Appendix 12 – Greenhouse Gas Assessment (SLR, 2017d)

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6 April 2017

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Centennial Mandalong Pty Ltd
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NSW 2264

Attention: Iain Hornshaw

Dear Iain

SSD-5144 MOD 5
Longwall Panel 24-24A Extension Modification (Mod 5)
Greenhouse Gas Assessment

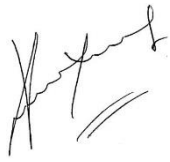
SLR Consulting has been commissioned by Centennial Mandalong Pty Limited (Centennial Mandalong) to prepare a greenhouse gas (GHG) assessment for the extension to longwall panel 24 and addition of longwall panel 24A, located within the approved Project Application Area of SSD-5144.

A GHG assessment for the Mandalong Southern Extension Project (Extension Project) was completed by BDM Resources in 2012 (BDM 2012). Further, GHG assessments for the Mandalong Tonnage Increase Modification (Mod 3) and Longwall Panel 22-23 Extension Modification (Mod 4) were submitted as part of the Statement of Environmental Effects (SEE) in September 2016 and February 2017 respectively.

The current GHG assessment aims to quantify the life of mine (LOM) GHG emissions due to secondary extraction of extended longwall panel 24 and addition of longwall panel 24A (Mod 5). The methodology, results and conclusions of the GHG assessment are attached.

We trust this letter provides you with the information required, however if you should have any questions or require further information, please do not hesitate to contact the undersigned.

Yours sincerely



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1 Background

Mandalong Mine is an existing underground longwall coal mining operation producing thermal coal for supply to domestic and export markets. It is located approximately 35 kilometres south-west of Newcastle near Morisset in New South Wales. Mandalong Mine is 100 percent owned and operated by Centennial Mandalong, a subsidiary of Centennial Coal Company Limited. Centennial Coal Company Limited is a wholly owned subsidiary of Banpu Public Company Limited.

Mandalong Mine operates under Development Consent SSD-5144 which was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The Development Consent provides for extension of the mining area with a production limit of 6 million tonnes per annum of thermal coal from the West Wallarah and Wallarah-Great Northern Seams.

The currently approved Mandalong Mine comprises the following underground workings and surface infrastructure:

- The Mandalong Mine Access Site (MMAS), encompassing underground workings and associated surface infrastructure near Morisset.
- Delivery of run-of-mine coal via conveyor from the underground workings to the Cooranbong Entry Site. The Cooranbong Entry Site coal handling and processing facilities are approved under the Northern Coal Logistic Project (SSD-5145).
- Delivery of run-of-mine coal via conveyor from the underground workings to the Delta Entry Site, located near Wyee at the Vales Point Rail Unloader Facility. The coal handling facility is approved under DA35-2-2004.
- The Mandalong South Surface Site (MSSS), which is yet to be constructed, encompassing ventilation shafts, ventilation fans and underground delivery boreholes located approximately 6 kilometres south-west of the MMAS.

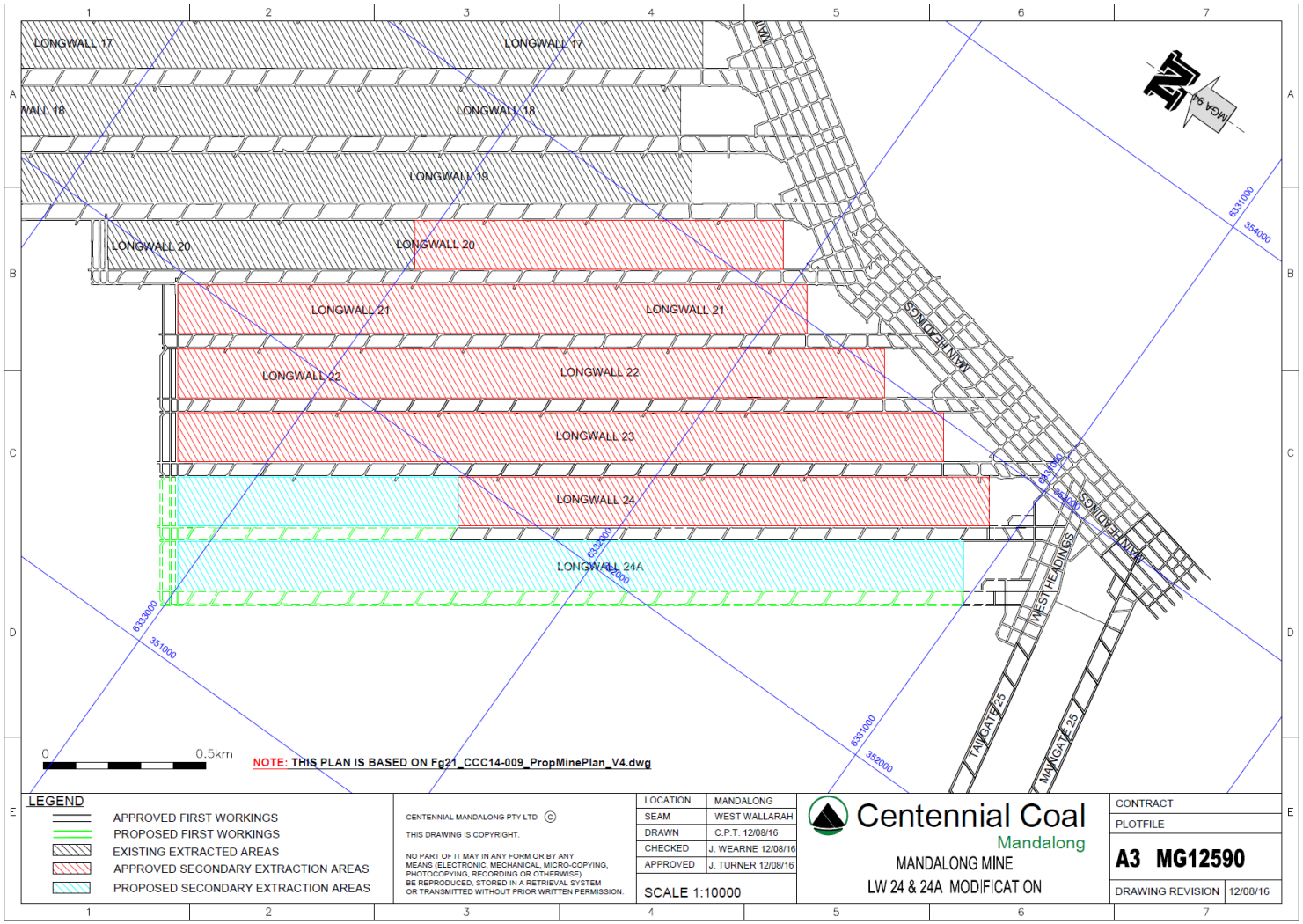
An igneous sill exists to the west of approved longwall panels 22 to 24. Due to historic uncertainty associated with the extent of the igneous sill, longwall panels 22 to 24 were shortened as a conservative measure to mitigate the sill's impact on the mine's production. As a result of recent geological exploration and the successful extraction of adjacent longwall panels below the igneous sill, its extent and condition has become better understood. This has resulted in the proposed extension of longwall panel 24 and the addition of longwall panel 24A within the Project Application Area of SSD-5144. **Figure 1** illustrates the proposed extension of chain pillars and longwall mining regarding these two panels.

Centennial Mandalong has prepared a Statement of Environmental Effects (SEE) to support an application seeking to modify Development Consent SSD-5144 under Part 4 of the EP&A Act. The modification is seeking to undertake the extended development of Maingate 24 and extended secondary extraction of longwall panel 24 in addition to the development of Maingate 24A and extraction of longwall panel 24A within the Project Application Area of SSD-5144 (the proposed Modification) as illustrated on **Figure 1**.

Outlined below are the primary components of the proposed Modification:

- Extension of Longwall 24 from 1,631 m to 2,570 m. This yields 1,030,813 additional tonnes beyond 1,766,912 tonnes already approved.
- Addition of Longwall 24A. Longwall 24A is proposed to be 2,470 m in length which yields an additional 2,679,560 tonnes.

Figure 1 Mandalong Mine – Proposed extension to Longwall 24 and New Longwall 24A



2 Legislative Framework

State Significant Development (SSD) Consent SSD-5144 was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4 Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). SSD consents may be modified under Section 96 of the EP&A Act provided that the development as modified will be substantially the same development as the development for which consent was originally granted. Centennial Mandalong is now proposing to modify SSD-5144 to extend Longwall 24 and develop and extract new adjacent longwall, Longwall 24A. The proposed modification would constitute the fifth modification to SSD-5144 (Mod 5).

It is considered the proposed modification to SSD-5144 (Mod 5) is substantially the same development as the development for which consent was originally granted being an underground longwall coal mine. The proposed modification will provide access to additional coal resources for extraction using existing plant and equipment at the Mandalong Mine. As such, it is considered that SSD-5144 can be modified pursuant to Section 96(2) of the EP&A Act.

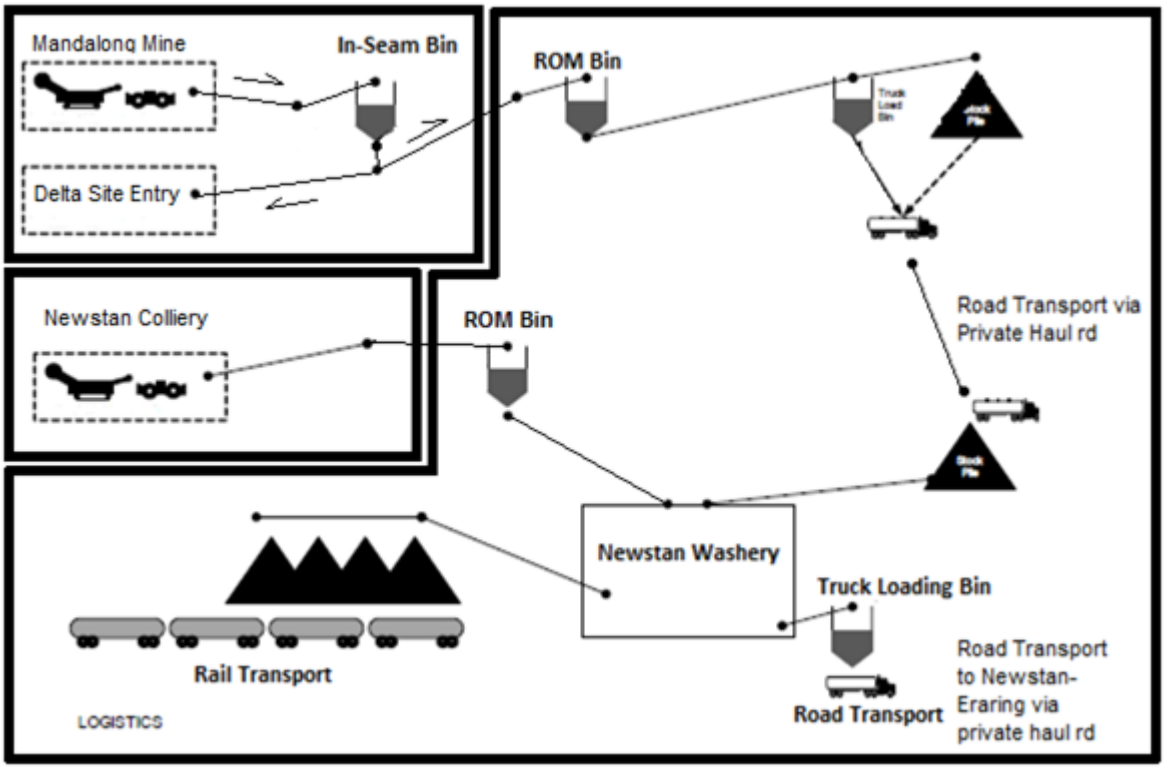
3 Project Boundary

Approved activities under the Mandalong Southern Extension Project (SSD-5144) interact with, or exist in close proximity to, activities approved under the Northern Coal Logistics Project (SSD-5145) and Centennial's Newstan Colliery (DA 73-11-98). As a result, there are significant overlaps between these projects.

The boundaries used to delineate GHG inventories in the GHG assessments completed for previous modifications to SSD-5144 (SLR 2016) are illustrated schematically in **Figure 2**.

The same boundaries have been adopted for this GHG assessment.

Figure 2 GHG inventory boundaries between the three concurrent northern Centennial projects (BDM 2012)



This GHG assessment aims to quantify GHG impacts from modified operations at the Mandalong Mine. Specifically, emissions from the diesel and electricity usage associated with the additional coal extracted from longwall panels 24 and 24A are quantified.

For comprehensiveness, this report includes an assessment of Scope 3 emissions, including combustion of the product coal by the end user.

4 GHG Emission Sources

The GHG emissions associated with the Project 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 Project GHG emission sources considered in this assessment is provided in **Table 1**. It is noted that a number of Scope 1 emission sources have not been included in the GHG emission calculations due to their contribution being less than 1% of total Project emissions. Specifically, emissions from sulphur hexafluoride (SF_6) leakage, oils and grease consumption (not combusted), LPG consumption and waste to landfill are considered to be negligible compared to the total Scope 1 and Scope 2 GHG emissions from the Project.

Table 1 Summary of Potential Project Greenhouse Gas Emissions

Project Component	Direct Emissions	Indirect Emissions	
	Scope 1	**Scope 2**	**Scope 3**
Fugitive Emissions (drainage gas)	Emissions from the release of coal seam methane and carbon dioxide as a result of extraction activities.	N/A	N/A
Modification 5	No additional drainage gas over the life of mine[1]	N/A	N/A
Fugitive Emissions (mine ventilation gas)	Emissions from the release of coal seam methane and carbon dioxide as a result of extraction activities.	N/A	N/A
Modification 5	No additional mine ventilation gas over the life of mine [1]	N/A	N/A
Diesel	Emissions from the combustion of diesel at the Project in both mobile and fixed plant and equipment	N/A	N/A
Modification 5	Additional diesel usage over life of mine	N/A	N/A
Electricity	N/A	Emissions associated with the consumption of generated and purchased electricity at the mine.	N/A
Modification 5	N/A	Additional electricity usage over life of mine	N/A
Coal Combustion	N/A	N/A	Emissions from the combustion of coal from the Project.
Modification 5	N/A	N/A	Emissions due to combustion of additional coal

N/A = Not applicable

[1] There will be no change to the estimated total LOM drainage gas and ventilation gas emissions, however a portion of those emissions can be attributed to the coal extracted under Mod 5 and these emissions have been calculated in the following sections for transparency.

5 Activity Data

The activity data used for the GHG emissions calculations for this Project are shown in **Table 2**.

As shown in **Table 2** the proposed Modification will result in an additional 3.7 Mt of coal being extracted from Mandalong Mine over the life of the mine. The GHG emissions associated with extracting this additional resource have therefore been compared to the total approved life of mine GHG emissions, rather than the Mine's annual GHG emissions. It is also noted that the extraction of this additional 3.7 Mt is proposed to be achieved within the existing approved mine life at the same annual extraction rate. The estimated incremental GHG emissions associated with the proposed Modification therefore should be regarded as a component of the total life of mine GHG emissions presented in this report (which are based on 6.5 Mtpa being extracted over 25 years).

Table 2 Project Activity Data

Activity Data	Modified Mandalong Mine Project (up to Modification 4)	Modification 5	Units
Maximum annual coal production	6.5	Additional 3.7 Mt over life of mine	Mtpa
Project commences	2016	No change	-
Project ceases	2040	No change	-
Years of Project operation	25	No change	years
Drainage Gas			
Maximum pre-drainage gas flow of CH_4	800	No change	L/sec
Maximum pre-drainage gas flow of CO_2	33	No change	L/sec
Mandalong Ventilation Air			
Maximum flow rate of mine ventilation air (MVA)	500	No change	m^3/sec
Average ventilation CH_4 concentration (VAM)	0.46	No change	%
Average ventilation CO_2 concentration	0.019	No change	%
Cooranbong Ventilation Air			
Cooranbong maximum ventilation flow rate	75	No change	m^3/sec
Concentration of CH_4 in Cooranbong ventilation flow	0.09	No change	%
Concentration of CO_2 in Cooranbong ventilation flow	0.05	No change	%
Electricity			
Internal power needs (average demand)[1]	131,911,000	Additional 75,298,310 kWh over life of mine	kWh pa
Diesel			
Maximum annual underground diesel usage [1]	1,066	Additional 609 kL over life of mine	kL pa

Note:
[1] Scaled up based on the usage provided for production of 6 Mtpa coal
[2] Estimated based on the usage provided for production of 6 Mtpa coal

6 Emission Factors

The emission factors used for the estimate of Scope 1, 2 and 3 emissions are presented below in **Table 3**. These have been sourced from the *National Greenhouse Accounts Factors* published by the Australian Government's Department of the Environment and Energy (DEE 2016 b).

Table 3 A Summary of Emission Factors used for the Calculation of GHG Impacts (DEE 2016 b)

Scope 1				
Emission Source	**Energy Content (GJ/m^3)**	**Emission Factor (kg CO_2-e/GJ)**		
		CO_2	**CH_4**	**N_2O**
Combustion of diesel oil for stationary energy purposes	38.6	69.9[a]	0.1	0.2
Combustion of diesel oil for transport energy purposes (post-2004 vehicles)	38.6	69.9[a]	0.01	0.6
Scope 2				
Emission Source	**Emission Factor (kg CO_2-e/kWh)**			
Consumption of purchased electricity	0.84[b]			
Scope 3				
Emission Source	**Energy Content (GJ/m^3)**	**Emission Factor (kg CO_2-e/GJ)**		
		CO_2	**CH_4**	**N_2O**
Total coal combusted - Bituminous coal	27	90[c]	0.03	0.2
Other Factors				
Description	**Units**	**Value**		
		CO_2	**CH_4**	
Greenhouse gas GWPs	(t CO_2-e/t CO_2)	1	25	
Volume to mass conversion	(m^3 [STP] to t)[d]	1.861×10^{-3}	6.784×10^{-4}	
Oxidation factor for flaring	-	0.98	-	

[a] The CO_2 emission factor for diesel combustion for stationary energy purposes changed from 69.2 (NGA Factors 2012) to 69.9 kg CO_2-e/GJ (NGA Factors 2016)

[b] The emission factor for electricity usage in NSW changed from 0.88 (NGA Factors 2012) to 0.84 kg CO_2-e/GJ (NGA Factors 2016);

[c] The CO_2 emission factor for bituminous coal combustion changed from 88.2 (NGA Factors 2012) to 90 kg CO_2-e/kWh (NGA Factors 2016)

[d] All gas values are stated at Standard Temperature and Pressure (STP) of 288.15 K and 101.325 kPa (NGER (Measurement) Determination 2008, page 71)

7 GHG Emissions

7.1 Scope 1 Emissions

Scope 1 emissions refer to the "direct emissions" that occur as a result of the Project. The Scope 1 emissions from the Project are:

- Fugitive emissions from drainage gas;
- Fugitive emissions from Ventilation Air Methane (VAM); and
- Emissions from the combustion of diesel.

7.1.1 Fugitive Emissions from Drainage Gas

Scope 1 fugitive emissions from the extraction of coal from underground mines are determined using Method 4 - Extraction of coal, Division 3.2.2 Subdivision 3.2.2.2 Section 3.6 of the NGER technical guidelines (DEE 2016 a).

The annual pre-drainage gas emission rate will not increase as a result of Mod 5 as the in-situ seam gas pressures will remain unchanged and the gas generation rate is independent of production rates. The pre-drainage maximum gas flow rate used in the calculations of 833 L/s (96% CH_4 and 4% CO_2) is therefore unchanged from the previous assessments (BDM 2012 and SLR 2016). The calculated annual and life of mine (LOM) Scope 1 fugitive emissions from drainage gas are shown in **Table 4**. The associated contribution of Mod 5 to the total LOM emissions is shown in the shaded cells. It is noted that the fugitive emissions due to Mod 5 are not 'additional' LOM emissions, as the emissions are based on the maximum gas flow rate over 25 years, which will remain unchanged.

Table 4 Calculated Fugitive Emissions from Drainage Gas – Scope 1

Source	Modified Mandalong Mine Project (up to and including Modification 4) (6.5 Mtpa)		Modification 5[2] (3.7 Mt)
	Annual GHG Emissions (tonnes CO_2-e per annum)	LOM GHG Emissions (25 years) (tonnes CO_2-e)	LOM GHG Emissions (25 years) (tonnes CO_2-e)
Emissions from drainage gas	429,837[1]	10,745,925[1]	245,351

[1] Source: Centennial 2016

[2] Emissions are not additional LOM emissions, however a portion of the LOM emission can be attributed to the coal extracted under Mod 5 and these emissions have been calculated for transparency.

7.1.2 Fugitive Emissions from Mine Ventilation Air

The Project comprises three sites, the existing Mandalong Mine and Cooranbong sites, and the proposed MSSS (yet to be constructed). All three sites will be connected via an underground ventilation network. Ventilation fans are currently located at Cooranbong and Mandalong Mine and will be installed at the MSSS. The Cooranbong fan does not draw in air from new mine workings and subsequently has a lower methane concentration and contribution to Project emissions.

For a production rate of 6 Mtpa (Extension Project [Mod 3]), the maximum ventilation air flow rate was reported to be 500 m^3/sec (0.46% CH_4 and 0.019% CO_2) for Mandalong Mine and 75 m^3/sec for Cooranbong (0.09% CH_4 and 0.05% CO_2). To provide a conservative estimate of the GHG emissions due to Mod 5, these air flow rates have been scaled accordingly. The GHG emissions due to the Mandalong Tonnage Increase Modification 3 (6.5 Mtpa) are sourced from the SEE prepared for Mod 3 (Centennial 2016). The resulting calculated annual and LOM Scope 1 fugitive emissions from mine ventilation air are shown in **Table 5**. The associated contribution of the proposed Modification to the total LOM emissions from the approved Project is shown in the shaded cells.

It is noted that the fugitive emissions due to Mod 5 are not 'additional' LOM emissions, as the emissions are based on the maximum ventilation air flow rate over 25 years, which will remain unchanged.

Table 5 Calculated Fugitive Emissions from Mine Ventilation Air – Scope 1

Source	Modified Mandalong Mine Project (up to and including Modification 4) (6.5 Mtpa)		Modification 5[2] (3.7 Mt)
	Annual GHG Emissions (tonnes CO_2-e per annum)	LOM Emissions (25 years) (tonnes CO_2-e)	LOM Emissions (25 years) (tonnes CO_2-e)
Emissions from mine ventilation	1,385,486[1]	34,367,150[1]	787,857

[1] Source: Centennial 2016

[2] Emissions are not additional LOM emissions, however a portion of the LOM emission can be attributed to the coal extracted under Mod 5 and these emissions have been calculated for transparency.

7.1.3 Diesel Combustion Emissions

Scope 1 emissions from the use of diesel fuel in mobile and fixed plant and equipment were estimated using Method 1 - Emissions of carbon dioxide, methane and nitrous oxide from liquid fuels other than petroleum based oils or greases, Division 2.4.2 Section 2.41 of the NGER technical guidelines (DEE 2016 a). The energy content of diesel fuel was taken to be 38.6 GJ/kL and the relevant Scope 1 emission factors are shown in **Table 3**.

Diesel consumption is linked to production. To assess the incremental contribution of the proposed Modification, the maximum diesel consumption rate for the production of 6 Mtpa (984 kL) was scaled accordingly to give 1,066 kL at 6.5 Mtpa and 609 kL for the Longwall 24 and 24A panel extensions (3.7 Mt). The resulting calculated annual and LOM Scope 1 emissions from diesel consumption are shown in **Table 6**. The additional contribution of Mod 5 to the total LOM emissions is shown in the shaded cells.

Table 6 Calculated Emissions from Diesel Combustion – Scope 1

Source	Modified Mandalong Mine Project (up to and including Modification 4) (6.5 Mtpa)		Modification 5 (3.7 Mt)
	Annual GHG Emissions (tonnes CO_2-e per annum)	LOM Emissions (25 years) (tonnes CO_2-e)	LOM Emissions (25 years) (tonnes CO_2-e)
Emissions from diesel combustion	2,889[1]	72,844	1,649

[1] Adjusted from Centennial (2016) to account for the updated NGA Emission Factor as discussed in **Section 6**.

7.2 Scope 2 Emissions

Scope 2 emissions refer to indirect emissions associated with the generation of imported electricity. Scope 2 GHG emissions as defined by NGERS were estimated using Method 1 – purchase of electricity from main electricity grid in a State or Territory, Chapter 7, section 7.2 of the NGER technical guidelines (DEE 2016 a).

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 at Centennial Mandalong is primarily associated with the operation of conveyors and to meet current ventilation requirements, as well as bath house operations etc. It has therefore been assumed that the contribution of Mod 5 to the total LOM emissions will be proportional to the 3.7 Mt extracted. The annual and LOM Scope 2 emissions from electricity consumption are shown in **Table 7** and the additional contribution of Mod 5 to the total LOM emissions is shown in the shaded cells.

Table 7 Calculated Emissions from Electricity Consumption – Scope 2

Source	Modified Mandalong Mine Project (up to and including Modification 4) (6.5 Mtpa)		Modification 5 (3.7 Mt)
	Annual GHG Emissions (tonnes CO_2-e per annum)	LOM Emissions (25 years) (tonnes CO_2-e)	LOM Emissions (25 years) (tonnes CO_2-e)
Emissions from electricity consumption	110,805[1]	2,794,292	63,251

[1] Adjusted from Centennial (2016) to account for the updated NGA Emission Factor as discussed in **Section 6**.

7.3 Scope 3 Emissions

Scope 3 emissions for the Mandalong Mine are primarily associated with combustion of the product coal by the end user. Other sources of Scope 3 GHG emissions, such as product transport and employee travel, total less than 5% and are considered negligible in comparison to the total Scope 3 emissions.

Scope 3 emissions as a result of combustion of product coal have been calculated using Method 1 - Emissions of carbon dioxide, methane and nitrous oxide from solid fuels, Division 2.2.2, Section 2.4 of the NGER technical guidelines (DEE 2016 a). The annual and LOM Scope 3 emissions from the combustion of bituminous coal are shown in **Table 8**. The additional contribution of Mod 5 to the total LOM emissions is shown in the shaded cells.

Table 8 Calculated Emissions from coal combustion – Scope 3

Source	Modified Mandalong Mine Project (up to and including Modification 4) (6.5 Mtpa)		Modification 5 (3.7 Mt)
	Annual GHG Emissions (tonnes CO_2-e per annum)	LOM Emissions (25 years) (tonnes CO_2-e)	LOM Emissions (25 years) (tonnes CO_2-e)
Emissions from coal combustion	15,835,365[1]	404,923,373	9,039,248

7.4 Summary of Emissions

A summary of the estimated annual and LOM Scope 1, 2 and 3 emissions is shown in **Table 9**. It is noted that the emissions associated with proposed Modification represent the contribution of the extraction of this additional resource to the LOM emissions which are based on the maximum production rate of 6.5 Mtpa and the full 25 year life of the mine. The 3.7 Mt coal proposed to be extracted as part of the proposed Modification will be achieved within the current approved annual extracted rate and mine life.

Table 9 Summary of Scope 1, 2 and 3 Emissions from the Project

Source	Modified Mandalong Mine Project (up to and including Modification 4) (6.5 Mtpa)		Modification 5 (3.7 Mt)
	Annual GHG Emissions (tonnes CO_2-e per annum)	LOM Emissions (25 years) (tonnes CO_2-e)	LOM Emissions (25 years) (tonnes CO_2-e)
Scope 1			
Emissions from drainage gas	429,837	10,745,925	245,351[1]
Emissions from mine ventilation	1,385,486	34,637,150	787,857[1]
Emissions from diesel combustion	2,889	72,844	1,649
Scope 2			
Emissions from electricity consumption	110,805	2,794,292	63,251
Scope 3			
Emissions from coal combustion	15,835,365	404,923,373	9,039,248
TOTAL – Scope 1	**1,818,212**	**45,455,919**	**1,034,857**
TOTAL – Scope 1 & 2	**1,929,017**	**48,250,211**	**1,098,108**

[1]Emissions are not additional LOM emissions, but quantified to give an estimate due to Mod 5.

As shown in **Table 9**, the additional contribution of proposed Modification to the total Scope 1 and Scope 2 LOM emissions is minimal, at approximately 0.13%.

7.5 Comparison with National and State GHG Emissions

Emissions of GHG in NSW were reported to be 130.1 Mt in 2014, (DEE 2016c) which was approximately 25% of the total Australian GHG emissions of 523.1 Mt (DEE 2016c). A comparison of the emissions estimated for Mandalong Mine with NSW and Australia emission totals is presented in **Table 10**. It is noted that the contribution of Scope 1 GHG emissions due to Mod 5 represents approximately 0.001% of the total NSW GHG emissions and 0.0003% of the total Australian GHG emissions.

Table 10 Comparison of Modified Project GHG Emissions with State and National Totals 2014

Emission Scope	Modified Mandalong Mine Project (up to and including Modification 4) (tCO_2-e/annum)	Additional Estimated Emissions due to Modification 5 (tCO_2-e/annum)	Contribution of Modification 5 as Percentage of NSW 2014 GHG Emission Total	Contribution of Modification 5 as Percentage of Australian 2014 GHG Emission Total
Scope 1	1,818,212	1,649	0.001%	0.0003%
Scope 1 and 2	1,929,017	64,900	0.05%	0.012%

8 References

- BDM 2012, Mandalong Southern Extension Project (MLS) Greenhouse Gas Report for EIS, BDM Resources 12/12/2012.
- Centennial 2016, Statement of Environmental Effects, Mandalong Mine – State Significant Development 5144 – Modification 3, September 2016.
- DEE 2016a, National Greenhouse and Energy Reporting Scheme Measurement, *Technical Guidelines for the estimation of emissions by facilities in Australia*, Australian Government's Department of the Environment and Energy, August 2016.
- DEE 2016b, *National Greenhouse Accounts Factors* published by the Australian Government's Department of the Environment and Energy, August 2016.
- DEE 2016c, National Inventory Report 2014 (revised) - Volume 1, The Australian Government Submission to the United Nations Framework Convention on Climate Change, Australian National Greenhouse Accounts, Department of the Environment and Energy, August 2016
- SLR 2016, SSD5144-MOD4, Longwall Panel 22-23 Extension Modification – Greenhouse Gas Assessment; report # 610.16314-L02-v1.1, 9 November 2016.