB technology at Mandalong beyond the initial demonstration project will be considered subject to initial tests, project finance and further project approvals.

4.1 Stage 1 VAM-RAB

The most significant direct emissions from the Mandalong mine are associated with fugitive emissions resulting from VAM due to long wall coal extraction at the project site. The VAM-RAB demonstration project aims to mitigate one thirtieth of the VAM with the installation of one VAM-RAB unit. The total direct (Scope 1) emissions attributed to fugitive methane from Mandalong are estimated to be approximately 1,189,985 t CO_2-e per annum (as reported in **Table 4** above), with 380,795 t of CO_2-e emissions due to high purity methane and 809,190 t CO_2-e due to VAM (32% v/v and 68% v/v of VAM respectively (GSS Environmental 2011)).

Assuming a reduction in the emissions of VAM of 23,430 t CO_2-e, this would reduce the emissions due to VAM from 809,190 t CO_2-e to 785,760 t CO_2-e, as shown in **Table 7** below. Emissions from the High Purity Methane emissions will remain unchanged at 380,795 t CO_2-e.

It is predicted that Scope 2 emissions associated with installation of the single VAM-RAB unit would increase due to the consumption of additional electricity by 180,000 kWh per annum. Assuming an emission factor of 0.89 kg CO_2-e/kWh (as reported in **Section 3.2**), Scope 2 emissions are estimated to increase from 52,648 t CO_2-e to 52,808 t CO_2-e (**Table 7**).

It is therefore estimated that the Stage 1 proposal for the installation of a single VAM-RAB unit will result in a change of 23,270 fewer tonnes of CO_2-e per annum, as summarised in **Table 7** below.

Table 7 Summary of Scope 1 and 2 Emissions with single VAM-RAB unit operational

Emissions Scope	Emissions Source	Activity Data		Activity Rate					
		Current	1 VAM-RAB unit		Emission Factor	Units	Source	Emissions (t CO_2-e per annum (With single VAM-RAB unit operational)	Difference after modification
Scope 1	Fugitive Emissions	6	6	Mtpa ROM	0.305	t CO_2-e/t ROM	NGERS method 4	1,166,555^	-23,430
	Diesel Combustion	1,798	1,798	kL/annum	69.91	kg CO_2-e /GJ	NGERS method 1	2,080	Nil Change
	Use of sulfur hexafluoride	0.025	0.025	t/annum	23,900	t CO_2 /kg	NGERS method 1	3	Nil Change
	Use of oils / grease	275	275	kL/annum	27.9 kg CO_2/GJ 38.8 GJ/kL	kg CO_2-e /GJ	NGERS method 1	298	Nil Change
	Diesel combustion, transport	1,023 kL	1,023 kL	1,023 kL	38.6 GJ/kL 69.9 kg CO_2/GJ	kg CO_2-e /GJ	NGERS method 1	2,760	Nil Change
Sub-Total Scope 1								**1,171,696**	**-23,430**
Scope 2	Electricity Consumption	59,155	59,355	MWh/annum	0.89	kg CO_2-e /kWh	NGERS method 1	52,808	160
Sub-Total Scope 2								**52,808**	**160**
TOTAL								**1,224,504**	**-23,270**

*Nil Change: Proposed VAM-RAB unit will not change ROM tonnage, therefore incidentals will remain the same
^ : Includes 785,760 t CO_2-e from VAM and 380,795 t CO_2-e from High Purity Methane per annum

5 DISCUSSION

Centennial Mandalong is proposing to mitigate the Ventilation Air Methane at Mandalong Mine through the use of the newly developed Ventilation Air Methane Regenerative After Burners by Corky's Carbon and Combustion.

Existing Scope 1 and 2 emissions are calculated in this report as 1,247,774 t CO_2-e. This includes the pro rata amount of 1,189,985 t CO_2e for a 6 Mtpa ROM coal production, calculated from the 08/09 and 09/10 Centennial Mandalong OSCAR report.

Installation of the single VAM-RAB unit at Mandalong will result in a reduction of the total of Scope 1 and Scope 2 emissions by 23,270 t CO_2-e to 1,224,504 t CO_2-e per annum. This will have a positive impact on the total CO_2-e output by NSW and Australia by reducing the total amount Greenhouse Gases released into the atmosphere.

The VAM-RAB demonstration project is phase one of a potential three phase project. Phases two and three could see installation and operation of up to 36 VAM-RAB units at Mandalong, and the integration of VAM-RAB technology with existing and/or approved infrastructure (gas flares and gas engines) to create what is referred to as the Mandalong Greenhouse Abatement Facility (MGAF). A fully developed and integrated MGAF could see the capture and abatement of up to 100 percent of the mine's Scope 1 emissions, with the potential to generate up to 19 megawatts (MW) of power. This is over 2.5 times the mine's electricity requirements. The new technology, once integrated with existing and/or approved infrastructure at Mandalong, would reduce the quantity of methane being ventilated into the atmosphere from the mine through the oxidation of methane to carbon dioxide, whilst also providing a potential source of electricity generation that could be fed into the mines high voltage substation, providing additional capacity to the NSW power grid. The long term over-arching objective of the MGAF is to therefore provide an innovative local solution to not only reduce potential climate change impacts of Mandalong operations, but to improve power generation options for both the mine and the community. Expansion and integration of VAM-RAB technology at Mandalong beyond the initial demonstration project will be considered subject to initial tests, project finance and further project approvals.

6 CLOSURE

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of Centennial Mandalong P/L. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR Consulting.

SLR Consulting disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

References

The following documents and resources have been used in the production of this report:

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