SWANITI GLOBAL
THE GLOBAL CLIMATE AND DEVELOPMENT INSTITUTE

minerals to metals

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Coal Mine Methane in South Africa

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About Us

This report was produced through a partnership between Swaniti Global and The Minerals to Metals Initiative at the University of Cape Town.

Swaniti Global, is an international policy and governance organization that operates at the intersection of policy, governance, and community needs to drive meaningful, long-term change. Swaniti works across regions to identify opportunities, unlock critical resources, and accelerate the energy transition through context-specific, collaborative strategies. Its approach is rooted in building partnerships with governments, communities, industry clusters, and civil society organizations to co-create solutions that are both innovative and impactful. By engaging with government systems to understand existing capacities and aligning them with community aspirations, Swaniti facilitates the design and implementation of integrated programs that address structural and developmental challenges.

The Minerals to Metals Initiative is an interdisciplinary research, education and engagement platform at the University of Cape Town, which aims to play a leading role in the global minerals industry. It aims to contribute to Africa's sustainable development through minerals beneficiation research, nurturing the future leaders of the minerals industry as well as bridging the gap between academia and industry via partnerships and collaboration.

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Research from the University of Cape Town's Minerals to Metals Initiative and Swaniti Global's Global Climate and Development Institute finds that coal mine methane (CMM) is a critical but overlooked climate challenge in South Africa. Coal mining is the country's largest source of primary energy and a major emitter of methane, a greenhouse gas far more potent than carbon dioxide. The report highlights that reducing methane from operating and abandoned mines offers some of the fastest, most cost-effective emissions cuts available, while also improving mine safety, creating jobs, reducing air pollution, and supporting South Africa's Just Energy Transition. Yet weak data systems, fragmented policy, and limited financial incentives remain barriers. The authors call for stronger measurement and reporting, integration of methane into climate and transition policies, and mobilization of finance to unlock these opportunities.

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Executive Summary

In 2024 the average annual global temperature exceeded 1.5°C above pre-industrial levels for the first time. This limit is widely regarded as being critical for dangerous climate change and highlights the urgency of identifying and implementing measures across the economy for mitigating greenhouse gas (GHG) emissions. Among the most effective short-term levers available is reducing emissions of methane. Methane is responsible for roughly 30% of observed global warming since the industrial revolution and has over 80 times the global warming potential (GWP) of carbon dioxide over a 20-year period. Coal mining is the fourth-largest source of anthropogenic methane worldwide. South Africa is the world's seventh-largest coal producer and relies heavily on coal for electricity and primary energy supply. Mitigation of coal mine methane (CMM) could thus potentially represent an opportunity for South Africa to address its own emissions profile. However, information on the scale of emissions is uncertain, and as such the extent of opportunity is still unclear.

This study set out to provide a comprehensive assessment of the current state of methane emissions from South Africa's coal sector, mitigation opportunities, and the enabling policy environment. Structured around six key research questions, the analysis identifies urgent data gaps, technical and institutional barriers, and critical opportunities to advance the national agenda on methane mitigation.

Summary of Key Findings

The research questions, and the findings of the study, are as follows:

Q1. What is the availability and quality of data with respect to methane emissions from South African coal mining?

Official data on methane emissions from coal mining in South Africa is limited. The most recent national inventory reports CMM emissions of only 0.06 Mt CH_4 in 2022. Independent studies from the IEA, GEM, and top-down satellite analyses suggest actual emissions could be between 0.6 Mt and 1.2 Mt per year — 7 to 14 times higher than national estimates. These disparities arise from outdated emission factors, lack of mine-level measurement, and limited incorporation of advanced monitoring technologies.

Satellite instruments such as TROPOMI and Carbon Mapper have detected methane plumes from active mines in Mpumalanga, but their effectiveness is limited by spatial and temporal resolution, as well as environmental conditions (e.g., cloud cover). Additionally, abandoned mine methane (AMM) remains unaccounted for in all current monitoring and reporting systems, despite growing evidence of its long-term contribution to GHG emissions.

Improving the accuracy and coverage of emissions data will require the development of mine-specific emission factors, deployment of on-site measurement technologies, and integration of remote sensing with ground-truth data.

Q2. What is the current and historic policy landscape on methane reporting and mitigation in South Africa?

There is currently no cohesive strategy for methane measurement and mitigation in the coal sector. Methane emissions are nominally covered under the National GHG Emission Reporting Regulations - Air Quality Act (DFFE, 2020) - and larger emitters are required to submit emissions data to the South African Greenhouse Gas Reporting system (SAGERS). However, this data is not publicly accessible and omits key sources, including emissions from abandoned mines (AMM), spontaneous combustion, and post-mining coal handling. The policy landscape is further fragmented by the lack of coordination across responsible departments, including the Department of Mineral and Petroleum Resources (DMPR), the Department of Forestry, Fisheries and the Environment (DFFE), and the Department of Electricity and Energy (DEE). Methane is not integrated into the design of South Africa's carbon tax regime, nor is it explicitly addressed in the Just Energy Transition Investment Plan (JET-IP). This absence of policy clarity and institutional mandate limits the scope and scale of mitigation efforts.

Q3. What are the key opportunities associated with methane mitigation from coal mining?

Mitigating methane from coal mining presents immediate and cost-effective opportunities for reducing South Africa's GHG emissions. International assessments suggest that up to 90% of CMM emissions in operating mines could be abated at a cost of less than USD 20/tCO_2e. These mitigation measures include pre-drainage of coal seams, flaring, methane utilisation for power generation, and ventilation air methane (VAM) oxidation technologies.

In South Africa, targeted mitigation at a small number of high-emitting mines could deliver significant mitigation benefits, along with multiple co-benefits: improving mine safety, reducing explosion risks, lowering air pollution, and enabling the repurposing of methane for productive uses.

Moreover, CMM mitigation aligns closely with Just Energy Transition objectives. It can sustain economic activity in coal-dependent regions, create skilled jobs in environmental monitoring and engineering, and provide transitional livelihoods for workers in the declining coal sector. Revenue streams from carbon credits, power sales, or avoided carbon tax liabilities could improve the commercial viability of these interventions.

Q4. What are the main challenges to implementing Coal Mine Methane mitigation in South Africa?

Several systemic barriers hinder the development and implementation of methane mitigation projects. Technically, not all mines emit methane in concentrations suitable for capture or utilisation. Emissions tend to be intermittent, diffuse, or below economic thresholds. This is compounded by a lack of reliable, real-time monitoring infrastructure, which limits project planning and risk assessment.

Economically, CMM projects require high upfront capital investment and depend on long-term revenue certainty. The failure of the New Denmark flaring project, which collapsed due to a crash in carbon markets and low methane concentrations, has made investors cautious. Financial models based on carbon credits or energy sales remain fragile without policy guarantees or floor prices.

Institutionally, the absence of a lead agency with clear responsibility for CMM governance undermines action. No public funding instruments currently exist to de-risk early-stage projects or support data collection. The marginality of methane in national mitigation policy and nationally determined contribution (NDC) planning reduces the incentive for both public and private actors to prioritise intervention.

Q5. How can methane mitigation initiatives support South Africa's Just Energy Transition?

Methane mitigation contributes directly to the objectives of South Africa's Just Transition by addressing climate change, improving public health, and enabling a more equitable energy system. It provides an opportunity to generate new economic activity in regions that are most vulnerable to the decline of the coal industry, particularly Mpumalanga.

CMM mitigation projects can create technical and engineering jobs, promote skills transfer, and provide alternative employment for displaced mineworkers. Environmental remediation of abandoned mines through AMM capture also improves safety, reduces pollution, and restores land for alternative uses. Health co-benefits from improved air quality and reduced exposure to toxic emissions are substantial but often overlooked in policy assessments.

Including methane abatement in the JET-IP and aligning it with Just Energy Transition finance mechanisms can attract additional resources and position South Africa as a global leader in implementing integrated climate and development solutions. CMM mitigation is thus not only a technical intervention, but also a platform for inclusive, place-based climate action.

Q6. Who are the key actors and potential champions in the methane mitigation space within South Africa?

The primary actors are South Africa's major coal producers, including Seriti, Exxaro, Thungela, Glencore, Sasol, and African Rainbow Minerals (ARM), which collectively produce over 70% of national coal output. These companies are obligated to report emissions under national regulations, but public disclosures vary in completeness and transparency. Only a few companies have published methane-specific data or indicated interest in mitigation projects.

Beyond the mining sector, critical roles can be played by government departments (including the Department of Forestry, Fisheries & the Environment, DFFE, the Department of Mineral & Petroleum Resources, DMPR, and the Department of Energy & Electricity, DEE). Special Government bodies such as the Presidential Climate Commission (PCC), in partnership with other multi-stakeholder Research, Development & Innovation (RD&I) organisations such as Coaltech and the Mpumalanga Green Cluster Agency, are well positioned to drive cross-sectoral coordination. These organisations can be supported by specialist consultants and researchers at public science councils and higher education institutes (HEIs).

Community organisations and labour unions should be recognised as key stakeholders, particularly in integrating CMM mitigation into the Just Energy Transition. Early engagement and participatory planning can help align climate goals with social and economic priorities in coal-producing regions.

Concluding thoughts: Policy-related recommendations

The report concludes by proposing a set of policy-related recommendations linked to coal mine methane in South Africa. These are summarised as follows:

- **Improve Measurement and Reporting Systems:** Methane emissions data from coal mining are currently uncertain due to limited direct measurements and reliance on default emission factors. Strengthening measurement, reporting, and verification (MRV) systems – potentially via existing GHG reporting regulations – could include mandatory on-site measurements and enhanced data reporting by mine operators. Integration of satellite data and ground-truthing would further improve emission estimates.

- **Integrate CMM into Climate Policy Frameworks:** Fugitive emissions from coal mining are not yet adequately addressed in national climate policies. Inclusion of CMM and AMM in instruments such as the Climate Change Act and Sectoral Emission Targets should be considered as emissions estimates improve.

- **Mobilise Market and Financial Support for Mitigation Projects:** Given the limited economic incentives for methane abatement — particularly from surface mines — policy support through climate finance, carbon tax revenues, or the Just Energy Transition Investment Plan could improve project feasibility. Enabling the inclusion of CMM and AMM in carbon crediting schemes and offset mechanisms would further support mitigation.

- **Address Methane in Mine Closure Policies:** Emissions from closed and abandoned mines represent a major policy gap. Integrating AMM management into mine closure certificates and environmental liability frameworks would help ensure long-term mitigation.

- **Embed Methane Mitigation in the Just Energy Transition:** Incorporating methane management in JET planning could create employment opportunities in monitoring and methane utilisation, support community resilience through targeted investments, and deliver public health benefits by improving local air quality.

- **Promote South-South Cooperation and Technology Transfer:** Encouraging collaboration on R&D and sharing best practices with peer countries could accelerate progress on methane mitigation in the coal sector.

Chapter 1. Introduction

In 2024, for the first time ever, the global average temperature exceeded 1.5 degrees Celsius (°C) above pre-industrial levels for an entire year. The 1.5 °C warming level is considered by scientists as significant as being that above which the impacts of climate change will be exacerbated, with an increase being seen in the intensity of the heatwaves, droughts, floods, and other extreme weather events already being experienced. Furthermore, a recent United Nations Environment Programme (UNEP) report states that if countries continue to pursue their current policies and fail to curb greenhouse gas (GHG) emissions, an overall rise in temperature of 3.1°C over the course of the century could be seen (UNEP, 2024).

A range of GHGs contribute to global warming and climate change, with carbon dioxide (CO2) being that emitted in the greatest volumes. Methane is the second most significant GHG by volume and has a global warming potential of more than 80 times greater than that of CO_2 during the first 20 years after release into the atmosphere (Garthwaite, 2024). Methane has a shorter atmospheric lifespan than CO2, meaning that cutting emissions can be particularly beneficial in slowing short term global temperature increases (European Space Agency, 2025). While naturally present in the atmosphere, methane levels have tripled since 1850, rising from 680–790 parts per billion (ppb) to over 1900 ppb due to human activities (European Space Agency, 2025). More recently, global methane emissions have risen by 61 million tons (around 20%) in the past two decades (Garthwaite, 2024).

In recognition of the need to reduce methane emissions to limit global warming, the European Union and the United States launched the Global Methane Pledge (GMP) at the Conference of Parties (COP) 26. The aim of the GMP is to collectively reduce global methane emissions by at least 30% by 2030 from 2020 levels. If this goal is reached, it could reduce warming by over 0.2°C by 2050. As of March 2024, 158 countries had joined the GMP (GMP, 2024).

One of the major contributors to anthropogenic methane emissions is coal mining, particularly in regions with high levels of underground mining. Three categories of methane emission sources from coal mining are identified:

- **Coalbed Methane** (CBM) remains trapped in unmined coal seams and can be extracted through surface boreholes. The presence of CBM in underground geology does not necessarily pose an emissions liability until it is intentionally or unintentionally brought to the surface. For the purposes of this study, drainage and utilization of CBM in areas where mine expansion or development will occur is considered a method of methane emissions mitigation. However, extraction of CBM from areas that are not likely to become commercially viable for mining is not considered a mitigation measure.

- **Coal Mine Methane** (CMM) is released from active mining sites, either from the coal seam or surrounding underground formations (Karacan, Ruiz, Cotè, & Phipps, 2011). This methane escapes as fugitive emissions. Sources include:

  - Underground mining: Methane that is captured using underground drainage methods during mining and that which is released into mine ventilation systems (Cook, 2005). A key function of ventilation systems in underground coal mines is to maintain methane concentrations well below explosive levels by diluting the methane released during mining operations (Karacan, Ruiz, Cotè, & Phipps, 2011). Underground mines are believed to represent 90% of CMM emissions globally, and ventilation air methane represents about 70% of the CMM from these underground mines (Howell & Tang, 2024).

  - Surface mining: Methane that is emitted directly to the atmosphere (Cook, 2005) from coal during opencast mining. Surface mine methane emissions are believed to be under-reported, largely due to the lack of active on-site measurements (RystadEnergy, 2023).

  - Post-mining: Methane that is emitted after mining, during coal storage and transport. With no pre-drainage of methane, the Intergovernmental Panel on Climate Change (IPCC) recommends using a emission factor of 30% of the in-situ gas content as remaining in the coal, and emitted post mining (Cook, 2005)

- **Abandoned Mine Methane:** Methane that is released from coal seams in mines that are no longer operational (closed and/ or abandoned mines)[1].

1.1 South African methane

The DFFE reports that South Africa's methane emissions rose from 12.9% to 13.2% of national GHG emissions between 2000 and 2022 — excluding Land Use, Land-Use Change, and Forestry (LULUCF) (DFFE, 2024a; DFFE, 2025). As in the rest of the world, South Africa's methane emissions mainly originate from the agriculture sector, particularly through livestock enteric fermentation, and the waste sector specifically solid waste disposal (DFFE, 2024a; DFFE, 2025). The energy sector is the third largest contributor, with methane emissions being produced across the coal value chain, from mining and extraction to combustion.

South Africa is a significant player in the global coal industry, ranking as the seventh-largest producer worldwide, with an annual production of approximately 245 million tons. Coal is central to the country's energy infrastructure, accounting for about 70% of its primary energy demand (IEA, IRENA & UN Climate Change High-Level Champions, 2024). This heavy reliance

1 Methane emitted from coal waste piles, tailings, or discard dumps is not typically included under AMM.

on the fossil fuel poses challenges for South Africa's commitment to the Paris Agreement and addressing methane emissions from coal mining represents one potential opportunity for contributing to the country's international climate commitments.

Emissions from coal mining are typically not well incorporated into GHG reporting (Howell & Tang, 2024), with AMM largely being overlooked (Lloyd & Cook, 2012). Measurement, calculation, and reporting are complicated by the fact that volumes of methane emissions from underground and surface mining depend on multiple factors including mine productivity, coal seam gassiness, and geological conditions (GMI, 2016; Workshop Participants, 2025). As evidence, in the mid-1990s, South Africa was reported to be among the top five global CMM emitters due to high coal production, based largely on the assumption that coal seam gas content levels in the country were similar to Australia. These estimates were later found to be overstated. By 2010, South Africa's rank dropped to ninth, with emissions estimates of 8.2 million tons of CO2 equivalent (Mt CO2e) per annum (GMI, 2016).

Efforts to mitigate emissions in South Africa have been limited, with only one documented initiative, being Anglo American's New Denmark Colliery CMM Flaring Project which operated from 2010 to 2012 (GMI, 2024). The project aimed to secure carbon credits under the United Nations' Clean Development Mechanism (CDM) to offset costs and sustain operations (Anglo American, 2011; Anglo American, 2012). However, the initiative ultimately ceased operations due to a collapse in the CDM market and emissions being too low to warrant flaring (GMI, 2016; Workshop Participants, 2025).

1.2 Objectives, research questions, and methodology

This research report was commissioned to achieve two complementary objectives:

1. Study the challenges and opportunities for methane monitoring and mitigation in the South African coal sector and provide concrete recommendations for policy-related interventions.

2. Create momentum and awareness on coal-associated methane monitoring and mitigation amongst stakeholders with interests in coal mining in South Africa.

3. Six key research questions were defined to guide the assessment and to meet the overall study objectives:

4. What are the data availability and gaps with respect to methane emissions from South African coal mining?

5. What is the historic and current policy landscape on methane reporting and mitigation in South Africa?

6. What are the key opportunities associated with methane mitigation from coal mining?

7. What are the main challenges to implementing CMM mitigation in South Africa?

8. How can methane mitigation initiatives support South Africa's Just Energy Transition?

9. Who are the key actors and potential champions in the methane mitigation space within South Africa?

To answer these research questions, we conducted a systematic review study of the South

African coal sector. This involved a comprehensive review of academic and policy literature, including reports from government bodies, national and international organisations and institutions, along with articles from newspapers and journals. To further explore the diverse perspectives of stakeholders, and validate potential mitigation pathways, the team organised a two-day expert workshop with participants from South Africa and other coal producing countries (see Appendix A:).

This report examines the challenges and opportunities for South Africa to strategically manage its coal mine methane emissions in alignment with its climate goals in the years ahead. Section 2 discusses the data availability and gaps for methane emissions from South African coal mining. Section 3 presents the current policy landscape for coal mine methane mitigation in South Africa. Section 4 provides an overview of the options available for methane mitigation and explores the potential challenges for implementing them. Sections 5 and 6 explore the benefits of reducing methane emissions and the opportunities for action respectively. Section 7 provides concluding thoughts. Additional complexities for calculating coal mine methane emissions in South Africa are discussed in Appendix B, whilst Appendix C explores the potential links between South Africa's Just Transition journey and action on coal mine methane. Finally, Appendix D describes the evolving community of practice on coal mine methane in the country.

Chapter 2. Methane emissions from South African coal mining

Accurately quantifying methane emissions from coal mining remains a global challenge, with estimates subject to considerable uncertainty (Tate, 2022). Recent research suggests that actual emissions from coal mining — particularly coal mine methane (CMM) — may be more than twice the levels reported under the United Nations Framework Convention on Climate Change (UNFCCC) (Assan & Whittle, 2023). This large discrepancy arises from inconsistent reporting practices, outdated data, and methodological differences between bottom-up (activity-based) and top-down (satellite-based) approaches (Tate, 2022). In addition, many major coal-producing countries report data infrequently or present it in aggregated form, further contributing to potential underestimation.

2.1 Unpacking official estimates

The South Africa Department of Forestry, Fisheries and Environment's (DFFE) 9th National GHG Inventory Report draft (NIR) provides the most recent and comprehensive overview of national emissions, covering 2000 to 2022 (DFFE, 2023; DFFE, 2024a; DFFE, 2025). According to this report, methane emissions from coal mining and handling for 2022 were approximately 0.06 Mt (60 kt) – which equates to 1.6 $MtCO_2e$ (1,652 $ktCO_2e$). These emissions amount to approximately 0.38% of South Africa's 2022 inventory (435.8 MtCO2e in 2022) and include the following:

- Underground mines (mining): 16 kt CO_2 + 48 kt methane = 1.369 $MtCO_2e$
- Underground mines (post-mining seam gas emissions): 3 kt CO_2 + 11 kt methane = 0.32 $MtCO_2e$
- Surface mines (mining): 0 $MtCO_2e$
- Surface mines (post-mining seam gas emissions): 0 $MtCO_2e$

These emissions estimates were developed using IPCC guidelines and Tier 2 country-specific emission factors rather than direct measurements with coal production data from from the South African Minerals Industry (SAMI) Annual Reports and Minerals Council South Africa. It is worth noting that data from the Global Energy Monitor (GEM, 2022; GEM, 2024), the International Energy Agency (IEA, 2024a), and other independent studies (Deng, et al., 2022; Shen, et al., 2023; Scarpelli, Jacob, Grossman, Lu, & Qu, 2022) use various measurement techniques to estimate methane emissions from coal mining and estimate significantly higher levels of coal mine methane than those reported in the South African GHG national inventory. Methodology, gaps, and limitations for each source of emission estimates are explored in Table 1. Actual estimates from these sources are compared graphically in Figure 2.

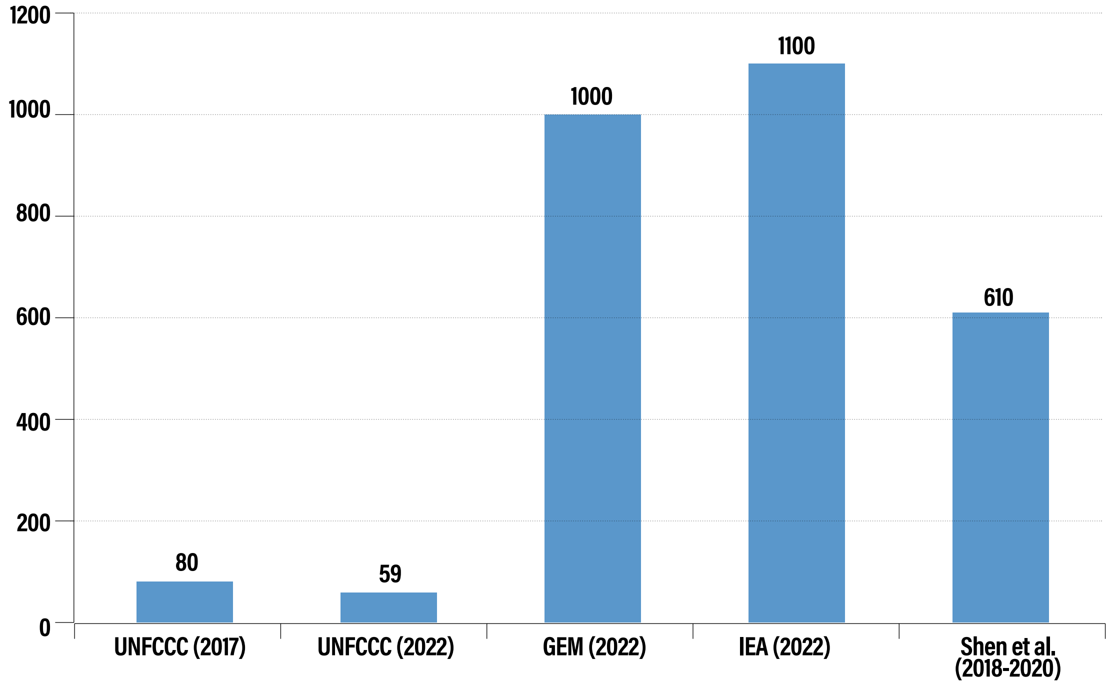
Table 1. Summary of sources of coal mine methane emissions estimates for South Africa

Data source	Methodology	Gaps (action required)	Limitations (research required)
UNFCCC ~0.06 Mt (60kt) per annum 2022 data South Africa's 9th NIR	▪ Tier 2 emission factors from coal seam and methane emission data - based on Lloyd & Cook (2005)	▪ High level – no mine-by-mine or company data	▪ Emission factors uncertain – can vary by a factor of two or more
	▪ One emission factor for surface mines and one for underground mines ▪ Activity-based emission factor estimates (i.e. coal production) over facility-level ▪ 100-year GWP (updated IPCC conversion factor)	▪ Tier 2 country-level estimates using limited samples over short periods ▪ Emissions from closed and AMM excluded	
GEM (2022) **~ 1 Mt per annum 2022 data 2024 data is available[2] ~ 1 Mt**	▪ Mine-by-mine emission calculations use production, gas content at given mine depth, and an emissions factor coefficient – as per Kholod et al. (2020) ▪ Data sourced from publicly available reporting. ▪ In-house estimates use database (remotely sensed methane observations) and asset-level profiles (government inventories and resource plans, company reports, news/media, NGOs, on-the-ground contacts) ▪ Report both 20- and 100-year GWP measures	▪ Database includes emissions from 14 mothballed coalmines, but this is not included in final reported values ▪ Emissions from closed and AMM excluded	▪ Bottom-up approach relies on nuanced assumptions for coal extraction volumes, method, coal rank and depth ▪ For plume emissions data, Carbon Mapper estimates are used – no observations for South Africa
IEA (2024a) **~1.1 Mt per annum 2022 estimate**	▪ Data sourced from GEM and the CRU ▪ Merge data, taking best estimates ▪ Emission intensities based on national inventories and disaggregated data sources ▪ Estimates use mine- and region-specific intensities (GEM)	▪ Unclear whether mine-by-mine ▪ Emissions from closed and AMM excluded	▪ Where direct data unavailable, emission intensities estimated using coal quality, mine depth, and regulatory oversight ▪ Satellite-detected data supplements estimates, but Carbon

2 69 operating coal mines with emission estimates for 63 coal mines. Together, these 69 coal mines are owned by approximately 40 different entities. Smaller mines may not be included, and so these would likely be an undercount.

	▪ Emission factors from independent studies supplemented with UNFCCC data ▪ Estimates verified using satellite & atmospheric data - Shen et al (2023), Deng et al. (2022) & Kayrros[3] data processing (Kayrros, 2025)		Mapper has no readings for South Africa yet
Satellite (Shen, et al., 2023) **~ 0.6 Mt per annum 2020 data**	▪ High-resolution satellite inversions[4] used to estimate source and quantity of emissions ▪ 22 months (May 2018-Feb 2020) of TROPOMI[5] observations to better quantify emissions	▪ Data collection can only be done in suitable weather[6] ▪ Emissions from closed and AMM excluded	▪ Accuracy still being improved ▪ Publicly available estimates for South Africa slim

Figure 1. Annual CMM emissions by source and year



Source: Author's own illustration (DFFE, 2024a; DFFE, 2025; GEM, 2022; IEA, 2024a; Shen, et al., 2023)

As illustrated above, South Africa could be emitting 7 to 14 times more CMM than it officially reports to the UNFCCC. It is also worth noting that all these emissions estimates omit methane emissions originating from abandoned mines in the country. Kholod et al. (2020) introduced an updated methodology for calculating fugitive emissions, incorporating factors such as extraction method, coal rank, mining depth, and using evidence-based emissions factors. The

3 Kayrros uses satellite imagery from multiple constellations to detect and measure significant human-caused methane emissions on a daily basis.

4 Inversion modelling takes observed concentrations of methane and works backwards to infer locations, magnitudes, and sources of emissions. It compares satellite data to a model of how methane disperses in the atmosphere, allowing scientists to estimate the sources of emissions, such as industrial activity or natural processes.

5 TROPOMI (Tropospheric Monitoring Instrument) is a space-borne imaging spectrometer that monitors trace gases and aerosols relevant for air quality and climate

6 For example, cloud cover skews readings, nighttime measurements are not possible, and offshore measurements have significant inaccuracies.

research found that AMM emissions accounted for 17% of total methane emissions from coal mining in 2010. Using short-term comparisons, the climate impact of South Africa's coal mines could therefore be adding up to a quarter to the country's total annual CO2e (EDGAR, 2022; Assan & Whittle, 2023).

Appendix B explores some additional complexities of reporting coal mine methane emissions in South Africa, including growing interest in using satellite-based atmospheric methane observations and company-reported data.

2.2 Key challenges on data and emissions calculations

Key challenges related to data availability and gaps can be grouped into several categories, which are described in detail below. While these challenges are evident in South Africa, they reflect a broader global issue concerning the accuracy, consistency, and transparency of emissions reporting across the global coal mining sector.

2.2.1 Standardizing report metrics

Research has demonstrated inconsistencies in how coal mining companies disclose their fugitive GHG emissions. Without standardisation in reporting, and clearly defined assumptions and methodologies, aggregated emissions assessments become unreliable. Central to this is how discrepancies arise when companies report emissions based on saleable coal production rather than run-of-mine (ROM) coal, even though fugitive methane emissions occur at the extraction stage. Using saleable production underestimates actual emissions, leading to inaccuracies in industry-wide emissions estimates.

2.2.2 Reliance on Tier 2 emissions factors

Initial baselines for methane emissions from South African coal mines rely on the IPCC guidelines and Tier 2 emission factors (Lloyd & Cook, 2005). Given heterogeneity in coal mines, there is a strong need for moving away from using averaged data towards more accurate, localised data on methane emissions in South African coal mines, methane emission factors for specific sites, and mitigation efforts. It is useful here to consider a study published in 2022 by Singh, et al (2022), which sought to update GHG estimates for Indian underground coal mining based on the 2019 IPCC refinements – see Box 1.

Box 1. Case study - updating GHG for underground mines in India (Singh, Singh, Panigrahi, & Singh, 2022)

Underground coal mining is a significant source of fugitive GHG emissions in India, and previous analyses relied on deterministic emission factors. This study therefore intended to address these gaps and conducted field measurements on 108 of India's 338 underground mines to advance GHG reporting in the sector (for both CO2 and methane emissions).

The results revealed substantial variability in both CO2 and methane emissions across different mines. Results show large heterogeneity across "degrees'' of mines, as categorised by the Indian government based on the methane concentration in the air and the emission rate per ton of coal produced. Specifically, shallower mines with lower "gassiness" showed considerable CO_2 emissions. The findings indicated that overall emissions from underground coal mining have decreased over the years, from 2.6–8.3 Mt CO_2e in 1980 to 1.3–3.6 Mt CO_2e by 2019. The study also discusses approaches that could be generalised to strengthen emissions inventories in the coal mining sector, aiming for more robust GHG reporting based on IPCC 2019 refinements. These findings could help inform ways of improving emission estimates from the South African coal mining sector, and include:

- **Field measurements:** Conducting on-site emissions measurements in a wider range of mines to capture more accurate and site-specific data, rather than relying solely on tier 1 and 2 emission factors
- **Differentiated emission factors:** Refining and expanding the use of emission factors to account for variations between mines, such as differences in depth, gas content, and mining methods, to improve the precision of emissions estimate
- **Improved data collection and reporting framework:** Establishing better protocols for data collection, reporting, and verification to ensure consistency and transparency in emissions inventories – including AMM emissions where possible.

2.2.3 Abandoned mines

Abandoned and inactive mines are not currently accounted for in official methane emissions estimates. Without proactive measures, closed coal mines can continue to emit significant amounts of methane gas (Tate, 2022; Workshop Participants, 2025). This means that merely phasing down coal power will not fully address the coal mine methane issue, highlighting the need for AMM to be carefully addressed in climate governance.

Abandoned coal mines in South Africa, particularly in the eMalahleni (Witbank) area, contain coal in pillars and floors. When coal pillars weaken and collapse, they can allow air to enter abandoned mines, reigniting spontaneous combustion, and therefore contributing significant amounts of GHG emissions – including methane (Lloyd & Cook, 2012).

There are a number of closed mines in key coal-producing areas in South Africa, and the condition of these sites ranges from properly managed closures to neglected, abandoned mines (Limpitlaw, Aken, Lodewijks, & Viljoen, 2005). Research on the estimation of GHG from South African surface and abandoned coal mines (Lloyd & Cook, 2012) found that quantifying these emissions is difficult due to the varied conditions of the waste, ranging from open heaps to rehabilitated dumps.

2.2.4 Emissions from spontaneous combustion

Quantifying methane emissions from partial spontaneous combustion of abandoned underground mines, open heaps and rehabilitated dumps is challenging due to high levels of variation between sites and combustion conditions. Research by Lloyd & Cook (2012) sought to assess the South African coal mining industry's emissions contribution from spontaneous combustion. They highlighted significant discrepancies between previous estimates and actual emissions and noted that rehabilitation efforts are effective at reducing emissions.

The mines sampled represented 53% of all surface coal mining activity – six surface mines and a large discard dump on a seventh mine (Lloyd & Cook, 2012). However, methane was detected only from burning coal and, due to the difficulty in sampling, no reliable estimate could be made of these methane emissions. Given that systematic and accurate sampling of methane was difficult in combustion zones (due to fire, smoke, and uneven terrain), they still took opportunistic samples at accessible locations, and these values are reported below:

- **Mine dump – burned and partially covered:** CO2 emissions of 58 kg/m2 per annum and methane emissions of 0.55 kg/m2 per annum
- **Burning area (fresh and smoking) – dump on which rehabilitation had started:** CO2 emissions measuring over 7,000 kg/m2 per annum and methane emissions of 0.0075 kg/m2 per annum
- **Burning area (fresh and smoking) – raw coal recently mined:** CO2 emissions measuring over 7,000 kg/m2 per annum and methane emissions of 1.2 kg/m2 per annum

These estimates are to be treated cautiously as the sample is not representative and the locations were hard to access consistently, meaning the data coverage was sparse. Therefore, the authors explicitly note that no reliable estimate for methane emissions from spontaneous combustion could be made on a national scale based on these spot samples (Lloyd & Cook, 2012). They do however estimate an upper bound on total annual methane emissions of 10,000 t/a CH_4 by combining prior estimates from Lloyd & Cook (2005) for seam degassing (approximately 3,000 t/a) and using a rough upper-bound for burning zones based on known methane readings (like the 1.2 $kg/m^2/a$ case).

Evidence has also suggested that estimating emissions from spontaneous combustion should consider the following, which are typically ignored (Otter, Piketh, Dlamini, & Burger, 2005):

Strong seasonal differences[7]: measurements need to be done in both summer and winter

Background concentrations or contamination from other industries nearby: these need to be accounted for if assessing direct emissions measurements (Otter, Piketh, Dlamini, & Burger, 2005)

7 A recent study using Sentinel5p data (satellite carrying the TROPOMI, which provides high-resolution data on air quality, climate gases, and other atmospheric pollutants. Sentinel 5P data is also processed by Kayrros) confirms seasonal variations in methane emissions, noting higher methane levels in the Eastern Cape during the summer months (Sibiya, Mhangara, & Shikwambana, 2024). Although this could be due to breeding patterns, as methane emissions are largely from cattle.

Chapter 3. Policy landscape

There is no formal mandate on mitigating coal mine methane emissions in South Africa; however, several existing policies intersect coal mine methane emissions and their potential mitigation. As explained below, this includes general environmental and mining regulations, climate policies, and evolving action on Just Energy Transition.

3.1 General environmental and mining regulations

The legislation governing the mining industry in South Africa is the Mineral and Petroleum Resources Development Act 2002, Act 28 of 2002 (Republic of South Africa, 2002). The Act requires the development of an Environmental Management Plan from the prospecting stage for a new mine, whereas for a mining right, both an environmental impact assessment and an environmental management programme are required. A mining right will be issued if, inter alia, "the mining will not result in unacceptable pollution, ecological degradation or damage to the environment" (Republic of South Africa, 2002: 32). The Act is no more specific than this and makes no mention of the potential GHG impacts of mining. It rather refers to the National Environmental Management Act (NEMA) of 1998 to define environmental management principles and responsibilities (Republic of South Africa, 1998).

NEMA requires that financial provision must be made for the rehabilitation or management of negative environmental impacts, prior to the approval of a prospecting right, mining right or mining permit. Looking towards closure, the Petroleum Resources Development Act states that "The holder of a prospecting right, mining right, retention permit, or mining permit remains responsible for any environmental liability, pollution or ecological degradation, and the management thereof, until the Minister has issued a closure certificate to the holder concerned" (Republic of South Africa, 2002: 46).

Despite these provisions, an audit of the DMRE noted that mine rehabilitation is often hampered by insufficient funding, ineffective project management, and incomplete or outdated data (AGSA, 2022)[8]. Unrehabilitated mines pose significant environmental and health risks, with many located near populated areas, exacerbating air and water contamination issues. Moreover, without proper oversight, the rehabilitation of mines becomes, by default, the financial liability of the government (AGSA, 2022).

3.2 Climate policies

In terms of In terms of GHG emissions, the country's 2021 Nationally Determined Contribution (NDC) submission to the UNFCCC lays out its commitment to contribute to global efforts for reducing GHG emissions. However, no mention is made of coal mine methane, or methane more broadly, in the NDC (DFFE, 2021).

The national climate response is framed by the Climate Act of 2024 (Republic of South Africa, 2024). The Act is, however, an umbrella piece of legislation which does not target specific emissions sources but rather puts in place the framework for development of regulations which will govern emissions in the form of Sectoral Emissions Targets (SETs) which focus on specific sectors, and carbon budgets which will focus on individual companies. Although the SETs legislation is still under development, the Draft SETs for Public Comment was released by government on 26 April 2024 (DFFE, 2024b). This document mentions one of the drivers for achieving South Africa's overall climate targets as being "monitoring and management of fugitive emissions from coal mines" (DFFE. 2024b: 24) and recognises the need for establishing monitoring systems for fugitive emissions. However, no further mention is made of this topic, so it is not known whether this will be addressed in further iterations of the SETs.

The National GHG Emission Reporting Regulations of the National Environmental Management: Air Quality Act (as amended in 2020) require emitters to register and report emissions, including emissions from coal mining and handling (DFFE, 2020). To support this process, the DFFE issued "Methodological Guidelines for Quantification of GHG Emissions" (DFFE, 2022), offering sector-specific methodologies to ensure consistent and accurate reporting. Reports prepared in compliance with this legislation are not, however, available in the public domain.

Finally, the Carbon Tax Act of 2019 requires emitters to pay taxes on each ton of emissions reported under the Emission Reporting Regulations (Republic of South Africa, 2019). A number of allowances reduce the effective rate of tax per ton of emissions from the baseline tax rate of around R190/tonCO2e as of 2025.

3.3 Evolving action on the Just Energy Transition

The Presidential Climate Commission (PCC) was set up by the South African government in September 2020 with the overarching goal of facilitating a just and equitable transition toward a low emission and climate-resistant economy. In June 2022, The PCC put forward a Just Transition Framework (JTF) to set out a shared vision and set of principles to guide the JET, as well as the policies and governance arrangements to give it effect. This framework defines South Africa's Just Transition as follows (PCC, 2022):

- The JET seeks to ensure a high quality of life for all South Africans by enhancing the ability to

8 2.25 mines were rehabilitated annually between 2009 and 2021, a marginal increase from 1.67 mines per year in the previous audit (AGSA, 2022).

adapt to the negative effects of climate change, fostering climate resilience, and achieving net-zero GHG emissions by 2050, in line with the best available science.

- It aims to support decent work for all, promote social inclusion, and eliminate poverty. The JET prioritises people in decision-making, especially those most affected, including the poor, women, people with disabilities, and the youth, by empowering them and preparing them for future opportunities.
- The JET strengthens the resilience of both the economy and society by promoting affordable, decentralised, and diversely owned renewable energy systems; conserving natural resources; ensuring equitable access to water; and providing a healthy environment and sustainable, inclusive land use, with a focus on protecting the most vulnerable.

The JET therefore focuses on transforming South Africa's energy sector as the country shifts from coal to cleaner energy sources, while also dealing with the problems of unemployment, poverty and inequality that will arise. These are not new problems in South Africa, but they could be exacerbated by the transition if it is not managed properly.

In line with this commitment and based on the JTF, the PCC published the JET Investment Plan (JET-IP) in December 2022 (PCC, 2022). The JET-IP, which will run from 2023 to 2027, provides an investment framework for spending the USD 8.5 billion investment of the Just Transition Partnership which was established between South Africa, France, Germany, UK, USA, and the EU at the 2021 UN Climate Change Conference (COP 26). One of the initial investments is in the Mpumalanga region, where ZAR 60.4 billion has been budgeted to facilitate the just transition of the region's coal mining sector. Key programs of this initial phase include repurposing coal plants and mining land, infrastructure development, local economy diversification, developing transition plans for the coal workforce, and investing in the skill development of future generations. To oversee implementation of the JET-IP, the PCC established a JET Project Management Unit (PMU) in January 2023. While recent research has begun to assess coal mine closures and mining community profiles within the context of the JET (Cole, Mthenjane, & van Zyl, 2023), no significant work has been done to explore the potential linkages between coal mine methane emissions mitigation in this context.

Chapter 4. Mitigating methane emissions from coal mining

As summarized in Table 2, there are several methane mitigation technologies available for coal mines in South Africa. Generally, these technologies provide methane management solutions for degasifying virgin coal seams and managing methane from ventilation systems and other parts of the mine.

Where coal mines are yet to be developed or expanded, pre-mine drainage of CBM can help to limit releases of CMM and post closure/AMM down the line. In many mines CBM can be highly concentrated, allowing it to be economically utilised prior to mining operations beginning[9]. In areas where mining is already taking place, the appropriate mitigation measures largely depend on the type of mine, the emission source, methane concentrations, and total emission volumes (IEA, 2024a; Workshop Participants, 2025). IEA research suggests that the coal industry's most impactful scope 1 emissions[10] reduction measure (apart from not extracting and/ or burning coal) is mitigating methane from ventilation systems, an intervention which could reduce global CMM emissions by nearly 30% (IEA, 2023a). However, strong policy and economic incentives are required as costs are high and energy recovery potential is limited.

Where methane utilisation projects are not economically feasible, flaring CMM can serve as an effective way to both reduce GHG emissions and mitigate methane-related mining hazards (EPA CMOP, 2021). Compared to energy recovery projects, enclosed flares offer advantages such as shorter planning, design, and installation timelines, as well as significantly lower capital and operational costs - the capital cost of a typical CMM flaring project can be just 5–10 percent of the cost of a CMM electricity generation project (EPA CMOP, 2021). However, flaring

9 CBM is sometimes also extracted for utilization from areas which are not feasible to be mined. While this is not a mitigation action per se, as the CBM would have likely remained in the ground if not extracted, CBM may represent a lower emissions fossil fuel than other options such as burning the coal itself or crude oil derived products.

10 Scope 1 emissions refer to direct GHG emissions that come from sources owned or controlled by an organisation.

projects typically rely on revenue sourced from GHG emissions reduction markets, including the market for carbon credits.

In many countries, a small number of mines account for a disproportionately large share of emissions (IEA, 2023a). Emissions are not linked solely to the size of the mine, as one mine can emit up to 67 times more methane than a mine of similar size (Tate, 2022). Targeting interventions to reduce methane emissions at high emitting mines can help leverage economies of scale, and large-scale anchor installations could help support broader CMM reduction efforts by helping build infrastructure for captured gas, such as grid connections, gas processing, or pipelines (IEA, 2023a). Such projects could further help increase industry knowledge of mitigation measures, reduce institutional barriers, and attract new companies, including service providers, project developers, and technical experts, to develop and maintain technologies.

Despite the availability of mitigation options, South Africa has only pursued one CMM mitigation project, Anglo American's New Denmark Colliery CMM Flaring Project, which operated between 2010 and 2012 (GMI, 2024; Anglo American, 2011; Workshop Participants, 2025). project, developed at one of the deepest underground mines in South Africa, cost approximately USD 1.2 million to construct. It utilised a system of blowers and Swiss-designed mobile flaring systems to destroy methane. Project developers planned to pursue carbon credits through the United Nations' CDM to recoup their initial investment and operate the system. Ultimately, the project's demise was tied to a crash in the CDM market and very low methane concentrations in the gas streams (GMI, 2016; Workshop Participants, 2025).

Table 2. CMM mitigation options

Emission source	Measure	Mine type	Further information (IEA, 2024a; IEA, 2023a)
Drainage system (degasification and methane control): extract methane before drilling into coal seams and after mining (boreholes over mined areas)	Drained methane utilisation	Virgin coal seams and surface and underground mines	Coalbed methane from virgin coal seams and high-concentration methane in active underground mines can be captured through degasification systems, reducing emissions before, during, and after mining operations. As mining progresses into gassier coal beds, mine operators are increasingly interested in control systems to supplement conventional ventilation and keep the specific emissions of the mines at low levels (Karacan, Ruiz, Cotè, & Phipps, 2011). The gas is then drained to surface pumping stations where it can be vented, flared, or prepared for use or sale.
	Flaring	Surface and underground mines	Where utilisation is not viable, flaring or combustion technologies are preferred due to methane's potency. Since methane volumes and concentrations fluctuate throughout a mine's lifespan, destruction methods like flares may be necessary to complement utilisation technologies and maintain continuous methane mitigation. Flaring is considered less environmentally damaging than venting, although CO2 is still released. In 2010, Anglo American initiated a methane flaring project at its New Denmark Colliery, citing that "flaring burns off methane, rendering it 18.5 times less harmful to the environment than venting" (Anglo American, 2011). The project operated for just two years and was shut down in 2012 (GMI, 2024; GMI, 2016).
Ventilation systems: shafts release methane from ventilation systems into the atmosphere	Oxidation (including RTO)	Underground mines	Technologies such as thermal oxidation can destroy low-concentration methane. VAM mitigator (VAMMIT) is a compact thermal flow reversal reactor with a regenerative bed, which oxidises methane to produce water and CO2 reducing the potency of GHG released Invalid source specified.. As an alternative to the recovery and use of VAM, thermal oxidation, destroys VAM. Oxidation projects can be expensive and technically challenging but enable methane destruction even at very low concentrations. A promising technology is regenerative thermal oxidation (RTO) in underground mines (Workshop Participants, 2025). At a pre-feasibility stage in Australia. RTO is an air pollution control process that destroys pollutants and uses regenerative heat recovery, making it fuel-efficient (Anglo American, 2023).

	On-site recovery and use	Surface and underground mines	In underground coal mines, on-site recovery and use of VAM can provide heat to mine facilities or be used for coal drying. Recovered methane can then be used to generate electricity, with the potential to supply ~40 TWh globally. It can be used on site or sold to industrial users. Therefore, CMM could be used in a variety of projects, including natural gas pipeline injection, power generation, and ventilation air methane (Karacan, Ruiz, Cotè, & Phipps, 2011). Not all extracted gas can be commercially utilised, depending on quality and volumes.
Other sources11: infrastructure at mines, including combustion at flares or utilisation units and fugitive emissions	Capture (seal) and route to abatement	Underground mines	Measures to capture and reroute fugitive emissions to abatement systems - monitoring, capturing, and sealing emission sources (e.g., closing inactive mine entries or boreholes) and directing CMM to drainage or VAM abatement systems.
	Efficiency improvements	Surface and underground mines	Efficiency improvements (e.g., ensuring high combustion efficiency in flares, gas engines, and related equipment through process control systems) can further reduce emissions from coal processing, storage, and transport. For example, in 2011, Anglo American was able to cut methane emissions at their Goedehoop Colliery in South Africa by isolating areas needing ventilation and fixing leaks (Anglo American, 2011; Anglo American, 2012).

It is worth noting that the financial viability for any methane mitigation project that relies on recouping costs through selling carbon credits will depend on the average price of carbon credits in the voluntary carbon market (MSCI, 2025). As the value of carbon credits increases, methane mitigation projects could be financially viable, presenting an opportunity for South Africa to revisit CMM abatement projects.

4.1 Determining the feasibility of mitigation options

Methane mitigation in coal mining is considered cheaper than addressing methane emissions in the agriculture and waste sectors, but more expensive than mitigation in the oil and gas industry. It has further been suggested that 90% of (abatable) methane emissions in coal mining would cost USD 20 per ton CO2 emissions (or less) to mitigate (Howell & Tang, 2024).

It is currently technically feasible to prevent around 53% of global CMM emissions using available technologies, with around 13% of these reductions achievable at no net cost (Assan & Whittle, 2023). The effectiveness and cost of the measures depends on a multitude of factors, including but not limited to the methane concentration, emissions sources and volumes, the type of mine, and the size of the mine (IEA, 2023a).

To determine the feasibility of mitigation activities in a particular context, it is crucial to consider the mitigation potential and the cost of the mitigation activity (IEA, 2023a). These are discussed in more detail below, with Box 2 illustrating what applying the IEA's methodology may look like in the context of South African coal mining.

4.1.1 Mitigation potential

According to the methodology used by the IEA (2023a), the mitigation potential can be calculated using two factors:

11 Outcrops and workings - surface mines also release methane through fractures, mine entries, and boreholes, where shallow areas often have cracked ground above them.

- Applicability factor: represents the percentage of emissions from facilities where mitigation measures can be applied (e.g., sufficient methane concentration)
- Effectiveness factor: reflects how much methane each measure can reduce (e.g., flares are assumed to combust 95% of methane emissions on average)

Table 3 outlines the criteria and mitigation potential for each measure used, based on emission type and source.

Table 3. How specific sources of emissions are abated and abatement potential of measures

Specific source	Choice of measure	Measure	Type	Applicability factor	Effectiveness factor	Abatement potential
Drainage system	Emission <1kt	Flare	Vented	80%	95%	76%
	Other mines	Drained CMM utilization	Vented	80%	95%	76%
Ventilation systems	intensity <10kgCH4/t or emissions <10 kt	VAM oxidation	Vented	78%	90%	70%
	other mines	On-site recovery & use	Vented	78%	90%	70%
other losses	All mines	Effciency improvements	Incomplete combustion	80%	75%	60%
Other losses	all mines	Capture and route	Fugitive	66%	75%	50%
Post mining	All mines	Capture and route	Fugitive	30%	65%	20%
Outcrops workings	All mines	Capture and route	Fugitive	10%	65%	7%

Source: (IEA, 2023a)

4.1.2 Mitigation costs

Costs include both capital and operational expenditures. Costs are annualised using, for example, a 10% discount rate and adjusted for the lifetime of the abatement measure. Capital and operational costs are based on US data but are scaled for other countries using region-specific information where available. For instance, mines in Russia and Kazakhstan face higher capital costs due to the need for dust removal systems (IEA, 2023a). Local power prices also affect operational costs.

For drained methane utilisation, costs vary with methane emission levels (IEA, 2023a). For example, for a mine emitting 2.5 kt methane/year, the IEA estimates the costs of a 2.5 MW facility at around USD 2.5 million, with additional costs for the collection system and other expenses. For VAM oxidation and on-site recovery, costs increase for mines emitting over 10 kt methane/year, while capture and route costs are scaled for mines producing over 5 million tons of coal annually. For example, costs for an 8 Mt coal mine are 1.6 times higher than those for smaller operations.

At the same time, mitigation activities can generate energy savings or revenue – for example, using methane for on-site power generation or selling extracted methane. If the value of the energy produced exceeds the cost of the technology, mitigation can result in overall savings (IEA, 2023a). Therefore, mitigation feasibility must not only account for the costs but also potential energy savings and sales, which must be discounted for transport, fees, and taxes. For example, the IEA methodology uses the following: For drained CMM utilisation, revenue is based on regional electricity prices discounted by 40%. For VAM on-site recovery, revenue is based on regional coal prices, discounted by 33%. If a mine has potential for either methane utilisation or VAM recovery, these are used for revenue calculations; if neither is possible, no revenue is assumed for the capture and route option (IEA, 2023a).

Box 2.: The feasibility of methane mitigation in South African coal mines

The IEA's methodology has not been applied to South African coal mines. However, using it as an indication, the IEA cost estimates indicate that with approximately 1.526 MtCO2e methane emissions from coal mining in 2023, the technical abatement possibility in South Africa would be 48% with a potential revenue from energy savings of USD 0.21 billion by 2030 (IEA, 2024a). For this, the average annual spending needed would be estimated as USD 0.34 billion from 2023 to 2030 (13% of emissions are avoidable at no net cost). In order to properly and accurately construct estimates of methane mitigation costs in South African coal mining, the following would need to be prioritised (RystadEnergy, 2023):

- **Accurate and standardised methane emissions reporting:** Crucial for obtaining precise methane emissions data (including on sources and allocations). Current reporting varies in accuracy, making it difficult to rely on, compare or aggregate the data and information accurately. With accurate and standardised metrics, South Africa could enhance the reliability of the data used in constructing the cost curves. This consistency would also help identify patterns over time and compare data across regions or companies, ultimately supporting regulatory efforts and improving transparency.

- **Inclusion of closed and abandoned mines:** Emissions from closed or abandoned mines, which is often neglected, can continue for years and could represent a significant methane source. Including AMM emissions data in the baseline is critical because this segment may respond differently to mitigation interventions compared to active mines.

- **A targeted approach:** Identifying key sources of emissions e.g., underground/surface mines, high concentration sources, and specific mines that are high emitters. The reduction of coal mine methane emissions requires a highly targeted approach. Methane emissions vary significantly based on mine type, operation method, and geographical location. Identifying high-emitting mines and specific emission sources (such as surface versus underground operations or geological hotspots) enables a targeted approach to measuring the cost and benefit of implementing mitigation measures. This prioritisation is necessary to focus resources and efforts where they will have the most impact. By mapping emission intensities across different sources, stakeholders can allocate funding more effectively and prioritise high-impact areas for intervention.

- **Assess viable actions and technologies in South Africa:** Sufficiently mature and commercially adopted, and best for each emission source. Mitigation technologies vary in their maturity and cost-effectiveness, especially when applied to different countries and mining environments. Identifying suitable, commercially proven technologies, such as methane drainage or flaring, for each source type allows for accurate assessment of potential interventions. Selecting technologies based on their compatibility with South African mines' operational realities is key, as it ensures practical adoption and helps minimise implementation barriers, optimising mitigation potential and cost-effectiveness.

- **Substantiate cost estimates and mitigation potential:** Through interviews and desktop research recording cost/benefit where companies have implemented mitigation measures. Accurate cost estimates affect the economic viability assessment of different mitigation actions. By substantiating costs through interviews with industry experts and desktop research, the estimates will reflect the actual expenditures mining companies face in South Africa. Additionally, quantifying the mitigation potential of each intervention provides a clear view of the likely impact on overall emissions. This evidence-based approach would allow policymakers and stakeholders to prioritise the most cost-effective and impactful measures.

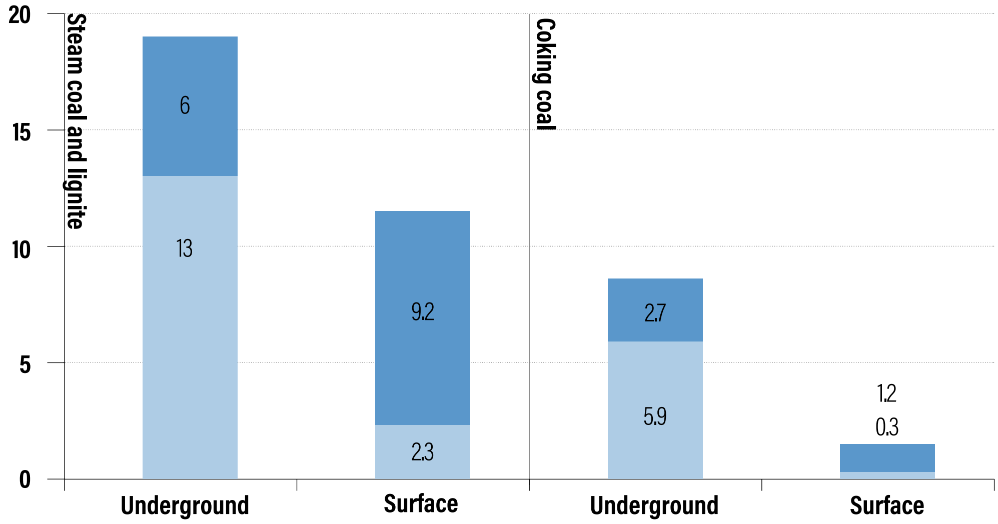
Integrating these considerations into the IEA methodology could provide a more realistic and actionable picture of methane mitigation costs and potential for South Africa's coal mining sector.

4.2 Understanding the South African coal mining context

As stated previously, underground mines are believed to represent 90% of CMM emissions globally (Howell & Tang, 2024). As such, the primary focus of coal mine methane mitigation is on underground mines. Larger, porous underground coal mines have higher emissions and hence mitigation potential, while surface mines have low to no mitigation potentials (see Figure 3). Globally, it is estimated that about 70% of CMM from underground mines can be mitigated, compared to only 20% from surface mines. In South Africa, 2022 data indicates that 75% of South Africa's total coal production is from open cut mines (GEM, 2022).

Methane mitigation opportunity potential also varies by coal rank. Approximately 50% of CMM can be mitigated from steam coal and lignite mines, while around 60% can be abated from coking coal mines (IEA, 2023a). In South Africa, coal reserves primarily consist of hard coals with no significant sub-bituminous and lignite reserves (GMI, 2016). Finally, the concentration of methane emissions affects mitigation potential, as the lower the concentration of methane, the more technically and economically difficult it is to (IEA, 2023a)In South Africa, CMM concentrations can be low and can fluctuate, making mitigation challenging, notably for VAM which typically contains less than 1% methane (IEA, 2024a).

Figure 2. Methane emissions and abatement potential of global coal supply, 2022 (Mt methane).



Source: (IEA, 2023a)

The GMI has created country profiles for major coal producers, evaluating their specific methane mitigation opportunities and challenges. This was last updated for South Africa in 2016, with the key takeaways being summarised in Table 4.

Table 4. CMM abatement opportunities and challenges

Focus	2016 findings	2024 updates
CBM extraction from virgin coal seams	As of 2016, there was no commercial production of CBM in South Africa. However, several pilot wells were undergoing testing. At that time, the most promising areas for CBM were the Waterberg Basin and the southwest portion of the Highveld coalfield.	There is still no commercial production of CBM. The Lephalale Basin and Ermelo coalfields are considered the country's most promising area for CBM extraction at present and have undergone significant exploration. The Mopane sub-basin, Tshipsie-Pafuri sub-basin, Tuli-basin, and Highveld coalfield are also promising.
Operating mines	In 2004, an industry-funded study (Lloyd & Cook, 2005; Cook, 2005), was carried out to better assess South Africa's CMM emissions. Conducted by the Council for Scientific and Industrial Research (CSIR), it measured methane concentrations in ventilation air from major mines. The study involved 243 methane measurements from 27 underground mine shafts in South Africa. Results showed significant variability, but estimates suggest methane emissions of 40.8 Gg methane per year from ventilation air (error of ± 30.2 Gg). Additionally, about 28.6 Gg per year was released from coal after it leaves the mine, with less than 3 Gg per year from surface mining. This gives a total methane release estimate of around 72 Gg per year. However, these estimates have large errors due to unpredictable methane release patterns and variability in coal seam gas content.	Continuous monitoring and further measurements are needed. Accurate measurement will enable more cost-efficient mitigation strategies and help companies steer clear of increasing reputational and regulatory risks (Howell & Tang, 2024).
Recovery and end-use	The coal seams in South Africa's main Karoo coalfields were found to be generally shallow and not considered highly gassy, with little focus being placed on methane recovery and use. Some mines, like the Majuba Colliery, had experienced unexpectedly high methane levels (tests showed up to 300 cubic feet of methane per ton of coal) and so in the early 1990s, horizontal wells were drilled to remove gas before mining. Although the mine explored methane recovery options, it was eventually closed for other reasons. Some mines in South Africa had also drained methane before mining through surface holes, with the potential for using the gas for local heating being studied.	Little evidence of study or implemented of methane recovery and use in coal mining.
Mitigation projects	In 2010-2012, Anglo America was pursuing a CMM abatement project at its underground New Denmark Colliery near Standerton (Anglo American, 2011; Anglo American, 2012). The project involved using two mobile flares to burn methane from the mine's drainage system. This was projected to reduce the mine's annual methane emissions from ventilation boreholes by an expected 15%. The system, powered by solar energy, could be monitored remotely. The project cost USD 1.2 million, and developers sought to claim carbon credits under the CDM.	Due in large part to a crash in CDM credit pricing, Anglo American discontinued the New Denmark project in 2012. Seriti acquired the colliery from Anglo American in 2018.
Abandoned mines (AMM emissions)	There was a lack of available data on emissions from abandoned mines in 2016 and it was believed that relatively few were gassy, since most of the gassy coal areas remained undeveloped. At the time, no companies were extracting methane from abandoned mines due to legal and regulatory challenges. Many companies worried that once they obtain a mine closure certificate, any further activities could lead to legal liabilities.	South Africa has many abandoned coal mines, with the number of operating mines halving from 1986 to 2004. This further declined to 69 mines in 2022 (GEM, 2022). This remains largely unchanged in 2025, except that mines are increasingly being placed on care and maintenance.

Uses	Methane from coal mining could be used for electric power generation, boiler fuel, transportation fuel, and as petrochemical feedstocks. Utilising this methane could help reduce the country's reliance on gas imports to meet rising demand and serve as an alternative to coal and firewood.	
In less gassy, shallow mines, methane collected could be harnessed for local heating, although infrastructure would need investment in and development.	Opportunities to capture CMM from surface mines for local power generation or industrial applications are limited due to a lack of infrastructure to capture, store, or transport methane. Here, flaring may be a suitable consideration, as it has a lower environmental impact compared to venting.	

Source: (GMI, 2016)

4.3 Challenges for methane mitigation in South Africa

Methane mitigation technologies have been deployed at various sites globally, yet they remain far from standard industry practice (IEA, 2024a). Projects frequently face obstacles such as a limited market for power or natural gas, economic constraints, and legal or regulatory challenges regarding methane ownership. In South Africa, there are currently no active CMM (or closed and AMM) capture and utilisation projects. The literature emphasises the need for targeted policies that address the specific challenges of methane reduction in both active and abandoned coal mines. There is a particular focus on improving market access, clarifying legal ownership, and enhancing rehabilitation and monitoring efforts. The key challenges associated with methane mitigation in South African coal mining are discussed in this section.

4.3.1 Operating coal mines

Commercial and institutional barriers, along with other project risks, can affect the economic viability of methane recovery and use projects (Karacan, Ruiz, Cotè, & Phipps, 2011). These challenges include technical difficulties due to fluctuations in gas quality and quantity, unresolved legal issues regarding ownership of the methane as a resource, a lack of pilot projects to demonstrate the economic feasibility of new technologies in specific locations, insufficient financing or limited access to funding, and issues related to location and capacity.

As discussed above, methane mitigation potential and costs vary significantly across different mining operations (IEA, 2023a). In particular, surface mines have lower mitigation potentials[12], where globally it is estimated that only 20% of CMM from surface mines can be abated. With 75% of South Africa's total coal production being from open cut mines (GEM, 2022), this presents a challenge. The concentration of the methane emissions is another important factor that effects methane mitigation, as the lower the concentration of methane the more technically and economically difficult it is to abate (IEA, 2023a). For South Africa, CMM concentrations can be low and fluctuate, making abatement challenging, especially for VAM, which typically contains less than 1% methane (IEA, 2024a). Finally, mitigation measures can be especially costly for small facilities (IEA, 2023a). The best option here may be to close older and smaller mines, with mitigation measures focusing on larger mines.

12 While surface mines generally emit less methane per ton of coal than underground mines due to lower gas content at shallower depths, this is not always the case (Irving & Tailakov, 2000).

This difficulty arising from variability is amplified by the measurement challenges contributing to uncertainty in mitigation potential and costs. Estimates have significant margins of error due to unpredictable methane release patterns and variability in coal seam gas content. Without accurate data, methane emissions from coal mining — from both CMM and AMM — may be underestimated, further complicating mitigation strategies. The increasing numbers of small-scale opencast miners in South Africa further complicates monitoring efforts, as these operations are often overlooked in methane emissions studies.

4.3.2 Closed and abandoned coal mines

Coal mines continue emitting methane even when the mine is closed and coal production has ceased (Kholod, et al., 2020). Additionally, when coal pillars in abandoned mines weaken and collapse, they can allow air to enter abandoned mines, reigniting spontaneous combustion (Lloyd & Cook, 2012). Issues also arise when artisanal miners illegally re-enter closed mines or when rehabilitated land is mismanaged, resulting in pollution, spontaneous fires, and safety hazards (Limpitlaw, Aken, Lodewijks, & Viljoen, 2005).

Given that abandoned and closed coal mines continue to emit methane, often exacerbated by rehabilitation mismanagement and illegal mining activity, questions should be raised about who holds liability for these emissions and hazards. The 2016 GMI report on CMM opportunities and challenges in South Africa highlights the fact that many abandoned mines pose challenges for methane extraction due to legal liabilities, with the situation remaining unclear in 2024 (GMI, 2016). So, should the responsibility for managing these risks lie with mining companies during closure and rehabilitation? If not, it would become a financial and environmental liability for the government, underlining the need for clear accountability in mine closure and rehabilitation regulations.

The rehabilitation of closed mines is slow, with legal and social challenges including illegal artisanal mining, mismanaged rehabilitated land, and environmental risks like fires and pollution (AGSA, 2022).

Workshop participants highlighted AMM as a key area warranting further exploration in South Africa (Workshop Participants, 2025).

4.3.3 Lack of supporting policy

The coal industry typically lacks incentives to voluntarily reduce methane emissions in coal mining (IEA, 2024b). While capturing and using methane can be profitable in a few cases, most mitigation efforts are not cost-effective without policies that price the environmental impact. To address this, explicit policy and regulatory measures may be necessary to change the industry's incentives. This could involve promoting best practices for monitoring and managing methane emissions, improving access to energy markets, and using a mix of rewards and penalties to encourage the reduction of methane emissions in coal mining. In addition, current policies primarily focus on thermal coal while neglecting metallurgical coal which is used in steelmaking and is more methane intensive than thermal coal (Olczak, 2023) and disregard emissions from closed or abandoned mines.

Common policy challenges include shifting priorities, limited market access for captured methane, complex legal frameworks, and ineffective monitoring and verification systems (Olczak, 2023). Additionally, some regulatory measures unintentionally promote flaring instead of more beneficial uses of captured methane when the latter would be preferable.

Clarifying resource rights to methane emitted from both active and abandoned coal mines is essential for enabling the productive use of the gas (IEA, 2023a). Incentives may include grants or subsidies for project development, feed-in tariffs for electricity generation, or incorporating projects into carbon offset credit programmes. For example, Germany's 2021 Renewable Energy Sources Act guarantees a fixed payback tariff for 20 years through feed-in tariffs or fees for electricity generated from approved CMM and AMM projects (IEA, 2023b).

Chapter 5. Potential benefits of reducing methane emissions

Reducing coal mine methane emissions not only helps combat climate change but could also provide certain co-benefits that align well with certain national initiatives like the JET-IP. These co-benefits are discussed below in the context of South Africa's broader Just Energy Transition goals.

Coal mining and climate change

The future impacts of climate change, particularly in regions reliant on coal mining such as Mpumalanga, pose significant risks to vulnerable populations. These communities may face increased exposure extreme weather events, reduced water availability, and declining agricultural productivity, all physical risks that are exacerbated by climate change (PCC, 2022). While CMM and AMM may contribute only a small percentage to overall GHG emissions in coal mining, addressing these emissions remains essential for ensuring a just energy transition.

Public health outcomes

Methane reductions from CMM and AMM are essential to South Africa's Just Energy Transition, not only for climate benefits but also for improving public health. Methane emissions contribute to ground-level ozone, which worsens respiratory conditions like asthma and bronchitis (Jung, Wei, & Fang, 2019). Capturing methane reduces these risks and prevents future health impacts, protecting vulnerable communities near coal mines. Additionally, methane mitigation in closed and AMM supports safer mine rehabilitation, aligning with broader goals of an equitable healthy environment.

Energy efficiency and security

Research has shown that methane drainage projects can enhance mine productivity by cost-effectively reducing downtime caused by high methane levels (Karacan, Ruiz, Cotè, & Phipps, 2011; Bibler, Marshall, & Pilcher, 1998). International case studies show that pre-mining methane drainage can boost productivity up to as much as 40 tons per man-hour and lower mining costs by up to 25% (Ahuja, Mondal, Mishra, Ghosh, & Kumar, 2023).

Furthermore, by capturing methane emissions from coal mines, this potent GHG can be repurposed as an alternative energy source that can supply energy to various sectors, reducing reliance on traditional fossil fuels (IEA, 2024a). This aligns with the JET's goal of promoting decentralised and diversely owned energy systems, as captured methane can be integrated into local grids or used directly by industries, strengthening the resilience of the economy and society.

As a caveat, South African researchers suggested that the concentrations of methane in South African mines are too low for capturing (Lloyd & Cook, 2012). This research suggested that methane in South African coal seams is primarily held in fissures, cleats, and pores rather than being adsorbed in the coal itself. However, the sporadic nature of emissions, along with discrepancies in national estimates, underscores the need for further investigation into methane release dynamics in South African mines before drawing firm conclusions about its capture potential.

Supporting the livelihoods of local communities

A 2022 report titled "Mitigating Methane in Texas: Reducing Emissions, Creating Jobs, and Raising Standards" found that the methane mitigation industry presents a dual opportunity: lowering GHG emissions and creating high-quality jobs (Cumpton & Agbo, 2023). The report also highlighted the need for policy measures like prevailing wages and project labour agreements to ensure these jobs are safe and well-compensated.

In countries such as India, which is increasing its coal mining activities, methane mitigation offers a substantial opportunity to create jobs. Pre-mining methane drainage projects could support a large number of direct jobs in methane capture, given the scale of the country's mining sector (Bajpai, James, & Pai, 2025). However, post-mining employment opportunities can be harder to quantify, as they depend on the longevity of monitoring and maintenance efforts. In South Africa, where coal mines are increasingly being closed or abandoned, focus must also lie on the employment potential for the mitigation of methane in closed and abandoned coal mines. As coal mines face increasing pressure to close, methane mitigation projects could be implemented during the wind-down of the industry supporting the efforts to minimise the job losses (Cumpton & Agbo, 2023).

By investing in methane mitigation projects, both CMM and AMM, the coal sector could maintain a number of jobs during the transition to a lower-carbon economy, supporting the JET's aim to ensure workers are not left behind in regions dependent on coal for employment. This includes workers employed in coal mining, workers in industries that support coal mining and miners, and downstream industries reliant on coal mining (e.g., power generation and steel).

Examples of direct and indirect job creation potential are given below:

Direct job creation from methane capture, management, and monitoring: Jobs in methane capture systems include installation, operation, and maintenance of technologies that drain methane before, during and after mining. These roles involve technical expertise and can create long-term employment in regions where coal mining is prevalent. Skilled workers are also needed for monitoring methane emissions and ensuring that projects comply with environmental regulations, ensuring safety and efficiency in methane capture processes. The scope for more unskilled workers would stem more from indirect job creation in downstream industries.

Indirect job creation – downstream use of captured methane: The captured methane can be used for power generation, coal drying, or as a supplemental fuel for boilers, generating jobs in energy and manufacturing sectors. These industries can benefit from a reliable source of methane and create additional employment in the supply chain.

However, there remains a need to explore the potential employment opportunities of methane mitigation in South African coal mining. Better understanding and quantifying these opportunities may compel the government and other stakeholders to act more ambitiously and provide financial and policy assistance for an activity that would support the livelihoods of those most affected by the transition to a low carbon economy.

Jobs can also be created in the rehabilitation of closed and abandoned mines. Closed and abandoned mines may continue to emit methane long after they have stopped producing coal (Kholod, et al., 2020). Not addressing these emissions risks prolonged environmental harm, whereas proper rehabilitation can create jobs in environmental restoration, methane management, and long-term monitoring. This supports restorative justice by addressing the ongoing impact of abandoned mines on local mining communities. Overall, methane mitigation in coal mining aligns with the JET by reducing environmental hazards, supporting long-term community resilience, and ensuring coal-dependent regions are not left behind.

As discussed in this report, methane mitigation from coal mines could generate carbon credits (MSCI, 2025). Revenues from selling these credits can be reinvested into local economies by funding skills training programs and supporting job creation in renewable energy, environmental management, and methane capture technologies. This would help to diversify local economies and reduce their dependence on coal mining. It could support restorative justice efforts for mining communities, many of which have suffered from environmental degradation. This supports the aims of the JET in that these communities will be the most affected by closure of coal mines and the physical effects of climate change.

Appendix C explores the potential links between coal mine methane mitigation and the broader Just Energy Transition imperative in greater detail.

Chapter 6. Opportunities for action

While methane mitigation potential in South African coal mining may be constrained due to the dominance of surface mining and low methane concentrations from underground mining, there are still opportunities to leverage knowledge and policies to achieve emissions reductions. The following opportunities were identified from the authors' systematic research and expert engagement. These opportunities can be explored and pursued by South Africa's budding community of practice on coal mine methane, which is discussed in more detail in Appendix D.

6.1 Emissions data improvement

Without reliable data, it is difficult to gauge the opportunity potential for coal mine methane mitigation in South Africa. Section 2.2 provides an overview of some of the key challenges related to data availability and gaps in the country, and there is broad consensus among interested stakeholders that South Africa should pursue a mixture of bottom-up and top down approaches to addressing these challenges and improving its coal mine methane emissions.

6.2 Preventative maintenance

Mitigating methane at active mines must start with preventative maintenance of existing systems. This is a cost-effective strategy to control methane emissions in coal mines by enhancing efficiency and safety. Regular inspection and upkeep of critical equipment, such as ventilation systems, methane drainage infrastructure, and gas monitoring devices, prevent methane accumulation and unintended leaks. This approach not only ensures mine safety by avoiding hazardous methane levels but also boosts operational efficiency by minimising unexpected disruptions. Additionally, it mitigates environmental impact by addressing methane emissions early, preventing them from escalating into more significant issues. Coal companies should prioritise regular, preventative maintenance of mine systems to better manage fugitive methane emissions.

6.3 Recovery and use and feasibility studies

The Karoo coalfields have received little attention for methane recovery in coal mines, despite some mines like Majuba Colliery (now closed) showing high methane levels. Methane recovery and use must be investigated further here and elsewhere to explore the technical feasibility of implementing recovery and use projects and other mitigation opportunities. Technologies like VAM recovery and thermal oxidation could be implemented in certain mines but may face challenges due to low and fluctuating methane concentrations. In addition, opportunities to capture methane from surface mines and use it for local power generation or in industrial applications are limited by the nature of South Africa's coal reserves and production processes. There is a lack of infrastructure to capture, store, or transport methane. Here, flaring may be a suitable consideration, as it has a lower environmental impact compared to venting[13].

Using the IEA's methodology with South African-specific data and context could create a practical tool for exploring the true feasibility of methane mitigation activities in the country. Here, adapting the methodology to the South African context would require considering local conditions, such as emission types, mine characteristics, and cost structures.

6.4 Carbon markets

Projects focused on capturing and utilising CMM (as well as closed and AMM), have shown the potential to generate significant carbon offset credits in both voluntary and compliance carbon markets. Revenue produced through these projects could be reinvested into further decarbonisation initiatives or support Just Transition efforts in the coal industry. As discussed, the financial viability of methane mitigation projects has shifted due to changes in the economics of carbon credit markets (MSCI, 2025). Thus, given the potential for methane reductions to deliver significant short-term climate benefits and meet growing global demand for high-integrity carbon credits, South Africa should reconsider such mitigation initiatives, and the community of practice should re-evaluate opportunities to leverage carbon markets for methane mitigation in the country.

6.5 Addressing the lack of policy

Integrating CMM (alongside closed and AMM where relevant) into the South African coal mining policy (for before, during and after mining activities) is important. Based on the information presented in this report, the following selection of policy-related recommendations are proposed to target action on coal mine methane in South Africa.

6.5.1 Strengthen Measurement, Reporting, and Verification (MRV) systems:

Estimates on methane emissions from coal mining were found to be highly uncertain, which is a consequence of the limited availability of direct measurement data, uncertainty on emission factors, and limited reporting of data. Policy interventions, (possibly linked to the National GHG Emission Reporting Regulations), could focus on supporting increased reporting of emissions by mine owners from different sources (e.g. ventilation air methane, pre-drainage, post-mining,

13 There are no updates or results from the 2011/12 methane flaring project at the New Denmark Colliery. Results from the project should be requested from Seriti, and the viability of flaring projects reconsidered.

and AMM), and possibly include mandatory on-site measurement at major mines, thus encouraging a move away from using default emission factors. Direct reporting could be supplemented by integration of satellite data (e.g. from MethaneSAT, Sentinel-5P, or Carbon Mapper) and incentivising ground-truthing and calibration to reconcile top-down and bottom-up estimates.

6.5.2 Integrate methane mitigation into climate mitigation policy:

CMM receives limited attention in the Climate Change Act (Republic of South Africa, 2024) and other climate policy instruments, including in the draft SETs (DFFE, 2024b). Consideration could be given to including fugitive emissions from coal mining, including CMM and AMM, into the policy framework, as appropriate. The extent to which this makes sense depends to some degree on volumes of emissions, which will be determined once emissions estimates are less uncertain.

6.5.3 Pursue opportunities for supporting methane mitigation projects through market and financial mechanisms:

The economics of methane abatement in South Africa are currently marginal, particularly given the dominance of low emitting surface mines. To improve project viability, consideration could be given to supporting methane mitigation projects through international climate finance, carbon tax revenues, or the Just Energy Transition Investment Plan. Methane capture projects (especially AMM) could be included in local carbon crediting schemes through the development of appropriate methodologies, as well as in the provisions for carbon offsets under the Carbon Tax.

6.5.4 Incorporate methane mitigation into mine closure and rehabilitation policy:

A particularly urgent gap in current policy is the treatment of emissions from closed and abandoned mines. Addressing this source of emissions requires defining responsibility for methane emissions in closure certificates and environmental liability frameworks. Consideration could be given to including AMM recovery and destruction technologies into mine rehabilitation requirements.

6.5.5 Align methane action with the Just Energy Transition (JET):

The transition away from coal presents both risks and opportunities. Methane mitigation, if embedded in JET planning, could potentially create skilled and semi-skilled jobs in emission monitoring, methane capture, equipment maintenance, and power generation from methane, as well as support restorative justice in communities affected by mine closures through targeted investment in AMM mitigation and land rehabilitation, and contribute to improved public health outcomes by reducing local air pollution.

6.5.6 Facilitate South-South collaboration and technology transfer:

This could include through joint R&D programmes and sharing of lessons learnt.

Chapter 7. Conclusion

This report has highlighted that South Africa's coal sector is a potentially significant source of methane emissions, with current reporting practices underestimating the sector's true contribution. Official estimates, which rely primarily on Tier 2 emission factors and saleable coal production data, do not fully account for actual methane releases, particularly those from underground operations and abandoned mines. Independent studies indicate that national inventories may underreport coal mine methane emissions by a factor of between seven and fourteen. Globally, methane emissions from abandoned mines are also often not included in official estimates, further widening the data gap.

Mitigation experience in South Africa is limited, with only one documented abatement project to date. The absence of comprehensive, site-specific measurement and a lack of standardised reporting protocols remain significant barriers to both accurate emissions accounting and the implementation of mitigation actions. Furthermore, the economic and technical viability of methane abatement options has not yet been demonstrated in the South African context.

While international initiatives—such as the Global Methane Pledge—are beginning to shape the global policy landscape, South Africa's domestic framework for methane monitoring and mitigation is still at an early stage of development. Effective integration of methane abatement into broader climate and energy policy, including within the Just Transition agenda, will be essential for meaningful progress.

There are clear opportunities to strengthen methane management in the sector. These include establishing standardised reporting protocols, investing in direct measurement technologies, and piloting abatement projects to assess feasibility and impact. Improved data transparency and increased stakeholder engagement will be critical to advancing these opportunities.

References

AGSA. (2022). Follow-up performance audit at the Department of Mineral Resources and Energy. On the rehabilitation of derelict and ownerless mines. Auditor-General of South Africa (AGSA).

Ahuja, M., Mondal, D., Mishra, D. P., Ghosh, S., & Kumar, M. (2023). Assessment of financial and environmental impacts of pre-mining methane drainage in Indian scenario: A case study using Jharia coal seams. Innovation and Green Development, 2. doi:https://doi.org/10.1016/j.igd.2023.100065

Anglo American. (2011). Sustainable Development Report 2010. Anglo American. Retrieved from https://www.angloamerican.com/~/media/Files/A/Anglo-American-Group-v5/PLC/investors/annual-reporting/2011/angloamerican-sd-reporthjz-2010.pdf

Anglo American. (2012). Sustainable Development Report 2012. Anglo American. Retrieved from https://www.angloamerican.com/~/media/Files/A/Anglo-American-Group-v5/PLC/investors/annual-reporting/2013/aa-sdr-2012.pdf

Anglo American. (2023). Sustainability Report. Anglo American. Retrieved from https://www.angloamerican.com/~/media/Files/A/Anglo-American-Group-v5/PLC/investors/annual-reporting/2023/sustainability-report-plc-2023.pdf

ARM. (2023). Climate Change and Water Report. African Rainbow Minerals (ARM) Limited. Retrieved from https://arm.co.za/wp-content/uploads/2023/10/ARM-CCW-October-2023.pdf

ARM. (2024). Condensed reviewed results for the financial year ended June 2024 and cash dividend declaration. African Rainbow Minerals (ARM). Retrieved from https://senspdf.jse.co.za/documents/2024/jse/isse/ARIM/FY2024.pdf

Arnoldi, M. (2025). Coaltech, Mpumalanga Green Cluster Agency partner to advance JET initiatives. Retrieved from Mining Weekly: https://www.miningweekly.com/article/coaltech-mpumalanga-green-cluster-agency-partner-to-advance-jet-initiatives-2025-01-14

Assan, S., & Whittle, E. (2023). In The Dark: underreporting of coal mine methane is a major climate risk. Ember. Retrieved from https://ember-climate.org/insights/research/in-the-dark-underreporting-of-coal-mine-methane-is-a-major-climate-risk/

Bajpai, V., James, J., & Pai, S. (2025). Methane Emissions in India's Energy Sector: Current Landscape and Future Prospects. Swaniti Global. Retrieved from https://www.swaniti.com/research-analysis/methane-emissions-in-indias-energy-sector/

Banks, V. J., Palumbo-Roe, B., van Tonder, D., Davies, J., Fleming , C., & Chevrel , S. (2012). Conceptual models of Witbank coalfield, South Africa. Project no: 244242, call 2009, Theme 6, Topic ENV.2009.4.1.3.2 . Earth Observation for Monitoring and Observing Environmental and Societal Impacts of Mineral Resources Exploration and Exploitation. Retrieved from http://nora.nerc.ac.uk/id/eprint/506746/1/EO-MINERS-D3.1-2%20CSM%20Witbank%20FINAL_signed_20120329.pdf

Bibler, C. J., Marshall, J. S., & Pilcher, R. C. (1998). Status of worldwide coal mine methane emissions and use. International Journal of Coal Geology, 35(1-4), 283-310. doi:https://doi.org/10.1016/S0166-5162(97)00038-4

Bloomberg. (2022). South Africa's 400 abandoned coal mines pose deadly risk. Business Tech. Retrieved from https://businesstech.co.za/news/energy/602946/south-africas-400-abandoned-coal-mines-pose-deadly-risk/

Carbon Mapper. (2025). Carbon Mapper. Retrieved from https://data.carbonmapper.org/?details=CO2_1A1_250m_27.97787_-26.74166%3Fstatus%3Dnot_deleted#12.1/-26.74812/28.02021

Carnie, T. (2022). Acid water trail of death reignites concern over South Africa's abandoned coal and gold mines. Daily Maverick. Retrieved from https://www.dailymaverick.co.za/article/2022-03-17-acid-water-trail-of-death-reignites-concern-over-south-africas-abandoned-coal-and-gold-mines/

Coaltech . (2024). Our Members & Partners. Retrieved from Coaltech : https://coaltech.co.za/members-and-partners/#:~:text=Here%20are%20links%20to%20Coaltech%20Members%20and%20Industry%20Partners.

Cole, M. J., Mthenjane, M., & van Zyl, A. T. (2023). Assessing coal mine closures and mining community profiles for the 'just transition' in South Africa. Journal of the Southern African Institute of Mining and Metallurgy, 123(6), 329–342. Retrieved from https://www.saimm.co.za/Journal/v123n6p329.pdf

Cook, A. (2005). Models for predicting methane gas release from coal seams. Coaltech 2020.

Cumpton, G., & Agbo, C. (2023). Mitigating Methane in Texas: Reducing Emissions, Creating Jobs, and Raising Standards. Texas Climate Jobs Project (TCJP). doi:https://static1.squarespace.com/static/60e76bd34e5317302f87f357/t/645d1db64453b27b47622494/1683824055315/TCJP+Methane+Report+2023.pdf

Deng, Z., Ciais, P., Tzompa-Sosa, Z. A., Saunois, M., Qiu, C., Tan, C., . . . Chevallier, F. (2022). Comparing national greenhouse gas budgets reported in UNFCCC inventories. Earth System Science Data, 14(4), 1639--1675. doi:10.5194/essd-14-1639-2022

DFFE. (2020). National Environmental Management: Air Quality Act: Regulations: National Greenhouse Gas Emission Reporting (Act No. 39 of 2004). Departent of Forestry, Fisheries and the Environment. Retrieved from https://www.gov.za/sites/default/files/gcis_document/202009/43712rg11174gon994.pdf

DFFE. (2021). South Africa's First Nationally Determined Contribution under the Paris Agreement. Department of Forests, Fisheries and the Environment (DFFE). Retrieved from https://www.dffe.gov.za/sites/default/files/reports/draftnationalydeterminedcontributions_2021updated.pdf

DFFE. (2022). Methodological Guidelines for Quantification of GHG Emissions, South Africa Government Gazette No. 47257. Pretoria: Department of Forestry, Fisheries and the Environment (DFFE). Retrieved from https://archive.gazettes.africa/archive/za/2022/za-government-gazette-dated-2022-10-07-no-47257-part-1.pdf

DFFE. (2023). 8th National GHG Inventory Report (South Africa: (2000-2020). Pretoria: Department of Forestry, Fisheries and the Environment (DFFE).

DFFE. (2024a). Draft 9th National GHG Inventory Report for the Republic of South Africa for public comment. Pretoria: Department of Forestry, Fisheries and the Environment (DFFE).

DFFE. (2024b). Draft Sectoral Emission Targets Report for Public Comment, South Africa Government Gazette No. 50571. Pretoria: Department of Forestry, Fisheries and the Environment (DFFE). Retrieved from https://static.pmg.org.za/240426Sectoral_Emission_Targets_SETs_Framework.pdf?_gl=1*5w26xn*_ga*NDA1NTIyOTQ5LjE3NTM0MjM3MjI.*_ga_EBG7VD75NV*czE3NTUzMzU1ODQkbzMkZzAkdDE3NTUzMzU1ODQkajYwJGwwJGgw

DFFE, (2025) 9th National GHG Inventory Report for the Republic of South Africa. Pretoria: Department of Forestry, Fisheries and the Environment (DFFE).

EDGAR. (2022). CO2 emissions of all world countries. Emissions Database for Global Atmospheric Research (EDGAR), EU Commission. Retrieved from https://edgar.jrc.ec.europa.eu/report_2022

EPA CMOP. (2021). Coal Mine Methane Flaring: Technology and Case Studies. United States (US): Environmental Protection Agency (EPA) - Coalbed Methane Outreach Program (CMOP). Retrieved from https://www.epa.gov/sites/default/files/2021-01/documents/cmm.flaring.document_2021.01.22.

pdf#:~:text=Methane%20emitted%20from%20coal%20mines%20presents%20a%20critical%20safety%20hazard

European Commission. (2022). oint Statement by the Government of the Republic of Indonesia and International Partners Group members on the Indonesia Just Energy Transition Plan. Brussels: European Commission. Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/statement_22_6892

European Space Agency. (2025). Satellite data analysis uncovers top 10 persistent methane sources. Phys.org. Retrieved from https://phys.org/news/2025-02-satellite-analysis-uncovers-persistent-methane.html#google_vignette

Exxaro. (2023a). Exxaro's Annual Results for the Twelve Months Ended 31 December 2023 Press Release. Exxaro Resources. Retrieved from https://www.exxaro.com/media-and-insights/press-releases/exxaro-s-annual-results-for-the-twelve-months-ended-31-december-2023-press-release/

Exxaro. (2023b). Environemental, social and governance report. Exxaro Resources. Retrieved from https://investor.exxaro.com/integrated-reports2023/pdf/exxaro-esg-2023.pdf

Garthwaite, J. (2024). Methane emissions are rising faster than ever. Stanford Doerr School of Sustainability, Standford Report. Retrieved from https://news.stanford.edu/stories/2024/09/methane-emissions-are-rising-faster-than-ever

GEM. (2022). Methane released by coal mining. Global Energy Monitor (GEM). Retrieved from https://www.gem.wiki/Methane_released_by_coal_mining

GEM. (2024). Global Methane Emitters Tracker. Global Energy Monitor (GEM). Retrieved from https://globalenergymonitor.org/projects/global-methane-emitters-tracker/methodology/

Glencore. (2023a). 2024-2026 Climate Action Transition Plan. Glencore. Retrieved from https://www.glencore.com/.rest/api/v1/documents/static/1dcd075b-bd27-4930-84c1-9f00aba0e129/GLEN-2024-2026-Climate-Action-Transition-Plan.pdf

Glencore. (2023b). Basis of reporting on selected ESG KPIs. Glencore. Retrieved from https://www.glencore.com/.rest/api/v1/documents/static/6e70ade9-3093-4510-af95-5e848f8f6233/GLEN-2023-Basis-of-reporting-on-selected-ESG-KPIs.pdf

GMI. (2016). Chapter 31. South Africa. Global Methane Initiative (GMI). Retrieved from https://www.globalmethane.org/documents/toolsres_coal_overview_ch31.pdf

GMI. (2024). International Coal Mine Methane Project List. Global Methane Initiative (GMI). Retrieved from https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fglobalmethane.org%2Fdocuments%2FInternational%2520Coal%2520Mine%2520Methane%2520Project%2520List.xlsx&wdOrigin=BROWSELINK

GMP. (2024). About. Retrieved from Global Methane Pledge (GMP): https://www.globalmethanepledge.org/#about

Hachmeister, J., Schneising, O., Buchwitz, M., Burrows, J. P., Notholt, J., & Buschmann, M. (2024). Zonal variability of methane trends derived from satellite data. Bremen: Institute of Environmental Physics (IUP), University of Bremen. Retrieved from https://acp.copernicus.org/articles/24/577/2024/acp-24-577-2024.pdf

Howell, A., & Tang, L. (2024). Coal Mine Methane - An Overview for Investors. Environmental Defence Fund (EDF). Retrieved from https://business.edf.org/wp-content/blogs.dir/90/files//Coal-Mine-Methane-An-Overview-for-Investors-1.pdf

IEA. (2023a). Strategies to reduce emissions from coal supply. International Energy Agency (IEA). Retrieved from https://www.iea.org/reports/global-methane-tracker-2023/strategies-to-reduce-emissions-from-coal-supply

IEA. (2023b). Germany's Renewables Energy Act. International Energy Agency (IEA). Retrieved from https://www.iea.org/policies/12392-germanys-renewables-energy-act

IEA. (2024a). Global Methane Tracker. International Energy Agency (IEA). Retrieved from https://iea.blob.core.windows.net/assets/d42fc095-f706-422a-9008-6b9e4e1ee616/GlobalMethaneTracker_Documentation.pdf

IEA. (2024b). Tracking pledges, targets and action. International Energy Agency. Retrieved from https://www.iea.org/reports/global-methane-tracker-2024/tracking-pledges-targets-and-action

IEA. (2024c). Progress on data and lingering uncertainties. International Energy Agency (IEA). Retrieved from https://www.iea.org/reports/global-methane-tracker-2024/progress-on-data-and-lingering-uncertainties#abstract

IEA, IRENA & UN Climate Change High-Level Champions. (2024). Breakthrough Agenda Report 2024. Paris: International Energy Agency (IEA). Retrieved from https://www.iea.org/reports/breakthrough-agenda-report-2024

Irving , W., & Tailakov, O. (2000). CH4 emissions: Coal mining, and handling. Intergovernmental Panel on Climate Change (IPCC). Retrieved from https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/2_7_Coal_Mining_Handling.pdf

Jung, J., Wei, Y., & Fang, Z. (2019). Ozone Pollution: A Major Health Hazard Worldwide. Frontiers in Immunology. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6834528/

Karacan, C. O., Ruiz, F. A., Cotè, M., & Phipps, S. (2011). Coal mine methane: A review of capture and utilization practices with benefits to mining safety and to greenhouse gas reduction. International Journal of Coal Geology, 86(203), 121-156. doi:https://doi.org/10.1016/j.coal.2011.02.009

Kayrros. (2025). The World's Leading Geospatial AI for Energy & Environmental Intelligence. Retrieved from Kayrros: https://www.kayrros.com/

Kholod, N., Evans, M., Pilcher, R. C., Roshchanka, V., Ruiz, F., Coté, M., & Collings, R. (2020). Global methane emissions from coal mining to continue growing even with declining coal production. Journal of Cleaner Production, 256. Retrieved from https://doi.org/10.1016/j.jclepro.2020.120489

Limpitlaw, D., Aken, M., Lodewijks, H., & Viljoen, J. (2005). Post-mining rehabilitation, land use and pollution at collieries in South Africa. Colloquium: Sustainable Development in the Life of Coal Mining. Boksberg: Centre for Sustainability in Mining and Industry, Anglo Coal, BHP Billiton. Retrieved from https://www.mineclosure.net/elibrary/post-mining-rehabilitation-land-use-and-pollution-at-collieries-in-south-africa

Lloyd, P., & Cook, A. (2005). Methane release from South African coal mines. Journal of the Southern African Institute of Mining and Metallurgy, 105(8), 483-490. Retrieved from https://open.uct.ac.za/server/api/core/bitstreams/9ae9ae2d-8bd2-4e37-a2e8-0bc59619ee58/content

Lloyd, P., & Cook, A. (2012). The estimation of greenhouse gas emissions from South African surface and abandoned coal mines. Journal of The South African Institute of Mining and Metallurgy. Retrieved from http://www.saimm.co.za/Journal/v112n12p1087.pdf

Maguire, Y. (2024). How satellites, algorithms and AI can help map and trace methane sources. Google. Retrieved from https://blog.google/outreach-initiatives/sustainability/how-satellites-algorithms-and-ai-can-help-map-and-trace-methane-sources/

Marquard, A., Merven, B., Hartley, F., McCall, B., Ahjum, F., Burton, J., . . . Stevens, L. (2021). South Africa's

NDC targets for 2025 and 2030. Prepared for the Presidential Climate Commission by the Energy Systems Research Group, University of Cape Town. doi:https://pccommissionflow.imgix.net/uploads/images/1eb85a_75d745eb859d43c288f461810b336dd3-compressed.pdf

MethaneSAT. (2025). MethanSAT. Retrieved from https://data.methanesat.org/en/emissions-map?view-latitude=-20.64436&view-longitude=20.94886&view-zoom=1.73&date=2024-09-30&platform=MethaneSAT

Mhlongo, S. E. (2023). Physical hazards of abandoned mines: A review of cases from South Africa. The Extractive Industries and Society, 15. Retrieved from https://www.sciencedirect.com/science/article/pii/S2214790X23000758#sec0011

Minerals Council. (2024). Facts and Figures Pocketbook 2024. Johannesburg: Minerals Council South Africa.

MSCI. (2025). Frozen Carbon Credit Market May Thaw as 2030 Gets Closer. MSCI. Retrieved from https://www.msci.com/www/blog-posts/frozen-carbon-credit-market-may/05232727859

Olczak, M. (2023). Policy Options for Addressing Methane Emissions from the Coal Sector. EDF Economics Discussion Paper No. 23-04. Environmental Defence Fund (EDF). Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4623998

Otter, L., Piketh, S., Dlamini, T., & Burger, R. (2005). Characterisation of spontaneous combustion emissions. Climatology Research Group, University of the Witwatersrand. Johannesburg: Coaltech 2020. Retrieved from https://coaltech.co.za/wp-content/uploads/2019/10/Task-6.1.1-Characterisation-of-Spontaneous-Combustion-Emissions-2005.pdf#:~:text=Determining%20the%20impact%20of%20coal%20mining,%20and%20specifically%20spontaneous%20combustion,

PCC. (2022). Just Transition Framework – Final Report and Recommendations. Presidential Climate Commission (PCC). Retrieved from https://www.climatecommission.org.za/publications/design-addition-and-amendment-to-just-transition-framework-with-dedication-to-pcc-secretary

Republic of South Africa. (1998). National Environmental Management Act 107 of 1998. Pretoria: South African Government. Retrieved from https://www.gov.za/sites/default/files/gcis_document/201409/a107-98.pdf

Republic of South Africa. (2002). Mineral and Petroleum Resources Development Act 28 of 2002. Pretoria: South African Government. Retrieved from https://www.gov.za/sites/default/files/gcis_document/201409/a28-02ocr.pdf

Republic of South Africa. (2019). The Carbon Tax Act 15 of 2019. 647. Pretoria: South African Government. Retrieved from https://www.gov.za/sites/default/files/gcis_document/201905/4248323-5act15of-2019carbontaxact.pdf

Republic of South Africa. (2024). Climate Change Act 22 of 2024. Pretoria: South African Government. Retrieved from https://www.gov.za/sites/default/files/gcis_document/202407/50966climatechange-act222024.pdf

RystadEnergy. (2023). Methane Tracking Technologies. Environmental Defence Fund (EDF). Retrieved from https://www.edf.org/sites/default/files/documents/Methane%20Tracking%20Technologies%20Study%20Oct%2018%202023.pdf#:~:text=Coal%20Mining%20%E2%80%A2%20Methane%20is%20a%20key%20product%20of%20O&G

Sasol . (2024a). Sales and production metrics for the year ended 30 June 2024. Sasol Limited. Retrieved from https://www.sasol.com/sites/default/files/2024-07/Production%20and%20sales%20metrics%20for%20the%20year%20ended%2030%20June%202024.pdf

Sasol. (2024b). Integrated Report. Sasol Limited. Retrieved from https://www.sasol.com/sites/default/files/2024-09/SASOL-Integrated-Report-2024_0.pdf

Scarpelli, T. R., Jacob, D. J., Grossman, S., Lu, X., & Qu, Z. (2022). Updated Global Fuel Exploitation Inventory (GFEI) for methane emissions from the oil, gas, and coal sectors: evaluation with inversions of atmospheric methane observations. Atmospheric Chemistry and Physics, 22, 3235–3249. doi:10.5194/acp-22-3235-2022

Seriti. (2025). Our Business. Seriti. Retrieved from https://seritiza.com/business/

Shen, L., Jacob, D. J., Gautam, R., Omar, M., Scarpelli, T. R., Lorente, A., . . . Lin , J. (2023). National quantifications of methane emissions from fuel exploitation using high resolution inversions of satellite observations. Nature Communications, 14(4948).

Sibiya, S. S., Mhangara, P., & Shikwambana, L. (2024). Seasonal and trend variation of methane concentration over two provinces of South Africa using Sentinel5p data. Journal of Environental Monitoring and Assessment, 196(713). doi:10.1007/s10661-024-12871-0

Singh, A. K., Singh, U., Panigrahi, D. C., & Singh, J. (2022). Updated greenhouse gas inventory estimates for Indian underground coal mining based on the 2019 IPCC refinements. iScience, 25(9), 104946. doi:10.1016/j.isci.2022.104946

Tate, R. (2022). Bigger than Oil or Gas? Sizing up coal mine methane. Global Energy Monitor (GEM). Retrieved from https://globalenergymonitor.org/wp-content/uploads/2022/03/GEM_CCM2022_final.pdf

Thungela . (2024). Chief Financial Officer's Pre-close statement for the financial year ending 31 December 2024. Thungela Resources Limited. Retrieved from https://www.thungela.com/sens-regulatory/pdf/chief-financial-officers-pre-close-statement-for-the-financial-year-ending-31-december-2024

Thungela. (2023). Environmental, Social and Governance Report. Thungela. Retrieved from https://thungela-reports.co.za/esg-2023/pdf/thungela-esg-2023.pdf

UNEP. (2024). Emissions Gap Report 2024. United Nations Environment Programme (UNEP). Retrieved from https://www.unep.org/resources/emissions-gap-report-2024

Vanselow, S., Schneising, O., Buchwitz, M., Reuter, M., Boesch, H., & Burrows, J. P. (2024). Automated detection of regions with persistently enhanced methane concentrations using Sentinel-5 Precursor satellite data. Bremen: Institute of Environmental Physics (IUP), University of Bremen. Retrieved from https://acp.copernicus.org/articles/24/10441/2024/acp-24-10441-2024.pdf

Workshop Participants. (2025, March 17-18). Opportunities and Challenges for Coal Mine Methane Mitigation in South Africa and the Global South.

WWF. (2020). Mine Closure and Rehabilitation in South Africa: Activating Coalitions of the Willing for a Just Future. Cape Town: Briefing Paper to World Wide Fund for Nature (WWF) - South Africa. Retrieved from https://wwfafrica.awsassets.panda.org/downloads/mine_closure_and_rehabilitation_in_south_africa.pdf

Appendix A: Multi-stakeholder Roundtable Discussion on the Opportunities and Challenges for Coal Mine Methane Mitigation in South Africa and the Global South

A1: Concept note and programme

Context

Methane is a short-lived climate pollutant that can trap more than 80 times the heat in the earth's atmosphere than an equivalent mass of carbon dioxide, when considered over a 20-year period. Major sources of methane include the agriculture, waste, and energy sectors, with about 60% of annual methane emissions being attributed to human activity. Measures to reduce methane emissions can thus play an important role in meeting the global climate targets of keeping temperature increases below 1.5°C. In response to this understanding, there is a growing global focus on achieving rapid methane emissions reductions, including in the energy sector and the coal mining sector.

The coal sector is the fourth largest global contributor to human-caused methane emissions. Government data contained in the country's greenhouse gas inventory suggests that fugitive emissions from South African coal mines account for approximately 60,000 tons of methane annually. However, independent studies using various measurement techniques have found actual emissions to be significantly higher. Reducing methane from coal mines in South Africa, where mitigation options are available and cost-effective, is potentially a "low hanging fruit" for limiting overall GHG emissions.

It is in this context that the University of Cape Town Minerals to Metals Initiative (which is focused on integrating and expanding minerals beneficiation research), and Swaniti Global (an international organisation working at the forefront of climate change and energy issues) hosted a two-day roundtable discussion to explore the techno-economic, socio-economic, and political challenges and opportunities for curbing coal mine methane emissions in South Africa. The event sought to provide a platform for sharing learnings amongst a wide range of stakeholders, catalyse momentum towards coal mine methane mitigation in South Africa and initiate long-term partnerships.

Four specific goals were identified:

1. **Understanding current methane emission trends:** Discuss the status of coal mine methane emissions, including specific sources, trends, and areas of concern.

2. **Identifying key challenges:** Identify and discuss the primary challenges associated with coal mine methane mitigation.

3. **Exploring key solutions:** Explore and assess existing and emerging methods for coal mine methane monitoring and mitigation – both technological and policy-based.

4. **Elevating the community of practice:** Foster collaboration among discussion participants, including industry representatives, researchers, environmental organizations, and other stakeholders to share best practices, lessons learned, and innovative approaches to methane mitigation.

Event Format

The event, held at the Southern Sun Rosebank Hotel in Johannesburg, included a combination of presentations, roundtable discussions and brainstorming sessions. The first day included presentations from four international experts from India, Colombia, and the United States, and served to frame discussions through an understanding of global experience with coal mine methane mitigation. Extensive opportunity was provided for questions, discussion and debate. On the second day, the event took a deep dive into the situation in South Africa and explore potential pathways for promoting coal mine methane mitigation in the country. Three expert panels were convened, with short perspectives from the panellists followed by extensive open discussions and debates. The event ended with a roundtable discussion on opportunities for action going forward.

Programme

17th March 2025, Monday

12h00 - 12h45	Finger Lunch
12h45 - 13h45	Welcome and context setting, introductions
13h45 - 14h25	International Speaker Session 1
14h25-14h55	Open discussion
14h55-15h25	Tea/coffee break
15h25 - 16h05	International Speaker Session 2
16h05-17h00	Open Discussion
17h00-18h30	Cocktail Event

18th March 2025, Tuesday

8h45 - 9h00	Tea/Coffee
9h00 - 10h00	Panel session 1: Quantification of South Africa's coal mine methane emissions
10h00-11h00	Panel session 2: Methane mitigation technologies and case studies
11h00-11h30	Tea/coffee break
11h30 - 12h30	Panel session 3: Policy and implementation landscape
12h30 - 13h30	Lunch
13h30 - 14h30	Panel session 4: The Just Transition nexus
14h30- 15h30	Round table discussion: Opportunities for action in mitigating coal methane emissions in South Africa
15h30-16h00	Feedback
16h00-16h30	Closing remarks

A.2 List of participants

Participants included individuals with interest and expertise in the subject area, including international experts, the private sector, civil society and academia.

Table 5. Participants in the two-day round table discussion event

Name	Affiliation	Designation
Alan Cook	Latona Consulting	Director
Andres Angel	POLEN Just Transitions	Researcher
Brett Cohen	Enuity Pty (Ltd)	Director
Carla Hudson	Mpumalanga Green Cluster Agency	Programme Manager
Catherine Horsefield	Centre for Environmental Rights	Head: Mining Programme
Celeste Dias	Mpumalanga Green Cluster Agency	Administration Manager
Charl van den berg	Schauenburg Solutions	Head of SBU: Occupational Safety Solutions
Clark Talkington	Advanced Resources International	Vice President
Dave Collins	Independent Consultant	-
Edwin Mametja	Presidential Climate Commission	Workstream member
Elisha Gujrajah	Thungela Coal	Head: Climate Change
Eric Kamdem	Seriti Resources	Senior Energy Specialist
Felicia Ruiz	Clean Air Task Force	Director of International Methane Partnerships and Outreach
Gcobisa Melamane	Sandi	Clean coal research specialist
Hisham Mundol	Environmental Defence Fund, India	Chief Advisor
Ian Hall	IH Energy	Director
Inus Labuschagne	Private consultant	
Jennifer Broadhurst	University of Cape Town	Professor
Jesse Burton	University of Cape Town	Research Associate
Joey James	Swaniti Global	Associate Director
Karen Surridge	Sanedi	Project Manager: Renewables and Cleaner Fossil Fuels
Kevin Schlorke	Schauenburg Solutions	Business Unit Manager for Smart Platform Solutions
Kim Mccann	Seriti Resources	Senior Environmental Specialist
Maria Eelena Huertas	POLEN Just Transitions	Co-founder
Martin Marias	Schauenburg Solutions	Sales and Business Development Director
Nathi Nkonyane	Mpumalanga Green Cluster Agency	Executive Director
Nicola Torley	Seriti Resources	Environmental Manager
Nicola Wills	DNA Economics	Consultant
Nikki Fisher	Thungela Coal	Head of Sustainability
Nontobeko Gule	Thungela Coal	Operating Model Assurance and Sustainability Specialist
Paul Lado	Centre for Environmental Rights	Attorney
Phillipa Burmeister	SRK Consulting	Principal Scientist

Name	Affiliation	Designation
Phillemon Mathebula	Dept. of Agriculture, Rural Development, Land and Environmental Affairs (DARD-LEA)	Head of Environment
Sandeep Pai	Swaniti Global	Director: Research & Strategy
Veera Reddy	Coal India Limited	Senior Advisor
Zanele Jordaan	Latona Consulting	

Appendix B: Additional complexities calculating South African coal mine methane emissions

B .1 Satellite-based atmospheric methane observations

There is a growing interest in using satellite-based atmospheric methane observations to assess and refine national inventories for climate policy (Scarpelli, Jacob, Grossman, Lu, & Qu, 2022). Satellites equipped with sensors capture data on atmospheric methane concentrations across the Earth's surface. These observations provide high-resolution data, meaning they should be able to detect methane emissions from coal mines with great detail and spatial precision. In this way, satellites allow for regional estimates of total methane emissions over extended periods (IEA, 2024c). While some of these methods are still in the early stages of technological development, they are improving global understanding of where and how often methane emissions occur (as well as attributing methane plumes to specific sites). Advances in satellite and other remote-sensing technologies can enhance transparency, improve emissions quantification, raise public awareness, and aid regulatory oversight[14]. Satellite studies frequently reveal higher emissions than national inventories, highlighting both gaps in monitoring and verification, and inaccuracies in satellite assessments. Advanced technologies are, however, exposing methane hotspots with increasing accuracy.

The scope of earlier efforts had been constrained by the limited availability of data, but new satellite observations from the Tropospheric Monitoring Instrument (TROPOMI) offer much greater data density, although early methane retrievals still exhibited regional biases. TROPOMI is a space-borne imaging spectrometer that monitors trace gases and aerosols relevant for air quality and climate. As TROPOMI data continue to improve, it will enable higher-resolution data, allowing for more precise quantification of national emissions and better identification of regional contributions from specific activities - enabling more effective satellite-based monitoring of national methane emissions, and thus aiding climate policy efforts.

Using data from the TROPOMI – onboard the Sentinel-5 Precursor satellite – researchers recently developed an automated system to detect and estimate emissions from persistent methane sources worldwide between 2018 and 2021 (Vanselow, et al., 2024). The research identified 217 major methane-emitting regions, responsible for about 20% of global methane emissions. These sources included CMM and found that that actual emissions from many of these regions are higher than previously reported.

In addition, the data from the Copernicus Sentinel-5 Precursor mission was used to track changes in in atmospheric methane by focusing on its background levels, excluding seasonal and short-term fluctuations (Hachmeister, et al., 2024). The methodology allowed the researchers to observe variations in methane growth rates between the Northern and Southern Hemispheres from mid-2018 to early 2023.

Notably, they found that in 2020, the Southern Hemisphere experienced a significant increase in methane growth rates, likely due to increased emissions from wetlands. In contrast, the

14 For example, Sasol's Pande-4 site in Mozambique is currently closed under supervision, with satellite surveillance conducted bi-monthly through GHGSat (49 sessions up to June 2024) revealed a slight dip in methane emissions to 36 tons per day (Sasol, 2024b).

Northern Hemisphere saw a decrease in growth rates in 2022, possibly linked to reduced human-made emissions. These findings highlight the importance of continuous satellite monitoring to understand regional differences in methane emissions and their impact on climate change.

International investment in satellite technology means that remote methane monitoring technologies are continuously and rapidly improving (Assan & Whittle, 2023). Recent satellites, as well as those in development, have higher spatial resolutions, more frequent coverage and improved detection thresholds. New satellites such as the GHGsat constellation, EnMAP, Carbon Mapper, CHIME, EMIT and MethaneSat provide a more thorough picture of national, and mine-by-mine, CMM emissions (Shen, et al., 2023).

In particular, the launch of MethaneSat in March 2024, was seen as a significant breakthrough in satellite-based monitoring (IEA, 2024c). This satellite is designed to provide high spatial resolution and accuracy, delivering frequent readings over large areas and integrating advanced computational techniques and automation. It is hoped that the data from MethaneSat, combined with Google's AI and infrastructure mapping, will create a better understanding on how to mitigate methane emissions (Maguire, 2024). However, MethaneSat does not pick up any observations in South Africa (MethaneSAT, 2025). As per the data portal, this may be due to environmental factors, or the area may not have been surveyed.

In contrast, filtering Carbon Mapper to look specifically at methane plumes from coal mining activity yields a positive result (Carbon Mapper, 2025). The satellite picks up five points where a specific methane emission plume has been detected. The map centres on the specified coordinates, highlighting the location of the detected methane plume and using colour gradients to indicate concentration levels. For example, two of the points detected are situated in Witbank, eMalahleni, Mpumalanga with coordinates of 26°01'36.2"S 29°10'19.8"E and 26°01'52.8"S 29°10'52.5"E, which fall within the Tweefontein Complex – a group of operating surface and underground coal mines jointly owned by Glencore and African Rainbow Minerals (ARM). The emission rates can be found in Figure 4, with none falling within a dangerous range when it comes to safety concerns. However, as discussed, even plumes with hundreds to thousands of parts per million contribute significantly to climate change due to methane's GWP.

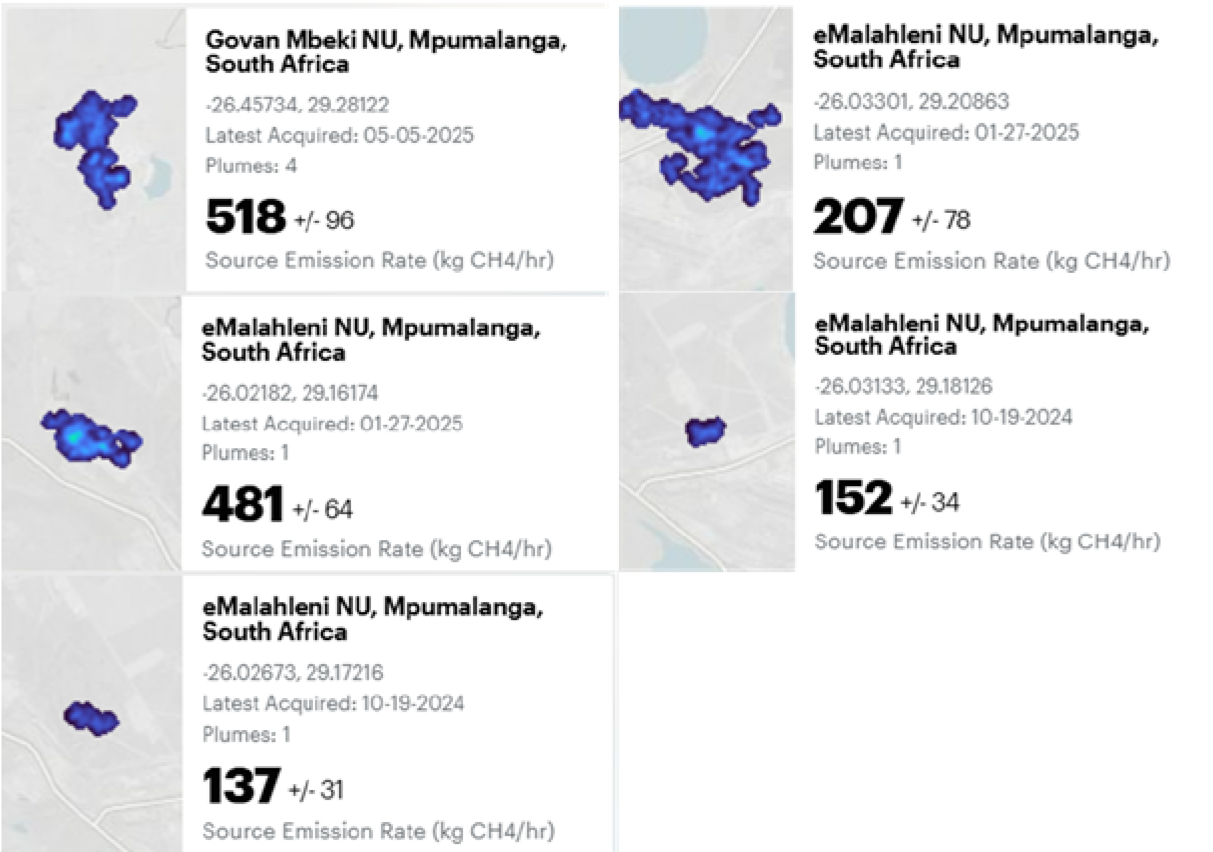
Despite significant technological advances, there are various limitations in estimating emissions based on satellite data (IEA, 2024c; Workshop Participants, 2025). Current satellites may struggle to obtain readings in certain environments, such as offshore areas, mountainous regions, snowy or icy terrains, and at high latitudes. Data collection is further limited by weather conditions, such as cloud cover, which can distort readings, while nighttime measurements are not feasible. For instance, countries with dense forests or in equatorial regions like Nigeria and Venezuela often experience frequent cloudiness, which impedes observation efforts. Other detection technologies may be better suited for different scales of measurement, such as at the source level.

B.2 Company-level emissions reports

As mentioned previously, companies in South Africa are mandated to report GHG emissions, including methane under the National GHG Emission Reporting Regulations of the National Environmental Management: Air Quality Act (DFFE, 2020). These regulations require entities to register and report emissions, including emissions from coal mining and handling (DFFE, 2023; DFFE, 2024a; DFFE, 2025). Furthermore, carbon tax is paid on reported emissions. Reports submitted to the DFFE in compliance with the National GHG Emissions Reporting Regulations are, however, not publicly available.

Methodologies are available for estimating fugitive emissions from coal mining and handling, differentiating between surface and underground mines. However, there are currently no reporting requirements or methodologies for emissions from abandoned underground mines (AMM), flaring of drained methane, conversion of methane to CO2, or uncontrolled combustion and burning of coal dumps (i.e., closed mines and abandoned mine methane).

Figure 3.Methane plumes picked up by Carbon Mapper.



Source: (Carbon Mapper, 2025)

In compiling this study, publicly available reports on methane emissions from the top five mining houses (by coal production) in South Africa were analysed[15]. Collectively, these five companies account for more than half of South Africa's total coal production of 231.2 million tons in 2025 (calculated as ~70% based off company reporting) (Minerals Council, 2024).

Table 6 provides a summary of the information found, and illustrates that, in general, publicly available company-level reporting of methane emissions is limited and inconsistent with some companies reporting methane and others CO2e. Additionally, except for a brief mention by Exxaro, no explicit detail was provided on methane mitigation research or projects.

15 This kind of data is not publicly available for the many small mining companies operating in South Africa. Some requests were made by the team, but to no avail.

Table 6. Company-level methane emissions reporting

Company	Latest coal production (per annum)	Information and data on methane emissions	Sources
Seriti Resources	Headline total = 54.4 Mt (2023) Kriel: 4 Mt New Denmark: 4 Mt New Vaal: 16 Mt. Khutala: 7 Mt Klipspruit: 11.4 Mt Middelburg: 7 Mt New Largo: 5 Mt	Methane emissions are included as part of the company's Scope 1 fugitive emissions. They are calculated in accordance with the methodological guidelines for the quantification of GHG emissions. However, no explicit values are provided.	On request, methodological detail was provided by the Sustainability team at Seriti; Website (Seriti, 2025).
Exxaro	Headline total = 42.5 Mt (2022) Belfast: 3.2 Mt Grootegeluk: 26 Mt Leeuwpan: 4.8 Mt Matla: 6 Mt Mafube: 2.4 Mt	Of the 0.31 MtCO_2e Scope 1 emissions, fugitive emissions made up approximately 19% - 0.06 MtCO_2e. The percentage of fugitive emissions that are methane is unclear, as well as the source (ventilation, degasification, or other). According to public reporting, Exxaro is evaluating opportunities to reduce emissions, including methane capture.	Exxaro's Annual Results for the 12 Months Ended 31 December 2023 (Exxaro, 2023a); Environmental, social and governance report (Exxaro, 2023b).
Sasol	Headline total = 30.2 Mt (FY2023/2024) Bosjesspruit, Impumelelo, Shondoni, Syferfontein, Twistdraai Thubelisha, Sigma, Mooikraal	In 2023, Sasol's direct methane emissions from mining were 0.00319 Mt (down from 0.00657 Mt in 2021). In 2024, direct methane emissions were only given at group level – 0.13 Mt – this includes the gas value chain and so methane emissions associated directly with mining cannot be determined.	Production and sales metrics (Sasol , 2024a); Integrated Report – 2023 and 2024 (Sasol, 2024b).
Thungela	Headline total = 15.6 Mt (2023) Greenside = 3.1 Mt Goedehoop = 3.9 Mt Isibonelo = 3.2 Mt Khwezela = 3 Mt Mafube (50% of production): 2.4 Mt	In 2023, Scope 1 fugitive emissions (released from the coal seams in underground mines) were reported as 0.17 Mt CO_2e. This comprises of ~ 90% methane and represents an 11% decrease in fugitive methane emissions from 2022. Thungela is currently pursuing real-time monitoring of methane emissions on their coal mines (Workshop Participants, 2025).	Chief Financial Officer's Pre-close statement (Thungela , 2024); Environmental, social and governance report (Thungela, 2023)
Glencore and ARM - **Glencore operational control**	Headline total = 17,45 Mt (FY2023/24) Goedgevonde: 7.18 Mt Participative coal business (ARM) - Impumzi and Tweefontein: 10,27 Mt Zonnebloem: 0,9 Mt	GHG emissions reported to the DFFE - Scope 1 emissions include diesel for (mobile and stationary combustion) and fugitive methane (released from the coal seams in underground mining). It seems here that fugitive emissions are assumed to be 100% methane. The value provided is not split by line item but rather presented as an aggregate, so methane from coal mining cannot be determined.	2024 results for financial year ended 30 June (ARM, 2024); Climate Change and Water Report (ARM, 2023); Basis of reporting on selected ESG KPIs (Glencore, 2023b).

Although information on the methodologies used by companies for estimating their emissions is inconsistently reported, it is assumed that they will typically use the methodological guidelines for the quantification of GHG emissions as specified in Government Gazette 47257; 7 October 2022 (DFFE, 2022).This assumption is based on the observation that companies are required to report these emissions to the South African GHG Emissions Reporting System (SAGERS), which requires use of the IPCC guidelines and Tier 2 emission factors (Table 7).

Table 7. Country specific emission factors for fugitive emissions from coal mining.

Mining method	Activity	GHG	South african specific emission Factor (m3 tonne1)
Underground mining	Coal mining	CH_4	0.77
	Post mining (handling and transport)		0.18
Surface mining	Coal mining		0
	Post mining (storage and transport)		0
Underground mining	Coal mining	CO_2	0.077
	Post mining (Storage and Transport)		0.018
Surface mining	Coal mining		0
	Post mining (storage and Transport)		0

Source: Extracted from the Methodological Guidelines for the Quantification of GHG Emissions (DFFE, 2022)

The Tier 2 calculation approach outlined in the methodological guidelines is as follows:

Emissions = (Emission Factor) x (Coal Production) x (Conversion Factor)

Where units are:

- Emissions (tons per year)
- Emission Factor (m3 per ton)
- Coal Production (tons per year)
- Conversion Factor: This is the density of methane (CH4) or CO2 and converts volume of CH4 or CO2 to mass of CH4 or CO2. The density is taken at 20°C and 1 atmosphere pressure and has a value of 0.67 x 10-3 ton m-3 and 1.843 x 10-3 tons m-3 respectively

Tier 2 emission factors are estimated using country-level data (Cook, 2005; Lloyd & Cook, 2005) and are not specific to variables such as extraction method, coal rank, and mining depth. Methane emissions from surface mining operations are assumed to be zero due to the low seam-gas content in surface-mined coal, combined with the low methane concentration in seam gases (Cook, 2005), and so a **zero-emission factor is assigned to coal extracted via surface mining activities.** This observation was confirmed by workshop participants (Workshop Participants, 2025).

The research from which the South African emission factors were established, reviewed the data on methane releases from South African underground coal mines and attempted to align these with the IPCC guidelines. Efforts to calibrate the IPCC guidelines using local measurements revealed inaccuracies, as the IPCC's assumptions about methane release – based on methane adsorbed in coal and subsequent slow release as a result of mining activities – did not align with the observed variability in methane emissions from South African coal mines (Lloyd & Cook, 2005). Measurements indicated that methane release in South African mines can be intermittent and often drops to zero, as South African coal seams, influenced by igneous activity, release methane differently from comparable mines in other regions.

The model proposed by Lloyd & Cook (2005) found that methane was largely displaced from the coal and stored in fissures, cleats, and pores around the coal – which release methane into the ventilation stream when intersected by mining. This "fissure-held methane" is released rapidly once a pathway through the coal into the mine atmosphere is established. The remaining methane adsorbed in the coal, and measured as the seam gas, desorbs relatively slowly. Measurements suggest that on average about 50% of the adsorbed methane is lost one day after mining – but by that time, the coal will have left the mine, so that the remaining seam gas will be released to the atmosphere outside the mine (Lloyd & Cook, 2005).

These findings were strengthened by the development of alternative models for predicting methane gas release from coal seams in South African underground coal mines (Cook, 2005; Lloyd & Cook, 2005). Later, models estimating the release of GHG from surface and abandoned coal mines in South Africa were also published (Lloyd & Cook, 2012).

A final note on company-level emissions reporting relates to the distinction between Run of Mine (ROM) and saleable production. It appears that some companies may report emissions based on saleable production rather than ROM coal, even though fugitive emissions occur during mining rather than just during processing. ROM coal includes all extracted material before processing losses, meaning methane emissions should be tied to ROM rather than only the portion of coal that is ultimately sold. For example, at Exxaro's Grootgeluk Mine, 26 Mt production was reported in 2022, although ROM was ~56 Mt (Exxaro, 2023a). If a company calculates and reports emissions based on saleable coal production, the methane emissions will be underestimated.

Appendix C:Links between CMM mitigation and the Just Energy Transition

This Section aims to explore the view that methane mitigation in South African coal mining aligns with the Just Energy Transition (JET), a strategy designed to ensure an equitable transition from coal to cleaner energy sources (PCC, 2022).

C.1 The future of coal mining in South Africa

National coal use is projected to decline by 21-23% by 2030 compared to 2019 (from 176Mt in 2019 to 135-140Mt in 2030) based on the country's IRP 2019 and planned coal plant closures. This would mean that the IRP 2019 would result, assuming stable exports, in a 15-16% lower national production in 2030 versus 2019 (Marquard, et al., 2021).

A JET must account for local realities to balance environmental goals with the need for economic growth and energy security (PCC, 2022). By 2030, South Africa is projected to close five coal plants (8.9 GW) and 15 coal mines (29.5 Mt/a); and by 2040, four more plants (14 GW) and 23 more coal mines (106 Mt/a) are expected to close (Cole, Mthenjane, & van Zyl, 2023). At the same time, the communities that will be affected by these mine closures are already socio-economically vulnerable, with high poverty levels and low education rates. This means that mine closures, while reducing emissions, could undermine the JET. Therefore, it is important to understand and account for how mine closures affect both national energy strategies and vulnerable host communities.

While the planned closures of coal mines in South Africa will automatically reduce methane emissions, another opportunity exists in the form of existing closed and abandoned mines. As coal mines close, they continue to emit methane into the atmosphere (Kholod, et al., 2020), with abandoned coal mines presenting additional hazards beyond methane emissions (Mhlongo, 2023). Moreover, spontaneous combustion exacerbates methane emissions and introduces additional pollutants into the atmosphere (Lloyd & Cook, 2012). Projections indicate that methane emissions from abandoned coal mines will continue to rise, potentially increasing eightfold by 2100 – even with mitigation efforts (Kholod, et al., 2020).

The slow pace of rehabilitating the large number of derelict and ownerless (D&O) mines in South Africa therefore presents significant environmental and social risks, including air and water pollution, land degradation, and public health concerns (AGSA, 2022). This mismanagement of rehabilitated land, coupled with illegal artisanal mining, further compounds environmental degradation, leading to pollution, spontaneous fires, and safety hazards for local communities (Limpitlaw, Aken, Lodewijks, & Viljoen, 2005). This highlights the urgent need for long-term monitoring, methane management, and structured rehabilitation strategies.

A 2012 report from the British Geological Survey (Banks, et al., 2012) highlights that South African legislation previously placed little focus on rehabilitating mining areas. As a result, many mines were closed and abandoned without undergoing any rehabilitation. The result? The South African government has accrued over 6,000 D&O mines – including more than 400 empty coal mines – for the remediation of which they have become responsible (Carnie, 2022; Bloomberg, 2022). The financial liabilities of these mines, notably the direct costs of their remediation, now sit as a tax burden on the broader economy. Moreover, the environmental impacts of abandoned mines are significant, including acid mine drainage, water pollution, and land degradation as well as the atmospheric issues highlighted in this report. These issues pose ongoing challenges for surrounding communities and ecosystems (Bloomberg, 2022).

A recent briefing paper from the World Wide Fund for Nature (WWF, 2020) highlights the challenges of mine closure and rehabilitation in South Africa, despite existing legislation. Key issues include weak enforcement, inadequate financial provisions, liability transfers, lack of community engagement, and unregulated artisanal mining. To address these, the paper advocates for stronger legislation, early planning for post-mining economies, inclusive stakeholder engagement, and improved research. It calls for “coalitions of the willing” to drive sustainable mine closure and a Just Transition, aligning with South Africa’s decarbonisation goals.

Proper rehabilitation can create new employment opportunities in environmental restoration and long-term monitoring, aligning with the JET’s goal of safeguarding vulnerable communities and ensuring coal-dependent regions are not left behind in South Africa’s shift toward a sustainable economy.

C. 2 Linking CMM mitigation to the JET

The IEA (2023a) suggests that global initiatives, like the JET Partnership launched by Indonesia (European Commission, 2022), can support the adoption of methane mitigation technologies in coal mining. This could reduce climate impacts and create jobs. However, it was noted that financial and technical support may also be needed for large coking coal producers, with industries such as steel potentially helping drive these efforts.

Given that methane is a potent GHG with significant climate impacts. Reducing methane emissions from coal mining could contribute to South Africa’s climate targets and JET goals by:

- Reducing emissions (AMM)
- Preventing physical and environmental risks associated with climate change
- Generating revenues and creating jobs in methane management, monitoring, and downstream industries (CMM and AMM)
- Job creation in the rehabilitation of closed and abandoned mines
- Supporting coal mining communities through reinvestment from carbon credit revenues
- Improving public health by reducing harmful methane-related air pollution

Despite these potential contributions, there has been no significant work done on exploring the potential linkages between methane mitigation in coal mining (CMM and AMM) and the JET in South Africa. Recent research has started to assess coal mine closures and mining community profiles within the context of the JET (Cole, Mthenjane, & van Zyl, 2023). However, this does not include the effects of methane emissions and the opportunity for mitigation efforts of either CMM or AMM.

Appendix D: Community of practice

The methane mitigation agenda has to date been largely absent in the South African coal mining, research, and policy contexts. Potential actors and champions that could push the agenda of methane mitigation in South African coal mining going into the future include coal mining companies active in South Africa, companies with research and development (R&D) capabilities, as well as researchers active in the methane mitigation space.

D.1 Mining companies in South Africa

In 2009, there were about 90 operating coal mines in South Africa (GMI, 2016). Forty operations were surface mines, eighteen combined surface and underground mining operations, and thirty-five were solely underground mining operations. More recent data from GEM estimates that there are now about 69 operating coal mines, which are owned by approximately 40 different entities.

The coal mining industry is operated primarily by private companies. According to GEM (2022), the 69 operating coal mines are currently under ownership of 40 legal entities. Five companies are responsible for the majority of the country's coal production. These are Sasol Mining, Seriti, Thungela, Exxaro, and Glencore South Africa. A full list of companies is as follows:

- **Sasol Mining:** 6 operating mines
- **Seriti:** Seriti Power (3 operating mines) and Seriti Coal (3 operating mines)
- **Thungela:** 4 operating mines
- **Exxaro:** Exxaro Coal (2 operating mines) and Exxaro Coal Mpumalanga (2 operating mines)
- **Glencore:** Glencore SA (2 operating mines) and Glencore Operations SA (1 operating mine)
- **Salungano Group:** 5 operating mines
- **Canyon Coal:** 4 operating mines
- **Overlooked Colliery:** 4 operating mines
- **Ndalamo Resources (51%) & Universal Coal (49%):** 3 operating mines
- **Ichor Coal:** 3 operating mines
- Two independent third parties have ownership of 1 mine each
- The remaining companies each own one operating mine: Mafube Coal Mining, New Largo Coal, Umsimbithi Mining, HCI Coal, Ndanganeni Colliery, Bisichi Mining (62.5%) & Vunani Mining (37.5%), Anker Coal and Mineral Holdings, Rietvlei Mining, Nkomati Anthracite, Puckree Group, Coal of Africa, MC Mining, Alfieri Holdings, Goedgevonden Coal, Beryl Group, Black Royalty Minerals, Mbuyelo Coal, Anglo American Inyosi Coal (AAIC), Kuyasa Mining, Langcarel, Joe Singh Group, Msobo Coal, and Ilima Coal.
- **African Exploration Mining and Finance Corporation,** a state-owned entity, owns two operating coal mines.

Using the 2022 GEM data, the largest mines in terms of annual coal production (above 7 Mt per annum) are as follows, with the list showing the company that owns the mine, the annual coal production (Mt), and the CMM emissions estimate from GEM (Mt per annum).

1. Grootegeluk Coal Mine – Exxaro Coal (56.52 Mt with methane emissions estimate of 0.199 Mt)
2. New Vaal Coal Mine – Seriti Coal (17 Mt with methane emissions estimate of 0.06 Mt)
3. Middelburg Mining Services – Seriti Power (11.3 Mt with methane emissions estimate of 0.04 Mt)
4. Klipspruit Coal Mine – Seriti Power (7.85 Mt with methane emissions estimate of 0.028 Mt)
5. Twistdraai Thubelisha Coal Mine – Sasol Mining (7.7 Mt with methane emissions estimate of 0.061 Mt)
6. Syferfontein Coal Mine – Sasol Mining (7.6 Mt with methane emissions estimate of 0.04 Mt)

Significant R&D capacity exists in South Africa, which could be leveraged to assist in the assessment of methane emissions in coal mining, recovery potential, and technology (GMI, 2016). In particular, Coaltech is an industry-led consortium of coal mine research and technology organisations (Coaltech , 2024). Current members and industry partners include Seriti, Sasol Mining, Thungela, Eskom, Glencore, Exxaro, Minerals Council South Africa, Nafasi Water, University of the Witwatersrand, CSIR, Consulting Evolution Mining (CEM), Namane Resources, University of Pretoria, Agreenco, Kuyasa Mining, University of Cape Town, Mintek, EXM Advisory Services, University of Johannesburg, North-West University, University of the Free-State, Genet South Africa, Fraser Alexander, Minopex, Mandela Mining Precinct, Future Coal, Overlooked Group, Talonite, South African Colliery Environmental Safety and Health Association (SACESHA), South African Colliery Managers Association and south African Colliery Engineers Association (SACEA).

D.2 Other Active stakeholders

Active stakeholders and/or potential "Interested and Affected Parties" are summarised in Table 8.

Table 8. Identified South African Stakeholders

Sector	Organisation	Description
Mining Organisations	Coaltech	Coal research hub comprising key industry stakeholders with a focus on mining, coal processing, surface environment and future technologies
	Minerals Council South Africa	A mining industry employers' organisation that supports and promotes the South African mining industry
Government	Department of Forestry, Fisheries and the Environment (DFFE)	The legal mandate and core business to manage, protect and conserve South Africa's environment and natural resources. The DFFE administers the National Environmental Management Act (NEMA).
	Department of Mineral and Petroleum Resources (DMPR)	Responsible for regulating and promoting the mining and petroleum industries. The DMPR administers the Mineral and Petroleum Resources Development Act (MPRDA) which is South Africa's primary legislation governing the acquisition, use, and disposal of mineral and petroleum rights.

Sector	Organisation	Description
	Department of Energy and Electricity (DEE)	Responsible for energy policy.
	Presidential Climate Commission (PCC)	Established in 2020 to facilitate the Just Energy Transition in South Africa.
	Just Energy Transition Presidential Management Unit (JET PMU)	Established by the PCC in 2023 to oversee implementation of the Just Energy Transition Investment Plan (JET-IP)
NGO/NPO	Centre for Environmental Rights (CER)	An NPO comprising activist lawyers who defend the right of communities and civil society organisations to an environment not harmful to health or wellbeing.
	Mpumalanga Green Cluster Agency	The Mpumalanga Green Cluster Agency in partnership with the Mpumalanga Department of Economic Development and Tourism, works with local businesses and to advance a sustainable and inclusive green economy and create shared value in the Mpumalanga province.
	National Association of Clean Air (NACA)	Dedicated to promoting clean air quality.
	Life after Coal	A joint campaign by Earthlife Africa, groundWork, and the Centre for Environmental Rights which aims to: discourage the development of fossil fuel developments; reduce emissions from existing coal infrastructure and encourage a coal phase-out; and enable a just transition from fossil fuels.
Consultants	SRK consulting	SRK is an independent, international consultancy with expertise in GHG emission monitoring, measurement and reporting.
	Latona Consulting	An independent consultancy company specialising in the fields of rock engineering, geology, methane, flammable gases and health and safety.
	IH Energy	A consultancy with expertise in coal business and marketing strategies.
	Schauenberg Systems	An Original Equipment Manufacturer (OEM) for mine safety systems, include methane exposure monitoring.
Research, Development & Innovation Organisations	North-West University (NWU)	Hosts the South African Research Chair for Clean Coal Science & Technology
	University of Cape Town (UCT)	Air quality monitoring expertise in the Department of Geographical Sciences. Coal-related emissions expertise in the Department of Chemical Engineering.
	University of Johannesburg (UJ)	Hosts the DSI-NRF Centre of Excellence in Integrated Mineral and Energy Resource Analysis (CIMERA) with expertise of local coal geology and petrography.
	Council for Scientific and Industrial Research (CSIR)	A public Science Council, hosting a Fires and Explosion Research, Testing and Training Facility.
	South African National Energy Development Institute (SANEDI)	A public RD&I institute focussing on developing innovative clean energy and energy efficient solutions.

A multi-stakeholder organisation that has been established more recently is the Mpumalanga Green Cluster Agency, which collaborates with the Mpumalanga Department of Economic Development and Tourism as well as several green businesses and academic institutions. In January 2025, Coaltech and the Mpumalanga Green Cluster Agency signed a Memorandum of Understanding (MoU) to support research and innovative solutions towards JET work in the Mpumalanga province (Arnoldi, 2025).

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