

In The Dark: underreporting of coal mine methane is a major climate risk

New analysis finds that methane emissions from coal mines may be twice as large as reported by governments, presenting a major risk for international climate commitments.

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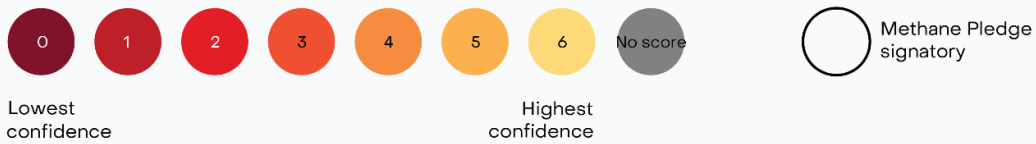
This report aims to improve visibility on global coal mine methane (CMM) emissions data, where there are gaps, and how country estimates stack up in comparison to independent studies.

Ember compiled and assessed methane emissions data collected from the [United Nations Framework Convention on Climate Change \(UNFCCC\)](#), and compared this with estimates from three independent studies: [International Energy Agency](#), [Global Energy Monitor](#), and [Shen. et al \(2023\)](#).

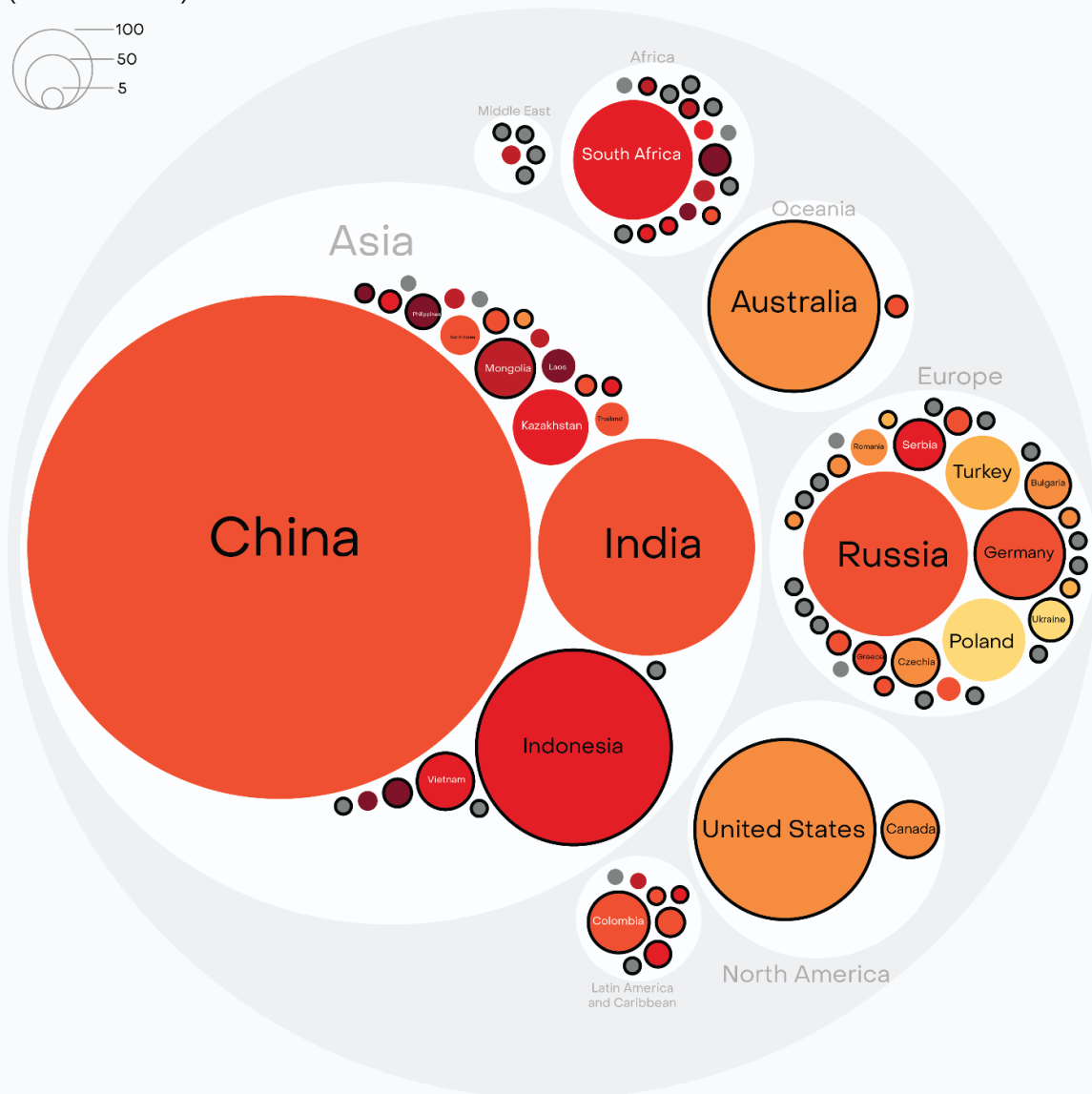
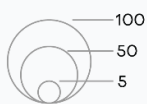
The report is accompanied by a new data tool, the [Coal Mine Methane Data Tracker](#), which scores countries on how well they were found to be reporting on coal mine methane emissions.

Which countries are accurately reporting their methane emissions?

Confidence in government emissions estimates (see methodology for calculation details)



Coal production (million tonnes)



Executive Summary

Methane emissions from coal mines may be double official estimates

Coal mine methane emissions are [low-hanging fruit](#) in tackling climate change, but the poor level of monitoring and reporting leaves governments blind to the scale of their emissions, and the opportunities to mitigate them.

150 countries have now signed up to the [Global Methane Pledge](#), committing to a 30% collective reduction in methane. If the reduction goal proposed is reached, it could eliminate over 0.2C warming by 2050. Whilst the world has seen growing momentum from countries across the globe to act on their methane emissions, coal mining continues to emit methane seemingly unnoticed.

01 If coal mine methane were a country it would be the third largest emitter

According to government data reported to UNFCCC, coal mines release 30.5 million tonnes of methane emissions per year. Methane's climate impact is 82.5 times that of carbon dioxide over the first 20 years in the atmosphere, making the methane released by coal mines equivalent to 2.5 billion tonnes of CO₂. This is more than the total CO₂ emissions of India, and adds 17% to the climate impact of burning coal.

02 CMM emissions could be twice as high as reported by governments

Independent studies reveal that global coal mine methane emissions could be more than twice as high as reported by governments. Across three studies that used various techniques, Ember finds that emissions estimates range between 38-67 million tonnes of methane per year. At the top end, that means CMM could have a greater climate impact in the next two decades than the annual CO₂ emissions of the United States, so if it were a country it would be the second largest emitter worldwide.

03 97% of CMM emissions are not even measured

There are major gaps in how governments measure coal mine methane. 97% of emissions come from countries that use standard emissions factors for whole regions rather than directly measuring the methane actually emitted by mines. Many countries don't report regularly, and some have never reported CMM. Independent studies have found that 22 countries could be emitting double the emissions they currently report, including South Africa, Germany and [Indonesia](#).

The International Energy Agency (IEA) makes it clear that a [75% reduction of fossil fuel methane by 2030](#) is required for the world to remain on a pathway aligned with 1.5C. Ember's three recommendations cover improving monitoring, verification and reporting of CMM emissions to aid governments in understanding the scale of their coal mine methane emissions, and unlocking the potential to destroy or capture and utilise the potent greenhouse gas.

“Methane is accelerating climate change this decade and yet we have no idea of the scale of the issue. The lowest estimates put the climate impact on a par with India, at the top end more than the United States. In reality, we have no idea how big the problem is.”

“It is shocking that the vast majority of mines are allowed to operate without measuring what they emit. Closing the information gap between estimated and emitted emissions is the first step to cutting methane emissions, which is the strongest lever we have to slow climate change in the short term.”

Dr Sabina Assan

Methane analyst, Ember



Introduction

Coal's dirty secret

Coal mining globally releases millions of tonnes of methane every year, a potent greenhouse gas which adds to coal's considerable climate impact. Even though coal operators know exactly where their methane leaks are, accurate measurement or reporting of them is rarely required, leaving governments in the dark about this hidden climate multiplier.

Coal Mine Methane

Coal is known to be 'dirty' because of the emissions and pollution produced when it is burnt to produce electricity and steel. However, the [climate impact of burning coal is considerably larger](#) once we factor in the [methane emissions associated with mining it](#).

Methane is trapped inside and embedded throughout coal seams, and is released to the atmosphere before, during and after mining. As a potent and fast-acting greenhouse gas, it is 82.5 times more powerful than carbon dioxide over its first 20 years in the atmosphere, and 29.8 times more powerful when averaged over 100 years. This is why methane has important implications for climate change, particularly in the near-term.

Reducing Methane

[According to the IEA](#), reducing methane emissions from the energy sector is one of the best—and most affordable—opportunities to limit global warming in the near term. According to their global estimates, emissions from coal are just as large as those from the oil or gas sectors respectively. However, reliable national emissions estimates for the coal sector are particularly hard to come by, leaving most governments in the dark when it comes to understanding the scale of their methane problem, and the importance of tackling it.

150 countries have signed up to the Global Methane Pledge, a commitment to a collective reduction in methane of 30% overall. However, while more than 50 countries, including both

the US and China have developed or are developing economy-wide methane action plans, only the [European Union](#) and [Canada](#) have thus far committed to specific actions to reduce active coal mine methane emissions.

Risk of underreporting

Even today, coal operators know the exact location and sources of their coal mine methane emissions in order to prevent explosions. A major part of safely operating an underground coal mine is removing the methane which is released underground and venting it to the atmosphere. This methane will either be emitted at the drainage station or from ventilation air shafts. Methane from surface mines is vented directly to the atmosphere as the coal is mined.

Despite knowing these sources, efforts to accurately measure or mitigate them are rare. In many cases, coal operators are not required to report the methane measurements they do make to the government or public, who instead rely on emission estimates which have been found to [underestimate emissions in some cases by a factor of 30](#).

Additionally, no government has implemented systematic third party verifications or checks to confirm the measurements and estimates provided by coal operators in the first place, despite the availability of satellite monitoring.

How methane emissions can be estimated

There are two different methods which can be used to estimate and validate emissions.

“Bottom up” methods are based on using inventory/facility level data and aggregating that to produce an estimate at a national or global level. As facility-level measured data is often not available, emission factors are used instead.

Coal mine methane emissions factors are an average estimate of how much methane is emitted per tonne of coal, but it is uncertain how well they reflect actual emissions, which vary by geography, geology and other factors.

Governments report bottom-up CMM estimates to the United Nations Framework Convention on Climate Change (UNFCCC). Their estimates rely in large part on applying methane emission factors to activity (i.e. coal production) data rather than relying on facility-level, measured methane emissions. The emission factors used by governments can be typically very uncertain, in some instances [by a factor of 2 or more](#).

“Top-down” methods are based on measured methane observations, for example satellite measurements, and combined with bottom-up information to model emissions. They are often used to improve global, or national scale emission estimates.

Both methods generally have large uncertainties due to the lack of comprehensive data from all major producing countries.

Chapter 1 Global Assessment

World leaders flying blind on methane emissions from coal

Globally, emissions from coal are a major contributor to climate change. Countries that have reported methane emissions from coal mines to the UNFCCC indicate that global annual emissions sum up to around 30.5 million tonnes, equivalent to more than India's total CO₂ emissions, but independent studies suggest they could be twice as large.

If CMM were a country, it would be the world's 3rd largest emitter

Ember found that 64 countries have reported methane emissions from coal mining to the UNFCCC, albeit with varying reporting years.

In total, countries report 30.5 million tonnes of methane emissions to the UNFCCC.

Across 100 years, the climate impact of those methane emissions is equivalent to 0.9 million tonnes of CO₂.

Acknowledging methane's fast-acting impact, the climate impact in the next two decades is equivalent to 2.5 billion tonnes of CO₂ emissions, similar to the CO₂ emissions emitted by [India in 2021](#).

In total, methane adds on average 17% to the climate impact of burning coal in the first 20 years, and 6% when averaged over 100 years.

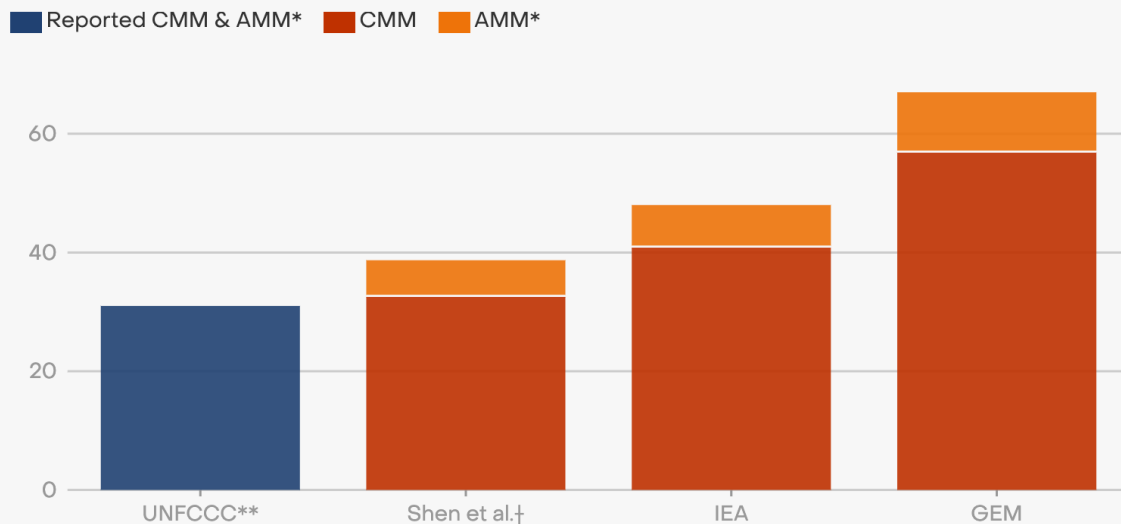
For more information on methane's short-term and long-term [global warming potential](#) see the Methodology.

Global coal mine methane emissions may be twice as high as reported

Ember compared total government-reported emissions to three independent estimates from the [International Energy Agency](#) (IEA), [Global Energy Monitor](#) (GEM), [Shen et al. \(2023\)](#). All three studies use diverse methodologies to estimate global emissions, but do not include emissions from abandoned and closed mines (AMM). Ember accounted for AMM emissions using estimates from [Kholod et al. \(2020\)](#), further information can be found in the [Methodology Section](#).

Emissions from coal mines could be more than twice government estimates

Estimated annual methane emissions, million tonnes



Source: International Energy Agency (IEA, 2022), Global Energy Monitor (GEM, 2022), Shen et al. (2023) · Kholod et al. (2020), Ember calculations.
 *Abandoned and closed coal mine methane **2021 or last reporting year †Data from 2018-2020



Ember’s assessment of these studies found that methane emissions from coal mines may range between 38 to 67 million tonnes a year, which is around twice as high as the emissions reported by governments.

Averaged over 100 years, this is equivalent to 1 to 1.7 million tonnes of CO2. Using methane’s short-term (20 year) global warming impact, this is equivalent to 3.2 to 5.5 billion tonnes of CO2 per year. At the top end, this has a similar warming impact as the total annual CO2 emissions of the [US](#), putting global CMM emissions effectively on par with the world’s second biggest CO2 emitter.

Such studies demonstrate the real risk that we are grossly underestimating methane emissions from the coal mining industry and are therefore missing an opportunity to limit global warming in the near term.

Chapter 2 National Emission Estimates

There are major gaps in how governments measure these emissions

Most major coal-producing countries don't report CMM, and 97% of reported emissions are not based on directly measured methane. Consequently, 22 countries may have double the emissions they currently report, whilst a further 22 countries are potentially underestimating their emissions by 50% or more.

Ember's assessment of government reporting of CMM emissions looked at 3 distinct criteria. These are:

1. How recently they reported CMM emissions
2. How robust their reporting methods are
3. How closely reported estimates align with independent assessments

Criteria used to establish confidence ratings

Scores for each assessment criteria

Criteria	0	1	2
Reporting Recency	No data, or a 50% change in coal production volumes since last reporting year	Previous to 2019	2019 or more recent
Robustness of reporting methods	Majority of emissions reported using default IPCC emission factors (Tier 1)	Majority of emissions reported using national-level emission factors (Tier 2)	Majority of emissions reported using direct measurements (Tier 3)
Comparison to independent studies	Larger than 100% difference between reported and independent studies	Larger than 50% difference between reported and independent studies	Less than 50% difference between reported and independent studies
Overall score	Poor	Average	Good

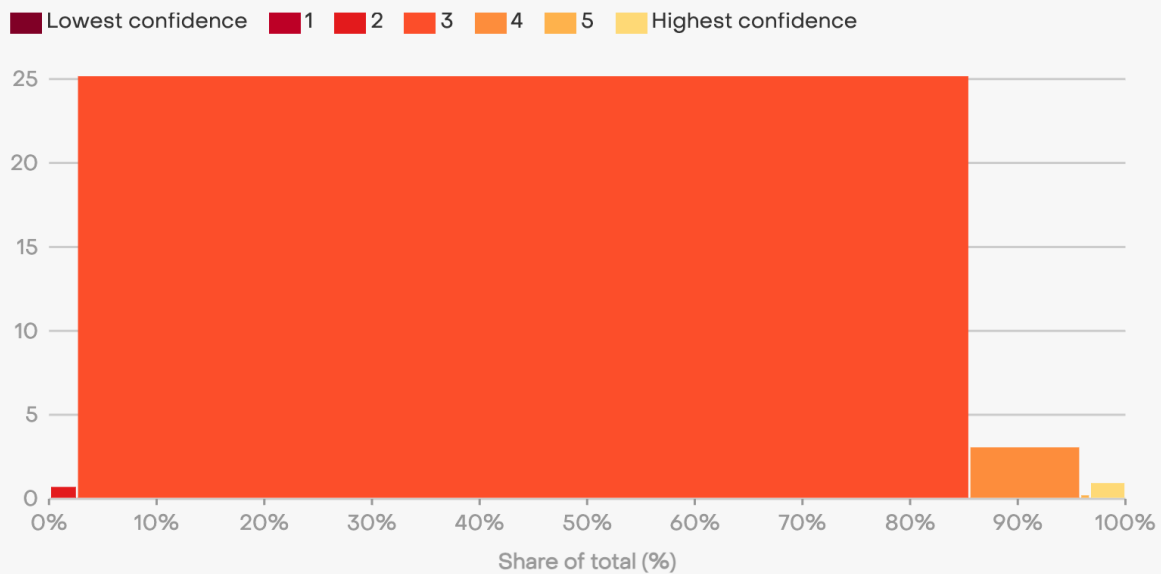
Source: Ember



Countries were scored between 0-2, following the scoring criteria for each question. Then, the overall score was determined by summing all three scores. A detailed methodology can be found [here](#).

83% of CMM emissions are reported with low-average confidence

Reported CMM emissions (million tonnes)



Source: Ember calculations, UNFCCC

We found that only 4% of reported coal mine methane emissions are reported with high confidence, with a further 10% reported with medium-high confidence. The large majority of emissions (83%) are medium-low confidence, and a further 3% have low confidence.

The national level analysis in this report has not taken into account emissions from closed or abandoned mines. Reporting for this methane source is found only for a subset of countries, and the lack of national level data and independent estimates means they have not been assessed here.

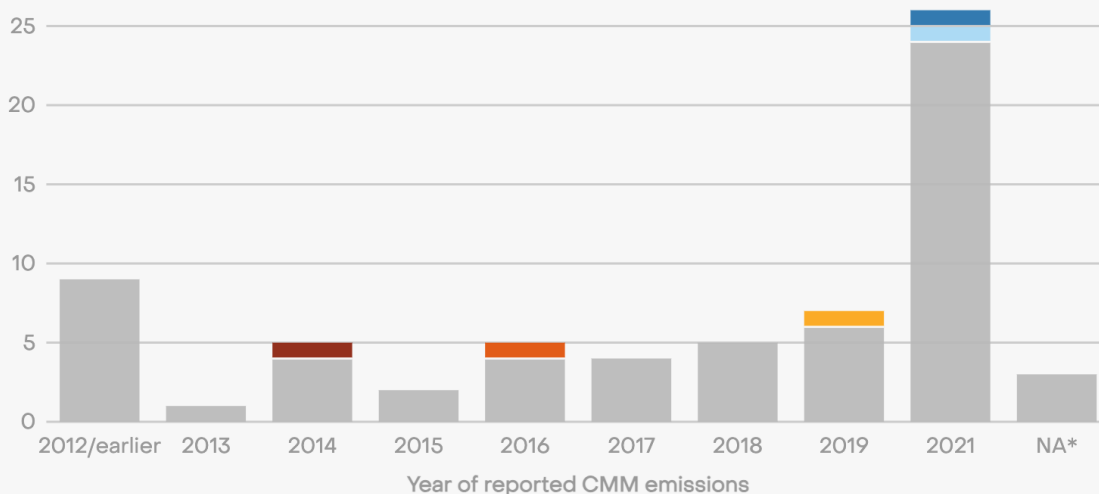
Many major coal producing countries don't report annually

Only 44 countries published data for CMM in 2021, reporting 7.5 million tonnes of methane emissions in total.

3 out of 5 of the largest coal producers did not report methane emissions in 2021

Number of countries

Source of coal China India Indonesia Australia US Other countries



Source: UNFCCC
*Countries that have never reported

Reporting annually to the UNFCCC is still uncommon for many of the largest coal producing countries. China last reported in 2014, South Africa in [2017](#) and India in [2016](#). Whilst industrialised countries and economies in transition (defined as 'Annex 1' by the UNFCCC) all reported emissions in 2021, the last reporting year for developing countries (Non-Annex 1) spans from 2021 to 1994. Bangladesh, Mozambique and Pakistan all have significant coal sectors and have never reported their emissions.

97% of reported CMM emissions are not measured directly

Ember's analysis found that the robustness of methods used to estimate and report national CMM emissions is particularly weak globally.

97% of reported CMM emissions use emissions factors to estimate their emissions, also known as [Tier 1 and 2 methods](#). This means the reported emissions are not based on direct measurements.

Only 3% of reported CMM emissions are from countries that measure the majority of their methane emissions from coal. Ukraine and Poland were the only two countries to have directly measured the methane emissions from the majority of their coal production, based on hard coal from underground mines.

Case study: The failure to accurately estimate open cut coal mine methane emissions in Australia

While Australia directly measures the methane emissions from its underground coal mines, it [allows](#) open cut coal mines, which represent close to 75% of the industry, to rely upon outdated emissions factors. Open cut coal operators have hidden behind extremely low emission factors, despite the uncertainty associated with the use of such factors. In Queensland, an Australian sub-national territory, [measurements](#) from 10 open cut coal mines showed certain mines have emission rates approximately 50 times higher than others.

However, new data from satellites and [remote surveys](#) conducted by car have spotted multiple, mega-emitting open cut coal mines, with methane emissions much higher than their estimates. For example, Glencore's Hail Creek open cut coal mine in Queensland has been [found](#) to be significantly under-estimating its methane emissions. In 2018-2019 it was estimated that Hail Creek was extracting coal with a methane intensity of 34 kg of methane per tonne of coal, a methane intensity that is [30 times higher](#) than the [State-based emissions factor](#) used to measure open cut Queensland coal mines.

The lack of any direct measurements of methane emissions at open cut coal mines leads to the risk that even countries reporting to the highest IPCC methodologies are missing significant emissions.

22 countries may have more than double the emissions officially reported

For 22 countries, the independent estimates show that they may have more than twice as much coal mine methane as they report. A further 22 countries may emit between 50% to 100% more than they report. Overall, this means that 94% of reported CMM emissions are estimated by independent studies to be significantly different.

Three countries with some of the largest percentage differences in reported and independently estimated active mine methane emissions are South Africa, Indonesia and Germany.

South Africa

South Africa is estimated to emit 7 to 14 times more than it officially reports, potentially adding one million tonnes of methane emissions per year. The country currently reports to the UNFCCC using country based emissions factors and mines the majority of its coal from open cut mines. Using methane's short-term climate impact this means South Africa's coal mines could be adding a [quarter to the country's total annual CO2 emissions](#).

Indonesia

Independent studies suggest Indonesia could be emitting between 5 to 30 times as much as the government currently reports. At the higher end this would be an additional 3.8 million tonnes of methane annually for Indonesia. Indonesia reported to the UNFCCC using default emissions factors, and all of its coal is mined at surface mines. Using methane's short-term climate impact this means Indonesia could be emitting methane equivalent to 62-325 million tonnes of CO2 annually, equivalent to [half of Indonesia's annual CO2 emissions](#).

Germany

Germany is estimated to emit between 9 to 53 times as much as it officially reports from active mining operations, potentially adding a further 200,000 tonnes of methane emissions. Germany mines coal at open cut mines and uses a country-specific [emission factor based on a 1989 study](#). Using methane's short-term climate impact this would mean Germany's CMM emissions are between 3-17 million tonnes of CO2e, equivalent to some of the [country's dirtiest coal power plants](#).

22 countries may have more than double the emissions officially reported

Reported CMM emissions (thousand tonnes)

Reported (UNFCCC) GEM Shen et al. IEA



Source: Reported CMM (UNFCCC), Global Energy Monitor (GEM), International Energy Agency (IEA) - Shen et al. (2023)

Recommendations

Closing the gap

Coal mine methane emissions must fall by 75% by 2030 to be on track for 1.5 degrees, according to the IEA's Net Zero analysis. Closing the information gap between estimated and emitted emissions is the first step to cutting methane emissions, the strongest lever we have to slow climate change in the short term.

The first step towards reducing global CMM emissions is accurately monitoring and reporting on them. However, even today, estimates of global and national CMM emissions have been done using inventories and default emissions factors which do not adequately represent real-life emissions.

The technologies for measuring methane are already available and verification techniques are rapidly improving. With a concerted effort globally, understanding and mitigating this methane source is a feasible, rapid solution to slow near term global warming.

Ember has developed three key recommendations to aid governments in understanding the scale of their coal mine methane emissions, and unlocking the potential to destroy or capture and utilise the potent greenhouse gas.

1. Require all coal mines to directly measure and report their methane

All coal mines, including surface, underground and decommissioned mines, should be required to [directly measure and monitor](#) their methane emissions, using technologies and techniques that take measurements continuously, or as near as possible. Coal mine

operators should also be required to verify measurements of each mine's methane emissions using top-down methods. Improved monitoring will ultimately contribute to more effective methane management at the coal site, [increasing the safety of mine workers by reducing the explosion risk, and improving profit margins](#).

Principles for best-practice monitoring, verification and reporting (MRV) are being developed by the United Nations Environment Programme's International Methane Emissions Observatory (IMEO) as part of the [Steel Methane Partnership](#). We recommend that governments develop and implement MRV policies and laws that align with draft guidelines from UNEP's IMEO to improve domestic methane monitoring and allow governments to track progress towards national reduction targets.

2. Invest in satellite verification and publicly available emissions data

In addition to company-led verification, Ember recommends governments implement a program to periodically verify company reported emissions through aerial flyovers and satellite studies, to improve the accuracy of company reporting. Governments should also make coal mine level methane emissions data publicly available, to facilitate public access to information and to allow for verification by independent third parties.

International investment in satellite technology means that remote methane monitoring technologies are continuously and rapidly improving. 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](#) will provide a more thorough picture of national, and mine-by-mine, CMM emissions. Governments should utilise this new capability to better understand emissions, spot super-gassy mines, and design policy tools to improve the tracking and mitigation of CMM.

3. International support for low-income countries

There are many reasonable, and affordable steps that the coal industry could take to reduce emissions. [The IEA estimates](#) that it is technically possible to avoid 53% of global CMM emissions with existing technologies, 13% of this is at no net cost.

Financial and technical assistance should be given to low-income countries to ensure coal companies are adequately incentivised to capture their coal mine methane emissions. Support on developing National Methane Plans, improving the tracking of CMM emissions and reduction targets, and in implementing best-practice MRV will be vital to ensure that companies act on reducing their emissions.

The [Environmental Investigation Agency \(EIA\) found](#) that the current level of assistance is not adequate for delivering on the Global Methane Pledge, recommending that donor countries take the lead in providing financial support.

Where the coal is used must also be taken into consideration. For all signatories to the Global Methane Pledge, reducing coal mine methane emissions presents a big opportunity to meet the collective goal of reducing global methane emissions by 30% by 2030. Many middle-high income countries use the coal that is mined in lower income countries and should provide support to reduce these collective emissions at the source.

Supporting Materials

Methodology

Global CMM emissions

Ember compiled the CMM emissions reported by each country. Global CMM emissions were calculated by summing all reported emissions, using each country's last reported year.

When comparing the additional climate impact CMM has to burning coal, carbon dioxide emissions from burning coal were estimated to be [15 billion](#) tonnes in 2021.

[Methodology for the Data Tracker: Coal Mine Methane Emissions](#)

Comparison to independent estimates

The [Global Energy Monitor](#) (GEM) estimates methane emissions for individual mines across the globe using nuanced assumptions for coal extraction volumes, method, coal rank and depth. They use a bottom-up method, and estimate that active CMM emissions amounted to 57 million tonnes in 2022.

[Shen et al.](#) estimated national and global CMM emissions using top-down methodology. The study used 22 months (May 2018-Feb 2020) of satellite observations from the TROPOMI instrument to better quantify national fossil fuel emissions worldwide. This study finds that coal emissions are 32.7 +/- 5.2 million tonnes per year.

The [International Energy Agency](#) (IEA) estimates methane emissions using similar assumptions as GEM, with additional constraints provided by [atmospheric inversions and satellite data](#). The IEA estimates that emissions from active CMM emissions amounted to 40.3 million tonnes in 2022.

Including methane emissions from abandoned and closed mines

Neither IEA, GEM, or Shen et al. include an estimation of methane emissions from abandoned or closed coal mines. Research by [Kholod et al.](#) estimates that abandoned and closed mines contribute to an additional 17% of methane emissions from coal mines in 2010. This is predicted to increase to 23% by 2050.

Using the 2010 AMM estimate (although it is likely to be slightly higher in 2023) Ember finds that the above studies estimate global emissions could be between 38 to 67 million tonnes per year.

Global Warming Potential

Global Warming Potential (GWP) is a measure to express the effects of GHGs in CO₂ equivalent terms. Given that CH₄ absorbs much more energy when in the atmosphere, but has a shorter lifetime than CO₂, the IPCC considers its impact over 20 years (GWP = 82.5) and over 100 years (GWP = 29.8). One of the shortcomings of this metric is that it assumes a constant value of methane's effects over time, when in reality it varies significantly.

Historically, the 100-year value has been used by Governments and in major international agreements on the basis that global warming is a long term challenge.

At Ember, we propose to use the 20-year GWP. Climate change is an emergency, and the next 20 years are critical with regards to climate action. Methane's short atmospheric lifetime means emissions reductions can reduce global heating in the near term.

Comparison to country annual CO₂ emissions

When comparing CMM emissions to total country CO₂ emissions, we sourced the latest data from [The European Commission: Emissions Database for Global Atmospheric Research](#).

India: 2.649 billion tonnes in 2021

US: 4.752 billion tonnes in 2021

South Africa: 436 million tonnes in 2021

Indonesia: 603 million tonnes in 2021

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Contributors

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Cover photo

Polish miners working underground in Szczygłowice coal mine in Knurow town, Upper Silesia.

Credit: [Bartek Wrzesniowski](#) / Alamy Stock Photo

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