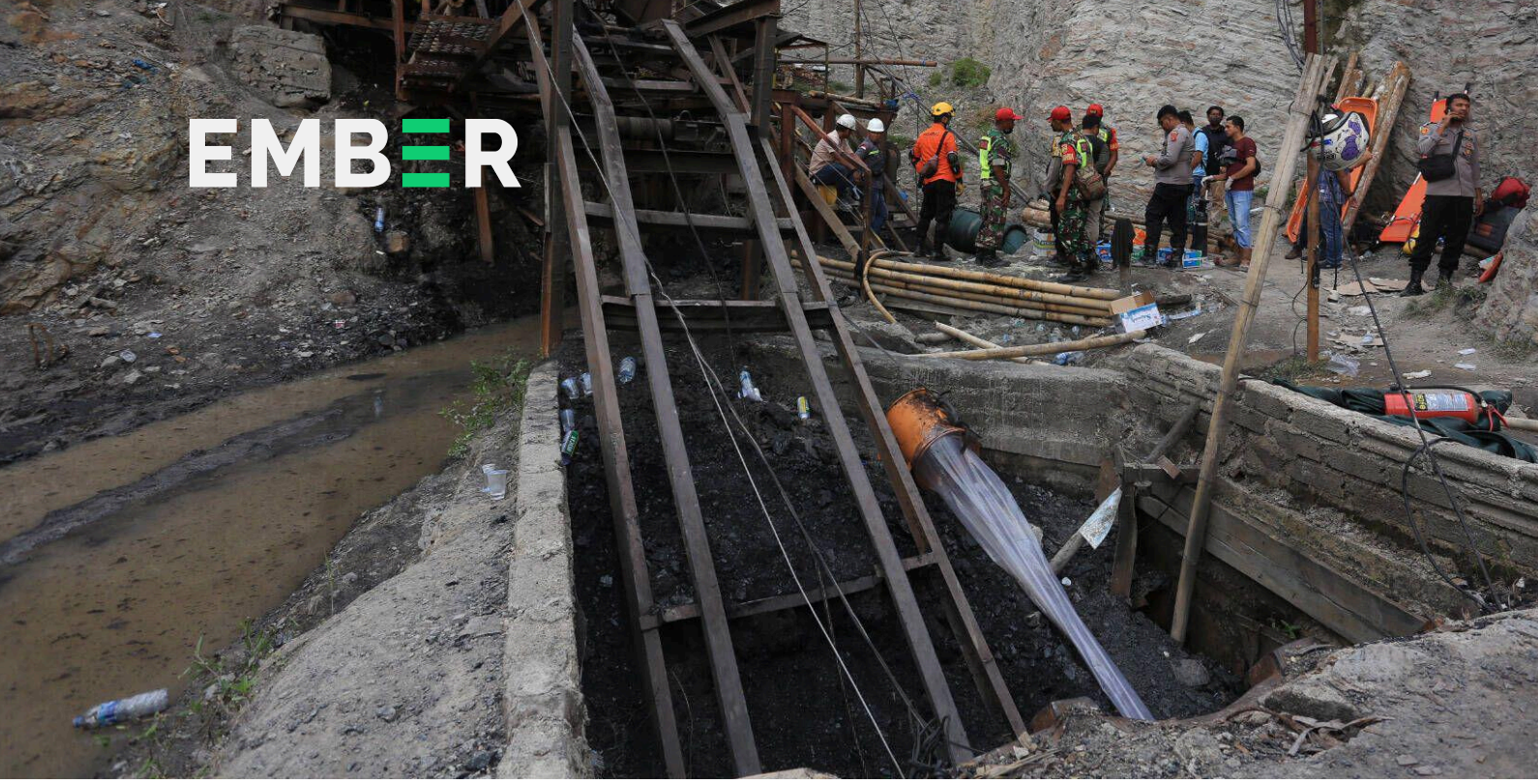

Uncovering Indonesia's hidden methane problem

Indonesia’s underreporting of coal mine methane emissions could risk undermining the country’s efforts to meet its Global Methane Pledge commitments.

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About

This report examines Indonesia's coal mine methane (CMM) emission trends and sources. CMM estimation methods based on IPCC guidelines are overviewed and stacked against current CMM estimates. Independent estimates are also used as benchmarks to assess the likelihood of underreporting. Finally, we present recommendations to improve Indonesia's monitoring, reporting and verification (MRV) framework as required by the Global Methane Pledge (GMP).

Highlights

+12%

Average annual growth of coal mine methane emissions between 2000 and 2019

775 Mt

Indonesia's coal production in 2023

1007 kt

Estimated methane emissions from Indonesia's coal mining in 2024

Executive Summary

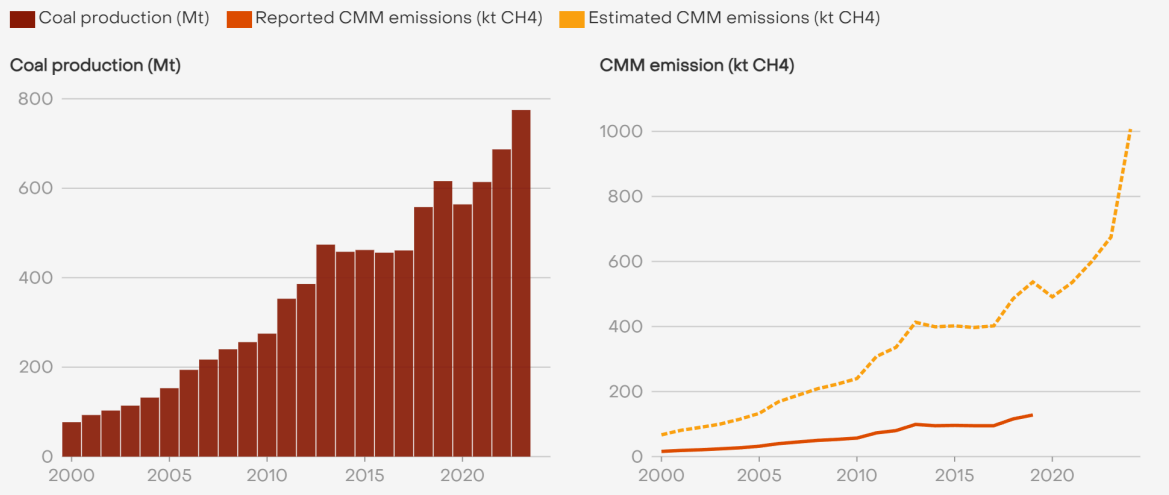
Indonesia's coal mining emissions are greater than currently reported

Indonesia stands to gain great benefits by closely monitoring its methane emissions from coal mining as part of the Global Methane Pledge, including improved transparency, a deeper understanding of its methane problem, effective mitigation measures, heightened safety for mine workers, and increased support for project developers.

Indonesia is the world's third-largest coal producer, after China and India. Its national coal sector is expanding rapidly, marked with record-breaking production levels over the past two years. Consequently, methane emissions from coal mining are rising and are the fastest growing emission sub-category within the energy sector.

Methane emissions from coal mining might be up to eight times higher than the latest official estimate

Coal production (Mt) and coal mine methane emissions (kt CH4)



Source: Handbook of Energy and Economic Statistics of Indonesia (HEESI), Indonesia's Third Biennial Update Report (BUR), Ember's analysis

EMBER

As a signatory of the Global Methane Pledge (GMP), Indonesia has committed to “take comprehensive domestic actions to achieve global reduction of methane emissions by 2030”. Yet Indonesia has not developed any comprehensive action plans to tackle methane emissions. Furthermore, independent studies suggest that the country’s coal mine methane emissions are significantly underreported.

The analysis of Indonesia's coal mine methane (CMM) emissions reporting framework reveals significant issues. These include a lack of data transparency, the use of inaccurate emissions factors and outdated conversion factors for methane's global warming potential, and the neglect of emissions from underground coal mines.

Improving the monitoring, reporting and verification (MRV) system is a critical first step to address these issues. Inaccurate reporting risks misallocation of resources meant for mitigating methane emissions and undermines the integrity of national emissions data as well as the credibility of Indonesia's international commitment. International support is available to help offset the costs associated with improving the on-site measurement of coal mine methane. These opportunities could be greatly enhanced by implementing a number of short-term changes outlined in this report, before Indonesia’s next biennial report to the UNFCCC.

01 CMM emissions have increased by 12% annually

Reported coal mine methane emissions—excluding overlooked fugitive emissions—have increased from 16 kilotonnes of methane (kt CH4) in 2000 to 128 kt CH4 in 2019 due to rising coal production.

02 Reported CMM emissions are six to seven times lower than independent estimates

Official CMM emissions figures are six to seven times lower compared to independent research estimates. This underpins the high uncertainty of

current reporting methodologies and potential underreporting of CMM emissions.

03 New underground coal mines would significantly increase CMM emissions

Official estimates have overlooked CMM emissions from several underground mines. The addition of Qinfa's new underground coal mines alone could result in annual 332 kt CH4 emissions, which, if included, would more than triple the latest CMM estimate.

04 Annual CMM emissions are bigger than wildfire emissions in 2022

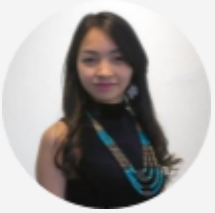
Future CMM emissions in Indonesia could potentially reach 1007 kt CH4 per year, taking into account all measurement adjustments and the projected rise in coal production. This is equal to 30 million tonnes of carbon dioxide equivalent (tCO2), which is more than the emissions from 200 thousand hectares (ha) of forest and land fires in 2022.

"The use of outdated methane estimation methods risks undermining the scale of Indonesia's coal mine methane problem. Consequently, Indonesia could jeopardise its international standing as it is committed to slashing methane globally. The first step is recognising this hidden issue and updating Indonesia's coal mine methane estimate in the upcoming Biennial Transparency Report (BTR) to the UNFCCC. This could be an important step in devising essential strategies to mitigate methane emissions."

Dody Setiawan
Senior Analyst Climate and Energy,
Indonesia, Ember

"As a major coal producer, Indonesia's active participation in methane reduction is essential to reduce global emissions. But the lack of transparency and the absence of a robust Monitoring, Reporting, and Verification (MRV) system poses substantial challenges to effective evaluation of its coal mining activities. Indonesia must plan to monitor its emissions, and improve the accessibility of its coal mining and methane data, to help fully achieve the goals of the Global Methane Pledge."

Dorothy Mei
Project Manager of Global Coal Mine
Tracker, Global Energy Monitor (GEM)



“Indonesia is a signatory to the Global Methane Pledge, which aims to reduce methane emissions by 30% by 2030. The importance lies in the fact that it is the "underestimated" cause of greenhouse gas emissions after CO2. Knowing this fact, it is important to have this report to analyse the actions that the government and all relevant stakeholders need to take to mitigate climate change, especially in relation to methane emissions.”

Wira A. Swadana
Green Economy Program Manager,
Institute for Essential Services Reform
(IESR)

Introduction

Understanding Indonesia's methane problem

Methane is the second most potent greenhouse gas. Over 150 countries, including Indonesia, have pledged to reduce man-made methane emissions, including those from coal mines.

Methane is a powerful greenhouse gas (GHG) and a short-lived climate pollutant (SLCP) that contributes to 30 percent of global warming since the pre-industrial age. The Intergovernmental Panel on Climate Change (IPCC) currently estimates that methane emissions have an atmospheric warming effect of about 30 times that of carbon dioxide, otherwise known as the global warming potential (GWP). While an exact comparison between greenhouse gases is challenging, this underscores the significant impact methane emissions can have on global warming.

Methane is known to contribute to rising tropospheric ozone—the ozone present in the lower part of the Earth's atmosphere, also known as surface ozone—causing 1 million respiratory deaths globally in 2010. Escalation of tropospheric ozone is also linked with temperature increase which would reduce agricultural productivity in Asia. Meanwhile, underground coal mines methane leaks present serious hazards leading to accidents that have killed 578 people between 2010 and 2017 in Turkey.

Global commitment to address methane

The IPCC's Sixth Assessment Report highlighted that global methane concentrations in 2019 surpassed levels observed at any point in the past 800,000 years. The modelling pathway suggests that the world must reduce 34% of methane emissions below 2019 levels by 2030

to limit global warming to 1.5C. Specifically for fossil fuels, a 75% reduction in methane emissions is necessary by 2030 to align with IEA's Net Zero Emission by 2050.

The Global Methane Pledge (GMP), initiated at COP26, aims to slash methane emissions by 30% against 2020 levels before 2030. Participating countries are expected to improve GHG inventory methodology, increase transparency and maintain up-to-date policies and commitments. They must also take concrete steps to achieve the GMP target by reducing methane emissions in the energy and waste sectors, while also pursuing mitigation strategies in the agriculture sector.

Indonesia's action on methane

As a signatory to the GMP and one of the top six methane emitters, Indonesia is expected to develop a comprehensive methane reduction action plan like other participating countries. However, their Enhanced Nationally Determined Contribution (NDC) currently outlines specific mitigation plans only for the waste sector.

Mitigation on fossil-fuel methane, on the other hand, is hardly found in any official documents submitted to the UNFCCC. This is a concerning issue given the big data gap between reported GHG inventory submitted to the UNFCCC and the actual methane emissions from fossil fuels.

Coal Mine Methane (CMM)

Coal mine methane is a general term for all the methane that is released during mining and post-mining operations. In Indonesia, coal bed methane (CBM) is a more commonly-used term which refers to extracted methane gas from coal seams—layers of coal in the earth's crust—prior to mining activities and is a non-conventional fuel source acknowledged by the government to enhance energy supply.

Methane emission from coal mining depends on several factors, but underground mining typically releases more methane than surface mining due to deeper coal seams and higher coal rank. In underground mines, methane emissions come from degasification and ventilation systems, whereas in surface mines, emissions occur over a large surface area during coal extraction.

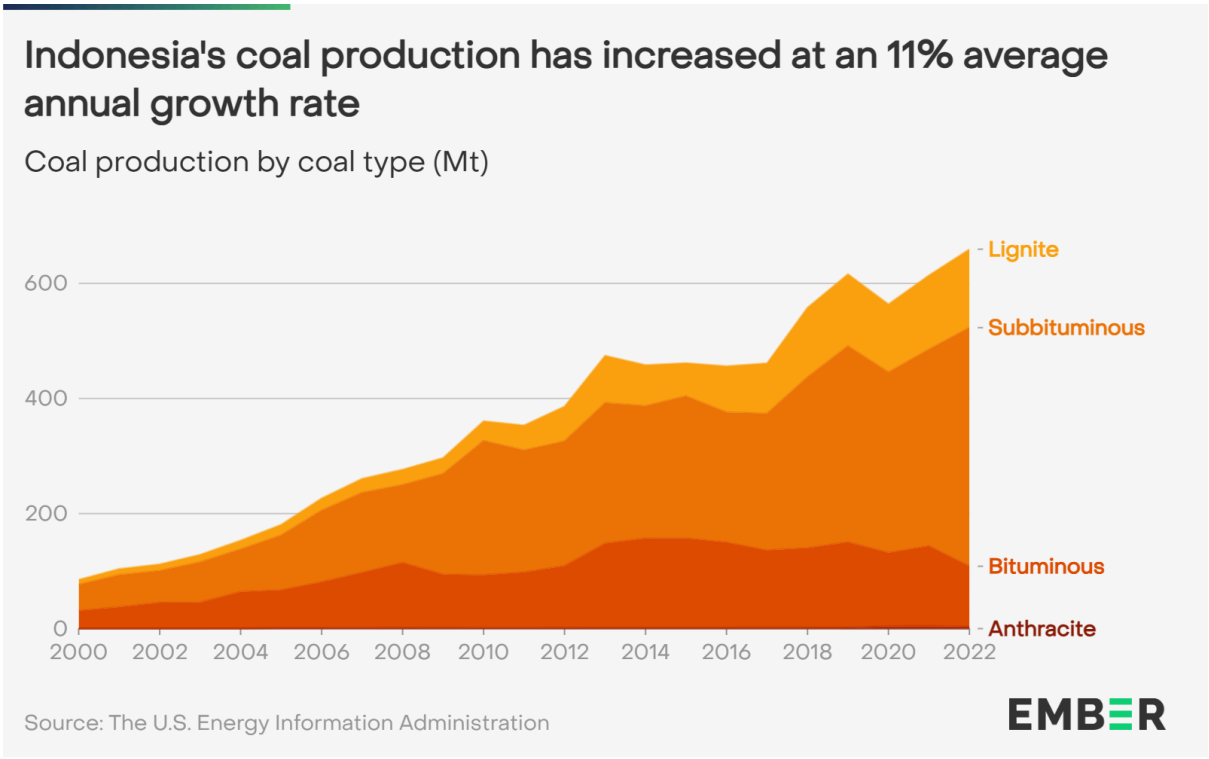
The energy sector represents nearly 40% of anthropogenic (man-made) methane emissions with coal mining representing one third of the emissions. Among methane emissions from coal mines, current estimates suggest that 84% of global CMM emissions come from underground mining. As satellite measurement techniques improve, the international scientific community is now openly questioning whether surface coal mines may emit significantly more methane than previously reported.

CMM emissions in Indonesia

Methane emissions from expanding coal operations are underestimated

Methane pollution from coal mining is the fastest growing emissions source across Indonesia's energy sector. Yet, Indonesia could be underestimating its surface CMM emissions by up to eight times.

Indonesia is the world's largest thermal coal exporter by volume, and the third largest coal producing country after China and India. The Ministry of Energy and Mineral Resources (MEMR) claims that coal production reached an all time high in 2023 (+13% from 2022).



80% of Indonesia's coal production consists of lower-quality coal such as lignite and subbituminous coal. These low-rank coal reserves are spread across seven main coal basins in Indonesia, notably in Central and South Sumatera, as well as in Kalimantan, spanning the Barito-Warukin, Kutai and Tarakan basins. Meanwhile, medium and high-quality coals are commonly found in Barito basin in South Kalimantan and the Ombilin Basin in West Sumatera.

How coal types affect methane emissions

Coal is classified into four types based on its energy content quality, measured in calorific value. These types are anthracite, bituminous, sub-bituminous, and lignite. Anthracite, with the highest energy content, is primarily used in the metal industry. Bituminous coal, with a calorific value between 5,833 and 7,777 kilocalories per kilogram (kcal/kg), is commonly used for power generation and steelmaking. Sub-bituminous coal, with an energy content ranging between 4,611 and 5,833 kcal/kg, is often utilised in steam power plants. Lignite, with the lowest energy content, typically has a calorific value below 4,611 kcal/kg.

The type of coal significantly influences methane emissions during the mining process. Higher-ranked coals, such as bituminous and anthracite, are generally more mature and contain less moisture, leading to higher methane emissions when extracted. These coals are usually found in deeper seams, which retain more methane. Conversely, lower-ranked coals like lignite and sub-bituminous coal have higher moisture content, resulting in lower methane emissions.

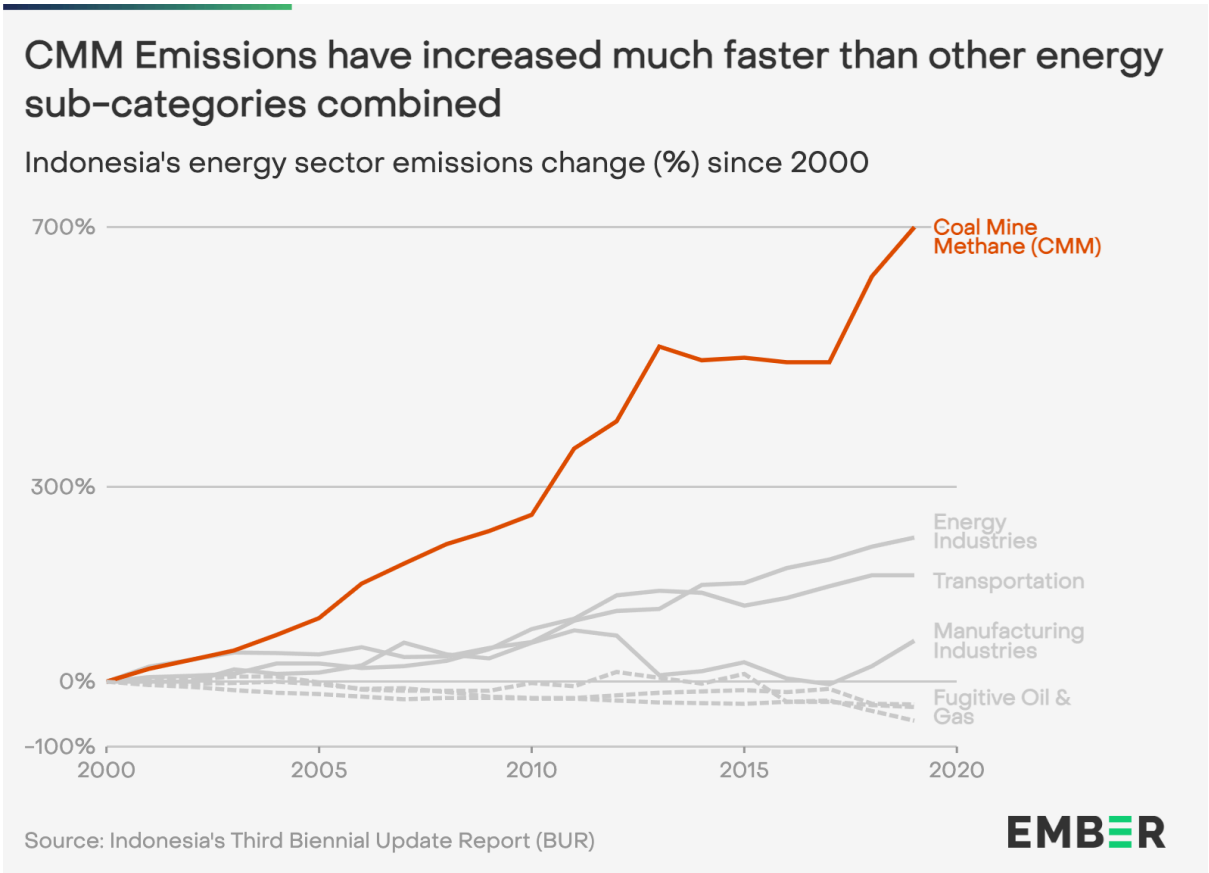
Although coal in Indonesia is primarily extracted using open-pit or surface mining methods, there are some companies operating underground mining in West Sumatera, Bengkulu and South Kalimantan. These companies typically produce bituminous coal with calorific values above 6,800 kcal/kg.

CMM emissions in Indonesia are increasing

Indonesia reported 128 kt CH4 from surface coal mines, which fall under the category of fugitive emissions from solid fossil fuels (1B1) according to the UNFCCC's GHG inventory.

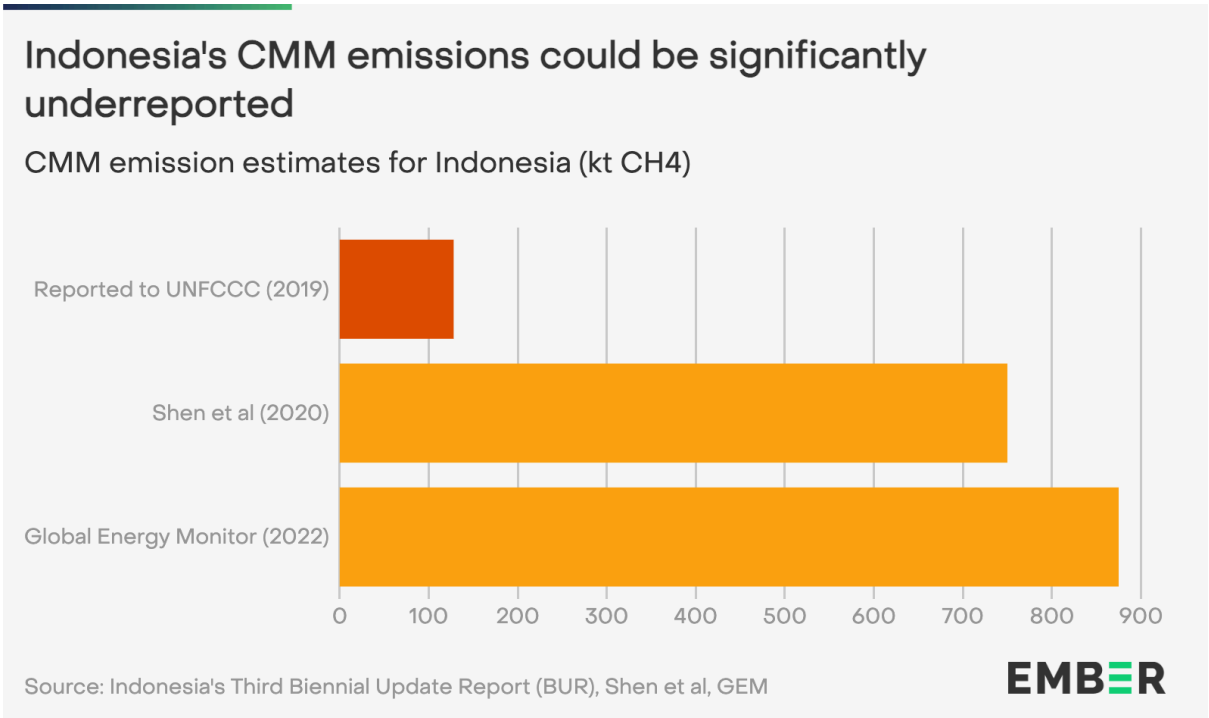
Fugitive emissions refer to unintentional releases of gases, such as methane, during mining activities. The reported surface coal mine methane estimate is relatively small compared to fugitive emissions from oil and gas at 554 kt CH4.

However, reported CMM emissions have been increasing rapidly. Since 2000, CMM emissions have grown by an average of 12% annually, making it the fastest growing source of emissions in the energy sector. Although it currently represents a minor fraction of the total energy sector emissions, CMM is set to become the sector's major methane emitter as fugitive emissions from oil and gas decline, even with current estimates still in place.



Independent estimates show higher CMM emissions than reported

Furthermore, Indonesia's CMM emissions are up to seven times higher than currently reported based on independent estimates using satellite and mine-level data. According to satellite data estimates, Indonesia's CMM emissions could be as much as six times greater than the government's official figure of 128 kt CH4, potentially reaching 750 kt CH4. Additionally, mine-level data estimates suggest up to seven times higher emissions than the reported amount, with figures reaching 875 kt CH4.



These independent estimates are important as they provide scientific evidence to help countries improve their emission estimates for more effective climate action. For example, Australia increased its methane emission factors for surface coal mines in Queensland following an independent assessment. Similarly, Indonesia could reference these independent findings to improve its country-specific emission factors for methane

emissions. This, in turn, would facilitate the identification of regions and coal mines responsible for producing the most CMM emissions and therefore provide clarity on where to focus mitigation efforts.

CMM underreporting

Why the government needs to re-assess its CMM estimate

The latest official estimate lacks clear assumptions and data disaggregation, resulting in high uncertainty. Our analysis suggests that CMM emissions are equivalent to the total wildfire emissions throughout Indonesia in 2022.

We find that Indonesia's current CMM emissions estimates lack clarity and detail. Specifically, there isn't any explanation regarding the assumptions used which includes disaggregation between surface and underground mine activity data as well as the emission factors being used.

Overall, there are a number of factors leading to the significant underestimate of Indonesia's CMM estimates. These include the continued use of inaccurate emissions factors, outdated GWP reference, and the exclusion of underground coal mines. Our analysis found these factors through a series of reverse calculations to determine the emissions factor and assumptions on future CMM emissions.

Official estimates are using inaccurate emissions factor and outdated methods

Indonesia is currently using the IPCC's Tier 1 method to estimate its surface CMM emissions. This simple estimation approach measures CMM emissions using a reference emissions factor, which is the multiplier used to estimate the amount of methane gas emitted for every tonnes of coal extracted or produced. Indonesia uses a low emissions factor of 0.3 m3 CH4/t (cubic metres of methane per tonne of coal), even though the IPCC

recommends that this is used only when the coal mine's overburden depth is less than 25 m. Coal mines in East and South Kalimantan, for example, have deeper overburden depths of 30 m and 60 m respectively. While an analysis on Kaltim Prima Coal reveals overburden depth between 27 to 64 m.

Therefore, Indonesia's CMM emissions from surface coal mines would increase by four times if the emissions factor is adjusted upwards to the recommended average level (1.2 m3 CH4/t). However, considering Indonesia's significant coal production, the IPCC also suggests breaking down activity data and emission factors at the level of specific coal-rich regions or coal basins. Specifically, it involves analysing coal production and methane emission factors for each region or basin separately, taking into account the unique characteristics of the coal, mining practices, and geological conditions present in those areas. This approach provides better estimation of methane emission from each area, allowing more accurate estimation and targeted mitigation efforts.

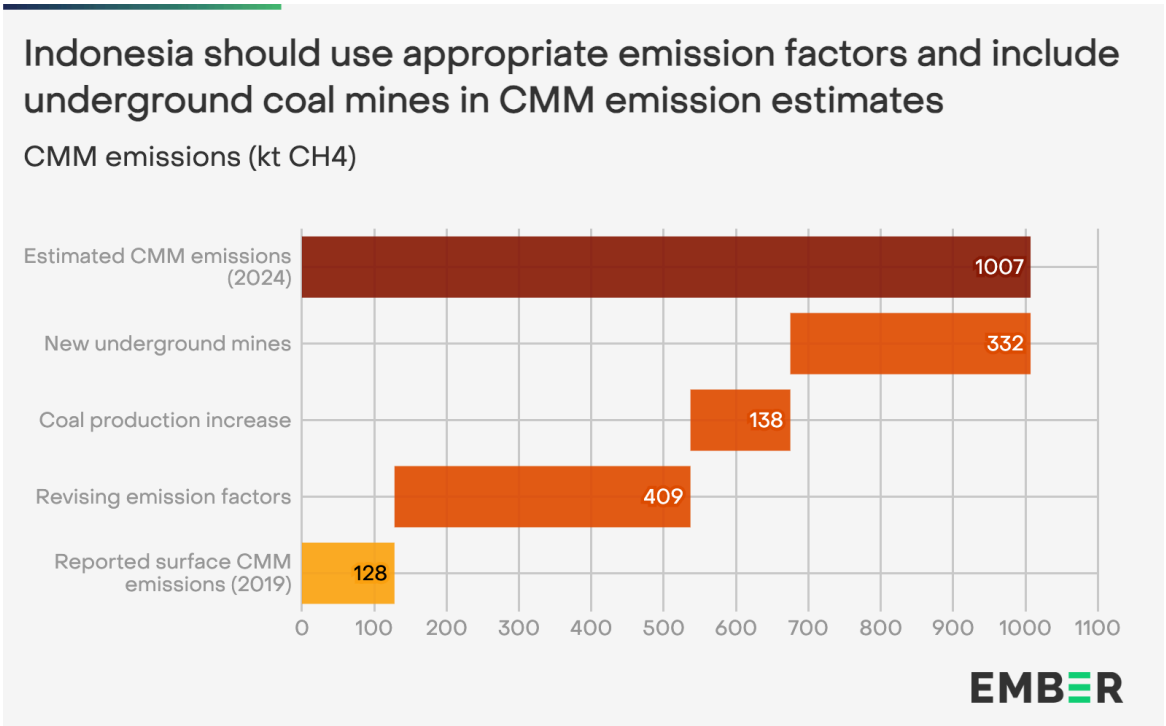
Similarly, Indonesia is still using the outdated methane GWP factor of 21, taken from the IPCC's second assessment report published in 1996. The latest IPCC report indicates that methane's GWP is about 30 times that of carbon dioxide. This means methane is now considered 40% more harmful to our climate than previously thought, highlighting the need for urgent actions.

Underground coal mine emissions are not being counted

There are currently 15 companies engaged in underground coal mining across Indonesia, despite the country's last biennial update report to the UNFCCC in 2021 stating otherwise. The recently commissioned Qinfa underground mine in Kotabaru, South Kalimantan alone is projected to add at least 332 kt CH4, effectively more than tripling the official reported CMM emissions in 2019. These developments, coupled with reports of underground coal mining accidents—such as the one in Sawahlunto, West Sumatera, which resulted in the loss of 50 lives—highlight a significant oversight in addressing methane emissions from underground coal mines, including those that have been abandoned.

Undoubtedly, underground coal mines do not only increase methane emissions, but also pose serious safety risks to mine workers. In response, the government issued a decree on

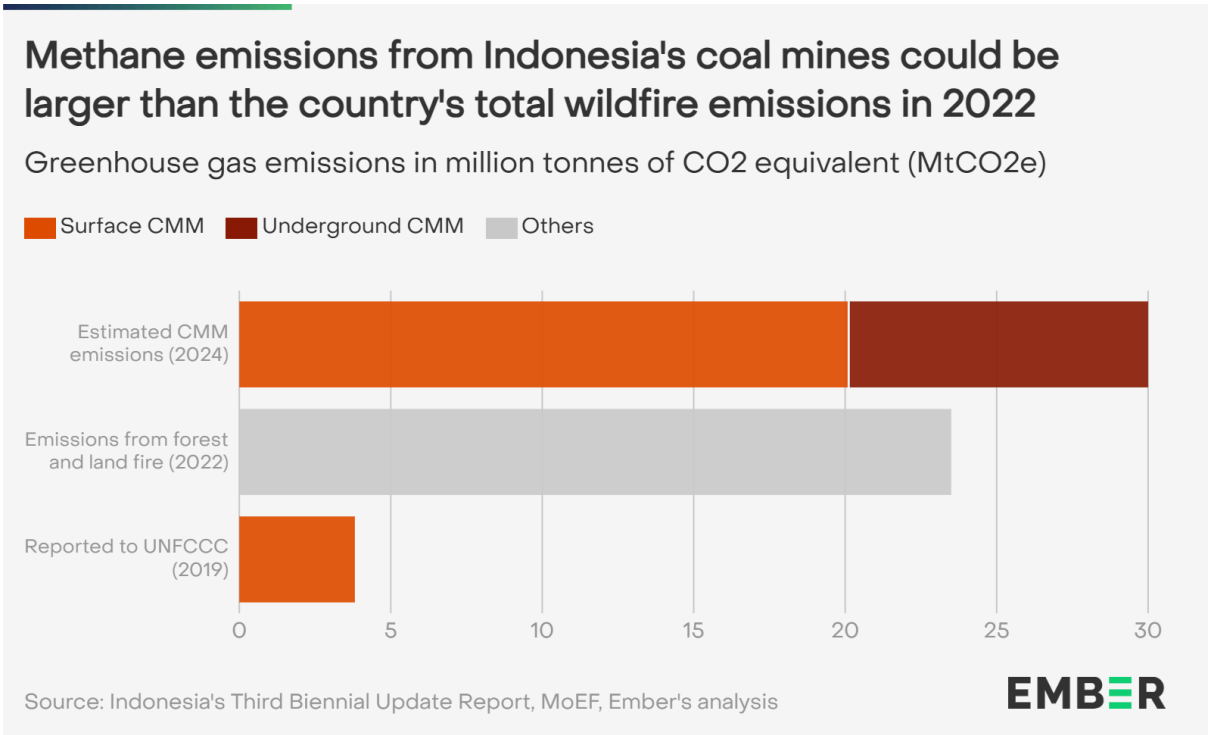
good mining practice in 2018, incorporating underground mine safety aspects such as methane drainage, ventilation air methane and monitoring devices. Combining these best practices with closely monitoring methane emissions from underground mining could help mitigate the environmental impacts of coal mines whilst ensuring miner safety.



Indonesia's CMM emissions are greater than the country's total wildfire emissions in 2022

The emissions from surface mining could reach 675 kt CH4 when using revised surface CMM emission factors with the latest coal production data. With the addition of Qinfa's new underground coal mine, future CMM emissions in Indonesia could reach at least 1007 kt CH4, higher than GEM's estimate in 2022. Against reported fugitive emissions from oil and gas in 2019, this estimate would make coal mine fugitive emissions become the energy sector's major methane emitter.

In other words, the estimated annual CMM emission would reach 30 million tonnes of carbon dioxide equivalent (tCO2e), using the latest 100-year conversion factor for fossil-fuel methane's global warming potential. This would be more than a tenfold increase from the CO2-equivalent of the official estimate in 2019 (2.7 million tCO2e), and is greater than emissions from over 200 thousand hectares (Ha) of forest and land fires in 2022 (23.5 million tCO2e).



Policy recommendations

Practical steps are available to improve CMM emissions reporting

Improving emissions MRV will enable Indonesia to better understand its methane problem, facilitating more effective mitigation measures. This will also bolster credibility and attract international support for climate action.

As part of its commitment to the GMP, Indonesia is required to establish an MRV framework to track its progress towards the 2030 methane reduction target. An incorrect baseline emission profile may lead to ineffective mitigation actions and underplay the significance of necessary actions to stay on track with both the GMP and 1.5C trajectory.

Improved monitoring of methane emissions, especially in underground mining, is also vital for ensuring the safety of mine workers and minimising operational disruptions. Moreover, it can support project developers in designing baseline studies on gas content and the most appropriate CMM mitigation projects.

The United Nations Economic Commission for Europe (UNECE) has published a best practice guide for coal mine methane MRV systems and a business case for mitigation. These resources could be leveraged by the Indonesian Government to tailor an MRV framework specific to Indonesia. Such an initiative could in turn garner considerable interest from international partners.

Three action points to improve Indonesia's MRV for CMM emissions

Implement data disaggregation

Data disaggregation is essential for effective MRV implementation. Currently, the government uses a bulk coal data assumed from surface mines and applies an emissions factor to estimate coal mine methane pollution. Disaggregating this data implies analysing methane emission at the mine-level and separating between surface and underground mines. This improves transparency and accountability in emission calculations, enabling policymakers to discern the sources of emissions, identify the sectors making the most contributions and prioritise mitigation actions accordingly.

Given the significant role of coal in Indonesia and notable data gaps confirmed by independent studies, refining estimates with disaggregated data is crucial. This approach will reduce uncertainty and affirm Indonesia's commitment to the Global Methane Pledge as well as allow precise monitoring of high-risk projects like underground mines.

In addition, it is essential to conduct data collection and analysis at the level of individual mines, both surface and underground, to allow further data processing. This will streamline the verification process and minimise the possibility of underreporting.

The US Environmental Protection Agency (EPA) has provided guidelines for calculating mine-level methane emissions. Furthermore, the US and Australia have mandated all underground coal mines with significant emissions (exceeding 25,000 tCO2e per year in the US) to report their scope 1 GHG emissions.

Use higher tier methods

Indonesia currently uses the IPCC's Tier 1 method to estimate emissions from the energy sector, including CMM, using a reference emissions factor. The country has planned to use a Tier 2 method by developing a country-specific emissions factor for methane emissions in the energy sector. Although this is the most common method for estimating surface CMM emissions, the government should also consider going further with a Tier 3 method by directly measuring CMM emissions from underground mines at the facility-level.

This follows major coal producing countries, such as the United States, Australia, Russia, China and India, which use a combination of tier 2 and tier 3 methods for estimating their CMM emissions.

More measurements should also be conducted to develop emission factors on a basin or regional level to capture different characteristics of coal basins. For example, the United States revised its methane emission factors by directly measuring 14 coal basins.

Improve reporting

MRVs should be conducted on a facility level to increase transparency and meet stakeholder demands for public disclosure. Each coal company with a production mining business licence (IUP OP) should report their GHG emission from mining operations at mine level, including CMM.

The approach for estimating GHGs, whether through emission factors or direct measurements, should prioritise transparency. The Directorate General of Electricity of Indonesia's energy ministry has a good example on how APPLE Gatrik is used to track emissions from each power plant across the country. In addition, US EPA and Australia's NGER provide other examples on how such emissions data is also available for public scrutiny.

Given that many major coal mining companies are publicly listed, methane emission from coal mining should also be incorporated into their sustainability reports. Consequently, the Financial Services Authority (OJK) needs to update its sustainability reporting guidelines to align with the Global Reporting Initiative (GRI) 305, ensuring coverage of the energy sector's fugitive emission. Indonesian Coal Mining Association (ICMA) has also developed sustainability report guidelines in accordance with OJK, CDP and GRI standards.

Supporting Materials

Disclaimer

We have identified instances where reported emissions or estimates may significantly underestimate the actual amount of methane released. It is important to note that this information is intended for informational or educational purposes only and should not be construed as financial, legal, or other professional advice.

The data presented in this report is based on the materials outlined below. While the findings are derived from an analysis of this material, we cannot guarantee the completeness, accuracy, or reliability of the statements or representations arising from it. The Center of Data and Information of MEMR was contacted for comment prior to the publication of this report.

Methodology

Ember conducted a reverse calculation to identify methane emission factor by comparing CMM emissions in the Third Biennial Update Report (BUR) with coal production data from the Handbook of Energy and Economic Statistics of Indonesia (HEESI). The calculation method and conversion factors follow the latest IPCC guidelines on fugitive emissions.

Estimating CMM emissions in 2024 involved calculating both surface and underground emissions. For surface CMM emissions, we used IPCC average emission factors (1.2 m3/t for mining and 0.1 m3/t for post-mining). Coal production data was gathered from HEESI and a press release from MEMR. Coal production for surface mines in 2024 was assumed to be similar to that of 2023.

CMM emissions from two Qinfa's underground coal mines are estimated using IPCC average emission factors (18 m3/t for mining and 2.5 m3/t for post-mining) for SDE-1 mine with mine depth of 180 - 410m and high emission factors (25 m3/t for mining and 4 m3/t for post-mining) for SDE-2 with mine depth of 440 - 650m. CMM emissions from existing underground mines were not estimated in this study due to data unavailability.

We used the latest Global Warming Potential (GWP) from the Sixth Assessment Report, setting the fossil-fuel methane GWP at 29.8. Emissions from forest and land fires in 2022 were sourced from a report by the Ministry of Environment and Forestry (MoEF).

IPCC guideline on tier approaches
There are three tier methods to estimate greenhouse gas emissions specified in the IPCC guidelines. Tier 1 approach is the most basic approach which estimates methane emissions by applying bulk coal production data with a global emissions factor. This simple method has the highest level of uncertainty. Tier 2 approach uses basin- or country-specific emission factors which represent average methane emissions in respective regions. Tier 3 approach employs direct measurement at the facility- or mine-level, making it the most accurate method and should be applied to gassy coal mines.

Coal mine methane estimation using satellite data
The study listed as Shen et al utilised a top-down approach incorporating 18 months of satellite measurements from TROPOMI (TROPOspheric Monitoring Instrument) satellite data to adjust GHG inventory models, including Global Fuel Exploitation Inventory (GFEI) v1 and v2, as well as the Emissions Database for Global Atmospheric Research (EDGAR) v6.

Global Energy Monitor coal mine methane estimates
The Global Energy Monitor (GEM) has developed a coal mine tracker to monitor more than 4,000 coal mines around the world, spanning various operational statuses, including over 400 active mines in Indonesia. Annual methane emissions are estimated at mine level using annual coal production, methane content and an emission factor coefficient. Methane gas content is estimated using the MC2M model, which follows Langmuir isotherm for the appropriate coal rank (sub-bituminous, bituminous and anthracite) and at the depth of mining. Finally, the emission factor coefficient is applied to estimate methane emission.

Acknowledgements

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