Environment Protection Authority

Greenhouse Gas Mitigation Guide for NSW Coal Mines

March 2026

Acknowledgement of Country

The NSW Environment Protection Authority acknowledges the Traditional Custodians of the land on which we live and work, honours the ancestors and the Elders both past and present and extends that respect to all Aboriginal people.

We recognise Aboriginal peoples' spiritual and cultural connection and inherent right to protect the land, waters, skies and natural resources of NSW. This connection goes deep and has since the Dreaming.

We also acknowledge our Aboriginal and Torres Strait Islander employees who are an integral part of our diverse workforce and recognise the knowledge embedded forever in Aboriginal and Torres Strait Islander custodianship of Country and culture.

Aboriginal artwork by Worimi artist Gerard Black

Executive summary

This mitigation guide provides state-specific guidance on opportunities for NSW coal mines to reduce greenhouse gas emissions. It represents a significant step change in the way greenhouse gases are managed in NSW.

It is the first in a series of NSW Environment Protection Authority (the EPA) mitigation guides. The coal mining sector was prioritised because it emits 30% of NSW's methane emissions[1] and is the largest source of fossil methane emissions in NSW.[2] Unlike biogenic methane from the agricultural and waste sectors, fossil methane releases new carbon into the atmosphere that would have been trapped for millions of years. Methane warms the Earth much faster than carbon dioxide and so taking early action to reduce methane emissions will help to slow the rate of atmospheric warming.

This guide is drafted for a non-technical audience so that community members and the mining sector alike are clear on what measures are available and where they can and should be used.[3]

The mitigation guide sets out the greenhouse gas mitigation measures that existing coal mine environment protection licensees (licensees) and proponents of new coal mining projects and modifications must consider as part of their climate change mitigation and adaptation plans and planning applications.

Reducing fugitive methane emissions

Fossil methane is formed within coal seams and the surrounding rock formations. During mining, this gas can be released into the atmosphere.

In 2023, fugitive emissions from coal mining, which are mainly methane, made up about 8% of total NSW scope 1 greenhouse gas emissions. Around 77% of coal mine fugitive emissions were from underground coal mines, and about 23% from surface mines.[4]

All coal mines should be minimising fugitive methane emissions.

Gas drainage is the process of drilling holes into the coal seam and surrounding strata and draining a proportion of the gas. This reduces the amount of methane released into the ventilation air during mining operations. Destruction of drainage methane via flaring or utilisation is a cost-effective and mature technology at underground mines. Gas drainage and destruction of methane could also be feasible at some surface mines.

Underground mines routinely seal old workings for safety and to reduce methane in the ventilation air. However, these seals can degrade over time. Checking for leaks and addressing them is also a cost-effective and readily available abatement measure.

Following drainage and sealing, the ventilation air released from a NSW coal mine contains methane in the order of 0.1–1.0%. Ventilation air methane (VAM) abatement using regenerative thermal oxidisation (RTO) is a proven technology, routinely used overseas for treating VAM at concentrations above 0.3%, for example, in China and the United States. In Australia, the NSW West Cliff Ventilation Air Methane Project ran from 2007 to 2017 and treated VAM of 1% concentration. It

[1] NSW EPA 2025a, Improving Measurement of Fugitive Methane Emissions, NSW Environment Protection Authority, Parramatta

[2] NSW EPA 2025a, Improving Measurement of Fugitive Methane Emissions

[3] See the *Glossary of terms and abbreviations* section for meanings of terms and abbreviations used in this mitigation guide.

[4] NSW Net Zero Emissions Dashboard, Sharing and Enabling Environmental Data in NSW (SEED) data portal, NSW Government website, accessed 3 March 2026

utilised 20% of the available ventilation air to generate 6 megawatts of electricity using a steam turbine. It proved RTO units can operate reliably and safely while effectively mitigating VAM emissions.[5][6] VAM abatement at lower concentrations of 0.2–0.4%, as occur at many NSW mines, is technically feasible and is currently being trialled in Australia and overseas.

The EPA's minimum requirements for fugitive emissions abatement for the coal mining sector are set out in Table 1.

The timeframes in Table 1 are driven by technical feasibility and ensuring the 'gassiest', methane-rich mines are required to implement VAM abatement first.

If VAM abatement is not installed by the implementation date, the coal mine licensee will need to have sufficient monitoring data to demonstrate the requirement does not apply. The expectations on the level of evidence needed to be available to the EPA is set out in *Appendix A* (see section 7.1). This includes continuous monitoring of VAM concentration and ventilation flow rates.

Table 1 EPA requirements for fugitive emissions reductions at NSW coal mines

Requirements	Implementation phasing
Drainage gas	
Drainage gas with a methane concentration of greater than 30% must be flared or utilised at operational[(a)] underground mines that: • are located outside of the Western coalfields, and • emit ≥25,000 tonnes of carbon dioxide equivalent per year (t CO_2-e/year) scope 1 and 2	By **1 July 2027**
Leaks from old mine workings	
Methane entering ventilation air must be minimised by detecting and managing leaks from old mine workings at operational[(a)] underground mines that: • are located outside of the Western coalfields, and • emit ≥25,000 t CO_2-e/year scope 1 and 2	By **1 July 2027**
VAM abatement	
VAM abatement must be installed at operational[(a)] underground mines if: • the mine has consistently[(c)] greater than 0.20% VAM concentration, and – is operating after 2030, and – is located outside of the Western coalfields, and – emits ≥100,000 t CO_2-e/year scope 1	Underground mines that emit ≥1 million tonnes (Mt) CO_2-e/year must: • have VAM abatement in place on at least one shaft by **1 July 2030**, and • abate at least 75% of VAM emissions annually[(b)] from **1 July 2032** Underground mines that emit <1 Mt CO_2-e/year must: • have VAM abatement in place on at least one shaft by **1 July 2032**, and • abate at least 75% of VAM emissions annually[(b)] from **1 July 2034**

(a) See the *Glossary of terms and abbreviations* section for definitions.

(b) Note this is not cumulative. Year is financial year.

[5] DPIE 2021, Net Zero Industry and Innovation Program: Driving a clean industrial future, NSW Department of Planning, Industry and the Environment, Parramatta

[6] BHP Billiton 2008, West Cliff Mine Surface Goaf Drainage Greenhouse Gas Assessment, accessed 3 March 2026

(c) 'Consistently' means methane concentration does not drop below 0.20% for periods of 60 minutes or more during routine operation. See section 7.1, *Appendix A*.

Outcome-based alternative to gas drainage and VAM abatement requirements

If a coal mine licensee does not wish to comply with prescribed requirements for VAM abatement or drainage gas as described in Table 1, an outcomes-based alternative is available.

Any mine captured by these requirements may implement alternative onsite (scope 1) abatement that achieves the same level of emissions reduction, either at their own site or at another coal mine in NSW, not subject to the requirements. These actions must represent direct emissions reductions at a mine, not the purchase of offsets. The coal mine licensee would need to have evidence to substantiate the effectiveness of the alternative abatement in their climate change mitigation and adaptation plan or planning application. Alternative abatement can only include measures not already required by the NSW EPA.

Reducing diesel emissions

For surface mines, the main opportunity for emissions reduction in the medium term will be through reducing the use of fossil diesel fuel. In 2023, emissions from diesel equipment made up around 29% of scope 1 greenhouse gas emissions from the NSW coal mine sector.[7] Diesel vehicles and equipment are widely used at surface coal mines, and to a much lesser extent at underground mines.

The EPA encourages coal mine licensees to use low carbon alternatives to fossil diesel and to use low emissions vehicles and equipment at mines. Given the limited availability of appropriate technology and constraints on the capacity of the electricity grid, the EPA has not mandated electrification of coal mining vehicles and there are no mandates for low carbon liquid fuels at this time. However, reducing emissions from diesel remains an ongoing priority for the EPA and low carbon fuel mandates for the coal mining sector will continue to be investigated. The EPA will periodically review opportunities to support electrification of coal mining equipment as battery and hybrid technology improves.

EPA advice on proposals seeking extensions or modifications through the NSW planning system

The EPA expects that all coal mine proposals seeking extensions or modifications through the planning system commit to reducing emissions in line with NSW legislated targets. The pathway to achieving this will need to include avoiding and/or abating greenhouse gas emissions onsite and meeting the requirements in Table 1. The EPA will consider that any proposals that do not commit to avoiding or abating material amounts of greenhouse gas emissions onsite do not adequately address the expectations set out in the *NSW Guide for Large Emitters* and will advise the planning consent authority of this. [8] The EPA will be supportive of longer consent durations for proposals that include material onsite abatement.

Supporting the NSW legislated emissions reduction targets

The latest NSW emissions projections show that NSW is not on track to meet the state's legislated 2030 and 2035 emissions reduction targets.[9] The expectations set out in this guide will help support emission reductions and reduce the abatement gap, but it will not be enough to reduce the fossil methane emissions in line with NSW legislated emissions reduction targets. As a result, the EPA will

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[9] EMM 2025, Greenhouse Gas Mitigation Guide for NSW Coal Mines: Literature review and industry scan. See Figure 3.2 (estimates based on data from Cth DCCEEW 2023 and CSIRO 2024, in EEM 2025)

[8] NSW EPA 2025b, NSW Guide for Large Emitters – Guidance on how to prepare a greenhouse gas assessment as part of NSW environmental planning processes, NSW Environment Protection Authority, Parramatta

[9] NSW EPA, Climate, NSW State of the Environment 2024 website, NSW Environment Protection Authority, accessed 2 July 2025

continue investigating a range of tools that can further support the reduction of greenhouse gas emissions onsite at NSW coal mines.

This guide supports implementation of recommendations of the Net Zero Commission and the NSW Parliament's Joint Standing Committee on Net Zero. The Commission found that regulatory measures will be required to achieve measurable onsite abatement. [10] The Parliamentary Committee recommended that government consider implementing regulatory changes to encourage the earlier adoption of low emissions technologies.[11]

[10] NSW Government 2025, NSW Government Response to the Net Zero Commission 2024 Annual Report and the Parliamentary Inquiry Report by the Joint Standing Committee on Net Zero Future, NSW Climate and Energy Action website, accessed 2 July 2025

[11] NSW Net Zero Commission 2025, Coal Mining Emissions Spotlight Report December 2025, accessed 6 February 2025

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1

Background and overview

1.1 Background

The NSW Environment Protection Authority (the EPA) has a legal requirement to develop environmental quality objectives, guidelines and policies to ensure protection of the environment in NSW from climate change. This is a statutory duty that the EPA must discharge under the *Protection of the Environment Operations Act 1997*, as confirmed by a court judgement in 2021.

In 2023 the EPA published its *Climate Change Policy* and *Climate Change Action Plan 2023–26*.[12] These documents outline the EPA's regulatory approach and actions to address the causes and consequences of climate change in NSW. They support and build upon the NSW Government's climate change policies and initiatives, and assist with meeting the net greenhouse gas emission reduction targets enshrined in the *Climate Change (Net Zero Future) Act 2023*.

In early 2025, the EPA published the *NSW Guide for Large Emitters,* which requires proponents of large greenhouse gas emitting proposals to prepare a greenhouse gas assessment as part of the planning assessment process.[13] The EPA is also progressively requiring its large emitting licensees to report on their emissions and develop climate change mitigation and adaptation plans (CCMAPs), as described in the EPA's guidance document *Emissions Reporting and Climate Change Mitigation and Adaptation Plans*.[14]

To support the requirements of the *NSW Guide for Large Emitters* and CCMAPs, the EPA is producing separate guides on greenhouse gas mitigation for key industries. The first of these – this guide – is for the NSW coal mining sector. Proponents of coal mining activities will need to consider this mitigation guide when preparing their environmental impact assessments as part of the development approvals process. Existing coal mine licensees will need to develop a CCMAP that considers this mitigation guide and to implement mitigation measures at their premises.

This mitigation guide fills a gap in the available information on emissions abatement relevant to NSW coal mines by providing clear, state-specific, up-to-date and publicly available guidance on opportunities for coal mines in NSW to reduce their greenhouse gas emissions.[15]

See the *Glossary of terms and abbreviations* section for meanings of terms and abbreviations used in this mitigation guide.

1.2 Development of this mitigation guide

To support the development of the mitigation guide, the EPA has drawn on a range of information and feedback, including:

- **Literature review:** The EPA commissioned EMM Consulting to undertake a review covering both Australian and international literature. The *Literature Review and Industry Scan* covers coal

[12] NSW EPA 2023a, EPA Climate Change Policy, NSW Environment Protection Authority, Parramatta; NSW EPA 2023b, Climate Change Action Plan 2023–26, NSW Environment Protection Authority, Parramatta

[13] NSW EPA 2025b, NSW Guide for Large Emitters: Guidance on how to prepare a greenhouse gas assessment as part of NSW environmental planning processes, NSW Environment Protection Authority, Parramatta

[14] NSW EPA 2026, Emissions Reporting and Climate Change Mitigation and Adaptation Plans: Guidance for environment protection licensees, NSW Environment Protection Authority, Parramatta

[15] EMM 2025, Greenhouse Gas Mitigation Guide for NSW Coal Mines: Literature review and industry scan found that there is no comprehensive, publicly available guidance on reducing greenhouse gas emissions relevant to the NSW coal mining industry

mining processes and emission sources, existing guidance, existing and emerging measures for managing greenhouse gas emissions at coal mines, and methane utilisation.[16]

- **Industry Scan:** This involved interviews with coal mining companies and industry experts to determine the practical applicability of measures that were identified in the literature review, and to determine which measures were currently implemented and likely to be implemented in the short to medium term. The Industry Scan report is included in the literature review.[16]
- **Independent Expert Review Panel**: The EPA established an expert panel to review and provide feedback on the relevance and suitability of the mitigation guide to NSW coal mines.[17]
- **Climate change advisory groups:** The EPA shared drafts of this guide with its climate change advisory groups.[18]
- **Interviews with stakeholders:** This involved interviews with stakeholders identified by members of the EPA's climate change advisory groups.
- **Public consultation:** The EPA received 154 submissions on its 2025 regulatory proposals and this guide. The EPA also held two technical workshops with coal mines and businesses in the technology supply chain during public consultation. The outcomes of that consultation are available on the EPA's *Have Your Say – Climate Change Licensee Requirements* webpage.[19]
- **Additional reviews by independent experts**: These provided advice on the technical aspects of the ventilation air methane (VAM) abatement and gas drainage requirements.

1.3 Objectives of the mitigation guide

The objectives of this greenhouse gas mitigation guide are to:

- support NSW to meet its emissions reduction targets legislated under the *Climate Change (Net Zero Future) Act 2023*
- assist coal mining companies to prepare a greenhouse gas assessment report (a requirement of the *NSW Guide for Large Emitters*) and a CCMAP
- drive onsite abatement and outline the EPA's expectations in terms of the mitigation measures to be implemented at NSW coal mines.

1.4 Scope of the mitigation guide

The mitigation guide covers:

- underground and surface coal mines in NSW
- the mine design phase and planning processes and the active mining[20] phase
- all relevant greenhouse gases, focusing mainly on methane and carbon dioxide

[16] EMM 2025, Greenhouse Gas Mitigation Guide for NSW Coal Mines: Literature review and industry scan

[17] Stewart M, Williams R, Thompson S, Su S & Kook S 2025, Independent Expert Review Panel Report: Review of the EPA's draft Greenhouse Gas Mitigation Guide for NSW Coal Mines, and accompanying draft literature review, 14 April 2025

[18] NSW EPA, Climate Change Advisory Groups, NSW Environment Protection Authority website, accessed 29 May 2025

[19] NSW EPA, Have Your Say – Climate Change Licensee Requirements, NSW Environment Protection Authority webpage

[20] See the *Glossary of terms and abbreviations* section for definitions on mine phases.

- the EPA's expectations for scope 1 emissions, and general guidance for scope 2 and scope 3 emissions.

This mitigation guide does not:

- provide a detailed technical explanation of coal mining processes or greenhouse gas mitigation measures and technologies
- apply to emissions from closed or abandoned mines
- cover the *National Greenhouse Account Factors* or National Greenhouse and Energy Reporting (NGER) methods for estimating emissions
- cover corporate strategies and frameworks for reducing or disclosing emissions
- include detailed costs of mitigation measures
- cover strategies for the use and disclosure of offsets and carbon capture and storage[21]
- seek to address reductions in greenhouse gas emissions from the coal mining sector that are associated with reducing overall coal production in NSW.[22]

1.5 Overview of scope 1 emissions from NSW coal mines

Scope 1 (direct) greenhouse gas emissions from coal mines made up about 11% of NSW total emissions in 2023.[23] The main sources of scope 1 emissions from NSW coal mines are fugitive emissions (mainly methane) and diesel emissions (mainly carbon dioxide). These are considered in detail in section 2 and section 3, respectively.

Reducing fugitive methane emissions from coal mines is a priority for the EPA. Methane is approximately 28 times more effective than carbon dioxide at trapping heat in the atmosphere over a 100-year timeframe.[24] However, over a 20-year time frame it is approximately 82 times more effective.[25] This is due to methane's very short atmospheric lifetime (approximately 12 years), which means its greenhouse effect is concentrated in the short term. As methane warms the Earth much faster than carbon dioxide, reducing methane emissions is important for slowing the rate of atmospheric warming.

Limiting global warming to between 1.5°C and 2°C requires a 50% reduction in emissions by 2030 and net zero emissions by 2050.[26]

[21] Carbon capture and storage (CCS) technologies may have a role to play in abating residual carbon dioxide (CO_2) emissions from NSW coal mining activities in the future. However, this technology is outside the scope of this mitigation guide as there are a number of practical limitations with respect to their application to coal mines in NSW (e.g. no available storage sites for captured CO_2). These limitations are described in: EMM 2025, Greenhouse Gas Mitigation Guide for NSW Coal Mines: Literature review and industry scan. There is research and development currently underway for CCS technologies in the coal industry.

[22] The NSW planning process is the pathway that approves the level of coal production for individual coal projects. The EPA's regulatory functions do not involve amending development consents or setting strategic government policy direction on these matters.

[23] Australian Government, Australia's National Greenhouse Accounts – Emissions by state and territory, Cth Department of Climate Change, Energy, the Environment and Water website, accessed 29 May 2025; and Boulter et al. 2022, Non-road Diesel Engines – Cost-benefit analysis: final report, Cth Department of Climate Change, Energy, the Environment and Water, Canberra

[24] Australian Government, Global Warming Potential, Clean Energy Regulator website, accessed 29 May 2025

[25] IPCC 2021, Chapter 7: The Earth's energy budget, climate feedbacks, and climate sensitivity, in *Climate Change 2021: The Physical Science Basis*, Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Intergovernmental Panel on Climate Change, Cambridge and New York

[26] IPCC 2023, Climate Change 2023 Synthesis Report, Intergovernmental Panel on Climate Change, Geneva

The EPA is initially focusing on regulatory requirements for its licensees. Over time this will broaden to other sectors beyond the EPA's licensees and include analysing policy and regulatory options to support the broader economy adopt best practice emissions reductions. This work is being undertaken in collaboration with colleagues across the NSW Government.[27]

The coal mining sector is the largest source of fossil methane emissions in NSW.[28] Unlike biogenic methane from the agricultural sector, fossil methane releases new carbon into the atmosphere that has been trapped for millions of years. Of the fugitive emissions from coal mining in 2023, around 77% were from underground coal mines, while around 23% were from surface mines.[29]

Table 2 shows a breakdown of 2023 scope 1 greenhouse gas emissions from the NSW coal mining sector by source. Table 3 shows a breakdown of methane emissions across NSW as well as by the sectors licensed by the EPA.

Reducing methane emissions will significantly contribute to NSW achieving its target of net zero emissions by 2050 under the Climate Change (Net Zero Future) Act.[30]

Reducing diesel emissions from coal mines is also a priority for the EPA. Diesel emissions are known to adversely affect human health (e.g. they contribute to particle pollution) and contain carbon dioxide and short-lived climate pollutants.[31] Diesel vehicles and equipment are widely used at surface coal mines, and to a lesser extent at underground mines.

Table 2 Scope 1 greenhouse gas emissions from the NSW coal sector by source, 2023/24

Source	Greenhouse gas emissions (Mt CO_2-e/year)	Percentage of emissions from the coal sector	Percentage of total NSW emissions
Fugitive emissions from surface coal mines	2.1 Mt[(a)]	16%	2%
Fugitive emissions from underground coal mines	7.1 Mt[(a)]	55%	6%
Non-road diesel mining equipment (mainly from surface mines)	3.8 Mt[(b)]	29%	3%

Table notes:

Mt CO_2-e/year = million tonnes of carbon dioxide equivalent per year.

(a) Australian Government, Australia's National Greenhouse Accounts – Emissions by state and territory.

(b) Estimate based on data from: Australian Government, Australia's National Greenhouse Accounts – Emissions by state and territory. The non-road diesel portion for coal mines was estimated using: Boulter et al. 2022, Non-road Diesel Engines – Cost-benefit analysis: final report.

[27] NSW Government 2025, NSW Government Response to the Net Zero Commission 2024 Annual Report and the Parliamentary Inquiry report by the Joint Standing Committee on Net Zero Future

[28] NSW EPA 2025a, Improving Measurement of Fugitive Methane Emissions

[29] Australian Government, Australia's National Greenhouse Accounts – Emissions by state and territory

[30] The EPA's fugitive methane fact sheet provides more information about the importance of reducing methane emissions and actions the EPA is taking to address these emissions. See: NSW EPA, Fact Sheet: Fugitive Methane, NSW Environment Protection Authority website, accessed 29 May 2025

[31] Diesel emissions contain **black carbon** (a component of fine particulate matter), which is a short-lived climate pollutant. Diesel emissions also contribute to the formation of **tropospheric ozone**, which is also a short-lived climate pollutant.

Table 3 Methane emissions from NSW and EPA licensees by sector

Sector	Methane emissions in NSW (Mt CO_2-e/year)[a]	Percentage of NSW methane emissions[a]	Methane emissions from EPA licensees (Mt CO_2-e/year)[a/b]	Percentage of methane emissions from EPA licensees[b/c]
Coal mining	9.9 Mt	30%	9.0 Mt	58%
(Underground)	(8.2 Mt)	(25%)	(7.1 Mt)	(46%)
(Surface)	(1.7 Mt)	(5%)	(1.8 Mt)	(12%)
Landfills and wastewater treatment	4.2 Mt	13%	4.2 Mt	27%
Agriculture	16.9 Mt	51%	1.0 Mt	6%
Oil and gas	0.6 Mt	<2%	0.5 Mt	3%
Other (electricity generation, stationary energy, etc.)	1.9 Mt	6%	0.8 Mt	5%

Table notes:

Mt CO_2-e/year = million tonnes of carbon dioxide equivalent per year.

(a) Australian Government, Australia's National Greenhouse Accounts – Emissions by state and territory for 2023/24.

(b) Australian Government, Australia's National Greenhouse Accounts – Emissions by state and territory for 2021–22.

(c) NSW EPA 2025a, Improving Measurement of Fugitive Methane Emissions for 2021–22.

2

Scope 1 emissions: fugitive methane

2.1 Fugitive methane emissions at NSW coal mines

As NSW underground coal mines contribute significantly more methane emissions than surface mines, many of the measures in this section focus on underground mines.

The amount of methane that is released from mines depends on several factors, including the depth of the coal seam, gas content, its permeability and thickness. As a result, there is considerable variability in the amount and concentration of methane from seam to seam. The level of methane concentration influences the effectiveness and technical viability of mitigation measures.

Methane is explosive in concentrations of 5–15% in air and poses a serious safety risk, particularly in active underground mines. There are health and safety statutory requirements for the control and monitoring of methane levels at underground coal mines intended to mitigate safety risks.[32]

2.2 Mitigation measures for fugitive methane

Most methane mitigation measures described in this mitigation guide involve the oxidation of methane. This means turning methane into carbon dioxide and water by reacting it with oxygen. Oxidation significantly reduces the overall global warming potential of the mine gas. However, oxidation does not *eliminate* greenhouse gas emissions completely because carbon dioxide is still ultimately released to the atmosphere.

The most effective approach to minimising methane emissions is to make a comprehensive plan at the mine design phase for the management of all sources of mine gas from the premises over the life of the mine.

A comprehensive plan for gas management could include, for example, planning for progressive gas drainage, the flaring or utilisation of methane in drainage gas, optimised mine ventilation, the destruction of methane in ventilation air, identification and management of gas in areas 'outbye' (away from) active (operational) mining, and gas management during the mine closure process. In large quantities, methane has the potential to be a resource (e.g. to generate electricity), rather than just a waste product.

2.2.1 Flaring or utilisation of drainage gas

Gas drainage is the process of drilling holes into the coal seam and surrounding strata and draining a proportion of the gas. This reduces the amount of methane released into the ventilation stream during mining operations. Gas drainage can occur at all phases of the mining process. Venting may be required from time to time for safety or maintenance reasons. Drainage does not occur at some NSW mines where the coal seam gas can be effectively managed through mine air ventilation. In the Hunter Valley and South Coast, coal seam gas can vary from 1–24 cubic metres per tonne (m^3/t).[33]

Methane in drainage gas at high enough concentrations can be destroyed by combustion using flaring or using the methane for beneficial purposes, such as energy generation.

[32] See NSW Government 2022, Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 (section 76 Control and monitoring of methane levels)

[33] Hodgkinson JH, Pinetown KL, Wilkes PG, Khanal M, Rachakonda PK & Marvanek SP (2015) Product 1.2 Resource assessment for the Hunter subregion, part of the Bioregional Assessment Program of coal and coal seam gas in the Northern Sydney Basin bioregion, Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia, Australia

Gas drainage for the purposes of flaring or utilisation is potentially feasible at 'gassy' mines[34] with thick (>3 m) coal seams, where the concentration of methane in the seam gas is greater than 5 m^3/t; and where methane concentrations in the subsequent drainage gas are greater than 30% (with the balance being carbon dioxide).

If the drainage gas has a methane concentration below 30%, it is likely to be difficult to combust. Combustion viability improves with increasing drainage gas methane concentration above 30%.[35]

The EPA encourages mines to prioritise the utilisation of methane wherever feasible, recognising that this is dependent on the quality, quantity and variability of gas being drained. Where utilisation is not possible, flaring represents a viable abatement option.

Flares may be either open 'candlestick' flares or enclosed (ground) flares. While enclosed flares are more expensive than open flares, they consistently achieve higher destruction efficiency. The EPA encourage mines to prioritise the use of enclosed flares and achieve a destruction efficiency that is as high as possible.

Many NSW mines currently flare or utilise their drainage gas, or have plans to do so. Some mines have high levels of carbon dioxide in the drainage gas, making flaring difficult. The volume and composition of gas extracted can vary significantly over the course of the mining process.

The EPA's requirements for the flaring and utilisation of drainage gas are set out in Table 1 of the *Executive summary*.

Coal mine licensees that deem flaring not feasible at their site must collect and maintain appropriate evidence to demonstrate they are not captured by the EPA's requirement. *Appendix B* (see section 7.2) sets out the information that would need to be made available to the EPA on request to validate an exclusion from this requirement.

At the time of publication, there were no examples of routine gas drainage at NSW surface mines. However, there are pilot projects underway using newer horizontal drilling techniques. Some NSW surface mines are considering modifications to mine deeper coal seams, which can contain higher methane gas concentrations and volumes, depending on site conditions. Gas drainage in these circumstances should be prioritised. If this is not feasible, then the disturbance of the seam should be avoided.

2.2.2 Ventilation air methane at underground mines

Methane is explosive in concentrations of 5–15% in air and poses a serious safety risk. To manage this issue, underground mines must inject sufficient fresh air to dilute methane concentrations to provide safe working conditions and to reduce the risk of explosions. To achieve this, the diluted gas is exhausted from the mine and diverted to the surface through large-scale ventilation systems. Any methane in this ventilation air is referred to as ventilation air methane (VAM).

VAM is exhausted from ventilation shafts at low concentrations, typically in the range of 0.1–1.0%, which requires accurate measurement.

[34] In NSW, gassy coal mines (with a higher methane content), are typically located in the Central, Southern, Newcastle and parts of the Lower Hunter coalfields, although some mines in the Upper Hunter and Gunnedah coalfields are also gassy. Coal seams in the Western coalfields generally have a lower methane and gas content due to geology.

[35] Personal communication EPA's expert panel; and CSIRO 2024, A Techno-economic Analysis of Coal-mine Fugitive-emission Reduction Strategies in Australia, October 2024, Commonwealth Scientific and Industrial Research Organisation, Canberra

The *Work Health and Safety (Mines and Petroleum Sites) Act 2013* and the Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 contain stringent safety requirements for mine ventilation.[36] Mines are also required to develop a ventilation control plan under this Regulation.[37]

Avoiding VAM

Fix methane leaks from old mine workings and seals

Methane emissions from old mine workings within active mining leases can make up a significant proportion (greater than 60%)[38] of VAM. Seals put in place can leak over time. To reduce the methane, the licensee can identify methane leaks in old mine workings (outbye, or away from, active mining panels) and prioritise the higher leakage sources for resealing and/or using ventilation balance methods. This method can be assessed and implemented relatively quickly and is likely to have a significant impact on reducing emissions (greater than 20%). This is a common activity at many NSW mines. In the older underground mines with extensive old mine workings, it is potentially one of the most cost-effective abatement measures available.

Destroying VAM

VAM regenerative thermal oxidation

Destroying VAM can significantly reduce greenhouse gas emissions from gassy underground mines. The only existing method for destroying VAM at the time of writing is regenerative thermal oxidation (RTO).

The West Cliff Ventilation Air Methane Project (WestVAMP) in NSW was the world's first commercial-scale VAM-to-power facility, running from 2007 to 2017.[39,40] It featured four VOCSIDIZER™ RTO units treating about 70 cubic metres per second (m^3/s) of ventilation air (20% of shaft flow), generating 5.8 megawatts (MW) gross power via steam turbine and delivering 300,000 megawatt hours (MWh) of electricity while abating about 2 million t CO_2-e over its life.[41] The West Cliff project increased the methane concentration in ventilation air to about 0.9–1.1% for the power generation by injecting drainage gas into the air when required.[42]

At the very large Buchanan Mine Complex in Virginia USA, Coronado first installed an RTO unit for VAM abatement in 2022 and installed a second unit in 2024. [43,44] The VAM concentrations at Buchanan range from 0.3–1.2%.[45]

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[36] These requirements include that methane concentrations in the general body of air must not exceed 2% by volume. See NSW Government 2022, Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 (section 76 Control and monitoring of methane levels)

[37] NSW Government 2022, Work Health and Safety (Mines and Petroleum Sites) Regulation 2022, (section 62 Ventilation systems); NSW Resources Regulator 2021, Technical Reference Guide: Ventilation Control Plan – Guide for the development of a ventilation control plan for underground mines, Department of Regional NSW

[38] This is variable but can be up to 80% (EPA's expert panel and NSW Resources).

[39] US EPA 2019, Ventilation Air Methane Utilization Technologies, US Environmental Protection Authority, Coalbed Methane Outreach Program, accessed 23 February 2026

[40] DPIE 2021, Net Zero Industry and Innovation Program: Driving a clean industrial future

[41] Somers JM & Schltz HL 2010, Coal Mine Ventilation Air Emissions: Project development planning and mitigation technologies, 13th United States/North American Mine Ventilation Symposium, 2010

[42] BHP Billiton 2008, West Cliff Mine Surface Goaf Drainage Greenhouse Gas Assessment

[43] Somers JM & Schltz HL 2010, Coal Mine Ventilation Air Emissions: Project development planning and mitigation technologies

[44] Coronado Global Resources 2025, Emissions Reduction, Coronado website, accessed 23 February 2026

[45] Biothermica 2025, VAMOX® Full Scale FTO Technology for the Abatement of VAM Emissions, International Best Practices Workshop on CCM Abatement and Fossil Fuel Regulatory Programme for the Coal Sector, Kazakhstan, July 21–22 2025, accessed 23 February 2026

RTO can technically treat VAM down to 0.2% concentration, depending on RTO unit supplier.[46,47,48,49,50,51,52] Some NSW mines operate consistently below 0.2% VAM concentration. For these mines, RTO is not feasible without enriching the VAM or adding another fuel source, which adds to the complexity of safety issues, emissions and cost.

The EPA's requirements for VAM abatement are set out in Table 1 in the *Executive summary*. The requirements apply to mines with consistently greater than 0.20% methane concentration. The highest emitting, methane-rich mines are to implement VAM abatement first. 'Consistently' means that the methane concentration does not drop below 0.20% for periods of 60 minutes or more during routine operation (see *Appendix A*, section 7.1) Development consent may also not be required, refer to Box 1 for more information.

If VAM abatement is not installed by the implementation date, the mine licensee will need to have sufficient monitoring data to demonstrate the requirement does not apply. The expectations on the level of evidence the EPA will be expecting are set out in *Appendix A* (see section 7.1). This includes continuous monitoring of VAM concentration and ventilation flow rates.

The VAM abatement requirement starts with the licensee having abatement equipment in use on at least one shaft and then scaling up to full operation over two years. There is no specific requirement as to the level of methane to be abated in the first year of implementation.

The abatement equipment must treat at least 75% of VAM each financial year, two years on from initial implementation. While RTOs are 95–98%[53,54] effective at destroying the methane, it will not be possible for the units to operate 100% of the time nor treat 100% of the ventilation air. The minimum 75% provides pragmatic leeway for such eventualities.

In 2025, GM3's Appin Coal Mine received planning approval to trial a VAM RTO plant on ventilation shaft 6. It will abate about 36,000 t CO_2-e per year, which is about 4% of the emissions from that shaft.[55] Construction is expected to take about 12 months and trial results are expected to be available in 2027–28.

Suppliers of RTO units have indicated that mines should have information about the characteristics of their ventilation air and flow rates over a period of 12 months to ensure that an RTO system can be designed for the site-specific conditions. Mines are encouraged to start the necessary data collection well before the requirement implementation date. More information can be found in *Appendix A* (section 7.1). If an RTO is to be implemented, then dust characterisation data, as well as

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[46] UNECE 2026, 21st Session of the Group of Experts on Coal Mine Methane and Just Transition, 27–28 April 2026, Geneva, accessed 4 March 2026

[47] Kestrel Coal Resources n.d., Decarbonisation Strategy: A legacy worth leaving, Kestrel Coal Resources, Brisbane, accessed 23 February 2026

[48] Gosiewski K & Pawlaczyk A 2014, 'Catalytic or thermal reversed flow combustion of coal mine ventilation air methane: What is better choice and when?', *Chemical Engineering Journal*, 238:78–85, accessed 24 February 2026

[49] Mao MM, Shi JR, Liu YQ, Gao M & Chen Q 2020, 'Experimental investigation on control of temperature asymmetry and nonuniformity in a pilot scale thermal flow reversal reactor', *Applied Thermal Engineering*, 175:115375, accessed 24 February 2026

[50] Zheng B, Liu YQ, Sun P, Meng J & Liu RX 2019, 'Dehydrogenation characteristics of lean methane in a thermal reverse-flow reactor', *International Journal of Hydrogen Energy*, 2019, 44:5137–5142, accessed February 2026

[51] Lan B, Li YR, Zhao XS & Kang JD 2018, 'Industrial-scale experimental study on the thermal oxidation of ventilation air methane and the heat recovery in a multibed thermal flow-reversal reactor', *Energies*, 11:1578, accessed February 2026

[52] Gosiewski K, Pawlaczyk A & Jaschik M 2012, 'Thermal combustion of lean methane — Air mixtures: Flow reversal research and demonstration reactor model and its validation', *Chemical Engineering Journal*, 2012, 207–208, 76–84, accessed February 2026

[53] Kestrel Coal Resources n.d., Decarbonisation Strategy: A legacy worth leaving

[54] UNECE 2026, 21st session of the Group of Experts on Coal Mine Methane and Just Transition

[55] Planning NSW 2025, MOD 4 – VAM Abatement Project, Campbelltown, NSW Government website, accessed 6 February 2026

gas composition and variability data, is needed to inform the RTO design. This is also included in *Appendix A*.

The EPA will review these requirements regularly to take account of the outcomes of current trials and any advances in RTOs that may bring down the operational threshold for VAM abatement.

Box 1. Development consent for RTO unit installation

In certain circumstances it is possible for RTO units to be installed without development consent and assessed under Part 5 of the *Environmental Planning and Assessment Act 1979*. If a licence variation is required, the licensee would prepare information that addresses the matters in section 45 of the *Protection of the Environment Operations Act 1997*.

Emerging VAM abatement options

Emerging methods include regenerative catalytic oxidation (RCO), and VAM enrichment with utilisation (see Table 4). These emerging VAM mitigation measures are not likely to be practical without many more years of research.

Table 4 Emerging methods for destroying VAM at underground mines

Method	Description	Status
Regenerative catalytic oxidation (RCO)	RCO differs to RTO only with respect to the use of a catalyst. The VAM is passed over the catalyst, typically made of precious metals like platinum and palladium, which allows the methane to oxidise at a lower temperature (e.g. 350–650°C). RCO can also operate at lower VAM concentrations than RTO. RCO may be the only option for some NSW mines with very low minimum VAM concentrations.	RCO technology is considered to be in the research and development to pilot-scale demonstration stage. There have been pilot-scale trials of a modified (catalytic) version of CSIRO's VAMMIT system at Appin Coal Mine in NSW.[(a)] A collaborative project between Mining3 and Low Emission Technology Australia aims to develop catalytic oxidation technology for mitigating low-concentration VAM.[(b)] [56] RCO technology may have fewer safety challenges, compared to RTO, due to the lower operating temperatures.
VAM enrichment and utilisation	'VAM enrichment' refers to technologies that separate methane and increase its concentration, enabling its recovery and use (e.g. to generate electricity).	VAM enrichment is an emerging technology in the research and development stage.

Table notes:

(a) EMM 2025, Greenhouse Gas Mitigation Guide for NSW Coal Mines: Literature review and industry scan.

(b) LETA 2025, Mining3 Catalytic VAM Abatement Commercialisation Program, Low Emissions Technology Australia website, accessed 12 February 2026.

Mines in suspended operations

During suspended operations (as defined in the *Glossary*), ongoing access to underground workings is needed. Air flow and ventilation to the underground is needed to ensure that the underground mine is a safe working environment. However, ventilation fans may be operated at a lower air throughput (speed). The *Best Practice Guidance on Ventilation Air Methane* provides examples of measures to keep the VAM concentration at or above the minimum level required for mitigation.[57] These include taking actions to reduce the volume of air moved by the main ventilation fans while still maintaining full safety in all parts of the mine. Such actions could include shutting off certain parts of the mine or increasing the efficiency of the air flow in other ways.

2.2.3 Progressive mine capping and sealing at underground mines

Once active (operational) coal mining has finished at a site, fugitive emissions can potentially still occur via seals/shafts, venting pipes, shaft covers, surface cracks and geological discontinuities. Without proper sealing, fugitive emissions can continue to be emitted for decades. Emissions can initially be high following mine closure, but they will decline gradually over time as the source decays or once the shaft is submerged under water.[58]

The most effective way to reduce emissions once mining operations have finished is to allow natural mine flooding through ground water infiltration. This is standard industry practice. However, mines can take from a few years to decades to completely flood, and over this time gas may escape if not sealed and closed.

[56] LETA 2025, Mining3 Catalytic VAM Abatement Commercialisation Program, Low Emissions Technology Australia website, accessed 12 February 2026

[57] UNECE 2025, Best Practice Guidance on Ventilation Air Methane, United Nations Economic Commission for Europe, Geneva

[58] UNECE 2021, Best Practice Guidance for Effective Management of Coal Mine Methane at National Level: Monitoring, reporting, verification and mitigation, United Nations Economic Commission for Europe Energy Series No. 71, United Nations Economic Commission for Europe, Geneva

In NSW, once active (operational) coal mining has finished at a site, the mine must progress through a mine closure process with the end result being that the mine is completely sealed. Ventilation shafts and other openings can be sealed by filling them with gravel or concrete. Mine workings can also be temporarily capped as mining progresses across the site.

The Work Health and Safety (Mines and Petroleum Sites) Act and the Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 contain stringent safety requirements for mine sealing that must be undertaken before a mining lease can be relinquished.[59]

Mine sealing is considered a 'high risk activity' under the Regulation, and mining companies must comply with stringent guidelines for methane management.[60]

Monitoring and gas capture can continue in mines going through the closure process up until the final seals are put in place.

Some decommissioned mines are required to report emissions under the National Greenhouse and Energy Reporting Scheme (NGERS).[61] Emissions could be material depending on a number of factors, such as the gassiness of the mine, time since decommissioning and the proportion of mine void flooded.[62]

Mines with suspended operations must retain active monitoring and ventilation controls. Parts of active mines may be progressively capped (temporarily sealed), however, the mine retains the capability to monitor and capture emissions.

During consultation it was noted that addressing gas leakage from outbye workings was one of the most expedient ways mines can reduce emissions. Feedback from industry indicated that capping and sealing outbye workings was a standard practice, however these seals degrade over time. This is why the EPA will be placing requirements on active operational coal mines emitting greater than or equal to 25,000 t CO_2-e/year to detect and manage gas leakage from old workings by 2027. Mine sealing can produce environmental issues such as saline seeps which give rise to water pollution and needs to be carefully considered. There are cases where flooding of old mine workings resulted in acid mine drainage and saline seeps which required solutions like water treatment plants. The NSW Resources Regulator has detailed guidance on groundwater and surface water management through the mine rehabilitation process that must be followed.[63]

[59] General safety obligations for mine operators are set out in the *Work Health and Safety (Mines and Petroleum Sites) Act 2013*. Specific requirements for mine sealing are set out in clause 71 of the Work Health and Safety (Mines and Petroleum Sites) Regulation 2022.

[60] NSW Resources Regulator 2024a, Guide – Notifying the Regulator of a high risk activity, NSW Department of Primary Industries and Regional Development, Queanbeyan

[61] Australian Government, National Greenhouse and Energy Reporting Scheme, Clean Energy Regulator website, accessed 29 May 2025

[62] CER 2025, Estimating Emissions and Energy From Coal Mining Guideline, Clean Energy Regulator, Canberra

[63] NSW Resources Regulator 2024b, Guidance Note – Groundwater and surface water, NSW Department of Primary Industries and Regional Development, Queanbeyan

2.3 Outcome-based alternative to flaring and VAM abatement requirement

If a mine licensee does not wish to comply with requirements for VAM abatement and/or flaring, an outcomes-based approach is available as an alternative to the prescriptive abatement requirements set out in Table 1 in the *Executive summary*.

Any mine licensee captured by these requirements may implement alternative onsite (scope 1) abatement that achieves an equivalent level of abatement at their mine site or another mine instead of meeting the requirements.

These actions must represent direct emissions reductions at a mine, not the purchase of offsets. The mine licensee would need to have evidence to substantiate the effectiveness of the alternative abatement in their CCMAP or planning application. Alternative abatement can only include measures not already required by the NSW EPA. Any abatement from VAM RTO installation over and above the minimum 75% cannot be used as abatement for another site. Abatement can include closed mine emissions abatement and low carbon liquid fuel use.

This allows mine licensees the flexibility to tailor their onsite abatement to their individual circumstances and direct funding to the most cost-effective abatement, while giving assurance that the same level of greenhouse gas mitigation will occur across the coal mining sector.

Since VAM is a very large emission, it will be necessary to work with other mine operators to reach the level of abatement prescribed. Licensees will need to provide evidence to substantiate the effectiveness of the alternative abatement in their CCMAP.

2.4 Continuous emissions monitoring at underground coal mines

Methane concentrations in ventilation air are highly variable. Currently, under NGERS, mine operators have the option to do periodic or continuous emissions monitoring to estimate their fugitive methane emissions. Accuracy is defined by the Clean Energy Regulator as neither over- nor under-estimating the true values at a 95% confidence interval.[64]

Effective management of VAM requires accurate monitoring because of the very low methane concentrations involved. The EPA understands that many coal mine licensees have already implemented continuous, highly accurate monitoring of methane concentrations in ventilation air for safety reasons. However, there may be other mines emitting large amounts of greenhouse gas emissions where upgrades to infrastructure to enable more frequent or continuous monitoring of emissions would reduce uncertainty associated with VAM emissions and provide a higher level of confidence in VAM emissions measurement data. Upgrading of such infrastructure was a recommendation of the CSIRO.[65] The EPA will work with individual mines and place specific emissions measurement requirements on licences where warranted.

[64] CER 2025, Estimating Emissions and Energy From Coal Mining Guideline

[65] NSW EPA 2025a, Improving Measurement of Fugitive Methane Emissions

3

Scope 1 emissions: diesel combustion

3.1 Diesel emissions at NSW coal mines

Diesel engines are used at mines because they are durable, reliable and flexible; and they cover a wide range of capacities and rated power. Large vehicles and equipment include haul trucks, bulldozers, excavators, loaders and graders. Various smaller diesel vehicles and equipment are also used at underground and surface coal mines, including loaders, forklifts, trucks, generators, compressors, pumps and drills.

Coal extraction, processing and transport involves the combustion of significant quantities of fuel. The hauling of overburden and coal at surface mines accounts for the largest proportion of diesel use in the coal mining sector.

3.2 Mitigation measures for diesel combustion emissions

Broadly, mitigation measures involve reducing diesel consumption through a range of efficiency measures, transitioning to vehicles and equipment with higher emissions standards, switching to low carbon fuels, and electrification.

3.2.1 Standard industry measures

NSW mining companies have already implemented various mine planning measures to improve operational efficiency, which reduces diesel fuel consumption (and costs) while also reducing greenhouse emissions. Companies routinely review the effectiveness of these measures and make adjustments where necessary to minimise diesel consumption. These standard measures are considered to be minimum requirements and include:

- **Mine layout planning**, such as designing haul routes to minimise energy consumption (e.g. shorter route lengths, reducing gradients and avoiding unnecessary stops).
- **Haul road management**, such as regular maintenance to ensure that gradients and rolling resistance are minimised.
- **Vehicle fleet planning**, such as:
  - procurement that prioritises fuel efficiency at the vehicle level (e.g. more efficient engines, use of lightweight materials), and that prioritises fit-for-purpose vehicles
  - tailoring the overall fleet to minimise fuel consumption (e.g. larger, more efficient diesel haul trucks can reduce the amount of fuel required per tonne of material hauled).
- **Operational efficiency measures**, such as:
  - scheduling operations to minimise material handling
  - payload management (i.e. so that haul trucks carry the optimal amount of material to maximise fuel efficiency – and potentially reduce the number of trucks needed in the fleet)
  - trip planning, vehicle utilisation planning and vehicle rationalisation.
- **Equipment maintenance** in accordance with manufacturers' specifications.
- **Minimising engine idling** for vehicles and equipment.
- **Driver training** to minimise fuel consumption.

The EPA is also working with NSW coal mine operators to bring emissions standards for non-road diesel equipment into line with global best practice and to encourage the uptake of cost-effective low emission technologies in NSW.

In 2026, the EPA intends to introduce licence conditions that require coal mines to transition to non-road diesel equipment that meets **US EPA Tier 4 final** emissions standards as a minimum or better (e.g. low emissions equipment) for all non-standby vehicles and equipment used on the surface of the mine.[66] This is an outcome of the NSW EPA's 2024 public consultation on the regulation of coal mines in NSW.[67]

3.2.2 Electrification

There has been significant research and development into electrification of mine vehicles and equipment, including the trialling and procurement of battery electric vehicles, fuel cell electric vehicles and diesel-electric hybrid vehicles. In addition to reducing diesel emissions at mine sites, electric vehicles are likely to have reduced maintenance costs and improved reliability, and form a clearer pathway to future automation. Some of the main developments are currently taking place at iron ore mines. For example, Fortescue and Liebherr Mining have announced a partnership to jointly develop autonomous haulage at iron ore mines, including an intention to use fuel cell and battery electric technology.[68] Technology for battery electric vehicles of the size used at NSW coal mines is not at the same level of maturity or trial stage.

Battery electric and hybrid vehicles

Electric trucks and loaders for **underground mines** have been on the market for several years, with a slow but steady adoption.[69] The batteries for underground haul trucks do not require a capacity of more than 500 kWh, making them easier to electrify than surface haul trucks.

For the large haul vehicles used in **surface coal mining**, there is future potential for on-board battery power or hybrid technology to replace or reduce diesel. Surface haul trucks would need large batteries (1.5–1.6 MWh capacity) and cooling systems. However, grid capacity in many regional areas is not currently sufficient to support charging large battery mine vehicles. The cost of batteries, cooling system, charging infrastructure, long downtime during charging and battery swapping stations are also challenges.[70]

Diesel-electric hybrid vehicles, which are at a similar maturity level, may provide the flexibility that coal mine operations require, without burdening the electricity grid.

Hydrogen fuel cell electric vehicles

Hydrogen fuel cells convert chemical energy from hydrogen and oxygen into electricity through electrochemical reactions, producing only water and heat as by-products.

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[66] US EPA 2004, Control of Emissions on Air Pollution from Nonroad Diesel Engines and Fuel: Final rule, Federal Register, Vol. 69, No. 124, 29 June 2004, US Environmental Protection Agency

[67] NSW EPA, Regulation of Coal Mines, NSW Environment Protection Authority website, accessed 29 May 2025

[68] Fortescue 2024, Fortescue signs US$2.8 billion green equipment partnership with Liebherr for zero emission mining solutions, ASX release, 25 September 2024

[69] IDTech EX 2024, Electric Vehicles in Mining 2024-2044: Technologies, Players, and Forecasts, IDTechEX webpage, accessed 29 May 2025

[70] FBICRC 2023, An Overview of Australia's Mining Vehicle and Mining Equipment Electrification, Future Battery Industries Cooperative Research Centre Ltd, Bentley, WA

The electricity powers the electric motor that drives the vehicle. Manufacturers and mining companies are researching and developing various hydrogen fuel cell technologies. Potential barriers to the uptake of fuel cell electric vehicles include cost, the lack of renewable hydrogen supply and suitable vehicles, low durability, high hydrogen purity requirements and safety issues associated with onsite hydrogen storage.

Hydrogen fuel cell technology is at the demonstration stage.

Cable-tethering

Cable-tethering involves the connection of electrical equipment to a fixed power supply via a cable. This may be feasible for fixed mining equipment, or vehicles that do not need to cover large distances. However, the use of tethering can be challenging at surface mines (e.g. where haul trucks at surface mines need to travel large distances).

Cable-tethering is a mature technology. The Industry Scan found some examples of large equipment at NSW surface mines that are cable-tethered, such as draglines and shovels.[71]

3.2.3 Low carbon fuel substitution

Low carbon fuels (e.g. biodiesel, renewable diesel, renewable methanol, renewable hydrogen and methane utilisation) can help to reduce greenhouse gas emissions from coal mining by replacing fossil diesel.[72] They are existing, available technologies and may need to act as an interim measure while electrification develops. The cost of these fuels can vary significantly based on feedstock, logistics and production technology.

Biodiesel

Biodiesel (produced from vegetable oils and waste fats) has been available for several decades and is produced at a number of production facilities on the east coast of Australia. It can be blended with fossil diesel at a 5% blend with minimal risk of engine operability issues for all engines. In some large mining vehicle engines, use of up to 20% biodiesel is within the engine manufacturers' warranty.[73] There is sufficient quantity of biodiesel production in Australia to support a 5% biodiesel blend for all coal mine diesel consumption in NSW. This provides an immediate opportunity for coal mines to reduce greenhouse gas emissions from diesel consumption.

Renewable diesel

An emerging alternative to fossil diesel is synthetically refined 'renewable diesel'. Renewable diesel can be produced from a wide variety of renewable feedstocks. It is a 'drop in fuel' that can 100% replace diesel without engine modifications. Unlike biodiesel, renewable diesel has similar chemical and physical properties to fossil diesel and behaves similarly to fossil diesel when combusted in an engine. Renewable diesel also has the additional benefit of having a slightly higher energy density and burns cleaner than fossil diesel.

The renewable diesel supply chain is still developing. Fuel suppliers in Australia are investing in sustainable aviation fuel and renewable diesel production domestically, with production expected onshore ahead of 2030. Most facilities are designed to produce both sustainable aviation fuel and

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[71] EMM 2025, Greenhouse Gas Mitigation Guide for NSW Coal Mines: Literature review and industry scan

[72] Fossil diesel refers to diesel fuel that is derived from crude oil (which is formed over millions of years).

[73] NSW EPA 2025c, NSW EPA Low Emissions Fuels and Vehicles at NSW Coal Mines, Workshop 2 October 2025, Sydney, accessed 6 February 2026

renewable diesel. Renewable diesel typically makes up at least 10–20% of output when optimised for sustainable aviation fuel production.[74] Demand-side signals and commitments will also help support investment in the renewable diesel supply chain. In March 2025, the Australian Government announced $250 million in funding to support the production of low carbon liquid fuels.[75] The *NSW Renewable Fuels Strategy* will also diversify and expand NSW's local renewable fuel industry.[76]

Fuel suppliers in NSW have measures in place to ensure the sustainable origin of feedstocks for low carbon fuels.

Renewable methanol

Through simple modifications, diesel engines can run as dual-fuel engines with a portion of the energy supplied by renewable methanol. Due to the ease of technology adoption, marine engine manufacturers have already commercialised methanol–diesel dual-fuel engines for cruise ships and ferries.[77] The technology involves the installation of a methanol injector in the intake manifold, which replaces a portion of the air with fuel. The air–fuel mixtures later burn together with diesel inside the cylinder.

Renewable hydrogen

There is current research and development into supplementing diesel internal combustion engines with hydrogen fuel (hydrogen–diesel direct injection dual-fuel technology[78]). This technology allows diesel engines to run primarily on hydrogen. Not to be confused with hydrogen fuel cell electric vehicles (see section 3.2.2), this new technology will allow existing diesel engines to be converted to hydrogen burning spark ignition engines or to be retrofitted to run on hydrogen as well as diesel. This means that haul trucks may be retrofitted instead of disposed of. There are several companies providing retrofitting solutions.[79]

Hydrogen internal combustion engines share the same uptake barriers of the fuel cell electric vehicles, such as limited supply of renewable hydrogen and safety issues associated with onsite hydrogen storage.

Methane utilisation (drainage gas)

There may be opportunities for methane in coal mine drainage gas to be used beneficially onsite as vehicle fuel. For example, trials of dual-fuel technology for mining trucks have been underway at a Queensland surface coal mine since 2023.[80] While the trial commenced using natural gas brought onsite, the trial is expanding into natural gas produced from the mine site. The technology allows methane from drainage gas to be used as a diesel fuel substitute. While the combustion of methane

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[74] NSW EPA 2025c, NSW EPA Low Emissions Fuels and Vehicles at NSW Coal Mines

[75] King 2025, Low-carbon liquid fuels of the Future Made in Australia, media release, The Hon Catherine King MP, Minister for Infrastructure, Transport, Regional Development and Local Government, 6 March 2025

[76] NSW Government, Building a Thriving Renewable Fuel Industry in NSW, NSW Climate and Energy Action webpage, accessed 3 March 2026

[77] For example, see MAN Energy Solutions, A Methanol Refit For Passenger Ships, MAN Energy Solutions website, accessed 29 May 2025

[78] See UNSW, Converting Diesel Engines to Run On Hydrogen, UNSW Sydney website, accessed 29 May 2025.

[79] For example, see Liebherr 2024, Pioneering work in the quarry: Liebherr and STRABAG test hydrogen wheel loader, Liebherr website, accessed 29 May 2025; and KEYOU 2025, KEYOU develops hydrogen-powered dump truck for global construction equipment leader Komatsu, media release 26/3/2025, KEYOU website, accessed 29 May 2025.

[80] This project is a partnership between Mine Energy Solutions and Thiess at the Curragh Mine Complex. MES 2021, Mine Energy Solutions / Thiess partnership announcement, media release 9/6/2021, Mine Energy Solutions website, accessed 29 May 2025; and Thiess 2024, Investing in transitional technologies, case study 1/1/2024, Thiess website, accessed 29 May 2025.

gas still results in carbon dioxide emissions, the global warming potential of the gas is significantly reduced (see section 2.2), lowering the overall emissions profile of the mine.

There may be opportunities in the future for this technology to be used at surface mines in NSW that are accessing deeper, gassier coal seams.

3.3 EPA expectations for diesel emissions

The EPA expects mining companies to continue implementing standard industry measures (section 3.2.1). This includes continuing to implement standard diesel efficiency measures, reviewing the effectiveness of those measures over time, and to begin transitioning to US EPA Tier 4 final emission standards or better.[81]

The EPA strongly encourages all mines, including coal mines, to transition their diesel vehicles and equipment to low emission alternatives as soon as possible, while implementing low carbon fuel solutions in the interim.

The EPA is of the view that low carbon fuel mandates for the coal mining sector may be warranted to help drive onsite emissions reductions of diesel emissions. However, the EPA considers that this is better progressed following an economy-wide analysis for low carbon liquid fuel mandates.

[81] An outcome of the EPA's 2024 public consultation on the regulation of coal mines in NSW (see section 3.2.1). See US EPA 2004, Control of Emissions on Air Pollution from Nonroad Diesel Engines and Fuel: Final rule

4

Scope 1 emissions: minor sources

4.1 Mitigation measures for minor scope 1 emissions

The sources in Table 5 are typically only minor contributors to scope 1 emissions at NSW coal mines and have been included in this guide for completeness.

Table 5 Mitigation measures for minor scope 1 emissions

Emission source	Application / emissions source	Mitigation measures
Petrol combustion	Small, portable equipment; on-road vehicles	• Electric battery equipment • Hybrid and battery electric passenger vehicles
Ammonium nitrate fuel oil combustion	Explosives	• Optimising blast strategies to improve coal yield • Recycling or reusing oils and greases, reducing virgin oil demand
Oils and greases	Lubricants on equipment, and cleaning	• Recycling or reusing oils and greases, reducing virgin oil demand • Switching to bio-lubricants
Sulfur hexafluoride (SF_6)	Leakages from cooling gas (refrigerant) in high-voltage electrical switchgear, circuit breakers and transformers	• Company operating procedures • Machine maintenance and replacement (to detect and address leaks) • Gas accounting and tracking • Training in SF_6 handling and use • SF_6 recycling
Coal handling, processing and storage	Methane released from fractured coal after extraction Carbon dioxide and other pollutants released from spontaneous combustion	• Minimising coal handling • Spontaneous combustion management plans • Regular monitoring of the coal temperature in stockpiles • Applying dust suppressants and water to cool coal • Introducing microbial or biochemical agents to stabilise coal • Covering and sealing stockpiles to reduce exposure to air • Enclosing stockpiles with gas capture and flaring
Vegetation removal	Land clearing to begin mining process, which disrupts the natural carbon sinks of vegetation	• Avoiding/reducing vegetation clearing as far as practical • Mulching or composting removed vegetation to avoid rapid decomposition or burning • Rehabilitation of land (especially with native plants) as quickly as possible, and progressively during construction and operations

4.2 Guidance for minor scope 1 emissions

The EPA recognises that many of the mitigation measures for minor scope 1 emissions are standard industry practice. The EPA encourages coal mining companies to continue implementing and reviewing the effectiveness of these measures, and to consider where additional measures could be adopted over time.

5

Scope 2 emissions

5.1 Scope 2 emissions at coal mines

This section of the mitigation guide provides information to help coal mining companies to reduce scope 2 emissions. Scope 2 emissions are indirect emissions primarily associated with the purchase of electricity, as well as the generation of steam, heating or cooling at a site. Scope 2 emissions are generated outside of an organisation's boundaries, such as by an external power station in the case of electricity.

Most NSW coal mines are connected via the electricity grid to the National Electricity Market. According to emissions reported under NGERS, scope 2 emissions from coal mining in NSW in 2023–24 were 1.5 million t CO_2-e/year.[82]

At many underground coal mines, most of the large equipment is powered by electricity. The most significant consumers of electricity include longwall/continuous miners, coal conveyor belts, winders and shuttle cars to transport people and materials, and ventilation fans. At both underground and surface mines, coal processing consumes a significant proportion of electricity. A coal processing plant contains many smaller motors operating equipment like pumps, fans and conveyors.

5.2 Mitigation measures for scope 2 emissions

The greenhouse gas emissions from a given mining process depend on the amount of electricity used by the process and the emission intensity of the electricity source. However, should the site invest in 'behind the meter' renewables[83], or the purchase of renewable energy from the grid, they do have the potential to access electricity at lower/zero emissions intensity (see Box 2). Measures to address scope 2 emissions therefore involve:

- reducing onsite electricity consumption by improving energy efficiency
- sourcing renewable electricity
- investing in onsite renewables.

Box 2. Spot price electricity market

The EPA's expert panel noted that operations with sophisticated metering and load shifting can take advantage of the electricity spot market to reduce the emissions intensity of their grid electricity. However, changes in spot market emissions intensity are not taken into account in current NGERS greenhouse gas accounting methods.[84]

5.2.1 Energy efficiency measures

Mitigation measures for improving energy efficiency are largely inexpensive and already commonplace in the coal mining sector. This section focuses on measures associated with the use of electricity that results in reduced total emissions to the site. In this context, coal mining companies should consider energy efficiency, energy management and demand response. Taken together,

[82] Data provided by the Clean Energy Regulator, accessed March 2025.

[83] 'Behind the meter' refers to a renewable power system that is installed directly on the mine site, reducing demand for grid electricity.

[84] AEMC, Spot and Contract Markets, Australian Energy Market Commission website, accessed 29 May 2025

these three sets of activities can reduce the total emissions associated with delivering the same production amount.

It is standard practice for NSW mining companies to implement various measures to improve energy efficiency and reduce greenhouse gas emissions, such as the installation of variable speed drives and control systems to match load to capacity on conveyor belts, or improving the efficiency of buildings in the design phase. In this area, companies should consider ways to ensure production is delivered at minimum emissions, including:

- traditional energy efficiency installations (standard practice)
- improved energy management through hard (metering) and soft (artificial intelligence and improved control algorithms, training and awareness) measures
- demand response, including load shaping and load shifting (aided by sophisticated management systems) to maximise process throughput and minimise associated emissions.

5.2.2 Reducing the emissions intensity of electricity

The NSW grid is undergoing rapid decarbonisation, and its emission intensity is projected to be significantly lower by 2030 and approaching zero by 2040 (Figure 1).

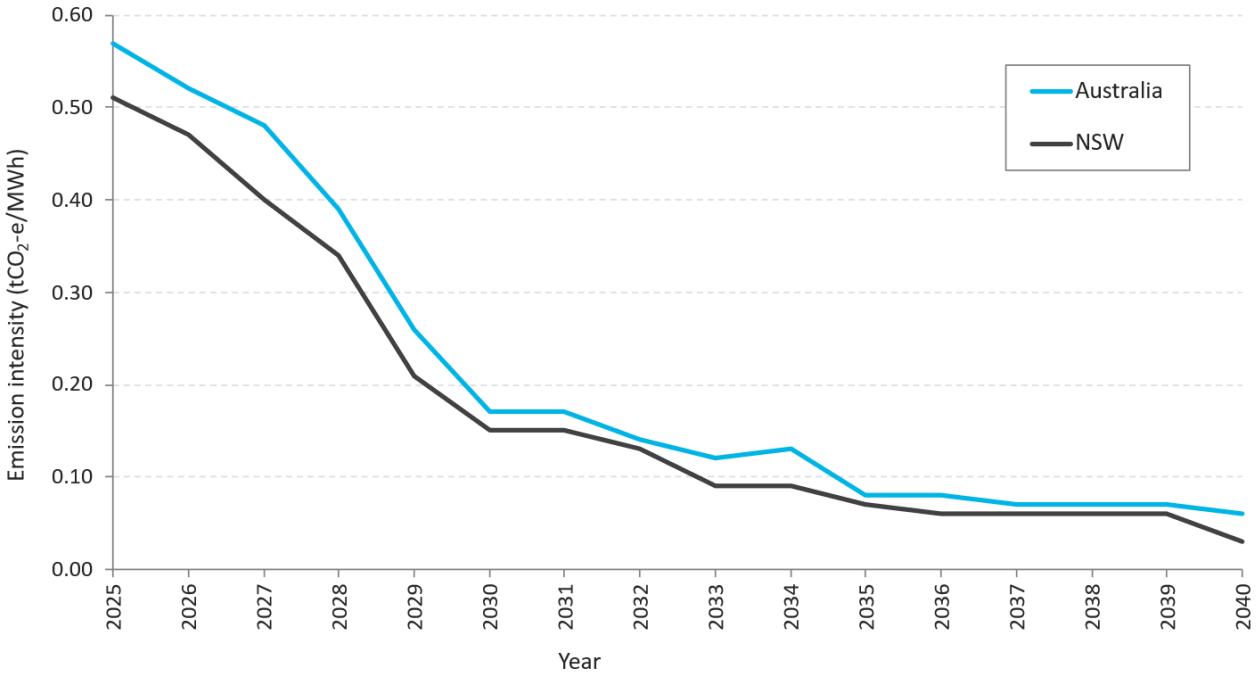

Figure 1 Scope 2 emission intensity of grid electricity in Australia and NSW[85]

The decarbonisation of the NSW grid and its intensity should reduce coal mine scope 2 emissions substantially, even though the demand for electricity at mine sites is likely to increase due to electrification.

Under the Commonwealth Renewable Energy Target, large energy consuming coal mines are required to purchase a certain percentage of their electricity from renewable sources each year (in 2025, this is 18%).[86] This is achieved through the acquisition of large-scale generation certificates.

[85] Cth DCCEEW 2024a, Australia's Emissions Projections 2024, Cth Department of Climate Change, Energy, the Environment and Water, Canberra

[86] Australian Government, Renewable Energy Target, Clean Energy Regulator website, accessed 29 May 2025

The Renewable Energy Target is finishing in 2030 and is likely to be followed by mechanisms such as the voluntary Renewable Electricity Guarantee of Origin scheme.[87]

In the meantime, the main option is to purchase renewable electricity (e.g. through a power purchase agreement or a progressive procurement process with exposure to the spot market).

The future electrification of NSW coal mines will be supported by the development of Renewable Energy Zones, which are intended to encourage investment in renewable generation and storage projects. This should reduce the cost of renewable electricity and create more opportunities for innovative approaches to buying electricity coupled with demand-shaping programs.

Further into the future, there is potential for renewable energy generation to be more widespread at mine sites, probably in combination with energy storage systems (e.g. batteries). Energy storage will be especially important for any off-grid coal mines. However, it is recognised that the grid could disincentivise the construction of onsite renewable electricity generation, as purchase from the grid may be more economical.

The key measures available for reducing emissions intensity at NSW coal mines include:

- onsite renewable electricity generation (wind and solar with energy storage)
- purchase of renewable electricity.

Mining companies can reduce the emissions intensity of their electricity consumption through:

- **the installation of onsite (often behind the meter) renewables**. Electricity generated by these systems can be utilised before electricity is drawn from the grid. These systems are usually operated by a third party. Batteries can also be installed to store electricity onsite.
- **the purchase of renewable electricity** from the grid, for example, through:
  - a **power purchase agreement**, which is a contract between an energy buyer, such as a mining company, and an energy seller, usually a project developer (a wholesale power purchase agreement) or electricity retailer (a retail power purchase agreement).[88] It is a contract for a fixed price and fixed supply of renewable energy, making it cheaper for businesses to use. Power purchase agreements guarantee that a mining company can purchase energy from renewable energy projects like offsite solar farms or wind farms at an agreed price, volume and term.
  - **the surrender of large-scale generation certificates**. Under the Australian Government's Large-scale Renewable Energy Target, large-scale generation certificates are a financial incentive for the generation of renewable energy from a power station. They are tradable certificates created for eligible large-scale renewable energy power stations. One certificate is equal to 1 MWh of renewable electricity generated or displaced by a power station. Many NSW coal mines are large users of grid electricity and have obligations to surrender a certain number of these certificates each year to meet their obligations under the Large-scale Renewable Energy Target.[89] As discussed above, the Renewable Energy Target is finishing in 2030 and is likely to be followed by mechanisms such as the voluntary Renewable Electricity Guarantee of Origin scheme.[90]

[87] Australian Government, Renewable Electricity Guarantee of Origin, Clean Energy Regulator website, accessed 29 May 2025

[88] Wholesale power purchase agreements are available to organisations with high energy consumption (over 60 gigawatt-hours per year).

[89] Australian Government, Large-scale Renewable Energy Target, Clean Energy Regulator website, accessed 29 May 2025

[90] Australian Government, Renewable Electricity Guarantee of Origin

5.3 Guidance for scope 2 emissions

The EPA strongly encourages mining companies to implement energy efficiency measures and to reduce the emissions intensity of their grid electricity consumption through measures such as a power purchase agreement and the installation of onsite renewable electricity generation, wherever practicable.

6

Scope 3 emissions

6.1 Overview

This chapter provides information to help coal mining companies to reduce scope 3 emissions. Scope 3 emissions are indirect emissions, other than scope 2 emissions, that are generated in the wider economy.

Scope 3 emissions may occur 'upstream' of a coal mine, such as during the extraction and production of the fossil fuels consumed onsite (e.g. diesel); or 'downstream' of a coal mine, such as from the transport of coal to customers, or the end use of coal by a power station.

The EPA acknowledges combustion of fossil fuels anywhere in the world impacts the climate system in NSW. The EPA also acknowledges the use of global commodities is beyond any individual jurisdiction and is primarily governed by regulatory architecture in the jurisdiction in which these commodities are used, as well as international agreements.

The topic of scope 3 emissions is therefore very large and complex, and for mining companies, emissions are generally beyond their control. Consequently, this mitigation guide focuses mainly on identifying opportunities for mining companies to reduce scope 3 emissions that are within their control.

6.2 Examples of opportunities to reduce scope 3 emissions

By far the largest source of scope 3 emissions in the coal mining sector comes from the downstream use of coal, particularly its combustion in power generation and industrial processes. It is difficult for coal mining companies to reduce scope 3 emissions from the downstream use of coal as the end result is always combustion. However, there are opportunities such as:

- selling coal to buyers who have lower emissions intensities (i.e. buyers that are investing in carbon capture and storage and high-efficiency combustion)
- selling coal to buyers in countries that have strong climate policies and emissions reduction targets (e.g. countries that are signatories to the Paris Agreement).

Examples of other opportunities to reduce scope 3 emissions are provided in Table 6.

Table 6 Potential opportunities for reducing scope 3 emissions

Aspect	Potential opportunities
Reducing upstream emissions	• Agreements with suppliers, such as: – encouraging manufacturers and suppliers to pursue net zero emissions for their own operations – agreements to implement sustainable transport polices and technologies, such as electric road vehicles, electric rail and renewable electricity supplies – use of green hydrogen in the manufacture of ammonia for explosives (green explosives). • Use of local equipment and materials suppliers, as well as contractors and consultants, where practicable. • Ensuring suppliers have appropriate sustainability credentials. • Reducing embodied carbon, including: – requirements for materials with a low carbon footprint to be built into procurement policies – supporting non-energy markets in the use of coal and waste materials, such as producing asphalt from coal and converting waste into construction materials.

Aspect	Potential opportunities
	• Purchasing green explosives (green ammonia): – green ammonia is a low carbon alternative to traditional ammonium nitrate which is made using fossil fuels. Green ammonia nitrate can directly replace conventional ammonia in mining explosives.[(a)]
Reducing downstream emissions	• Optimising transport routes and reducing the distance that coal needs to be transported to downstream users. • Agreements with end users of coal (and intermediates), such as: – implementation of sustainable transport polices and technologies (as above) – assistance with transport routes, and reducing the distance that coal needs to be transported – helping international customers to reduce their emissions – requiring the handling and storage of coal to be conducted according to best practice.
Supporting research and development	• Support for the development of low emission technologies, such as: – technologies to reduce emissions from thermal power plant (e.g. advanced boilers and turbines, ammonia injection, co-firing with biofuel) – technologies to reduce emissions from steelmaking – technologies to reduce emissions from shipping (e.g. vessel and route optimisation, and energy-efficient technologies such as hull coatings, and hydrogen and wind-assisted propulsion). • Research into carbon capture and storage, such as: – capturing carbon dioxide from thermal power plant and converting it into solid materials for concrete production – partnerships with industries that use coal or invest in carbon capture and storage technologies to capture and store carbon dioxide emissions from their operations or from coal utilisation.

(a) For example see: Cth DCCEEW 2024a, Australia's Emissions Projections 2024; Worley Consulting n.d., Green Ammonia Market Study available through Hydrogen Resources, NSW Environment Protection Authority website; and Nadig 2024, Revolutionising mining: the rise of nitrate-free explosive alternatives, Mining Technology website, 16 October 2024, GlobalData.

6.3 Guidance for scope 3 emissions

The EPA strongly encourages mining companies to implement a variety of measures to reduce their scope 3 emissions, including purchasing green explosives.

7 Appendices

7.1 Appendix A: Gas and dust characterisation, and emissions monitoring

Accurate monitoring plays a critical role in the effective management of ventilation air methane (VAM), given the low and highly variable methane concentrations at mine sites. This variability reduces the effectiveness of periodic measurements, making continuous monitoring of methane concentrations essential to determine the suitability of VAM abatement technologies.

This appendix outlines the EPA's expectations for VAM measurement, for the purposes of VAM reporting, demonstrating whether the VAM abatement requirement threshold is met, and preparing for the installation of VAM abatement in the future.

7.1.1 VAM abatement requirement threshold

Underground coal mines are required to abate VAM as outlined in the *Executive summary* (see Table 1). The threshold for implementing abatement equipment is whether the mine releases consistently above 0.20% methane concentration in ventilation air. 'Consistently' means methane concentration does not drop below 0.20% for periods of 60 minutes or more during routine operation.

If VAM abatement is not installed, the licensee will need to have evidence that the VAM abatement requirement does not apply to their mine. This evidence should be included in the licensee's climate change mitigation and adaptation plan (CCMAP) or development application.

Mines are encouraged to start the necessary data collection well before the requirement implementation date. If regenerative thermal oxidation (RTO) is to be implemented, then dust characterisation data, as well as gas composition and variability data, is needed to inform the RTO design.

7.1.2 Gas characterisation data

The mitigation of VAM presents significant challenges due to the following factors:

- VAM constitutes the largest proportion of methane emissions from coal mines
- VAM is characterised by high air volume flow rates and dilute, variable methane concentrations
- the ventilation air contains dust and is nearly fully saturated with moisture.

To determine if suitable VAM abatement through RTO is technically possible onsite, a mine should generate mine site VAM emissions data as outlined in Table 7.

Data must include methane (CH_4) and carbon dioxide (CO_2) concentrations and flow rates at preferably one-minute intervals or, at least, hourly intervals throughout a 12-month period (financial year).

Table 7 Required ventilation air methane emissions data

Date & time	Flow rate (m^3/s)	CH_4 (%)	CO_2 (%)	Wet bulb temperature (°C)	Dry bulb temperature (°C)	Barometer pressure (hPa)	Collar pressure (Pa)
example							
28/1/2026 8:08	350	0.45	0.31	23.75	26.9	1,013	1,400

More detail on VAM data expectations

1. Emissions data must cover the financial year, matching the annual emissions reporting requirements under the *National Greenhouse and Energy Reporting Act 2007*.
2. Reported data must be collected by using appropriate methods and measurements as specified by the Australian Government's guidelines for estimating emissions and energy from coal mining,[91] the Australian Coal Industry's Research Program (ACARP) report C21002 guideline[92] and the National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Compilation No. 20).[93]
3. Sampling positions need to be appropriate to measure the parameters completely and accurately. A typical location is in the return air roadways leading to the ventilation shaft. The sampling must monitor the complete return air ventilated.
4. The ventilation air flow rate, as well as methane and carbon dioxide concentrations, must be documented at intervals of one minute or, at least, once per hour via a continuous monitoring system such as Citect.
5. The flow rate of mine ventilation of underground coal mines is extensively monitored for safety purposes using a combination of continuous measurement and periodic checks.[94] If continuous data is unavailable, flow rates must be obtained from monthly statutory ventilation officer reports. All changes to ventilation air flow rates must be recorded with the corresponding rate, date and time. Periodic monitoring records should be kept.
6. If wet bulb temperature, dry bulb temperature, barometric pressure and collar pressure are not monitored continuously, their periodic readings must be obtained as per Item 5 above for the flow rate.
7. Measurement equipment must be appropriately maintained and calibrated according to the Measurement Determination, and Clean Energy Regulator and ACARP guidelines. [95,96,97] The equipment must be capable of measuring a suitable range and variability of gas proportions in ventilation air. It is important to note that equipment installed for safety purposes focuses primarily on monitoring that the gas proportion remains within safe operating thresholds.[98]

For all measurement equipment used to monitor ventilation air flow, Table 8 can be used to summarise the relevant information for each variable, adjusted to standard temperature and pressure and on a dry basis as applicable.[99]

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[91] CER 2025, Estimating Emissions And Energy From Coal Mining Guideline, Clean Energy Regulator, Canberra

[92] Black D 2014, Measurement and Reporting of Fugitive Emissions from Underground Coal Mines, Australian Coal Industry's Research Program (ACARP) Project C21002 report, December 2014

[93] Australian Government 2008, National Greenhouse and Energy Reporting (Measurement) Determination 2008, Compilation No. 20, 31 August 2024

[94] CER 2025, Estimating Emissions And Energy From Coal Mining Guideline

[95] Australian Government 2008, National Greenhouse and Energy Reporting (Measurement) Determination 2008

[96] CER 2025, Estimating Emissions And Energy From Coal Mining Guideline

[97] Black D 2014, Measurement and Reporting of Fugitive Emissions from Underground Coal Mines

[98] Australian Government 2008, National Greenhouse and Energy Reporting (Measurement) Determination 2008

[99] Black D 2014, Measurement and Reporting of Fugitive Emissions from Underground Coal Mines

Table 8 Measurement system summary

Variable	Flow rate	CH_4	CO_2	Wet bulb temperature	Dry bulb temperature	Barometer pressure	Collar pressure
Unit	m^3/s	%	%	°C	°C	hPa	Pa
Instrument							
Model							
Range							
Accuracy							
Calibration (internal)							
Frequency							
Last performed							
Calibration (external)							
Frequency							
Last performed							

Variability in methane concentration

To confirm that the VAM concentration meets or exceeds 0.20%, and to determine whether the VAM concentration falls below 0.20% for periods of 60 minutes or more, an analytical approach is recommended.

This approach should be applied specifically to the VAM emissions data compiled in Microsoft Excel and should follow the two steps outlined below:

Step 1: Conversion of CH_4 and CO_2 concentrations to an 'as received' basis

If the methane (CH_4) and carbon dioxide (CO_2) concentrations are measured on a dry basis, they need to be converted to an as-received basis according to the *Measurement and Reporting of Fugitive Emissions from Underground Coal Mines*[100]. The moisture content in the ventilation air is determined using **Equation 1**:

$$MC = (611.21 \times \exp(17.368 \times T_w \div (T_w + 238.88)) \div (P_M \times 1000) - (0.000644 \times (T_d - T_w))) \times 100$$

where:

MC = moisture content (% volume)

T_d = dry bulb temperature at the measurement location (°C) (refer to Table 7)

T_w = wet bulb temperature at the measurement location (°C) (refer to Table 7)

P_M = absolute pressure at the measurement location (kPa); it equals to barometer pressure divided by 10 minus collar pressure divided by 1,000 (refer to Table 7).

[100] Black D 2014, Measurement and Reporting of Fugitive Emissions from Underground Coal Mines

Then, the CH_4 and CO_2 concentrations on an as-received basis can be calculated using **Equation 2**:

$$C_{j,as} = C_{j,dry} \times (100 - MC) \div 100$$

where:

$C_{j,as}$ = the concentration of gas type (j) on an as-received basis

$C_{j,dry}$ = the concentration of gas type (j) on a dry basis.

Step 2: Calculate the duration of periods which the VAM falls under 0.20%

7.1.3 Dust characterisation data

Ventilation air flow contains various types of dust, including stone and coal dust. In underground coal mines in Australia, stone dust (usually calcium carbonate) is utilised as the main inert agent to prevent coal dust explosions. However, deposition of stone dust within an RTO bed can affect its long-term operability and increase maintenance costs, if its bed is prone to dust deposition. It is important to understand the loading, particle size and mineral composition of dusts present in the ventilation air.

It will be important for mines likely to be captured by the VAM abatement requirements to undertake dust characterisation studies.

Some coal mines may perform dust loading measurements at the location outlined in point 3 of the specific guidance for the collection of VAM data (see section 7.1.2), in addition to ventilation air flow rate and gas concentration measurements. Where applicable, it is recommended that relevant dust data be submitted to the EPA as outlined in Table 9.

Table 9 Desirable ventilation air methane emissions data

Date & time	Dust loading (mg/m^3)	Maximum particle size (µm)	Mineral matters
example			
28/1/2026 8:00	4.45	5	Results from scanning electronic microscopy with energy dispersive spectrum (SEM-EDS)

7.2 Appendix B: Necessary data to assess the potential for flaring and VAM abatement

Coal mines captured by the criteria in Table 1 (see *Executive summary*), must flare or utilise any drainage gas by 1 July 2027.

Accurate forecasts and measurement of methane emissions for drainage and VAM is critical for implementing abatement measures.

Mining licensees should have clear information on the potential for flaring within the greenhouse gas assessment (required to be developed under the *NSW Guide for Large Emitters*[101]) or climate change mitigation and adaptation plan (prepared in accordance with the relevant guidance[102]), whether or not flaring is deemed technically feasible. The information that will need to be included in these reports include:

1. The status of mining at the time of production of the plan (locations of mining, description of activity – mining and gas drainage in each area) and those activities planned up to the end of the next reporting period.
2. Indicative gas reservoir parameters for those areas – stratigraphic section, seam thicknesses, gas contents and composition.
3. Plans and data for the period being reported and an assessment for the next reporting period for:
    a. gas quantities, compositions and variability in the drained gas by source (pre- and post-drainage including air dilution)
    b. details of quantities flared or utilised and difficulties encountered.

[101] NSW EPA 2025b, NSW Guide for Large Emitters, NSW Environment Protection Authority, Parramatta

[102] NSW EPA 2026, Emissions Reporting and Climate Change Mitigation and Adaptation Plans: Guidance for environment protection licensees, NSW Environment Protection Authority, Parramatta

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Glossary of terms and abbreviations

Glossary of terms

Table 10 Glossary of terms – mine types

Mine type	Definition	Reference
Underground mine	A coal mine that allows extraction of coal by mining at depth, after entry by shaft, adit or drift, without the removal of overburden.	NGER Measurement Determination 2008
Surface mine	A mine in which the overburden is removed from coal seams to allow coal extraction by mining that is not underground mining. Also called open cut mines.	NGER Measurement Determination 2008

Table 11 Glossary of terms – mine stages

Mine phase	Typical activities at this phase	Synonymous term
Active mine	**Mining is operational** The following activities may take place: • pre-drainage (surface to inseam and underground inseam pre-mining) • active drainage (goaf and adjacent seam drainage) • operation of mining infrastructure (e.g. ventilation fans, monitoring equipment) • progressive temporary seals and caps as mining progresses	• Operational mine
	Suspended operations[a] (Coal production has ceased) The following activities may take place: • mine continues to be managed and monitored so that access is still possible • ventilation fans remain operational • monitoring continues • mine workings may begin to naturally flood • may include further temporary seals and caps	• Care and maintenance[b] • Inactive mine[c]
	Mine closure and rehabilitation process The following activities may take place: • gas drainage (post-mining) • withdrawal of infrastructure (including monitoring equipment)	• Mine decommissioning • Mine rehabilitation[d]

Mine phase	Typical activities at this phase	Synonymous term
	• mine workings continue to naturally flood • whole-of-mine sealing • rehabilitation process	
Closed mine	**Mine is fully rehabilitated and closed** • mining lease has been relinquished back to the government • flooding continues naturally over time • no monitoring infrastructure • permanent seals in place	• Decommissioned mine[e] • Abandoned mine[b]

Table notes:

(a) Various coal mines in Australia have remained in suspended operations for a number of years, without being fully closed and rehabilitated. Examples in NSW include Russell Vale Colliery, Wongawilli Colliery, Newstan Colliery and Awaba Colliery.

(b) Care and maintenance is used by the Clean Energy Regulator for coal mine methane monitoring. CER 2025, Estimating Emissions And Energy From Coal Mining Guideline.

(c) UNECE 2008, Glossary of Coal Mine Methane Terms and Definitions, August 2008, United Nations Economic Commission for Europe, Geneva.

(d) NSW Government, What is Mine Rehabilitation, NSW Resources website, accessed 29 May 2025.

(e) CER 2025, Estimating Emissions and Energy from Coal Mining Guideline, p 44.

Abbreviations

Table 12 Abbreviations

Abbreviation	Definition
ACARP	Australian Coal Industry's Research Program
CCMAP	climate change mitigation and adaptation plan
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
CSIRO	The Commonwealth Scientific and Industrial Research Organisation
EPA	NSW Environment Protection Authority
hPa	hectopascal
kW	kilowatt
kWh	kilowatt hour
m	metre
m^3/s	cubic metre per second
m^3/t	cubic metre per tonne
mg/m^3	milligrams per cubic metre
Mt	million tonne
MW	megawatt
MWh	megawatt hour
NGER	National Greenhouse and Energy Reporting
NGERS	National Greenhouse and Energy Reporting Scheme
NSW	New South Wales

Abbreviation	Definition
P	pascal
RCO	regenerative catalytic oxidation
RTO	regenerative thermal oxidation
SF_6	sulfur hexafluoride
t	tonne
VAM	ventilation air methane
µm	micrometre

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