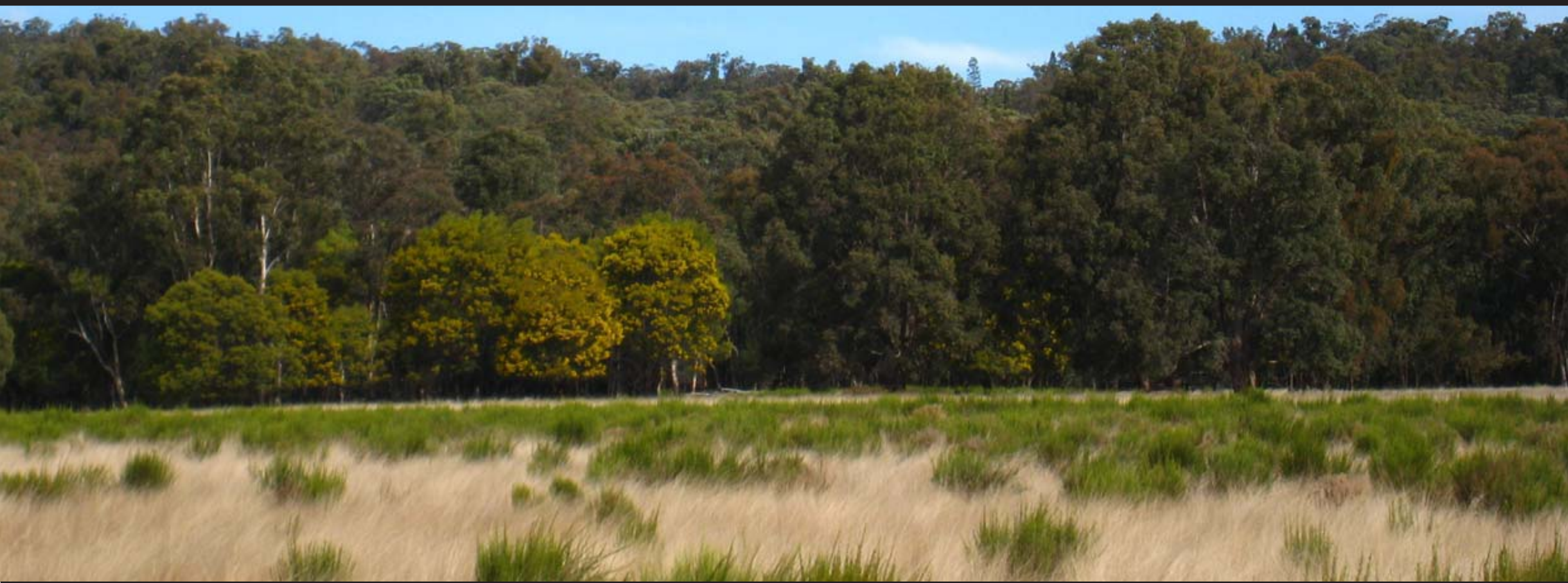
MOOLARBEN COAL PROJECT

Stage 2



APPENDIX 3B

Greenhouse Gas Assessment

GREENHOUSE GAS ASSESSMENT:
PROPOSED STAGE 2 OF THE MOOLARBEN COAL PROJECT, NEAR ULAN, NSW

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Prepared for
Moolarben Coal Mines Pty Ltd

by

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1 INTRODUCTION

This report has been preparedby Holmes Air Sciences on behalf of the Moolarben Coal Project (MCP) Stage 2 near Ulan and relates to the Stage 2 project.

The report provides, in respect of the MCP Stage 2:

- An assessment of Scope 1, 2 and 3 Greenhouse Gas (GHG) emission; and
- An analysis of the MCP Stage 2 and its compliance with Ecologically Sustainable Developemnt (ESD) principles in the context of global warming and climate change.

For the purposes of this report, the ESD principles have been taken to be those defined by the Department of Planning (**DUAP, 2000**), which are as follows:

1. The precautionary principle – namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
2. Inter-generational equity – namely, that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;
3. Conservation of biological diversity and ecological integrity; and
4. Improved valuation and pricing of environmental resources.

The submission revisits the estimated emissions of GHG associated with the MCP Stage1 and examines the scientific principles that relate GHG gases to the global warming effect and shows that even when all categories (that is Scope 1, 2 and 3) of GHG emissions from the MCP Stage 2 are taken into account the project will comply with the principals of ESD.

It is argued that global warming that is attributable to the increases in the concentrations of GHGs is an effect due to the cumulative emissions of all sources of GHGs. The effective management of the anthropogenic global warming effect will need measures that ensure that reductions of emissions of GHG in one location are not replaced by emissions from other sources. The measures to achieve this are currently being developed in Australia and elsewhere and at this stage appear to rely on economic instruments that will penalise those enterprises that make use of carbon-based fuels that result in releases of greenhouse gases to the atmosphere and measures that encourage the use of technologies that do not emit greenhouse gases or have a lower greenhouse gas intensity.

2 SCIENCE OF GLOBAL WARMING

Arguably, the most authoritative and comprehensive documents dealing with the science of global warming are the scientific assessment reports (SARs) produced approximately every five years by the Intergovernmental Panel on Climate Change (IPCC). To date, the IPCC has published four SARs, the most recent being in 2007 (**IPCC, 2007**). These documents are essentially the scientific community's consensus view on climate change. The SARs also provide a useful database that is necessary to understand the significance of various human activities in the context of climate change. In summary, the IPPC reports provide well written information critical to understanding the science of global warming. They include quantitative information on the production and fate of greenhouse gases and estimates of the expected increases in global temperatures for a range of scenarios intended to cover a range of possible futures. These scenarios are chosen to illustrate the range of uncertainty in the predictions of temperature increases.

The temperature of the earth's atmosphere is determined almost entirely[2] by the balance in radiation received from the sun and that re-radiated to outer space (see for example **IPCC, 2001**).

The parts of the radiation spectrum through which the earth can re-radiate and loose energy to outer space depends on the composition of the atmosphere. Certain gases including water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and a range of other gases absorb electromagnetic energy in the infrared. Solar radiation from the sun contains most of its energy in the infrared, visible and ultraviolet parts of the spectrum. Sunlight passes through the atmosphere and warms both the atmosphere and the earth's surface.

Clouds and the earth's surface directly reflect some of the sun's radiation back to space, but much of the sun's radiation is absorbed by the earth's surface and some by the atmosphere, which are warmed. The warmed earth and its atmosphere then reradiate this energy back to space. For the average global temperature to remain constant the incoming radiation from the sun must be balanced by the outgoing energy radiated from the earth and atmosphere.

The IPCC SARs attribute most global warming (and the associated climate change) to the changing composition of the atmosphere, namely the increasing concentrations of so - called GHGs, in particular CO_2, CH_4 and N_2O. These gases reduce the parts of the electromagnetic spectrum through which energy can be re-radiated from the earth. In response, the earth's temperature must increase to allow the rate of energy loss from the earth to increase and thereby allow the incoming and outgoing radiation to be brought back into balance.

In summary, GHGs absorb electromagnetic energy and change the radiation balance of the earth causing the temperature to increase so that the radiation balance is restored.

Without the presence of any greenhouse gases, the earth's average temperature would be extremely cold (-18 ^{o}C) (**Seinfeld and Pandis, 1998**) and most of the planet would be uninhabitable. However, the effect of increasing greenhouse gases is to change existing climates and this will place stresses on current ecological systems that have adapted to current climate regimes.

Increasing concentrations of CO_2, CH_4 and other greenhouse gases will cause the temperature of the atmosphere to increase, but because the earth transports heat from the equator towards the poles in a complicated way via ocean currents and winds, the precise effect of increasing concentrations is difficult to estimate for any particular location.

The cause of the increasing concentrations of CO_2 and CH_4 is largely attributable to the increase in the worldwide use of fossil fuels to provide energy for increasing populations, which also have increasing per capita consumptions of energy. However, land clearing on a global scale is also an important cause in the change in the concentrations of CO_2.

3 QUANTIFYING GREENHOUSE EFFECTS

Scientific publications sometimes refer to the quantity of carbon stored in the atmosphere or may refer to the equivalent quantity of carbon dioxide. In this context, 1.0 t of carbon is the same as 3.67 t of CO_2. Most of the analysis in this report will refer to CO_2 rather than carbon, as this appears to be the most common approach used in Australia.

[2] The words "almost entirely" are used because the residual heat from the earth's formation and from the decay of radioactive elements in the earth have some effect on the earth's temperature.

The estimated quantity of carbon stored in the atmosphere can be calculated from the measured concentration of CO_2 in the atmosphere and the calculated mass of the atmosphere, which can be estimated known the pressure of the atmosphere at the surface and the surface are of the earth. Based on an average atmospheric pressure at sea-level of (1013.25 hPa) and assuming that the earth's surface area is 5.094×10^{14} m^2 the mass of the atmosphere is estimated to be 5.267×10^{18} kg. If the mean CO_2 concentration is taken to be 379 ppm then the mass of CO_2 in the atmosphere is approximately 3.029×10^{15} kg or 3,029 Gt, which is consistent with the estimate of 750 Gt of carbon, equivalent to 2,750 Gt of carbon dioxide, made for the 1990s by Seinfeld and Pandis (**Seinfeld and Pandis, 1998**). A similar calculation can be made for CH_4. Assuming it is present at a concentration of 1774 ppb gives an estimated mass of CH_4 in the atmosphere of 5.155×10^{12} kg or 5.155 Gt. Since CH_4 has a warming potential of 21 this is equivalent to 108.255 Gt of CO_2.

The IPCC (**IPCC, 2001**) estimated that in the 1990s emissions of CO_2 from burning fossil fuels and the production of cement, was 6.3 Gt of carbon per year or 23 Gt of CO_2 per year. These figures can be compared with the estimated annual emission of 559 Mt of CO_2-equivalent for Australia in 2005 using the Kyoto accounting procedures (see http://www.ageis.greenhouse.gov.au).

NSW is estimated to be responsible for approximately 28% of Australia's emissions (157 Mtpa) (http://www.environment.nsw.gov.au/climatechange/emissionsoverview.htm).

The relationship between global warming and greenhouse gas concentrations is not linear[3] and there is no accepted method to determine the contribution that a given emission of greenhouse gases might make to global warming.

To understand this point it is useful to consider the following discussion from Section 1.3.1 of the Second Assessment Report prepared by the IPCC (**IPCC, 1995**).

> *"The amount of carbon dioxide in the atmosphere has increased by more than 25% in the past century and since the beginning of the industrial revolution, an increase which is known to be in large part due to the combustion of fossil fuels and the removal of forests (Chapter 2 [*of the report*]). In the absence of controls, projections are that the future rate of increase in carbon dioxide amount may accelerate and concentrations could double from pre-industrial values within the next 50 to 100 years (**IPCC, 1994**).*
>
> *The increased amount of carbon dioxide is leading to climate change and will produce, on average, a global warming of the Earth's surface because of its enhanced greenhouse effect – although the magnitude and significance of the effects are not yet fully resolved, If, for instance, the amount of carbon dioxide in the atmosphere were suddenly doubled, but with other things remaining the same, the outgoing long-wave radiation would be reduced by about 4 Wm^{-2}. To restore the radiative balance, the atmosphere must warm up and, in the absence of other changes, the warming at the surface and throughout the troposphere would be about 1.2 ^oC. However, many other factors will change, and various feedbacks come into play (see Section 1.4.1* [of the report]*), so the best estimate of the average global warming for doubled carbon dioxide is 2.5 ^oC (**IPCC, 1990**). Such a change is very large by historical standards and would be associated with major climate changes around the world.*
>
> *Note if carbon dioxide were removed from the atmosphere altogether, the change in out going radiation would be about 30 Wm^{-2} – 7 to 8 times as big as the change for doubling – and the magnitude of the temperature change would be similarly enhanced. The reason is*

[3] The warming effect of a given quantity of greenhouse gases to the atmosphere is less and less as the concentration become higher and higher.

that the carbon dioxide absorption is saturated over part of the spectral region where it absorbs, so the amount of absorption changes at a much smaller rate than the concentration of the gas (Chapter 2 [of the report]*). If the concentrations of carbon dioxide are more than doubled, then the relationship between radiative forcing and concentration is such that each further doubling provides a further radiative forcing of about 4 Wm^{-2}."*

4 GREENHOUSE GAS INVENTORIES

Greenhouse gas inventories are calculated according to a number of different methods. The procedures specified under the Kyoto Protocol United Nations Framework Convention on Climate Change are the most common.

The protocol nominates the following as greenhouse gases:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydrofluorocarbons (HFCs); and
- Perfluorocarbons (PFCs).

From the point of view of the MCP Stage 2, only CO_2, CH_4 and N_2O are relevant.

CO_2 and N_2O are formed and released during the combustion of gaseous, liquid and solid fuels. These are the most significant gases for the MCP Stage 2. They are liberated when fuels are burnt in diesel powered equipment and in the generation of the electrical energy that will be used by the project. In addition, there will be emissions of CH_4 and CO_2 which will be liberated as the coal seam is broken up during mining. These gases will be liberated directly from the exposed coal in the open cut mine and from the exposed coal via the underground mine ventilation system and while the coal is stored on the surface. The liberation of trapped gases can take a few days. The coal seams to be mined at Moolarben are not particularly gassy (see later).

Inventories of greenhouse gas emissions[4] can be calculated using published emission factors. Different gases have different greenhouse warming effects (referred to as warming potentials) and emission factors take into account the global warming potentials of the gases created during combustion.

The global warming potentials assumed in the Australian Greenhouse Office (**AGO, 2005**) emission factors are as follows:

- CO_2 – 1;
- CH_4 – 21;
- N_2O – 310; and
- NO_2 – not included.

When the global warming potentials are applied to the estimated emissions then the resulting estimate is referred to in terms of CO_2-equivalent emissions.

[4] Note the estimates of emissions quoted in this report are quoted to an implied accuracy of 1 kg in some cases. This is not intended to be the accuracy of the estimate and is done to assist in checking the arithmetic of calculations.

4.1 GHG emissions from the MCP Stage 2

A number of conventions on the determination, assessment and the reporting of GHG from development and human activity on the planet have been developed. The approach used here is that published by the Department of Climate Change (**DCC, 2008**) in the National Greenhouse Accounts (NGA) Factors publication, which will be referred to hereafter as the DCC Workbook.

The DCC Workbook defines the three scopes of emission as follows:

Scope 1 covers direct emissions from sources within the boundary of an organisation such as fuel combustion and manufacturing processes.

Scope 2 covers indirect emissions from the consumption of purchased electricity, steam or heat produced by another organisation. Scope 2 emissions result from the combustion of fuel to generate the electricity, steam or heat and do not include emissions associated with the production of fuel. Scopes 1 and 2 are carefully defined to ensure that two or more organisations do not report the same emissions in the same scope.

Scope 3 includes all other indirect emissions that are a consequence of an organisation's activities but are not from sources owned or controlled by the organisation.

Emissions associated with the burning of the coal by customers would be included in and classed as Scope 3 emissions, as would the emissions associated with the transport of the coal from the location where it is mined to the location where it is burnt to produce the energy. The emissions associated with Scope 3 emissions include (see **DCC (2008)**):

- Disposal of waste generated (e.g. if the waste is transported outside the organisation and disposed of);
- **Use of products manufactured and sold;**
- Disposal (end of life) of products sold;
- Employee business travel (in vehicles or aircraft not owned or owned by the reporting organisation);
- Employees commuting to and from work;
- Extraction, production and transport of purchased fuels consumed;
- Extraction, production and transport of other purchased materials or goods;
- Purchase of electricity that is sold to an end user (reported by electricity retailer);
- generation of electricity that is consumed in a transmission and distribution system (reported by end user);
- Out-sourced activities; and
- **Transportation of products, materials and waste.**

The reporting of Scope 3 emissions is generally not required in most reporting programs for the simple reason that it will be reported by the user, for example by the power generator in Japan when the Japanese GHG inventory is reported. In the case of the MCP Stage 2, the reporting of Scope 3 emissions is complicated because the end customer is not known and the way in which the coal might be used is not known. However, as will be seen later, some reasonable assumptions can be made and an indication as to the magnitude of the emission can be made.

4.2 Emission factors

The **DCC (2008)** publication also includes emission factors that allow CO_2-equivalent emissions to be estimated from the uses of electricity and diesel fuels as well as emission from fugitive sources associated with mining coal and ultimately with the burning of coal by customers. These factors have been used to convert fuel usage and electricity consumption into CO_2-equivalent emissions. The relevant emission factors are:

- 2.9 kg CO_2-equivalent/litre for diesel usage – based on full fuel cycle analysis (see Table 78 of **DCC (2008)**) – made up of 2.7 kg CO_2-equivalent for Scope 1 emissions and 0.2 kg CO_2-equivalent for Scope 3 emissions;
- 1.068 kg CO_2-equivalent/kWh of electrical energy used in NSW (estimated factor for NSW 2007 see Table 75 of **DCC (2008)**) – made up of 0.89 kg CO_2-equivalent for Scope 2 emissions and 0.17 kg CO_2-equivalent for Scope 3 emissions; and
- Black coal in NSW has an energy content of 22.5 GJ/t and results in 89.3 kg CO_2-equivalent/GJ when burnt (see Table 76 of **DCC (2008)**).

Table 24 of the **DCC (2008)** Workbook suggests that for open cut mines in NSW, the CO_2-equivalent emission factor to account for CH_4 and CO_2 liberated when coal is mined is 45.5 kg/t of ROM coal and for underground operations the emission factor for "less gassy mines" is 8.4 kg/t of ROM coal.

Since the preparation of the Environmental Assessment report (EA) for Stage 1, site specific emissions data for the Moolarben coal seams have become available from tests on drill samples of coal. Four samples have been tested to date. These indicate that the coal to be mined by the MCP Stage 2 will liberate 0.23 kg CO_2-equivalent/t (on a raw coal basis). This is substantially less than the default figures suggested by the DCC data.

The low value is consistent with values measured at Wilpinjong and is likely to be a result of the low depth at which the coal is buried, which has allowed the gases to be lost over geological time. The figure of 0.23 kg/t is much lower than the default figure of 45.5 and 11.3 kg/t assumed in the EA, which were the default AGO figures.

The coal will need to be transported to the Port of Newcastle or to a customer outside the project area. For the purpose of this analysis, it will be assumed that all coal is carried by rail to Newcastle a distance of approximately 280 km (one way). According to a study commissioned by **Network Access (2002)** the Australian average CO_2-e emission rate for rail transport is 12.3 g/net tonne-km. This factor has been used to estimate the CO_2-equibvalent emissions from transport assuming that 83% of ROM production is exported. The estimate assumes a one way trip and has been accounted for in the Scope 3 emissions.

The CO_2-equivalent emissions for each year in the life of the mine have been estimated using the factors above.

4.3 MCP Stage 2 Emissions

4.3.1 Emissions from mining

The CO_2-equivalent emissions for Scopes 1, 2 and 3 for each year in the life of the mine have been estimated using the factors above. The result are summarised in **Table 1**.

Table 1. Estimated Greenhouse Gas Emissions

Year	Diesel (L)	Open Cut ROM coal (t)	UG ROM coal (t)	Electrical Energy (MW)	Scope 1 (t)	Scope 2 (t)	Total of Scopes 1 and 2 (t)	Scope 3 (t)	Total (t)
2010	25,485,000	7,000,000	-	130,000	70,420	120,797	191,217	14,106,940	14,298,157
2011	37,270,000	12,000,000	-	130,000	103,389	123,154	226,543	24,167,540	24,394,083
2012	44,070,000	12,000,000	304,000	130,000	121,819	124,514	246,333	24,779,224	25,025,557
2013	47,020,000	12,000,000	2,743,000	130,000	130,345	125,104	255,449	29,686,785	29,942,234
2014	47,440,000	12,000,000	3,115,000	130,000	131,564	125,188	256,752	30,435,294	30,692,046
2015	47,440,000	12,000,000	3,173,000	130,000	131,578	125,188	256,766	30,551,997	30,808,763
2016	47,440,000	12,000,000	3,198,000	130,000	131,584	125,188	256,772	30,602,300	30,859,071
2017	47,540,000	12,000,000	3,188,000	130,000	131,851	125,208	257,059	30,582,179	30,839,238
2018	50,490,000	12,000,000	4,062,000	130,000	140,017	125,798	265,815	32,340,771	32,606,587
2019	50,490,000	12,000,000	4,432,000	130,000	140,102	125,798	265,900	33,085,256	33,351,156
2020	50,490,000	12,000,000	3,678,000	130,000	139,929	125,798	265,727	31,568,117	31,833,844
2021	50,490,000	12,000,000	2,428,000	130,000	139,641	125,798	265,439	29,052,967	29,318,407
2022	50,490,000	12,000,000	2,951,000	130,000	139,762	125,798	265,560	30,105,306	30,370,866
2023	50,490,000	12,000,000	2,901,000	130,000	139,750	125,798	265,548	30,004,700	30,270,248
2024	53,440,000	12,000,000	2,897,000	130,000	147,714	126,388	274,102	29,996,652	30,270,754
2025	56,390,000	12,000,000	3,953,000	130,000	155,922	126,978	282,900	32,121,450	32,404,351
2026	56,390,000	12,000,000	3,560,000	130,000	155,832	126,978	282,810	31,330,687	31,613,497
2027	53,440,000	12,000,000	3,822,000	130,000	147,927	126,388	274,315	31,857,863	32,132,178
2028	53,440,000	12,000,000	3,798,000	130,000	147,922	126,388	274,310	31,809,572	32,083,881
2029	53,440,000	12,000,000	3,963,000	130,000	147,959	126,388	274,347	32,141,572	32,415,919
2030	53,440,000	12,000,000	4,178,000	130,000	148,009	126,388	274,397	32,574,177	32,848,574
2031	53,440,000	11,000,000	4,076,000	130,000	147,755	126,388	274,143	30,356,821	30,630,965
2032	53,440,000	12,000,000	3,543,000	130,000	147,863	126,388	274,251	31,296,481	31,570,732
2033	53,440,000	6,384,000	3,139,000	130,000	146,478	126,388	272,866	19,183,519	19,456,385
Total	**1,186,945,000**	**276,384,000**	**73,102,000**	**3,120,000**	**3,285,133**	**3,014,189**	**6,299,322**	**703,738,170**	**710,037,493**
Average	**49,456,042**	**11,516,000**	**3,045,917**	**130,000**	**136,881**	**125,591**	**262,472**	**29,322,424**	**29,584,896**

The average annual greenhouse gas emissions from the project, including all scopes, are estimated to be 29.585 Mtpa of CO_2-equivalent /year and if only Scopes 1 and 2 are considered the emissions are 0.262 Mtpa. This can be compared with the estimated annual emission of 559 Mt of CO_2-equivalent for Australia in 2005 using the Kyoto accounting procedures (see http://www.ageis.greenhouse.gov.au). The figure of 29.585 Mtpa includes the Scope 3 emission from burning the coal by the ultimate customer (assuming the customer is a power station).

NSW is estimated to be responsible for approximately 28% of Australia's emissions (157 Mtpa) (http://www.environment.nsw.gov.au/climatechange/emissionsoverview.htm). It is important to note that the Scope 3 emissions from the project would not be included in the NSW or the Australian inventories as these would be accounted for in the inventory for the country in which the end user is located. This means that the figure of 0.262 Mtpa is the more relevant figure to compare with the 559 Mtpa figure for Australia.

4.3.2 Emissions from other processes

If the coal were to spontaneously combust there would be further emission of CO_2. However, the mine would obviously be operated in such a way as to minimise these types of emissions and these emissions are likely to be very small compared with the 0.112 Mt/year estimated above. In any event, this emission will be picked up in the estimated emission of GHGs when the coal is burnt by the customer. Any emission that occurs from the spontaneous combustion of the coal on the mine site or during transport will be an emission that cannot occur when the customer burns the coal because coal burnt by spontaneous combustion on-site or in transit will never reach the customer. Thus, this emission is completely accounted for by assuming that the customers receive all the product coal that is produced by the mine and exported to them.

The MCP Stage 2 does not propose, nor does its application for approval, seek approval to burn any of the coal produced.

4.4 Export and burning of the coal

Emissions from the transport of the coal to the Port of Newcastle has been included in the Scope 3 emissions as have the emissions from the end users. The emissions on burning the coal will of course be much larger than those associated with the mining of the coal. The adopted convention is that these emissions are attributed to the user of the coal not the producer and the inclusion of these into the inventory has been made to address the judgement of her Honour Pain J in the matter of *Gray v The Minister for Planning* estimates of the GHG emissions associated with the burning of the coal.

The convention of not including these emissions avoids double counting of the emissions. Leaving the accounting of the emissions from the use of the coal to the end user is also desirable as emissions due to the end use depend on the method by which the coal is used to produce energy and any control measures that might be in place. Various methods of burning will be used by different customers. As coal from the MCP Stage 2 is to (generally) be exported, any assessment of greenhouse emissions by its use in those other jurisdictions will be speculative and potentially unreliable.

If it is assumed that the coal is burnt in a power station, there will be emissions of CO_2 and N_2O. The quantity of CO_2 emitted can be estimated with a reasonable degree of reliability if the carbon content of the coal is known. It is reasonable to assume that all the carbon will be converted to CO_2 and that minor emissions of CO will be converted to CO_2 reasonable rapidly (in 1 to 4 months) (**Seinfeld and Pandis, 1998**). There will however be some uncertainty as to the production of N_2O, which depends not only on the nitrogen content in the fuel but the temperature of the combustion process. Some small quantity of carbon will also be retained in the ash.

5 IMPORTANT ADDITIONAL CONSIDERATIONS

While it is possible to assess the significance of these emissions by comparing them with other sources of greenhouse gases it is also important to note that the efficiency with which the coal is used also very important. All other things being equal[5] global CO_2-equivalent emissions could be halved if power station efficiencies were doubled, or halved if the efficiency by which end users' consumed electricity was doubled or waste was reduced and so on.

[5] Population remaining fixed and the per capita consumption of energy being fixed.

Different customers will use the coal in power plants of different thermal efficiencies. The Australian Coal Association provides some typical statistics for power station efficiencies on their web site (**ACA, 2006**).

The web site notes the following:

> "*Industry has continuously* striven to *increase efficiencies of conventional plant; for example, the average thermal efficiency of US power stations has increased from 5% in 1900, to around 35% currently. In China, most power plants are relatively small, average efficiency is about 28% compared to an OECD average of 38%. New conventional* [pulverised fuel] *PF power plants achieve above 40% efficiency.*
>
> *Advanced modern plants use specially developed high strength alloy steels, which enable the use of supercritical and ultra-supercritical steam (pressures >248 bar and temperatures >566°C) and can achieve, depending on location, close to 45% efficiency.*
>
> *Application of new advanced materials to PF power plant should enable efficiencies of 55% to be achieved in the future. This results in corresponding reductions in CO_2 emissions as less fuel is used per unit of electricity generated.*

6 CONTRIBUTION TO GLOBAL WARMING AND CONCLUSIONS

Finally, it is useful to consider the contribution that (1) emissions from mining, (2) emissions from burning MCP Stage 2 coal and (3) the combined emissions from both mining and burning MCP Stage 2 coal might make to global warming.

Because the relationship between global warming and greenhouse gas concentrations is not linear[6] there is no accepted method to determine the contribution that a given emission of greenhouse gases might make to global warming.

To understand this point it is useful to consider the discussion from Section 1.3.1 of the Second Assessment Report prepared by the IPCC (**IPCC, 1995**), which was provided earlier in **Section 3** of this submission.

At any point in time, it would be reasonably simply to compare the estimated emission of CO_2-equivalent from the various activities with the estimated equivalent global emission of 23 Gtpa. On this basis, the emissions from the mining and burning coal from Moolarben is estimated to be 0.1% of global CO_2-equivalent annual emissions (based on estimated global emissions for the 1990s as provided in the most recent IPPC report (**IPCC, 2001**)). Thus, the MCP could be considered to contribute 0.1% to the increase in global temperatures caused by the increase in greenhouse gas emissions as they are currently. This invites the question as to what temperature rise might be attributed to the GHG emissions from the MCP Stage 2.

Based on the IPPC estimate, doubling of the CO_2-equivalent concentration in the atmosphere would lead to a 2.5 ^oC increase in global average temperature (see **Section 3**), and that the current global CO_2 load is 2,750 Gt, we can estimate that the annual emissions from the MCP Stage 2 (including mining, transporting the coal to Newcastle and burning the coal) would lead to an increase in global temperature of 0.000027 ^oC [$(29.6 \times 10^6/2,750 \times 10^9) \times 2.5\ ^oC$]. If the equivalent calculation is done for the CO_2-equivalent liberated due to the mining of the coal the increase in global temperature

[6] The warming effect of a given quantity of greenhouse gases to the atmosphere is less and less as the concentration become higher and higher (see **Section 3**).

that could be attributed to the MCP Stage 2 would be 0.000000238 ^oC [262 x 10^3 /2,750 x 10^9 x 2.5 ^oC]. Both of these calculations assume that all the CO_2 liberated in a year stays in the atmosphere.

There will clearly be no measurable environmental effect due to the emissions of greenhouse gases from the MCP Stage 2 even when the customer's use of the coal is taken into account. Any environmental assessment would conclude that the effects of the emissions from the MCP Stage 2 are unmeasurable. Given this, it is clear that the MCP Stage 2 would comply with the principles of ESD.

In practice, of course the effects of global warming and associated climate change are the cumulative effect of many thousands of such sources and it is the cumulative effects that pose a threat to ESD principles.

This analysis highlights the problem of dealing with climate change on a mine-by-mine, or project-by-project basis. Indeed if this approach is adopted it is likely to be ineffective since the coal will simply be sourced from some other place.

Ultimately, the control of greenhouse gas emissions is likely to occur via economic instruments such as carbon taxes set as suggested in the recently released Stern Review and elsewhere (**Stern, 2006**). These taxes, set a appropriate levels, would encourage increases in efficiencies in the way that carbon-based fuels (including coal) are used, encourage the development of carbon capture and sequestration and encourage the development of renewable forms of energy generation, and improve the efficiency with which electricity is used.

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