



Illawarra Coal



Dendrobium Mine Greenhouse Gas & Energy Efficiency Management Plan DENMP0068

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VERSION HISTORY

| VERSION | DESCRIPTION OF CHANGES | DATE |
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| 1.0 | Original Document | November 2004 |
| 2.0 | Update following PRP9 and Department of Planning Compliance Audit | October 2006 |
| 3.0 | Three Yearly review as required by Development Consent | March 2008 |
| 4.0 | Review as required by the revised Development Consent (issued 8 December 2008) | April 2009 |
| 5.0 | Updated to reflect FY09 data | October 2009 |
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| 7.0 | Reviewed and updated | March 2012 |
| 8.0 | Energy Mass Balance diagram amended to include fugitive mine gas emissions | June 2013 |
| 9.0 | Review following triennial Independent Audit The following changes have been made: <ul style="list-style-type: none"> • Updated roles and responsibilities • References to parent company changed | January 2018 |
| 9.1 | Minor changes following comments from the Department of Planning & Environment | August 2018 |

PERSONS INVOLVED IN THE REVIEW OF THIS PLAN INCLUDE:

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1 INTRODUCTION

1.1 Mine Background

Dendrobium Mine extracts coal from the No. 3 Seam (Wongawilli Seam) of the Southern Coalfield. The No.3 Seam has relatively low gas concentrations, with inherent gas content in the range of 1.5 to 5 cubic metres per tonne of in-situ coal.

Gas released from mining coal is the main source of fugitive greenhouse gas (GHG) emissions and account for up to 85% of total GHG emissions for the Mine. Total GHG emissions associated with the Mine are in the order of 260 to 350 kt CO_{2e} per annum (depending on production performance and regional mining area gassiness).

Electricity is the main energy source for mining operations with diesel fuel consumption secondly, no other energy source is consumed at the mine. Total energy consumption is in the order of 0.22 PJ pa.

1.2 Plan Background

This Greenhouse Gas and Energy Efficiency Plan addresses:

- Schedule 6 of the Dendrobium Development Consent – to prepare and implement a Greenhouse and Energy Efficiency Plan for the development; and
- South32 Environment Standard – Section 3 – performance requirements for energy and greenhouse gas management.

The initial plan was also developed in consideration of the Department of Energy, Utilities and Sustainability (DEUS 2005) guidelines for the development of Energy Savings Actions Plans.

1.3 Scope

The scope of this Plan includes the following sites and facilities.

Dendrobium Pit Top – Consists of the main administration buildings, workshop, machinery and equipment storage areas, stores and supplies handling, bathhouse amenities, water management infrastructure and people and materials access to the underground workings via the Dendrobium Tunnel.

Kemira Valley Coal Loading Facility (KVCLF) – The KVCLF receives Run of Mine (ROM) coal from underground via the Kemira Valley Tunnel. Coal is transported from underground to KVCLF via a conveyor network. The coal is then fed into a rill tower and deposited onto a 150,000 tonne capacity stockpile from which it is loaded into trains via an enclosed rail-loading chute. This site also incorporates water management structures and facilities.

Ventilation Shaft Number 1 - The No.1 ventilation shaft, located within the Metropolitan Special Area administered by WaterNSW (WNSW), operates as a downcast shaft (i.e. drawing fresh air into the underground workings). The No. 1 ventilation shaft is on land owned by Illawarra Coal.

Ventilation Shafts Number 2 and 3 – Also located within the Metropolitan Special Area and within Mining Lease ML1566. Construction of the No.2 and 3 ventilation shafts was completed in 2008. The No.2 shaft operates as an additional downcast shaft whilst the No.3 shaft operates as an upcast shaft. No.3 shaft accommodates the main mine ventilation fans.

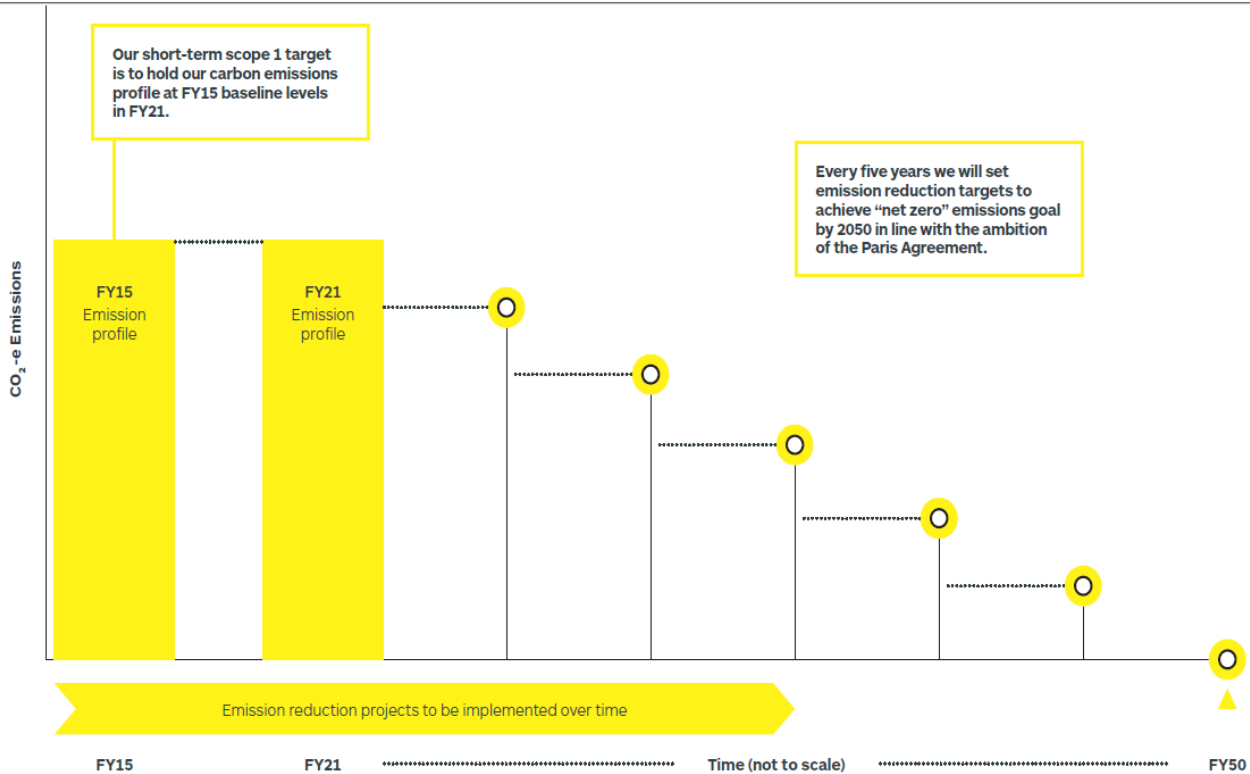
This Plan considers Scope 1 and Scope 2 greenhouse gas emissions and energy use associated with Mine operations and activities.

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1.4 GHG and Energy Targets

Dendrobium Mine, Illawarra Coal, and South32 are committed to operating in an environmentally responsible manner. To support this commitment, targets have been established at the corporate level with respect to GHG emissions, the current corporate targets are outlined in Figure 1 (zero scope 1 by FY50).



(3) The carbon emission reduction target is based on absolute, scope 1 carbon emissions and in the event of any mergers, acquisitions or divestments the FY15 baseline will be recalculated.

Figure 1: Scope 1 carbon emission reduction targets for South32.

2 OBJECTIVES

The objectives of this Plan are to:

- Comply with relevant regulatory and corporate requirements;
- Define key roles and responsibilities associated with GHG and energy management;
- Provide an overview of the energy usage and associated GHG emissions for the Dendrobium operations; and
- Describe the Dendrobium Operations GHG and Energy minimisation strategy.

3 RESPONSIBILITIES

South32 management has a key overview role in relation to GHG and energy management strategies for the Mine. This includes identification and evaluation of initiatives to address fugitive GHG emissions (primarily fugitive mine gas emissions), cost effective provision of energy commodities (electricity and diesel), tracking and reporting of GHG emissions and energy consumption, assessment and approval of key equipment purchases and projects to ensure cost effectiveness and energy efficiency are considered.

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Mine Engineering personnel (Engineering and Maintenance Managers) are responsible for the efficient operation of plant and equipment at the Mine.

Mine Management (General Manager and support staff) are responsible for ensuring that the principles and objectives of this Plan are adequately addressed and supported at the Mine.

Illawarra Coal management personnel who have a key supporting role for the Mine (in relation to GHG and Energy administration, review and reporting) include the Illawarra Coal HSE Lead, the HSEC reporting function and the Illawarra Coal Environmental Specialist.

It is the general responsibility of all employees and contractors to undertake their activities in a competent and efficient manner, and to raise opportunities for improvement with management where appropriate.

In relation to goal setting, South32 (Corporate) establish GHG and energy targets and performance requirements for the overall business, with Illawarra Coal senior management establishing goals for the asset level (Illawarra Coal operations).

Due to the nature and substantial costs associated with implementing material GHG emission reduction initiatives and projects, and the business risks, policy decisions and long-term strategies associated with them, these aspects are managed at South32 (Corporate) management level and in accordance with Corporate governance requirements.

Smaller scale initiatives and projects are directly undertaken by Illawarra Coal and site where appropriate.

4 LEGISLATIVE AND OTHER REQUIREMENTS

4.1 Legislative Requirements

National Greenhouse and Energy Reporting System (NGERS)

In accordance with the requirements of the National Greenhouse and Energy Reporting Act 2007, the South32 Corporation triggers the controlling Corporation group threshold and the Dendrobium Mine triggers the facility threshold for mandatory reporting of GHG emissions, energy consumption and energy production data to the Australian Government.

Associated Legislation includes:

- the [National Greenhouse and Energy Reporting Regulations 2008](#);
- the [National Greenhouse and Energy Reporting \(Measurement\) Determination 2008](#); and
- the [Clean Energy Legislation \(Carbon Tax Repeal\) Act 2014](#)

Dendrobium Mine accounts for its GHG emissions and energy consumption in accordance with the associated legislation requirements above.

4.2 Development Consent Conditions

Schedule 6 of the Dendrobium Mine Development Consent contains several conditions relating to GHG and Energy management. This management plan has been developed to address the requirements of the consent.

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4.3 South32 and Other Policies and Standards

The South32 Environment Standard - Section 3 - defines the performance requirements for GHG and energy management.

5 SITE ENERGY USE & GHG EMISSIONS

5.1 Energy Usage – Overview

Figure 2 provides an overview of the energy sources and Scope 1 and 2 GHG emissions associated with the Dendrobium Operations.

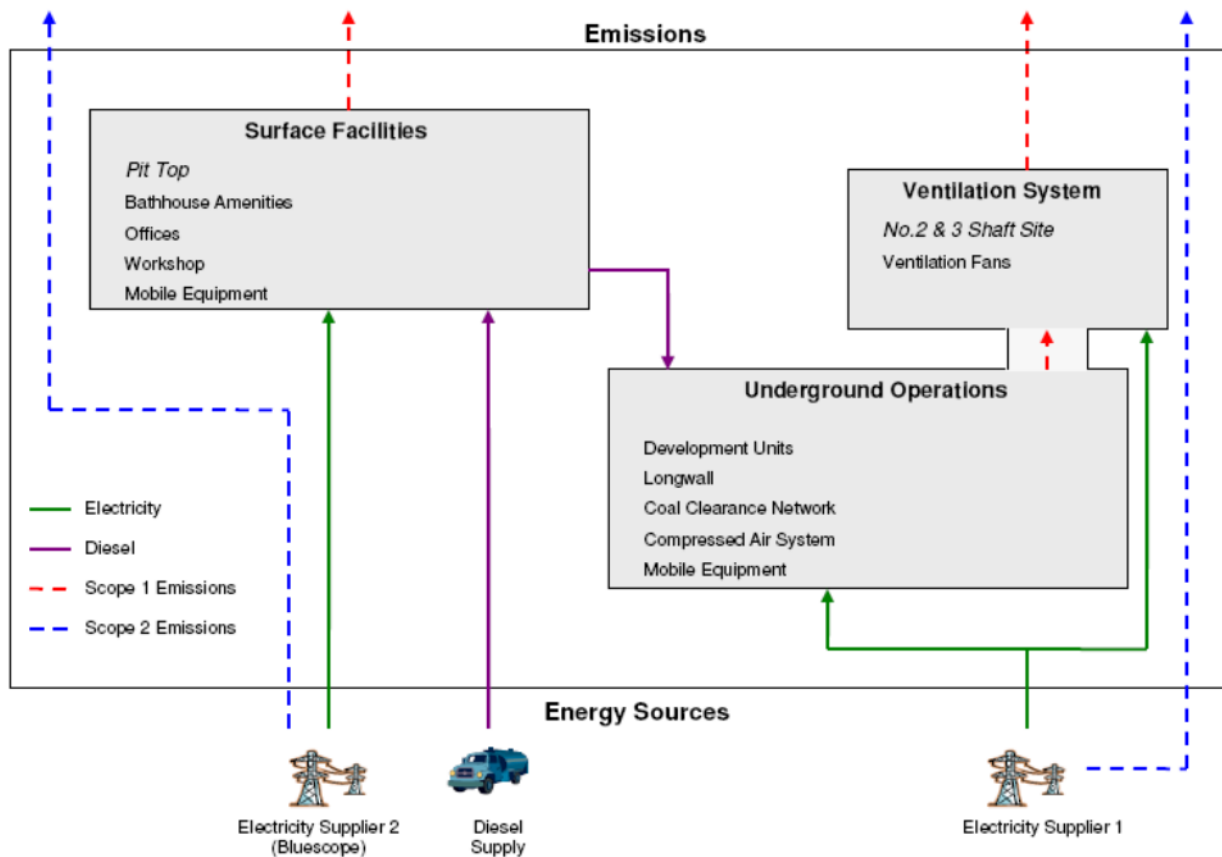


Figure 2: Energy Sources and GHG Emissions – Dendrobium Mine

Energy use for the Dendrobium operations comprises two main components:

- i. Equipment that maintains a relatively static energy demand regardless of whether the mine is producing coal or not (i.e. fixed component) includes air compressors (driving underground air pumps), fixed underground electric pumps used to de-water the mine, and main ventilation equipment that is required to operate 24 hours every day; and
- ii. Equipment that has a moderate to high relationship with mining operations and generally runs when coal is being produced, including conveyors, longwall and panel development mining equipment (i.e. variable component). Conveyors have a moderate relationship with production, since these carry a relatively high load even when coal production is interrupted for short periods, while longwall and development panel mining equipment have a high correlation with production. Diesel consumption has a close relationship to particular mining activities and processes undertaken at the time. e.g.: Diesel consumption may be at its highest during longwall mining

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equipment change-out periods due to the high demand for mobile diesel-powered equipment required to support the move.

The energy commodities consumed at the Mine are electricity and diesel fuel. No other energy commodities (e.g.: natural gas) are consumed.

5.1.1 Electricity

The main electricity demands in relative order are the mine ventilation fans, coal conveyance equipment, coal cutting equipment, compressors, bathhouse heating and other underground services.

The Mine consumes a total of ~50,000 MWh of electricity annually with ~90% of the electricity demand supplied from the Endeavour Energy High Voltage Distribution Network (state grid) and the remainder by a Bluescope privately owned High Voltage distribution network feeder.

The Endeavour Energy supply services the main fans and underground equipment loads and the Bluescope feeder principally services the pit top load.

Table 1 outlines the approximate consumption (as a % of total) for each of the key electricity use areas for the Dendrobium operations. As shown in the table, the electricity consumption of the mine ventilation system is considerably higher than the other areas accounting for approximately one third of the total electricity usage.

Table 1: Approximate Consumption (as a % of total) of Key Electrical Use Areas

| Area | Approximate Proportion of Total* |
|-----------------------------|----------------------------------|
| Main Vent Fans | 35% |
| Conveyors | 20% |
| Longwall mining equipment | 18% |
| Panel development equipment | 12% |
| Compressors | 8% |
| Bathhouse and other surface | 6% |
| Other ancillary loads | 1% |

5.1.2 Diesel

Diesel fuel demand is associated with the use of mobile equipment (men and materials transporters and vehicles servicing underground).

The fuel consumption is generally dependent on:

- The number of mine personnel working underground;
- The travelling distances;
- Gradient and roadway conditions;
- Size and type of vehicles;
- Size and rate of operations of the mine which determines material consumption and supply rates;
- Mine operational activities underway at the time (eg: longwall mining equipment change-outs);
- Mine layout; and
- Production plans.



The Mine presently uses ~920 kL of diesel fuel annually. Annual diesel fuel usage is expected to marginally and progressively increase over the operating life of the Mine as the mining areas move further away from the Pit Top facilities, hence increased travel distances and longer up-hill gradient hauls.

5.2 Greenhouse Gas Emissions

The GHG emissions are categorised as either Scope 1 (direct) or Scope 2 (indirect) emissions.

Scope 1

Scope 1 Definition: The release of greenhouse gas into the atmosphere as a direct result of an activity, or series of activities (including ancillary activities) those constitute the facility.

Scope 1 emissions for the Mine include fugitive mine air emissions (containing methane and carbon dioxide gas) and emissions associated with diesel fuel combustion on site.

Scope 2

Scope 2 Definition: The release of greenhouse gas as a result of one or more activities that generate electricity, heating, cooling or steam that is consumed by the facility but that do not form part of the facility.

The Scope 2 emissions associated with the Mine are related to electricity consumption of imported electricity.

Dendrobium Mine does not account for Scope 3 emissions and it is not a legal or prescribed obligation to report it. The Scope 3 emissions cannot be accurately accounted for by the operation as these are essentially third party down-stream emissions for which the operation has very limited to no control.

Table 2 below outlines the approximate breakdown of annual GHG emissions associated with the Dendrobium operations, and their respective categories

Table 2: GHG Emissions – Dendrobium Operations

| Source | Category | Amount (t CO ₂ e) |
|---|------------------|------------------------------|
| Emissions from purchased electricity | Scope 2 | 49,000 |
| Emissions from diesel consumption | Scope 1 | 2,600 |
| CH ₄ emissions from Ventilation (fugitive) | Scope 1 | 190,000 |
| CO ₂ emissions from Ventilation (fugitive) | Scope 1 | 25,000 |
| Post Mining Emissions | Scope 1 | 77,000 |
| Total | Scope 1+2 | 343,600 |

As shown in Table 2, direct fugitive emissions account for approximately 85% of total emissions.

Dendrobium Mine accounts for a relatively small percentage of the total overall Illawarra Coal organisational level fugitive emissions due to the relatively low gas concentrations in the Wongawilli Seam (No. 3 Seam) compared to the Bulli Seam (No. 1 Seam) in which Appin Mine operates.

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As a consequence of the relatively low volume of mine vent air emissions to atmosphere and the low methane purity of the vent air (nominally <0.25%), the use of appliances such as ‘Vocsidizers®’ for methane abatement are not feasibly practical or cost effective to adopt. Efforts in this area are concentrated on the Bulli Seam mine operations.

The potential for the Dendrobium Mine to be included in a large-scale mine vent air methane abatement project is maintained in focus by being included in the ‘**abatement cost curves**’ for the Illawarra Coal mining operations. The cost effectiveness of the projects identified on the curve is dependent on a carbon price relative to the project cost and abatement capacity.

5.3 Greenhouse Gas & Energy Balance

Variability in fugitive emissions is associated with mine production volumes and rates in addition to regional gassiness of the immediate mining area. As a consequence of the number of variables associated with the production process, fugitive mine gas emissions may not necessarily have a direct relationship to annual ROM production volumes.

Figure 3 shows the relationship between production, energy consumption and GHG emissions.

GHG emissions show a close relationship to production, being particularly evident at production peaks and dropping substantially with production reduction. The drop in production towards the end of the period of is representative of a longwall production unit change-out in FY17.

Electricity also shows a close relationship to production but does not reduce relatively (again as seen in the longwall production unit change-out period) due to the base-load of the mine still being supported. The key base-loads are the mine ventilation fans, pumping and conveyor systems.

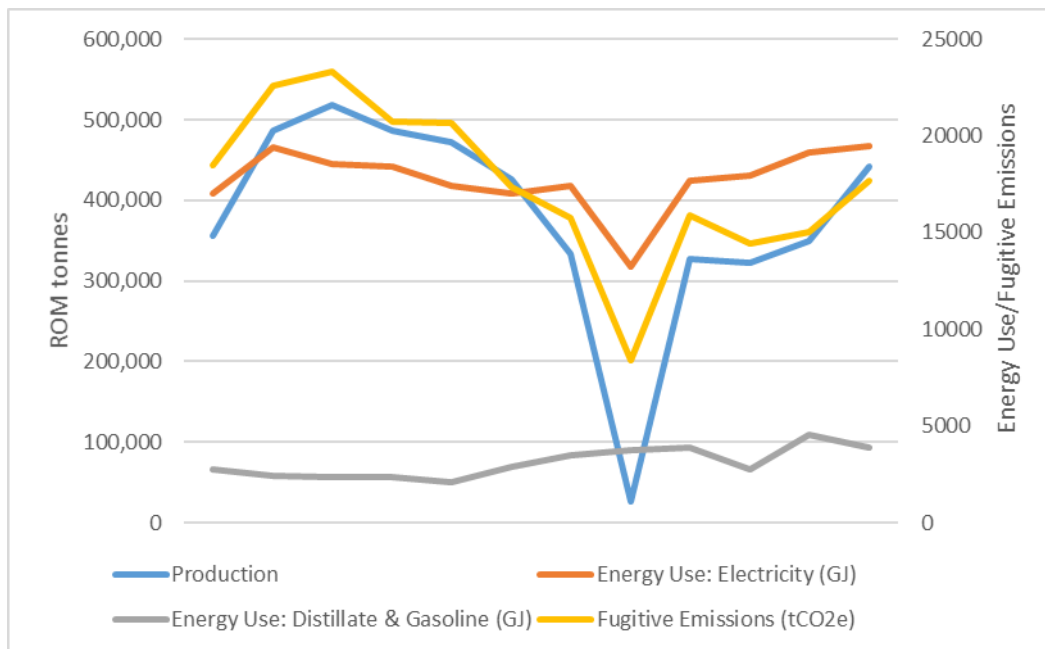


Figure 3: Energy and Emission Trends relative to Production

5.4 Greenhouse Gas and Energy Intensity

GHG intensity and energy intensity are very much influenced by production levels and are inversely aligned in profile. (i.e.: intensities reduce with increased production and the converse applies). See Figure 4 for GHG intensity and Figure 5 for Energy Intensity.

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Average GHG intensity is 0.06 t CO₂e / ROM t production and average energy intensity is 0.06 GJ / ROM t production. Both these intensities are considerably lower than intensities of Illawarra Coal's Bulli Seam operations.



Figure 4: GHG Intensity

Chart of Energy Intensity

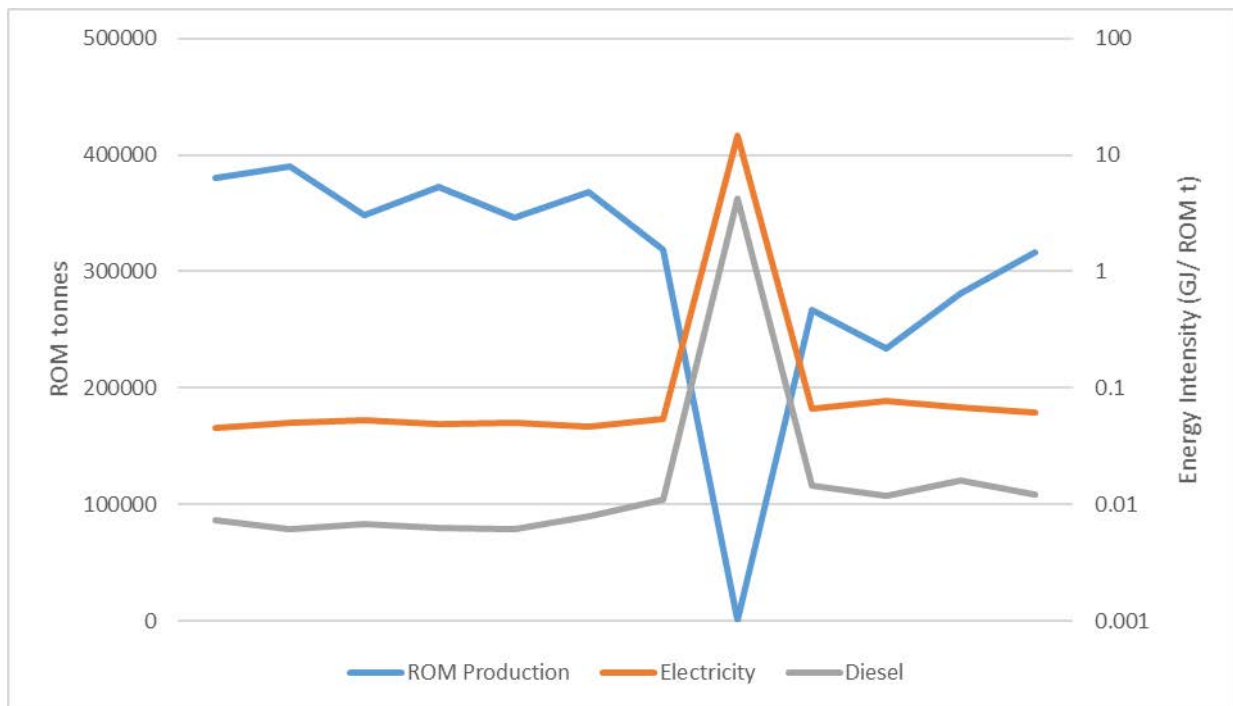


Figure 5: Energy Intensity

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6 GHG AND ENERGY MINIMISATION STRATEGY

The key elements of the Dendrobium Mine strategy for GHG and energy use minimisation are depicted in Figure 6.

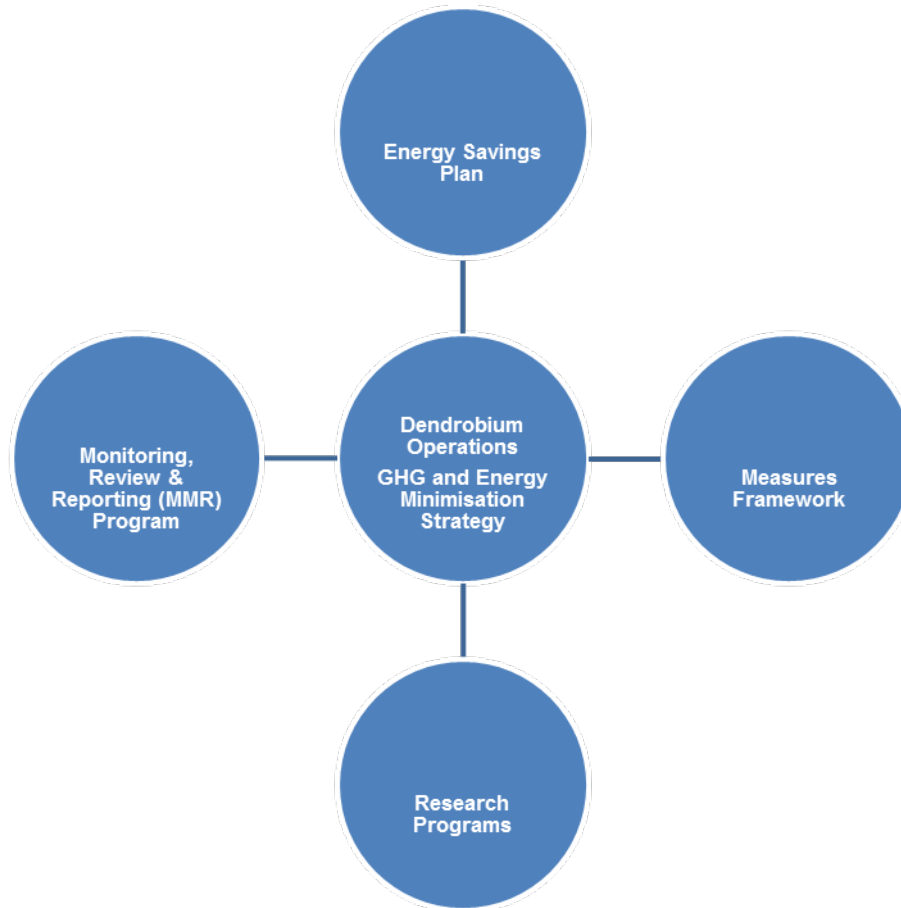


Figure 6: Dendrobium Operations GHG and Energy Minimisation Strategy

These key elements are discussed in more detail in the following paragraphs.

6.1 Energy Savings Plan

As a consequence of new equipment being installed to commence operations at the mine, negligible opportunity presents itself to date to upgrade the equipment as it was of the most reliable and fit for purpose equipment available at the time. Opportunities to upgrade equipment to improve performance and efficiency are dealt with as part of an item’s overall design lifecycle and maintenance / overhaul cycle.

Potential initiatives may present themselves as opportunities to be re-evaluated in the future as circumstances and operational requirements change and the equipment ages.

The existence of this Plan, the DEUS Energy Savings Action Plan and Corporate and Organisational goal setting provides for existing and new potential initiatives to remain in focus and documented for the site.

6.2 Measures Framework

This section describes the principles and processes (framework) for investigating and implementing GHG emissions and energy savings measures as per Condition 1 (d), Schedule 6 of the Development Consent.

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6.2.1 Energy Use

Where there is an opportunity to consider new and improved energy efficient apparatus and processes for new projects, equipment or upgrades, energy efficiency and cost effectiveness are evaluated as an integral part of the Project review and Project justification process.

Projects of significance are overseen by the IC's Project Review Committee (PRC) for effectiveness of implementation and deliverability of improvements expected.

Figure 7 outlines the framework for the investigation and implementation of energy efficiency measures at the Dendrobium operations. This framework details the process for reviewing, implementing and documenting initiatives related to energy efficiency.

FRAMEWORK – Investigation/Implementation of Energy Efficiency Initiatives

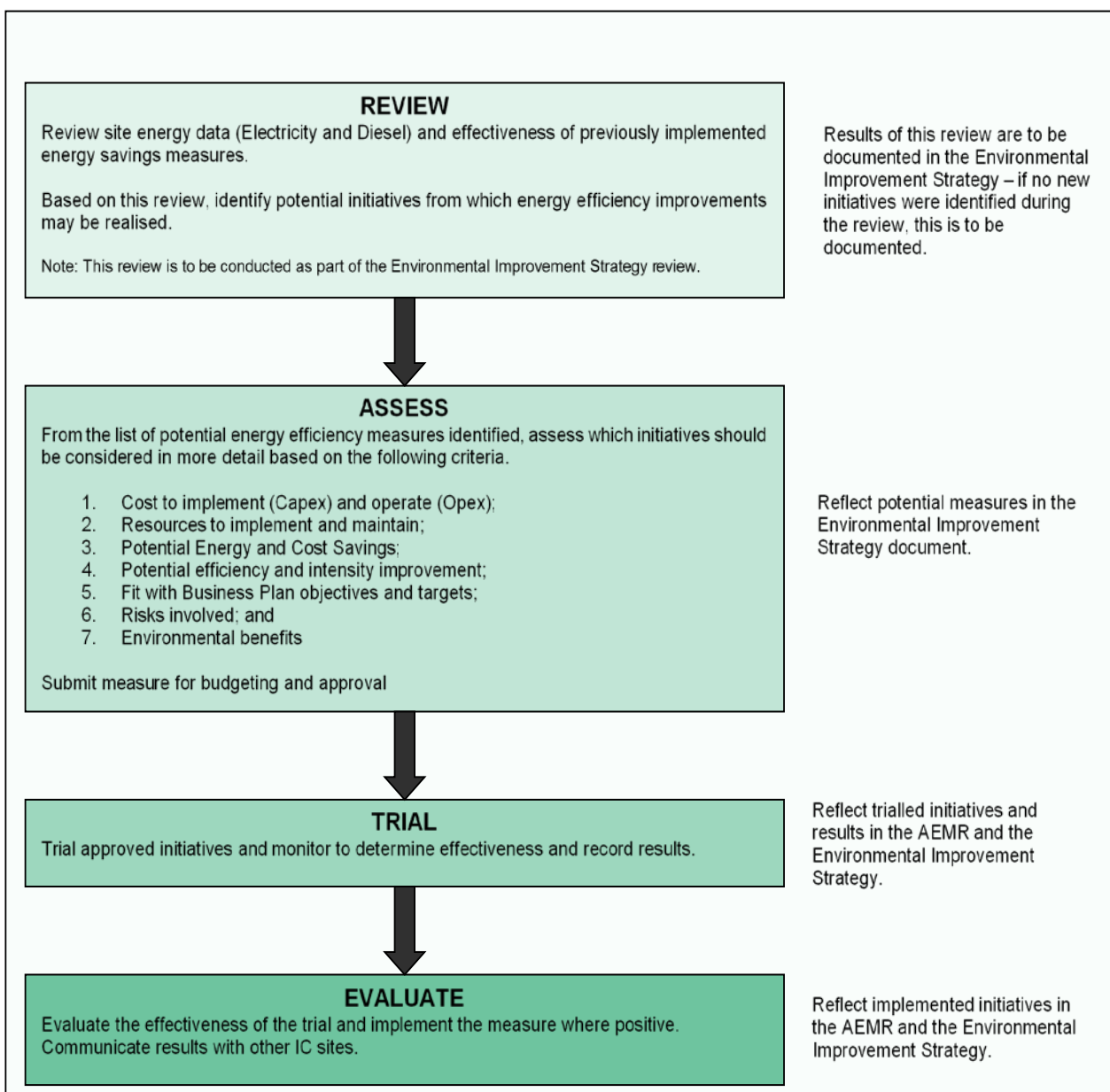


Figure 7: Framework – Identification/Implementation of Energy Minimisation Initiatives (Dendrobium)

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6.2.2 GHG Emissions

Dendrobium Mine does not have sufficient in-situ gas concentrations, gas volumes and gassiness to justify the use of a gas drainage facility. At this time, the Mine's ventilation fan system is sufficient to maintain low and safe operational gas levels underground.

As previously stated, the majority of GHG emissions (80 to 85%) are fugitive emissions associated with mine ventilation emissions to atmosphere. These emissions exhibit a routine methane concentration between 0.20 to 0.30% and 0.15 to 0.20% carbon dioxide, while producing at a rate of 3.5 to 4.0 Mt ROM production pa.

In 2017, Illawarra Coal commissioned a desktop review by the University of Newcastle to assess emerging ventilation air methane abatement technologies that could address South32's operational, environmental and social requirements.

Based on current and emerging technologies, the Mine's ventilation air methane concentration is not sufficient to make abatement practical or cost effective. Table 3 below summarises mitigation measures utilized at the Bulli Seam Operations at Appin.

Table 3: GHG Emission Minimisation

| Mitigation Action | Detail |
|-------------------------|---|
| Methane Drainage System | <p>Comprehensive methane drainage extraction infrastructure is in place above and below ground for the Appin mining domains. This infrastructure will be expanded to support future underground mining associated with the project.</p> <p>The extracted gas is beneficially utilised in the EDL Appin and Tower Power Plants. Utilisation of mine gas in the power generation projects results in the destruction of methane when utilised resulting in the release of carbon dioxide which has a Global Warming Potential (GWP) 28 times less than that of methane.</p> |
| Flaring | Where methane gas cannot be transferred to the power stations, it is flared to reduce its GWP. |
| Mine Safety Management | Gas Mine gas extracted by Mine Safety Gas Well means is either utilised, flared, or emitted under controlled conditions. |

South32 publicly report progress and encourage high standards of transparency and accountability in our business governance, risk and government interactions, this extends to the commitments made in the Climate Change Policy. Future actions taken to minimise GHG emissions will be reported in the Annual Report and published on the South32 website (listed below).

<http://www.south32.net/sustainability/sustainability-reporting>

6.3 Research Program

Due to the non-gassy nature of Dendrobium Mine, a majority of research into greenhouse gas abatement technologies has been focused at the Bulli Beam Operations (BSO).

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Research into Ventilation Air Methane (VAM) abatement technologies is currently being conducted by the CSIRO at the West Cliff Coal Preparation Plant. Using existing infrastructure, several methods for VAM abatement and capture are being tested. A description of each technology is summarised below.

- VAMCAT – Ventilation Air Methane Catalytic combustion is an electricity-producing gas turbine that can be powered with 0.8% methane.
- VAMMIT – Ventilation Air Methane Mitigator is a compact flow reversal reactor with a newly-structured regenerative bed. It can be operated with 0.3% methane in air for destruction.
- VAMCAP – Ventilation Air Methane Capture uses carbon composite absorbents to enhance VAM into a higher concentration gas. Captured gas can then be used for power generation or flared.

Potential research programs to inform the continuous improvement of the GHG minimisation measures for the Dendrobium operations include:

- Keep the Dendrobium Mine MVA abatement initiative on the Illawarra Coal GHG Abatement Cost Curve to ensure that opportunities are periodically assessed in consideration of newly developing technologies.

6.4 Monitoring, Review and Reporting Program

The monitoring, review and reporting associated with GHG emissions and energy consumption for the Dendrobium operations includes:

- Compliance with South32 Policy;
- Development Consent conditions;
- Monitoring and recording energy use and GHG emissions monthly;
- Correlation and compilation of energy and GHG data for monthly management review;
- Monthly reporting of energy and GHG data to South32;
- Assessing projects, initiatives and processes for opportunities for GHG and energy efficiency improvements;
- Evaluating projects for inclusion in operating and capital budgets;
- Evaluation and implementation of operational efficiency improvement projects;
- Corporate review of GHG and Energy data submitted for NGERS reporting purposes;
- Annual reporting of Energy and GHG data and performance within the Annual Review submitted to government and other stakeholders; and
- Establishment and implementation of GHG and Energy monitoring data capture and recording systems compliant with NGERS requirements.

In relation to reporting, Dendrobium accounts for all emissions and energy use as required by NGERS and as per reporting boundaries verified by legal advice.

GHG and energy consumption figures, performance and commentary are included in the Annual Review (AEMR) submitted to relevant agencies.

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7 REFERENCES

Department of Planning and Environment (2015) Notice of Modification – Dendrobium Development Consent

Energetics® Pty Ltd (2007) – Dendrobium Mine Energy Savings Plan

South32 Environment Standard

University of Newcastle – Emerging Ventilation Air Methane Abatement Technologies (2017)

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