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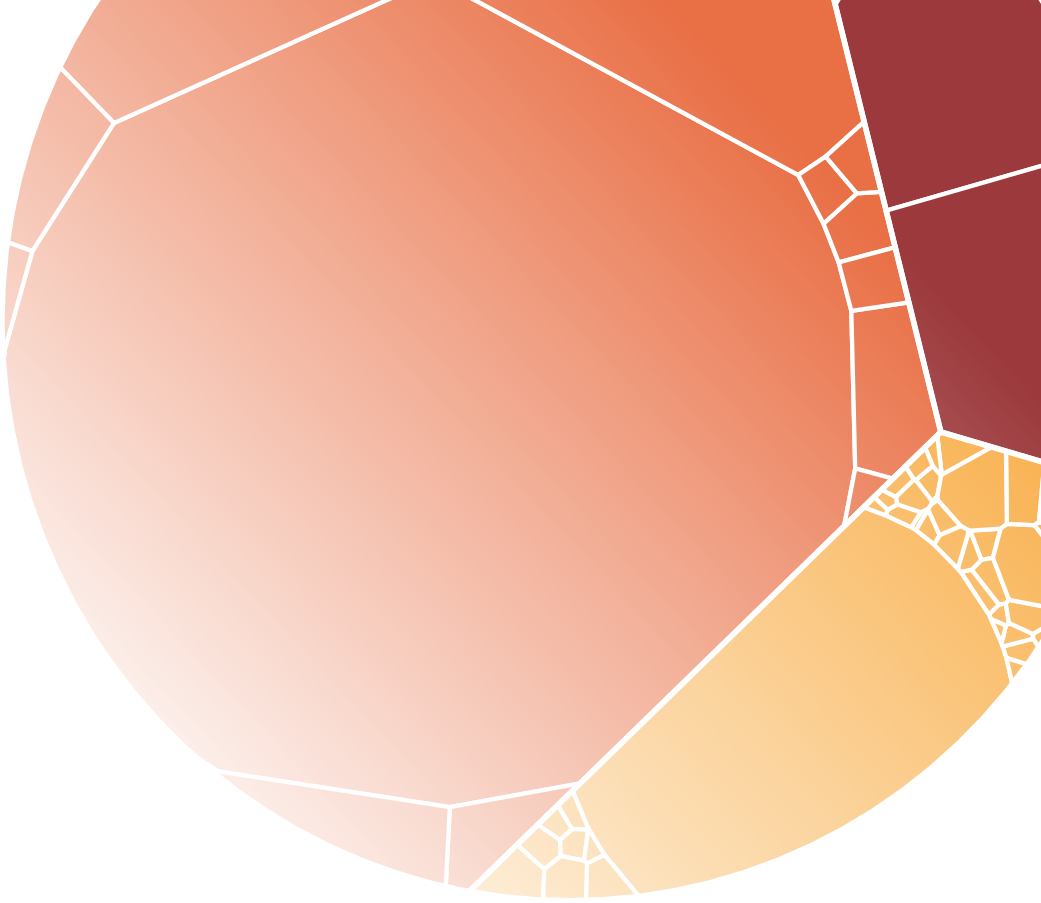

Global Coal Mine Methane Review 2026

Countries' reported coal mine methane inventories capture only a fraction of actual emissions. Yet affordable mitigation measures exist and could significantly reduce these emissions this decade.

29 April 2026

Rebekah Horner
Sabina Assan

About

Ember's first annual Global Coal Mine Methane Review provides the first comprehensive overview of the trends in coal mine methane emissions, based on reported data. This report compiles coal mine methane emissions from 1990 through to 2024, with a focus on what has happened since the Global Methane Pledge was formed in 2021. Almost five years on, it asks whether the coal sector is on track to play its part in emissions reductions, and what it would take to change course.

The report compiles data from a total of 73 countries and dives deeper into the nine countries with the largest coal production in 2024 – China, India, Indonesia, the United States, Australia, Russia, South Africa, Kazakhstan and Poland – which together account for around 94% of reported global CMM emissions.

It is written for anyone looking to understand more about the state of global- and national-level coal mine methane emissions. We make all of the data freely accessible via our Coal Mine Methane Data Tracker to empower others to do their own analysis and help speed up mitigation in this sector.

Read the report online at:
https://ember-energy.org/latest-insights/global-electricity-review-2026/

Highlights

35 Mt

Total global CMM emissions in 2023 if all coal-producing countries had reported.

31 Mt

Unreported CMM emissions in 2023 because only a third of all coal-producing countries reported

10%

Global hard coal production whose emissions have been detected via satellite

63%

Global CMM emissions that could be cut by 2030 using existing technologies, mostly at negative net cost

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Executive summary

CMM abatement offers a major near-term climate win, yet a lack of reporting masks the true scale of the opportunity

Coal mine methane (CMM) is an increasingly significant near-term climate risk. Emissions have remained broadly steady, falling short of required reductions as coal production continues to increase. CMM emissions also remain largely unaccounted for in official data, hindering the uptake of proven technologies that could cut emissions this decade.

Almost five years into the Global Methane Pledge, which aims for a 30% cut in global methane emissions by 2030, emissions have not fallen, including those from coal mining.

Methane is a potent greenhouse gas that is co-formed with coal and released before, during and even after mining.

According to Ember's analysis of reported data, coal mining emitted around 34.7 million tonnes of methane in 2023, comparable to emissions from the oil or gas industries.

Only a handful of countries account for the majority of CMM emissions, yet due to infrequent reporting, Ember estimates that 89% of emissions were not reported to the UNFCCC in 2023.

This, combined with evidence that six of the top-nine coal mine methane emitting countries are significantly underreporting emissions, signals a major lack of understanding of these emissions and consequently slow uptake of available abatement options.

Yet the economics of action are favourable. Deep cuts in CMM are affordable relative to coal industry profits. It is technically possible to avoid about 54-63% of current CMM emissions using existing technologies, with around 12% of abatement available at no net cost.

The disruption to the Strait of Hormuz since March 2026 has focused the world's attention to the fragility of fossil fuel supply chains. Yet coal mine methane, a fossil fuel emissions source that could be utilised, remains almost entirely unmonitored and unmanaged. Methane that can be captured and used directly from coal mines (through drainage systems and on-site recovery) represents around 15 bcm (billion cubic metres), equivalent to roughly one-eighth of the 112 bcm of LNG that transited through the Strait of Hormuz in 2025.

Key takeaways

01 No decrease in global CMM emissions, even as reported emissions per tonne of coal decline

Since the launch of the Global Methane Pledge in 2021, Ember analysis finds that coal production has continued to rise and total coal mine methane emissions remain steady at around 35 million tonnes. At the same time, many countries report falling methane emissions per tonne of coal produced, largely due to changes in emission estimation methodologies.

02 Most CMM is neither directly measured nor reliably reported

99% of reported coal production comes from countries that rely on generic emission factors rather than direct mine-level measurements. Only 23 countries reported any CMM data in 2023, out of 73 countries that mined coal that year, leaving around 31 million tonnes of global CMM emissions unreported and policymakers to manage this risk with low-confidence numbers. This weakens urgency and delays action.

03 Large methane releases from coal mines are increasingly visible from space, but many remain unseen

Satellite observations are uncovering significant, previously unobserved methane emissions from coal mines worldwide, with around 70% of global coal production located in regions theoretically favourable for detection. However, satellites currently observe about 10% of coal production, leaving major emissions unaccounted for.

04 Existing technologies could cut more than half of CMM by 2030

According to UNEP and the IEA, fully deploying proven abatement options could reduce global CMM emissions by 54-63%. Ventilation air methane (VAM) abatement would cut around 24%, requiring an investment of $2.5 billion USD as of 2024, less than 11% of global coal mining profits in 2025 (around $23.7 billion USD). Drainage station capture offers a further 19% of total abatement potential, with 62% of that available at negative net cost.

Stronger measurement and reporting, clear methane reduction and utilisation targets, and policies and incentives that encourage rapid deployment of mitigation measures can accelerate progress.

Improving transparency and accountability will help ensure that available opportunities are acted on quickly, unlocking significant near-term reductions in coal mine methane emissions and supporting broader climate goals.

"Coal mine methane emissions are largely unreported, masking their true scale. Transparent, measurement-based reporting would raise confidence in official figures, and existing abatement technologies could reduce emissions by more than half within this decade. Yet solutions already exist and are ready to be widely implemented. This creates a clear opportunity to accelerate climate progress using tools that are already available, while rebuilding confidence in international methane commitments. By improving data quality and deploying proven solutions, the sector can reduce its climate impact and support a smoother energy transition."

Rebekah Horner
Data Analyst, Coal Mine Methane,
Ember

"Coal mine methane remains a major blind spot in global climate action. Emissions are largely unreported, yet proven solutions already exist to cut more than half of them this decade. Improvements in measurement and transparency would raise confidence in official figures and unlock these reductions, while strengthening the credibility of global methane commitments. Global methane targets will not be met unless coal mine methane is addressed directly. This is a clear, actionable part of the problem that has been overlooked for too long. Addressing it now would deliver immediate climate benefits at a pace that few other measures can match."

Nishant Bhardwaj
Coal Mine Methane
Programme Director, Ember

Chapter 1

Global CMM emissions remain steady despite rising coal production

Global coal mine methane emissions have not decreased since the inception of the Global Methane Pledge in 2021, based on Ember analysis. However, in 2023, six of the world's nine largest emitters submitted no official CMM data to the UNFCCC. This lack of reporting means the scale of national CMM emissions remains poorly understood. As a result, tracking progress towards 1.5C pathways and assessing delivery against the Global Methane Pledge is more difficult.

Methane is a short-lived greenhouse gas that traps roughly 80 times more heat per tonne than carbon dioxide over the first 20 years, making it a key driver of near-term warming. Coal mining is estimated to account for around 33% of total fossil fuel-related methane emissions.

The 2021 Global Methane Pledge (GMP) commits 159 signatory countries to collectively cut annual anthropogenic methane emissions by at least 30% by 2030 compared to 2020 levels. This is equivalent to roughly 100 million tonnes of methane.

According to the United Nations Environment Programme (UNEP) Global Methane Status Report, global anthropogenic methane emissions were about 352 million tonnes in 2020.

Under current legislation, they are projected to rise to around 369 million tonnes in 2030, a 5% increase compared to 2020. This would put the world off course from meeting the GMP goal and from pathways consistent with limiting warming to 1.5C.

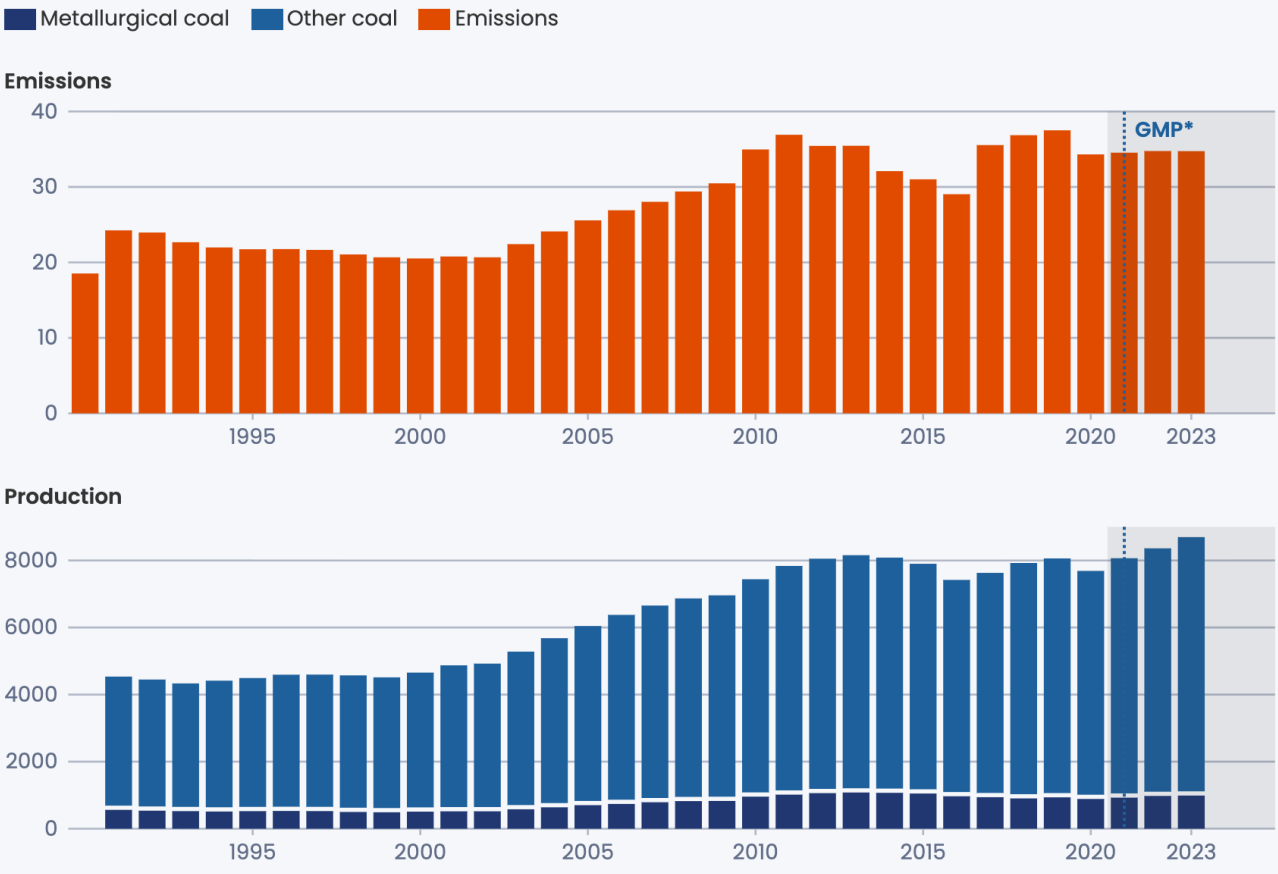
Turning global climate goals into real progress requires focusing on sources where action is practical and effective. Coal mine methane (CMM) is a manageable source, as it is released from known locations during routine mining activities and from closed mines. Experience from many countries shows that this methane can be captured and used or destroyed using proven and widely available methods.

1.1 Global coal production has increased while emissions have remained

Since the Global Methane Pledge was launched in 2021, coal production has increased and associated methane emissions have remained steady, pushing the world further away from the pledge's targets.

Global coal mine methane emissions have not fallen since the Global Methane Pledge

Global coal production and methane emissions (million tonnes)



Source: Ember's Coal Mine Methane Tracker, United States Energy Information Administration
*Global Methane Pledge in 2021
Methane emissions based on Ember analysis of UNFCCC reported data

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Global coal production has risen 8% since 2021

Coal demand has continued to grow despite global climate commitments. Data from the United States Energy Information Administration (EIA) indicate that global coal production has risen since the inception of the Global Methane Pledge, increasing from 8,100 million tonnes in 2021 to over 8,650 million tonnes in 2023. The majority of this coal (88%) is thermal coal used for power generation, while 12% is metallurgical coal used for iron production.

No shift in CMM emissions since the Global Methane Pledge in 2021

Countries report their estimated CMM emissions through national greenhouse gas submissions to the United Nations Framework Convention on Climate Change (UNFCCC). As many countries do not report annually, Ember has filled gaps in this data to construct a continuous national and global CMM emissions timeline (see the full methodology for details).

This UNFCCC-derived data show that global CMM emissions have remained broadly steady. Global emissions reached 34.7 million tonnes in 2023, the most recent year countries reported their greenhouse gas emissions to the UNFCCC. This is 0.6% higher (+0.2 million tonnes) than in 2021.

Notably, this increase is less than an eighth of the rate at which coal production grew over the same period, indicating that reported methane emission factors have declined on average, a trend explored further in Section 1.3.

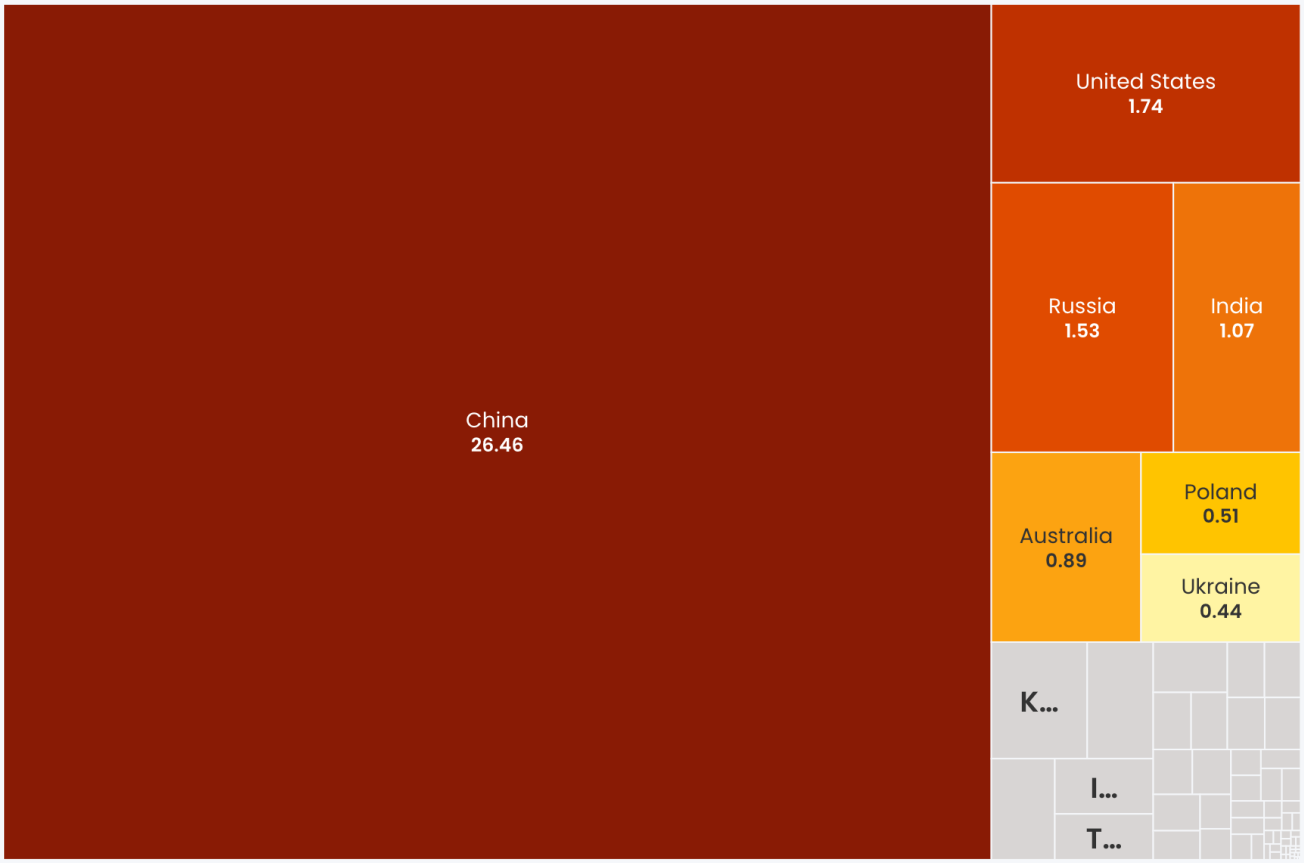
Seven countries account for nearly all CMM emissions

Most CMM comes from a handful of major coal producers. Our UNFCCC-derived data show that almost all (94%) of CMM emissions originate from just seven countries: China, the United States, Russia, India, Australia, Poland and Ukraine.

China alone accounted for 76% of global CMM emissions in 2023 and around half of global coal production.

Seven countries account for 94% of global CMM emissions in 2023

Methane emissions (million tonnes)



Source: Ember's Coal Mine Methane Tracker
Methane emissions based on Ember analysis of UNFCCC reported data

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1.2 Independent estimates reveal uncertainty in the scale of CMM emissions

Independent global datasets consistently indicate that actual CMM emissions differ from what governments officially report to the UNFCCC, although the exact scale varies between sources.

These datasets use different methodologies, which can be broadly grouped into bottom-up inventories, top-down satellite-based measurements and hybrid approaches.

Bottom-up inventories, which use sector-specific emission factors and mine-level data:

- The Global Energy Monitor (GEM) estimated about 56 million tonnes of methane per year from active coal mines in 2024, the highest estimate for global CMM emissions. GEM estimates are based on a peer-reviewed study that applies established physical principles linking methane emissions to coal depth and rank, though it does not account for any mine-level mitigation.
- The Emissions Database for Global Atmospheric Research (EDGAR) estimated emissions of 47 million tonnes in 2022 using IPCC-aligned emission factors and activity data.

Top-down satellite-based measurements, which infer emissions directly from atmospheric observations:

- Shen et al. (2023) estimate global emissions at around 33 million tonnes per year based on TROPOMI observations from 2018–2020.

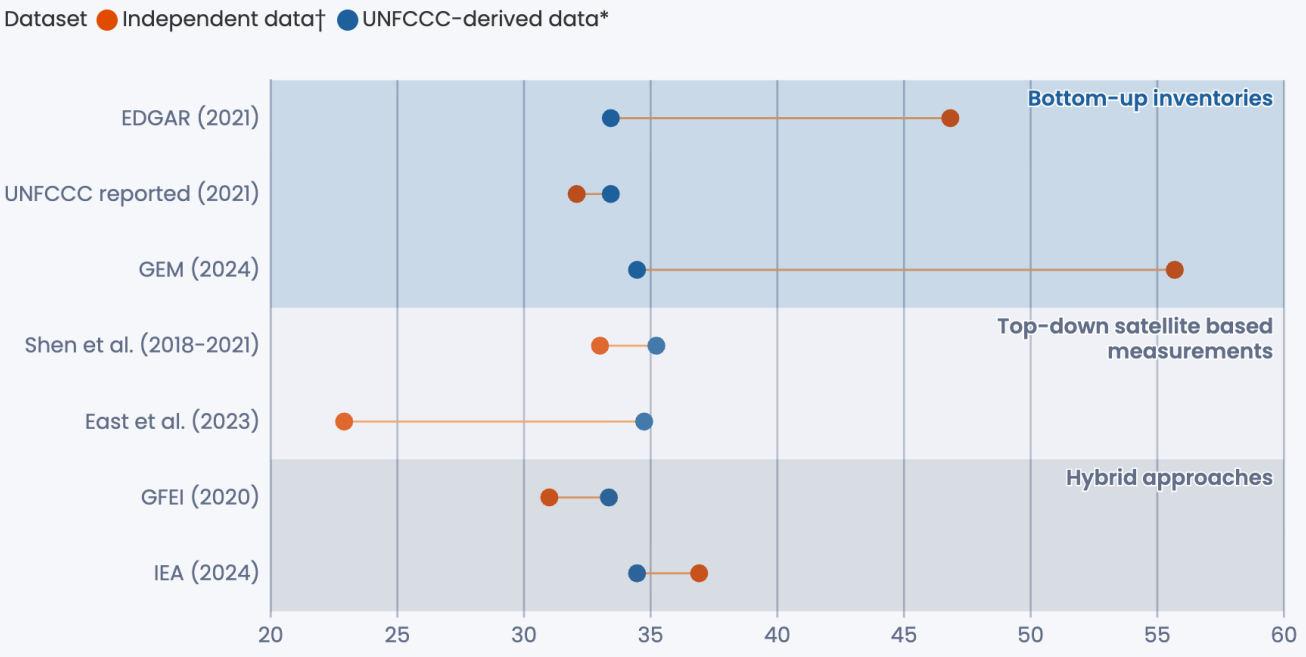
- East et al. (2025) find lower emissions of around 23 million tonnes in 2023, reflecting a decline driven in part by China's shift from underground to surface mining, and provide more granular country-level estimates used in the comparisons below.

Hybrid approaches, which use a bottom-up methodology as their foundation but also integrate or are evaluated against satellite-based measurements to refine or verify their estimates:

- The International Energy Agency (IEA) estimates 36.9 million tonnes from active coal mines in 2024, applying country- and production-specific emission factors while incorporating data from measurement campaigns and satellite detections of large emissions events.
- The Global Fuel Exploitation Inventory (GFEI) similarly builds from UNFCCC-reported national emissions and is explicitly evaluated against satellite atmospheric inversions and also falls in the 30–45 million tonne range.

Global coal mine methane emissions are highly uncertain, with independent estimates ranging from 23 to 56 million tonnes

Methane emissions (million tonnes)



Source: Ember's Coal Mine Methane Tracker, Shen et al., East et al., EDGAR, GFEI
* Gap filled methane emissions based on Ember analysis of UNFCCC reported data
† Emission inventories and independent analysis

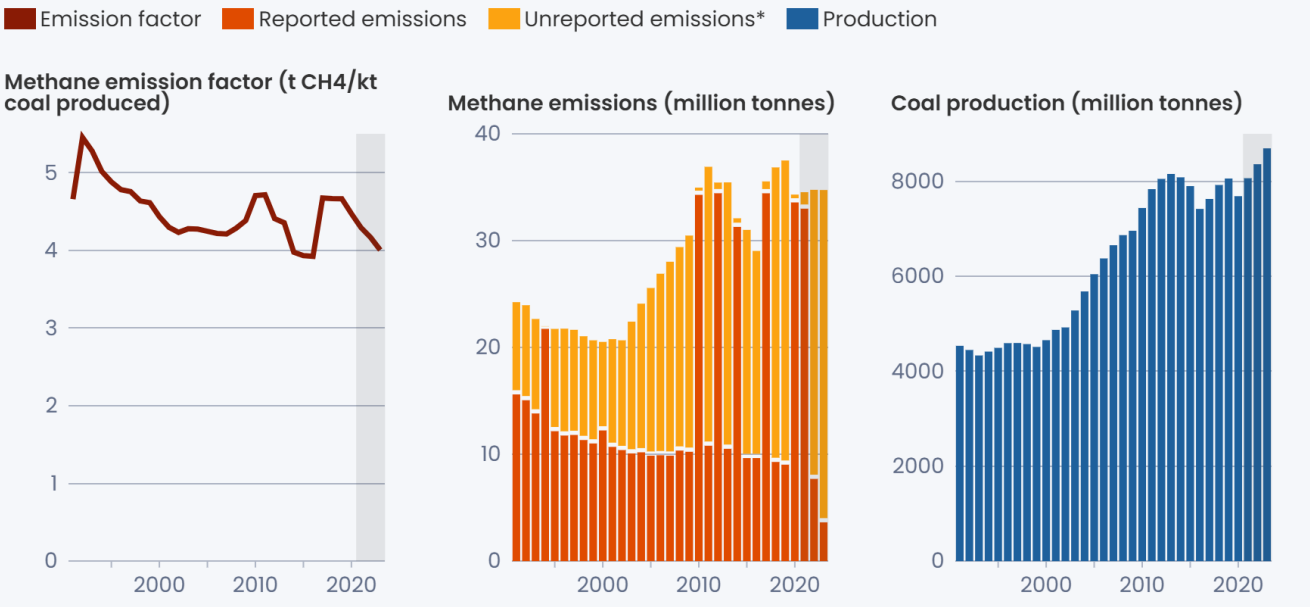
Taken together, the majority of independent sources indicate that emissions differ from what governments report, highlighting limited understanding of this emissions source and large uncertainties in national reporting.

Note: Coal mines can continue to emit methane after production ends, known as abandoned mine methane (AMM). Some countries include AMM emissions in their reports to the UNFCCC. The independent estimates used here do not include AMM emissions.

1.3 Reported methane emissions per tonne of coal are declining

Reported methane emissions per tonne of coal are falling in many countries, even as total production rises and total emissions remain steady. However, this appears to be largely due to changes in reported emission factors rather than significant targeted abatement measures.

Coal mine methane emissions per tonne of coal have continued to decline since the Global Methane Pledge



Source: Ember's Coal Mine Methane Tracker
*Methane emissions based on Ember analysis of UNFCCC reported data

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Globally, the reported methane emission factor of coal production has declined by 0.29 tonnes of methane per thousand tonnes of coal produced (tCH4/kt) since 2021, including a decline of 0.67 tCH4/kt since 2019.

Among the nine largest coal producers, five have reported reductions in their coal methane emission factors since 2019.

The likely reasons for this decline are:

- **Production shifts away from gassy basins.** In China, moving coal output from high-emitting provinces to lower-emitting basins has reduced total emissions since 2016.
- **Operational shifts from underground to surface mines.** In Australia, the rapid expansion of open-cut mining, which relies on low-methane intensity emission factors rather than measured emissions, has reduced average methane intensity.
- **Changes in reporting and methodology.** The switch from generic Tier 1 emission factors to country or mine-level measurement (Tier 2/3), especially for surface mines in some locations, has produced lower intensity estimates.
- **Underreporting of methane emissions from closed mines.** Whilst countries such as Australia, Poland and China retire older, gassy underground mines, these emissions are rarely measured, meaning they are frequently absent or significantly underestimated in national-level reporting.

1.4 Country Insights for 2024

Different national approaches to measurement and reporting help explain why independent estimates and UNFCCC-based estimates diverge so sharply.

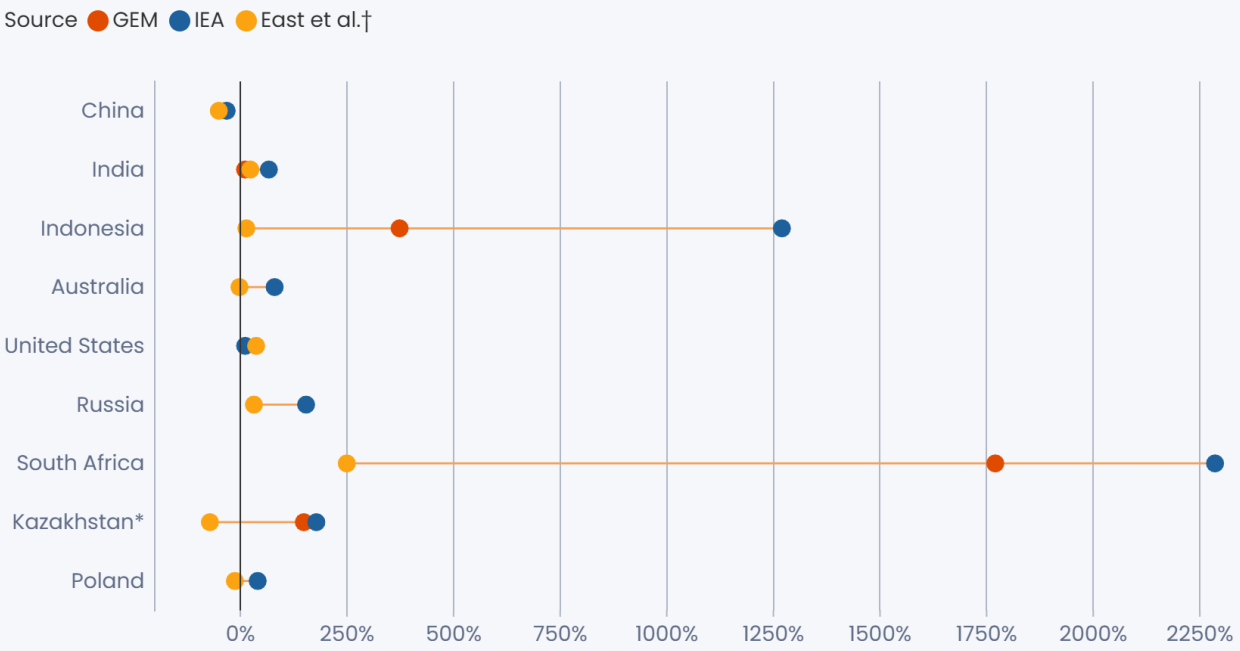
A comparison of UNFCCC-derived estimates with independent assessments from GEM, IEA and values from East et al. (2025) consistently reveals large differences. Across the nine economies analysed, IEA estimates range from 32% lower than UNFCCC-derived values in China to more than 2,000% higher in South Africa. East et al. (2025) satellite-based estimates range from 250% lower in South Africa to 50% higher in China.

In countries that do not report significant methane abatement activities, emissions are also compared with estimates from GEM. Where this is the case – in India, Indonesia and South Africa – estimates range from broadly consistent with UNFCCC-derived figures in India to nearly 2,000% higher in South Africa.

These gaps reflect countries' continued reliance on emission factors rather than mine-level measurements to estimate and understand their emissions.

Coal mine methane emission estimates vary widely across the top nine coal producing countries

Percentage difference from UNFCCC-derived methane emissions in 2024 (%)



Source: Ember's Coal Mine Methane Tracker, East et al.
UNFCCC-derived methane emissions based on Ember analysis of UNFCCC reported data
* UNFCCC-derived data for Kazakhstan is from 2023.
† East et al. data performs satellite inversions using data reported to the UNFCCC for 2023.

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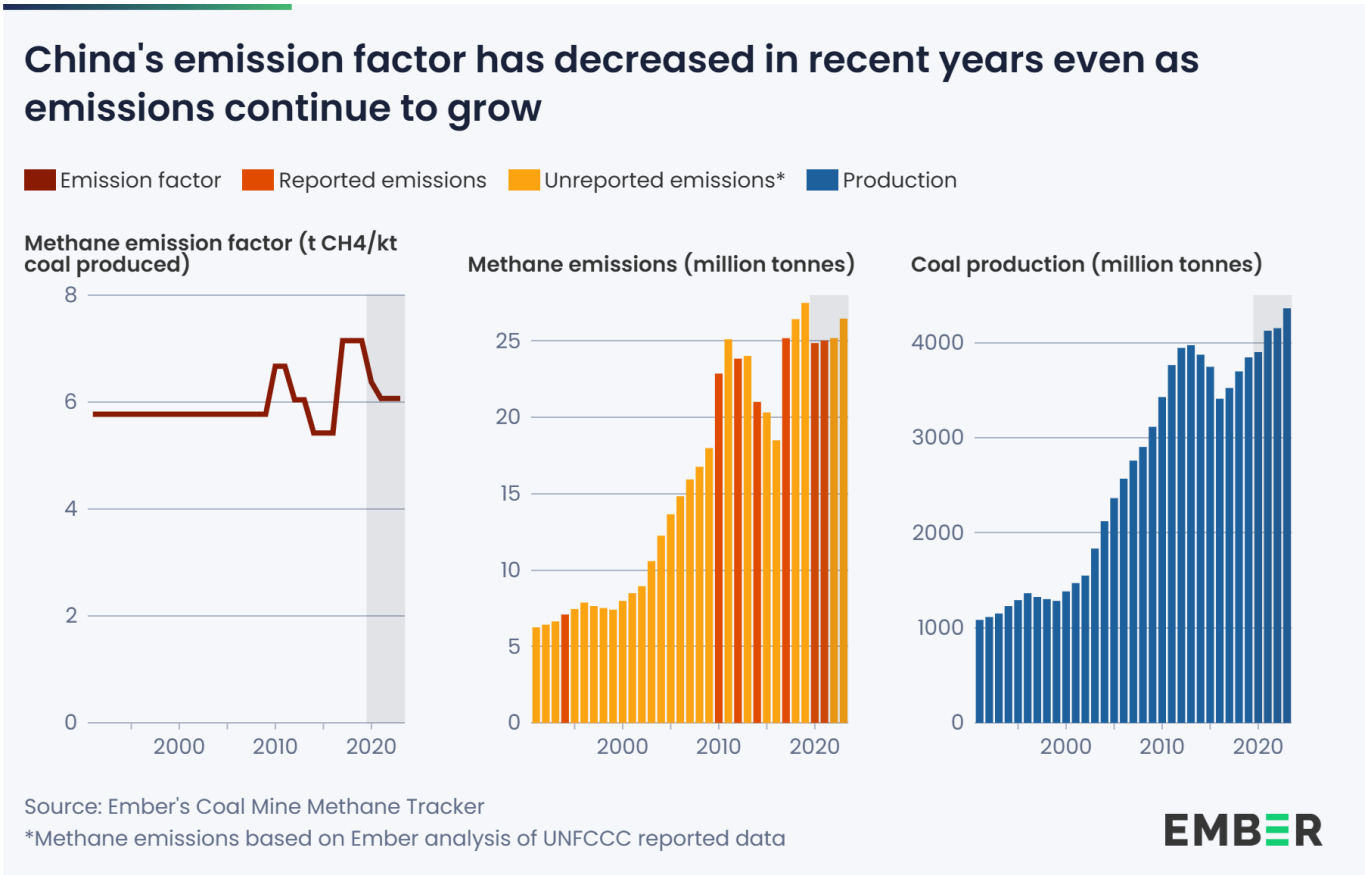
China

China is the world's largest CMM emitter and its mining and reporting choices have a major impact on the global methane picture.

Using China's most recently reported CMM emissions submitted to the UNFCCC in 2021 and EIA coal production data, Ember estimates that China's CMM emissions were around 28 million tonnes in 2024. The IEA estimated 32% lower methane emissions from active coal mines in 2024 while East et al. estimated emissions were 50% lower in 2023.

Reported data suggests an overall reduction in methane emission intensity from 6.4 to 6.1 tCH4/kt of coal between 2020 and 2021, even as absolute emissions increased by 170 kilotonnes over the same period. This trend mirrors the sustained decline observed between

2010 and 2019, attributed to the geographical shift of coal production away from high methane-content regions, alongside the closure of high-methane mines and the growth of surface mining.



India

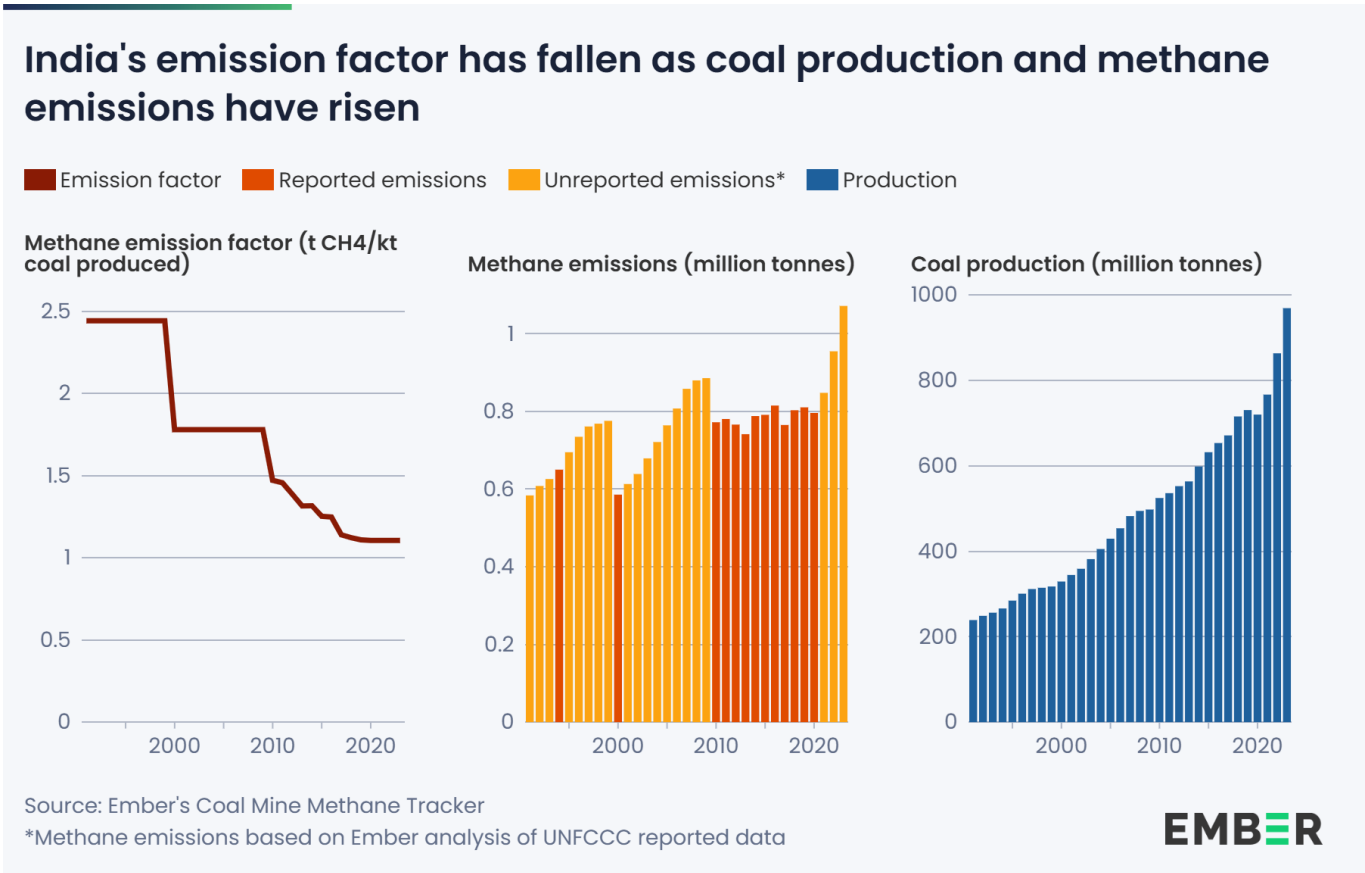
India's CMM emissions are rising as production expands, but past methodological changes have lowered reported intensity.

Using India's most recently reported UNFCCC emissions from 2020, CMM emissions were estimated at around 1.2 million tonnes in 2024, matching GEM estimates. The IEA emission estimates in 2024 were 67% higher, while East et al. emission estimates were 23% higher in 2023.

India's reporting shows two major drops in reported methane emission intensity. Between 1999 and 2000, emission intensity fell from 2.4 to 1.8 tCH4/kt after moving away from IPCC

default emission factors and adopting country-specific emission factors for both surface and underground coal mines.

A decade later, between 2009 and 2010, emission intensity dropped again to 1.5 tCH4/kt. This reflected refinement of India's country-specific emission factors using methane flux measurements from a select number of surface mines. Looking ahead, India is planning to increase its domestic production from both surface and underground mines.



Indonesia

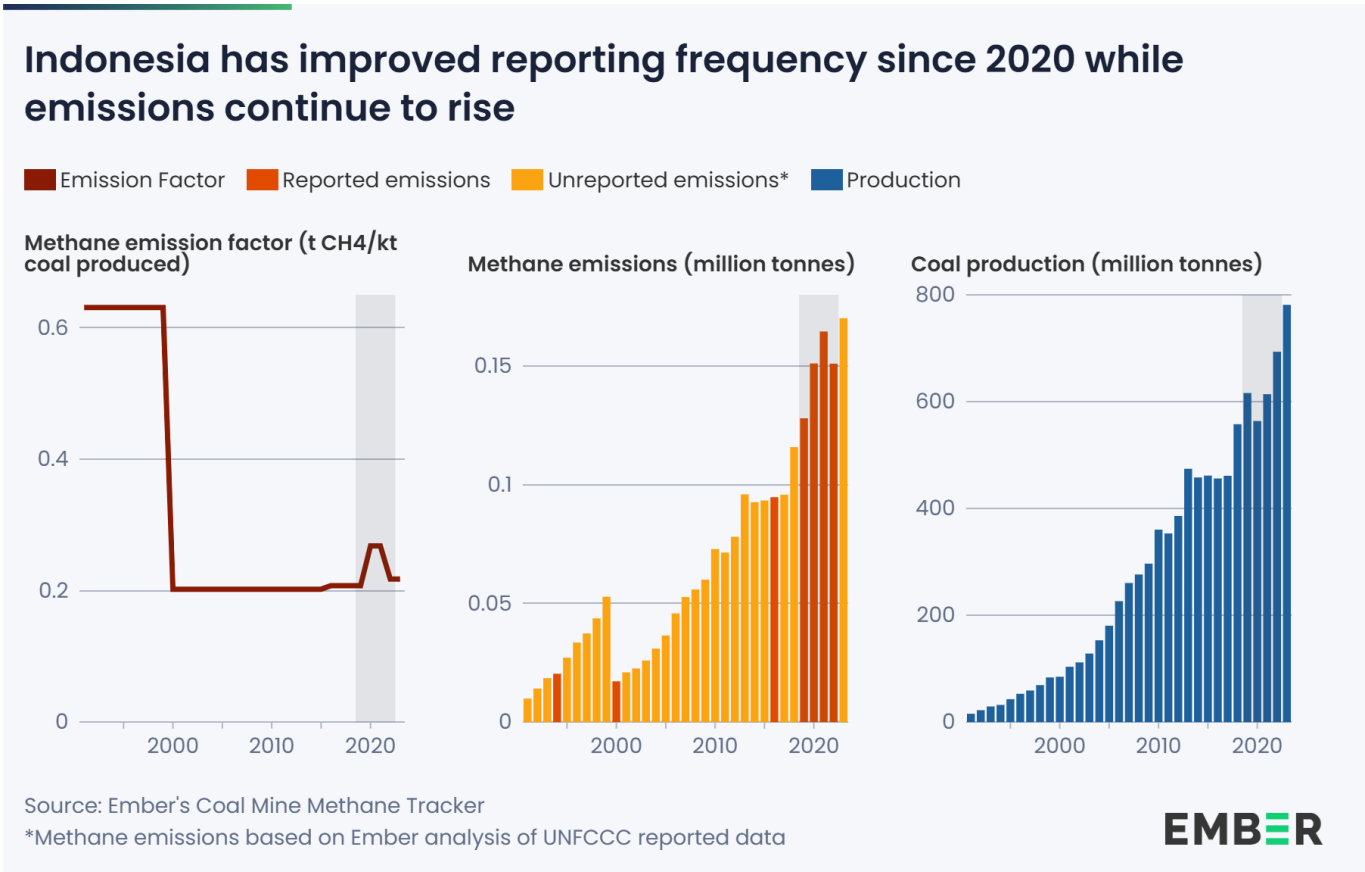
Indonesia's reported CMM emissions remain low on paper, but independent estimates suggest they may be an order of magnitude higher.

Using Indonesia's most recently reported UNFCCC emissions from 2022, CMM emissions were estimated at around 0.2 million tonnes in 2024. Independent estimates from GEM and the IEA place emissions between 400% and 1,300% higher.

East et al. emission estimates were 14% higher for 2023. However, their satellite inversion was unable to correct Indonesia's low reported coal emissions due to sparse TROPOMI satellite observations caused by persistent cloud cover and ocean surfaces.

The steep drop in emission factor in 2000, from 0.6 to 0.2 tCH4/kt, is the result of the IPCC 1996 Revised Guidelines for National Greenhouse Gas Inventories, which updated default coal mine methane emission factors.

Indonesia continues to estimate its CMM emissions using global emission factors and does not account for emissions from underground coal mines.



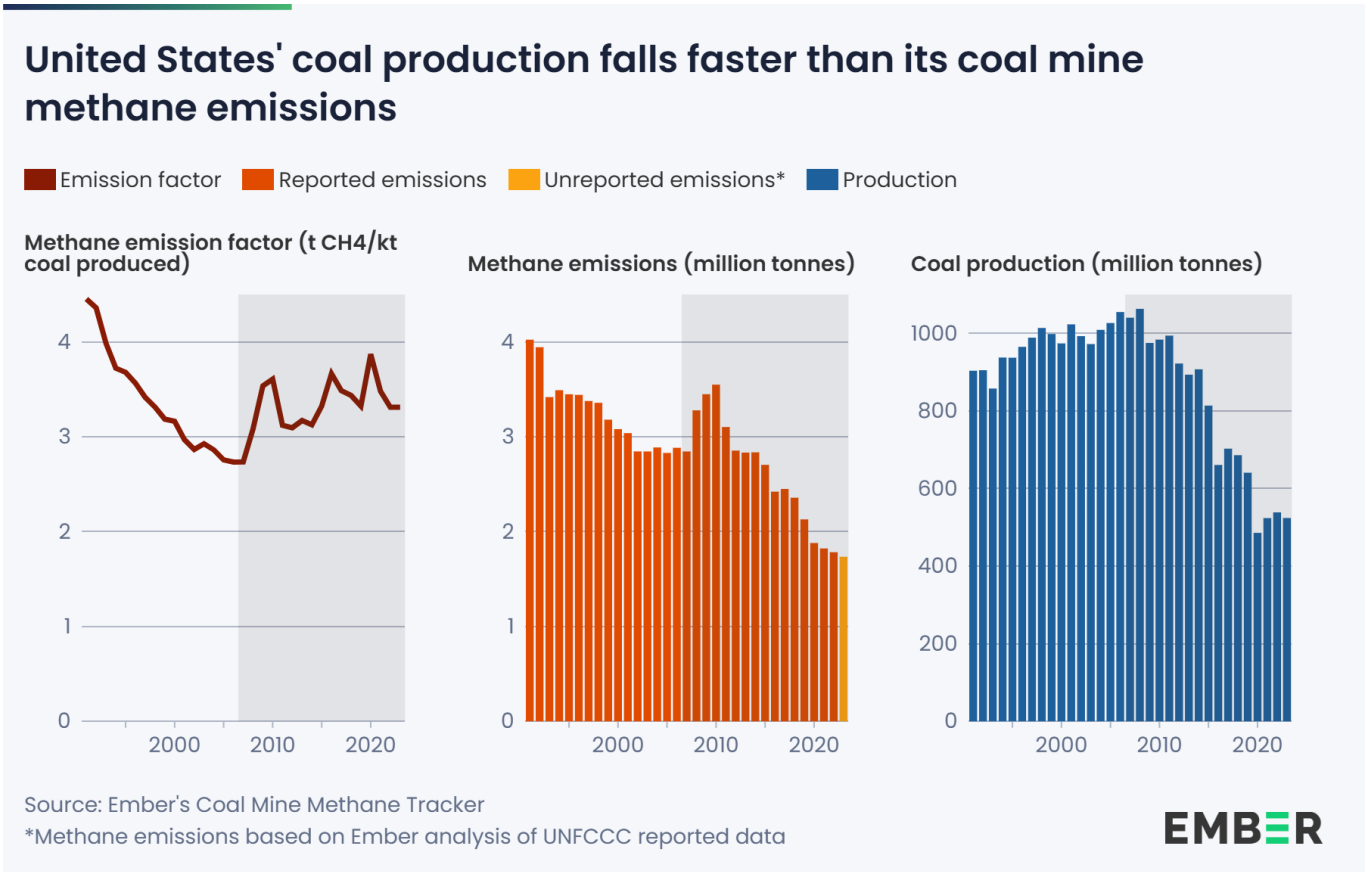
United States

In the United States, coal production has fallen faster than CMM emissions, pushing reported methane intensity higher.

Using the most recently reported UNFCCC emissions from 2022, US CMM emissions were estimated at around 1.5 million tonnes in 2024. The IEA emission estimates were 11% higher in 2024 and East et al. emission estimates were 37% higher in 2023, suggesting emissions may be higher than both UNFCCC-derived and IEA figures.

The analysis relies only on officially reported CMM submitted to the UNFCCC. For the United States, 2023 data have not yet been officially reported to the UNFCCC, but draft estimates are available on the US Environmental Protection Agency (EPA) website.

The reported methane emission intensity of coal production in the US has increased from 2.7 to 3.3 tCH4/kt since 2007. This reflects an increase in the proportion of emissions from closed coal mines, from 9% to 13% during this period.



Australia

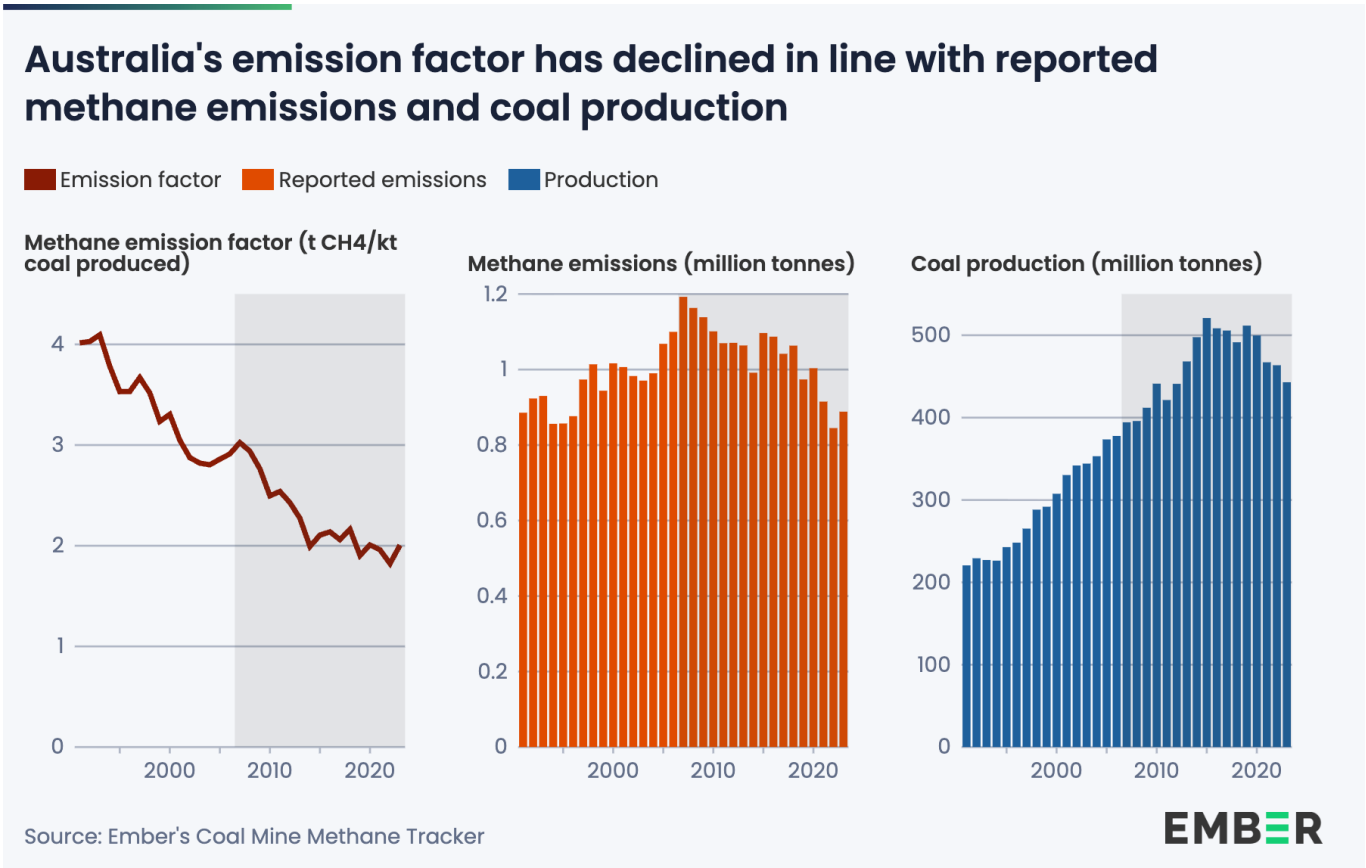
Australia's official data report falling methane intensity and low emissions along with falling coal production.

Using Australia's most recently reported emissions submitted to the UNFCCC in 2023, CMM emissions were estimated at around 0.9 million tonnes in 2024. The IEA emission estimates were 80% higher in 2024, while East et al. emission estimates were consistent with the UNFCCC-derived figure.

Australia's reported emission intensity has fallen by 0.1 tCH4/kt over the past decade, mainly due to a greater share of surface mining, historically believed to have lower emission intensity than underground mines. Previous analysis found that emissions from Australia's coal industry dropped to a record low even as production doubled.

However, numerous recent examples of satellite data suggest this may not always be the case. TROPOMI satellite plume detections indicate around 40% more methane from Australian coal mines than is reported in national inventories.

Australia has begun reviewing its methods for estimating methane from open-cut mines.



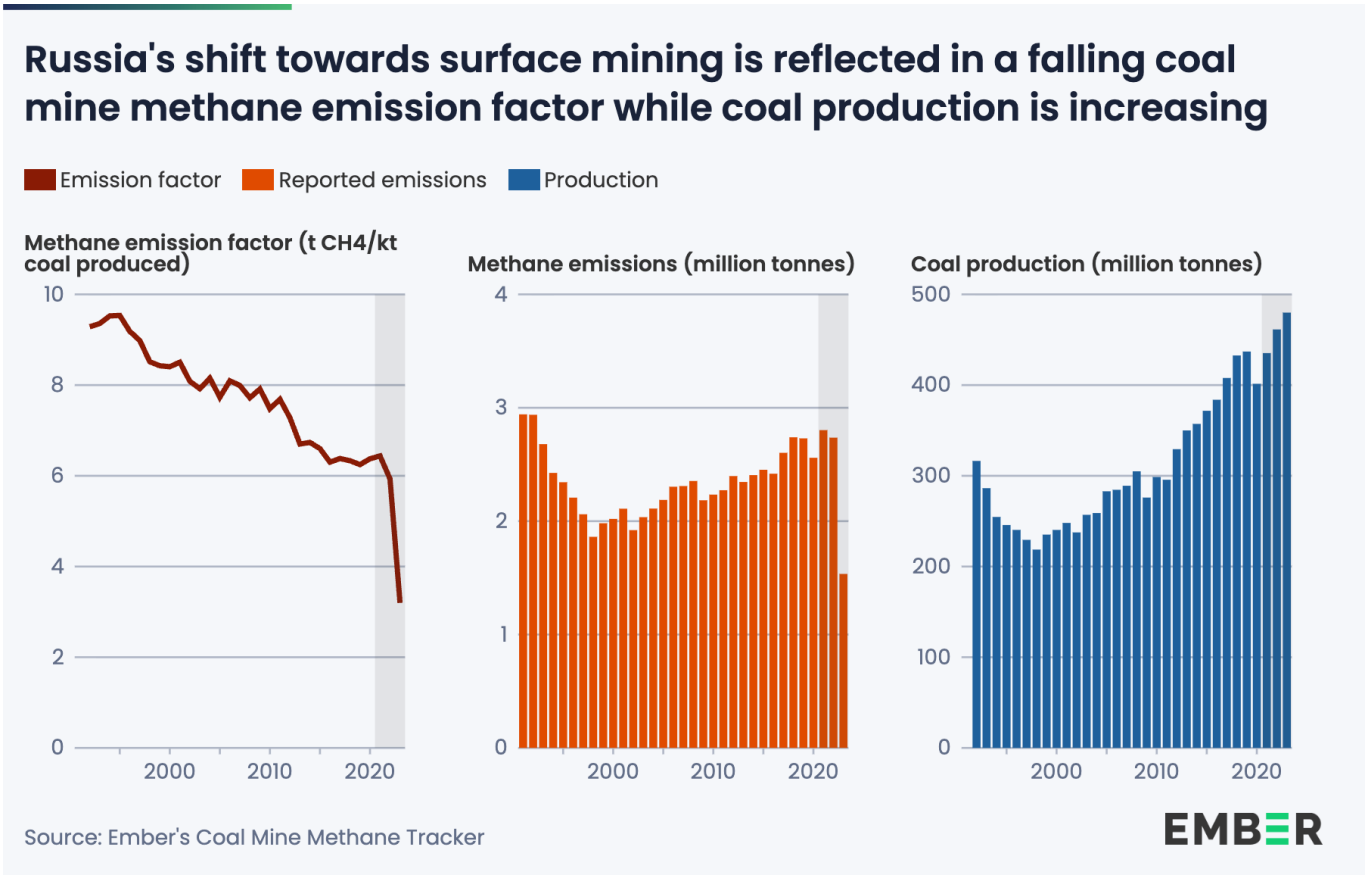
Russia

Russia reports that improved methane management at underground mines is lowering CMM emission intensity, but independent estimates show much higher emissions than national data.

Using Russia's most recently reported emissions submitted to the UNFCCC in 2023, CMM emissions were estimated at around 1.4 million tonnes in 2024. The IEA emission estimates were 154% higher in 2024 and East et al. emission estimates were 32% higher in 2023, though the authors note particularly large uncertainty in their Russia results due to sparse TROPOMI observations at high latitudes.

Russia's reported emission intensity has decreased by 1.6 tCH4/kt over the past decade. In 2022, new national emission factors were developed based on data from coal mining companies, significantly reducing emission intensity for underground and surface mines throughout the country.

Russia reports that intensified degasification, improved methane control standards and the closure of gassy mines have reduced overall methane emission intensity.

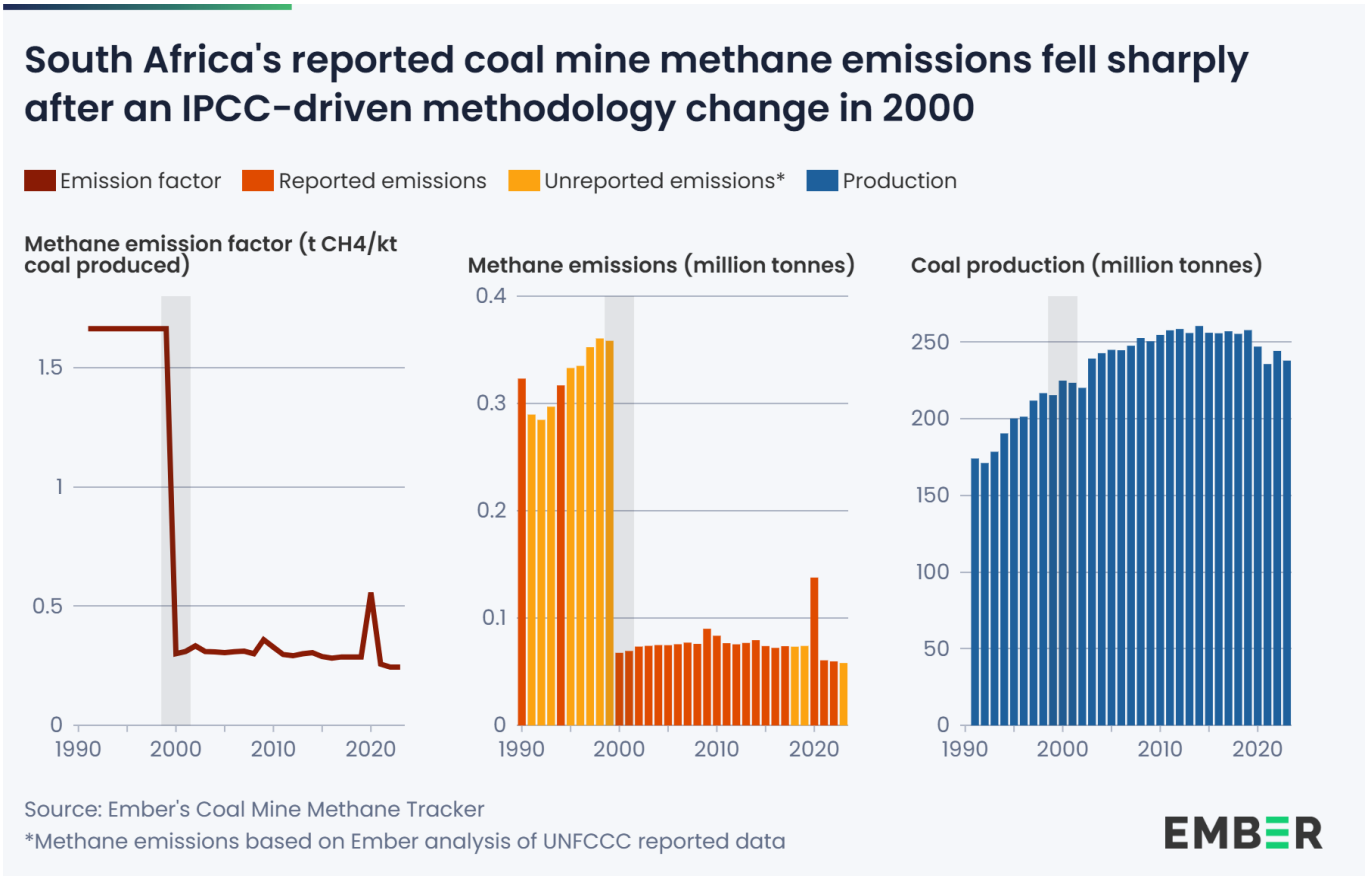


South Africa

Using South Africa's most recently reported emissions submitted to the UNFCCC in 2022, CMM emissions were estimated at around 0.06 million tonnes in 2024. Independent estimates were much higher: the IEA emission estimates were 2,300% higher, GEM emission estimates were 1,800% higher, and East et al. emission estimates were 250% higher in 2023.

The steep drop in emission factor from 1.7 tCH4/kt in 1999 to 0.3 tCH4/kt in 2000 is the result of the IPCC 1996 Revised Guidelines for National Greenhouse Gas Inventories, which updated default coal mine methane emission factors.

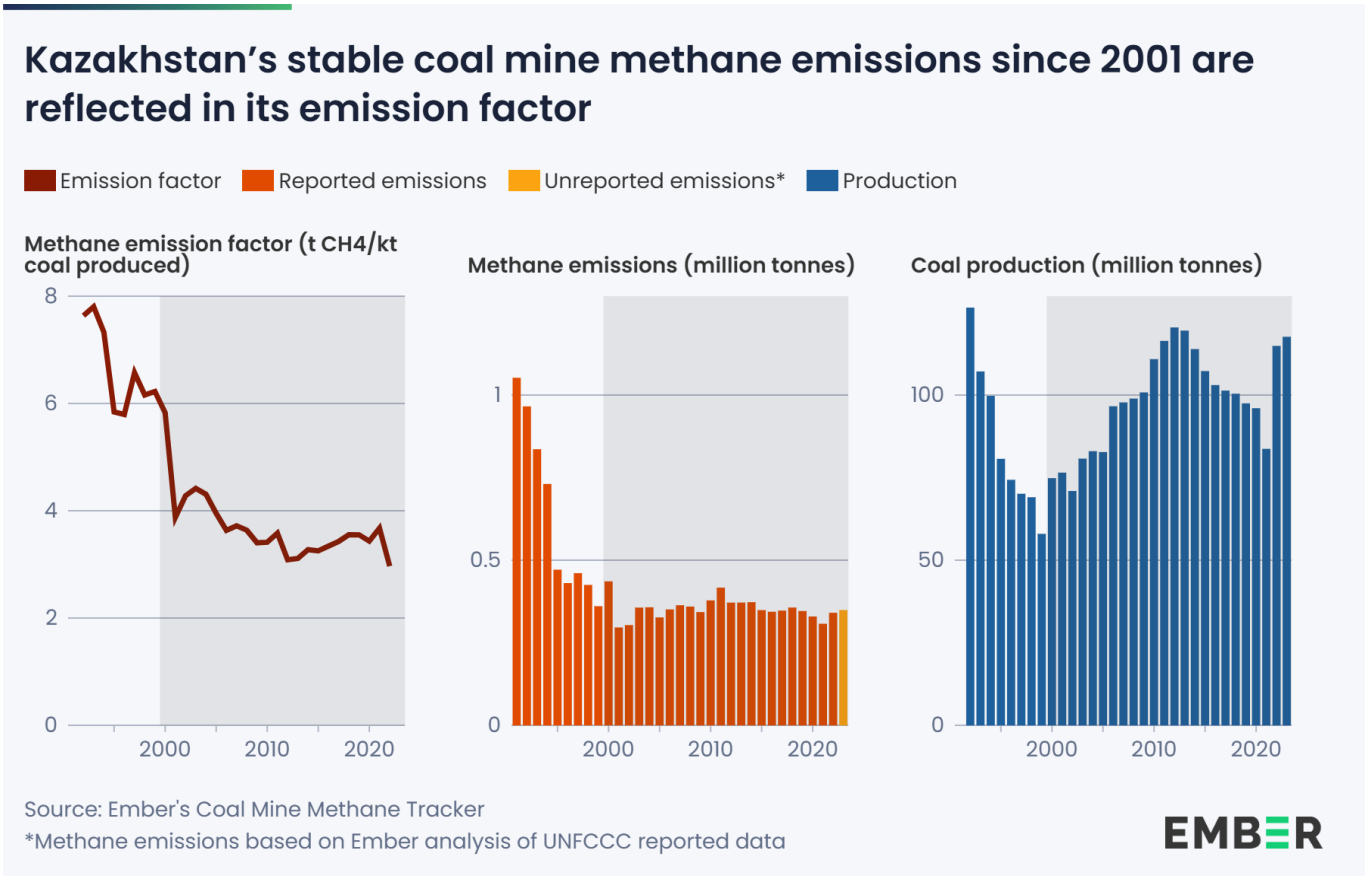
The increase in South Africa's 2020 CMM figure is due to a change in reported coal production statistics, not the emission factor. South Africa does not report emissions from its surface mines.



Kazakhstan

Using Kazakhstan's most recent UNFCCC-reported emissions in 2022, CMM emissions were estimated at 0.35 million tonnes in 2023. The IEA emission estimates were 178% higher and GEM emission estimates were 149% higher in 2024. East et al. emission estimates were 71% lower in 2023, though this figure should be interpreted with caution given limited TROPOMI observation density over the region.

Kazakhstan's CMM emissions have remained stable since the early 2000s. The emission factor dropped from 7.8 tCH4/kt in 1993 to an average of 3.6 tCH4/kt after 2001. This gradual shift is attributed to the country's transition away from traditionally very deep and gassy underground mines to surface mining.

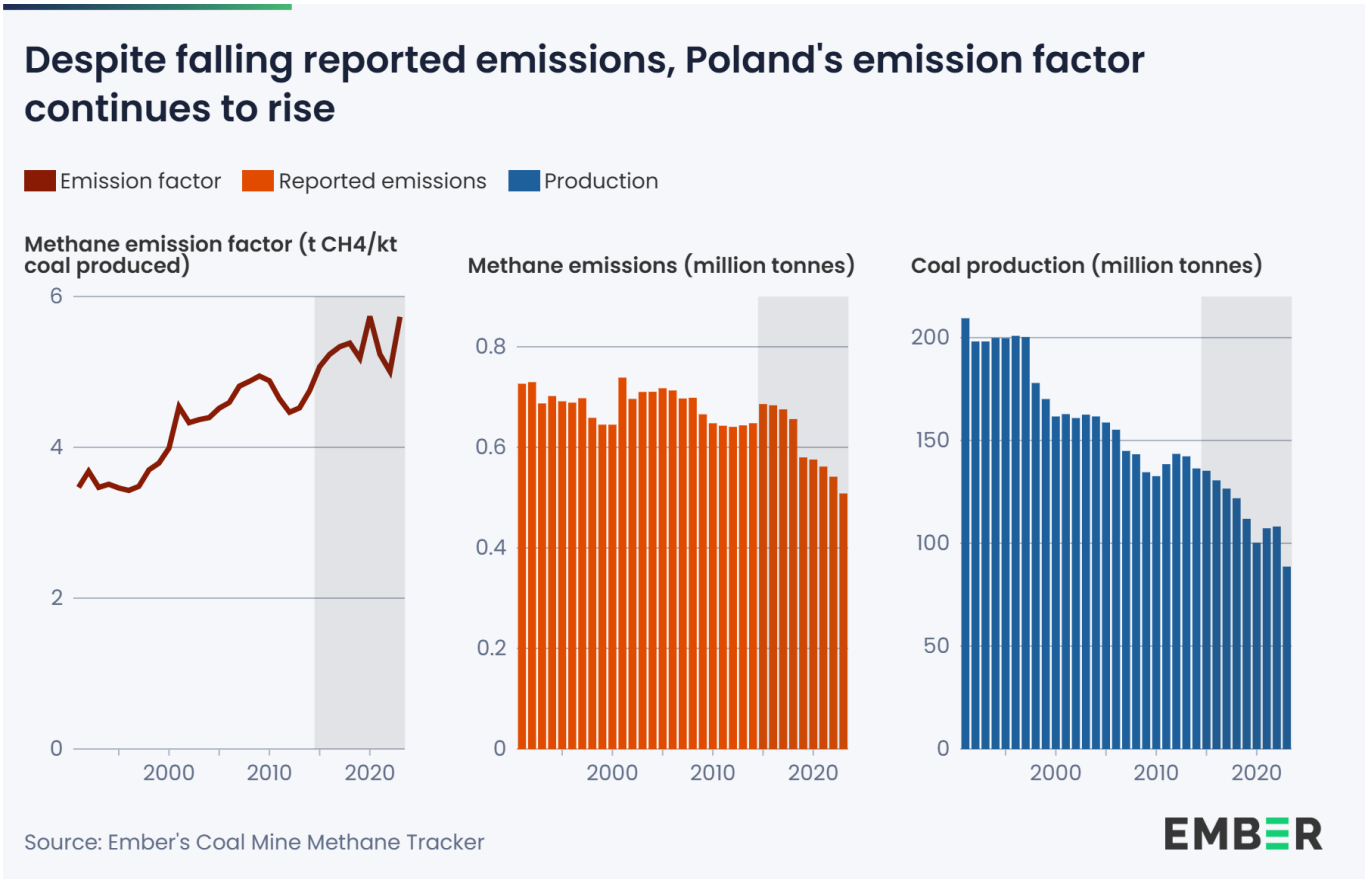


Poland

In Poland, declining coal output has not yet translated into lower methane intensity, as deeper and older mines remain in operation.

Using Poland's most recently reported emission factor submitted to the UNFCCC in 2023, CMM emissions were estimated at around 0.5 million tonnes in 2024. The IEA emission estimates were 41% higher in 2024 and East et al. emission estimates were 13% lower in 2023. All three estimates are broadly consistent, reflecting Poland's relatively strong mine-level measurement practices.

Methane emission intensity has risen from 5.1 tCH4/kt in 2019 to 5.7 tCH4/kt in 2023. This likely reflects continued mining at greater depths in older underground coal mines, which tend to become gassier over time, as well as continued methane release from closed mines even as coal production declines.



Chapter 2

Direct, continuous measurement is needed to increase confidence in

Government-published CMM figures are highly uncertain, undermined by both limited reporting and the poor quality of available data. Around 89% of emissions were left unreported in 2023, and where reporting does occur, 87% of coal production is estimated using generic global or national emission factors. Investing in mine-level, real-time monitoring would raise confidence and give a solid foundation for designing mitigation policies.

2.1 The majority (89%) of methane emissions left unreported in 2023

A barrier to understanding global CMM emissions is infrequent reporting from many of the world's largest coal-producing nations.

Of the 73 countries that mined coal in 2023, only 23 countries submitted emissions reports to the UNFCCC. These countries reported a combined 3.8 million tonnes of CMM, roughly 11% of the UNFCCC-derived estimate of total global CMM emissions in the same year, leaving 89% unreported.

In 2023, only three of the world's nine largest coal producers submitted CMM data to the UNFCCC. China, India, Indonesia, the United States, South Africa and Kazakhstan did not report any greenhouse gas emissions that year.

While most industrialised countries and economies in transition (Annex I under UNFCCC rules) reported emissions in 2023, the most recent reporting year for developing countries (Non-Annex I) ranges from 1994 to 2023. Some coal producers, such as Bangladesh, Mozambique and Pakistan, have never reported CMM emissions.

To close these reporting gaps, new UNFCCC rules now require all countries to report annually. The Enhanced Transparency Framework (ETF) is the EU- and UN-agreed system that sets out how countries report their greenhouse gas emissions and the actions taken to reduce them.

Under the ETF, each nation must produce a Biennial Transparency Report (BTR) every two years, with the next round due in 2026. The BTR is a compulsory, standardised report that shows:

1. **What the country emitted** (including methane from coal mines).
2. **What policies or actions it has taken to reduce those emissions.**
3. **How the figures were calculated.**

While submitting a BTR is mandatory under the Enhanced Transparency Framework, the framework is explicitly designed to be non-punitive and flexible, with no formal penalties for non-submission. Non-submission is, however, publicly noted, and may affect a country's standing in international climate processes, including the Global Stocktake.

2.2 Most countries report emissions using generic estimates rather than direct measurements

Because most CMM estimates are derived from emission factors, the resulting inventories remain highly uncertain and may not reflect the true magnitude of methane released from mines.

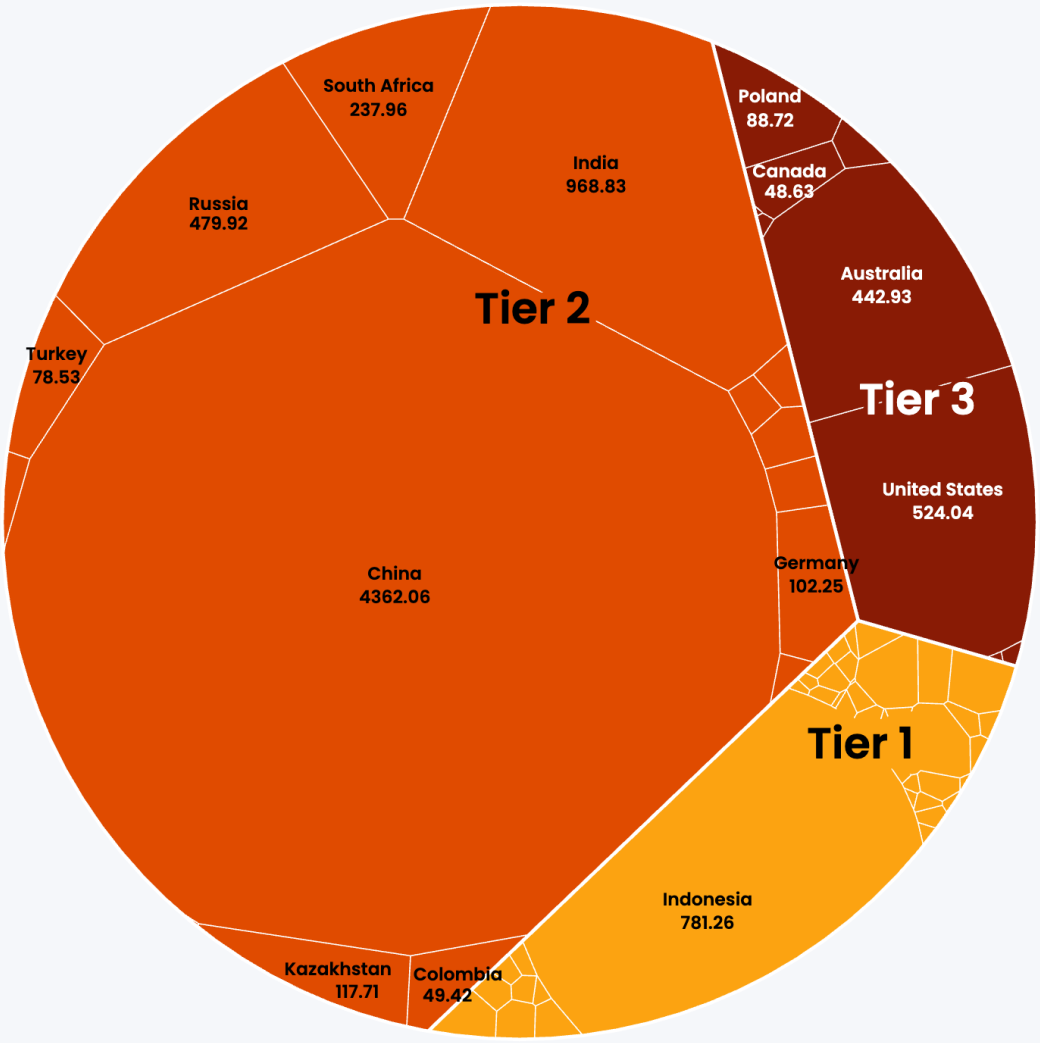
The Intergovernmental Panel on Climate Change (IPCC) categorises reporting methods into three tiers that differ in scientific rigour and data requirements:

- **Tier 1** uses global CMM emission factors and aggregated national data such as coal production and the number of closed mines.
- **Tier 2** incorporates country- or basin-specific emission factors.
- **Tier 3** uses process-based models or direct, facility-level measurements and is therefore mainly applied to underground mines.

87% of global coal production is still reported to the UNFCCC using Tier 1 or Tier 2 methods*

Coal production in 2023 (million tonnes)

Tier 1: Global emission factors and national-level coal data.
Tier 2: Country or basin-specific emission factors and national-level coal data.
Tier 3: Process-based models or direct facility measurements mainly for underground mines.



Source: Ember's Coal Mine Methane Tracker
*A country is classified in the highest tier that it reports to

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The overwhelming majority of coal-producing countries (67 of 68) rely exclusively on Tier 1 or Tier 2 methods for estimating emissions rather than direct mine-level measurements, representing 87% of global coal production.

A further 13% of global coal production uses measurement-based Tier 3 reporting to some extent. This tier of measurement is often only applied to underground mining operations, for example in the United States and Poland.

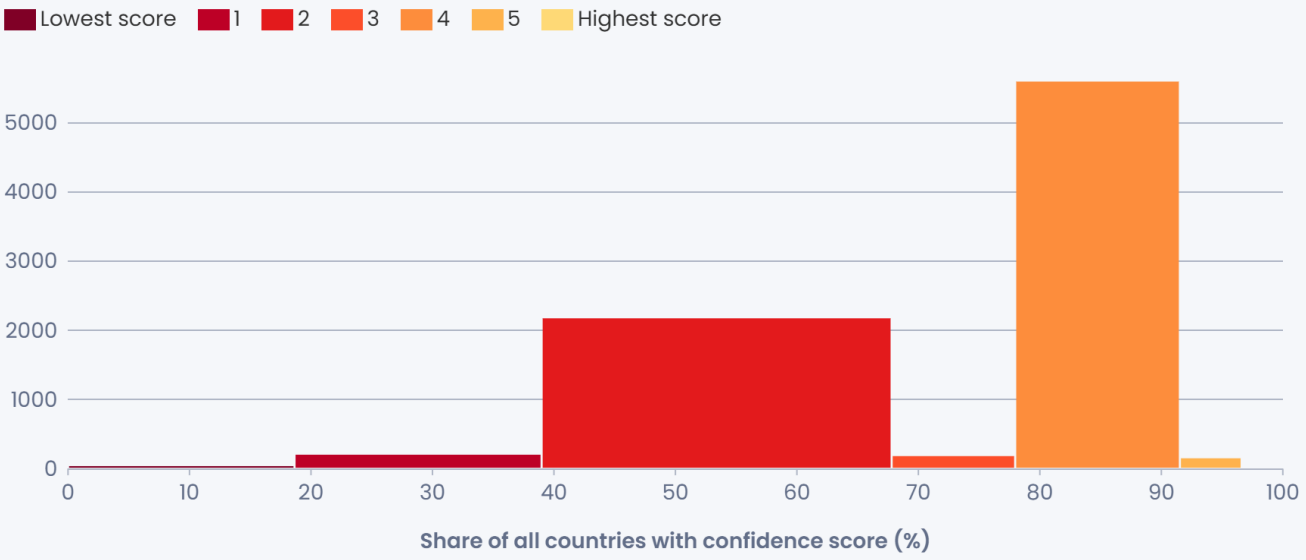
2.3 Ember's confidence in national inventories varies widely

Ember's assessment, which quantifies data quality across all reporting countries, found that confidence in reported CMM emissions is low-to-medium for most of the world's coal output.

While the IPCC tier system reflects the methodology a country uses, Ember's confidence score takes a broader view, also accounting for the recency of reporting to the UNFCCC, the robustness of the methodology used and the degree of alignment with independent measurements. More details on this can be found in the methodology.

Ember has low confidence in the CMM emissions reported by 68% of countries

Global coal production in 2023 (million tonnes)



Source: Ember's Coal Mine Methane Tracker

CMM emissions from only 4% of countries are rated high confidence, with a further 19% medium-high. The majority of countries (59%) are medium-low confidence, and a further 19% have low confidence.

The confidence scores assigned to the top coal producers are China (medium), India (medium-low), Indonesia (low), Australia (medium), United States (medium), Russia (medium), and Poland (medium-high).

Only countries for which the majority of coal production has measurement-based emissions reporting receive high confidence scores. For example, Poland achieved a high score due to mine-level measurements for much of its coal production and good agreement with independent estimates. Indonesia and India received low scores as they rely on emission factors, and comparisons with independent estimates vary significantly.

Raising confidence in official CMM numbers requires moving from estimates based on emission factors to continuous, direct monitoring and verification.

Chapter 3

Ember Research Spotlight: satellite observations reveal coal super-emitters, but monitoring gaps persist

Satellite data are exposing large, previously unseen methane emissions from coal mines around the world. However, even though 70% of coal production is located in regions deemed favourable for detection, satellites currently only capture emissions from 10%, highlighting the need to expand targeted coverage over major coal-producing regions.

New high-resolution satellites are rapidly expanding the number of methane sources that can be observed from space. The Tanager-1 satellite from Carbon Mapper became fully operational in the summer of 2025, and early insights suggest a large increase in the number of observations.

This growth in satellite data, combined with extensions of current missions, is already helping to close the gap between official inventories and independent measurement-based estimates.

Yet coverage remains uneven. This spotlight examines how well current satellite infrastructure maps onto the geography of global coal production, comparing where

satellites are effectively capturing emissions and identifying regions where countries should focus on expanding or improving satellite monitoring to better track coal mine methane.

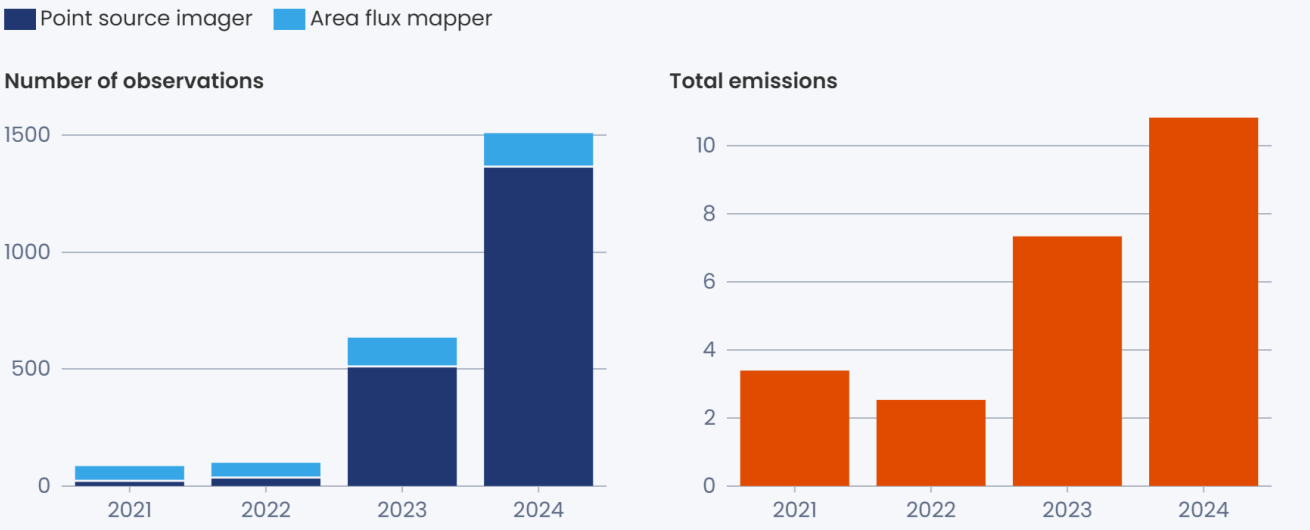
The analysis in this chapter relies on publicly available data; additional high-resolution satellite detections owned by private companies are not included and may provide more comprehensive coverage.

3.1 Satellite monitoring of coal mine methane emissions is increasing

The number of methane plumes detected from coal mines has risen sharply in recent years. Between 2019 and 2024, satellite observations of methane emission plumes from coal mines increased from 101 to 1,509, an approximately 1,400% increase, while cumulative detected emissions rose from 6.8 to 10.8 million kilograms per hour.

Coal mine methane satellite observations have increased fifteenfold since 2021

Number of observations detected via satellite and total methane emissions (kilotonnes per hour)



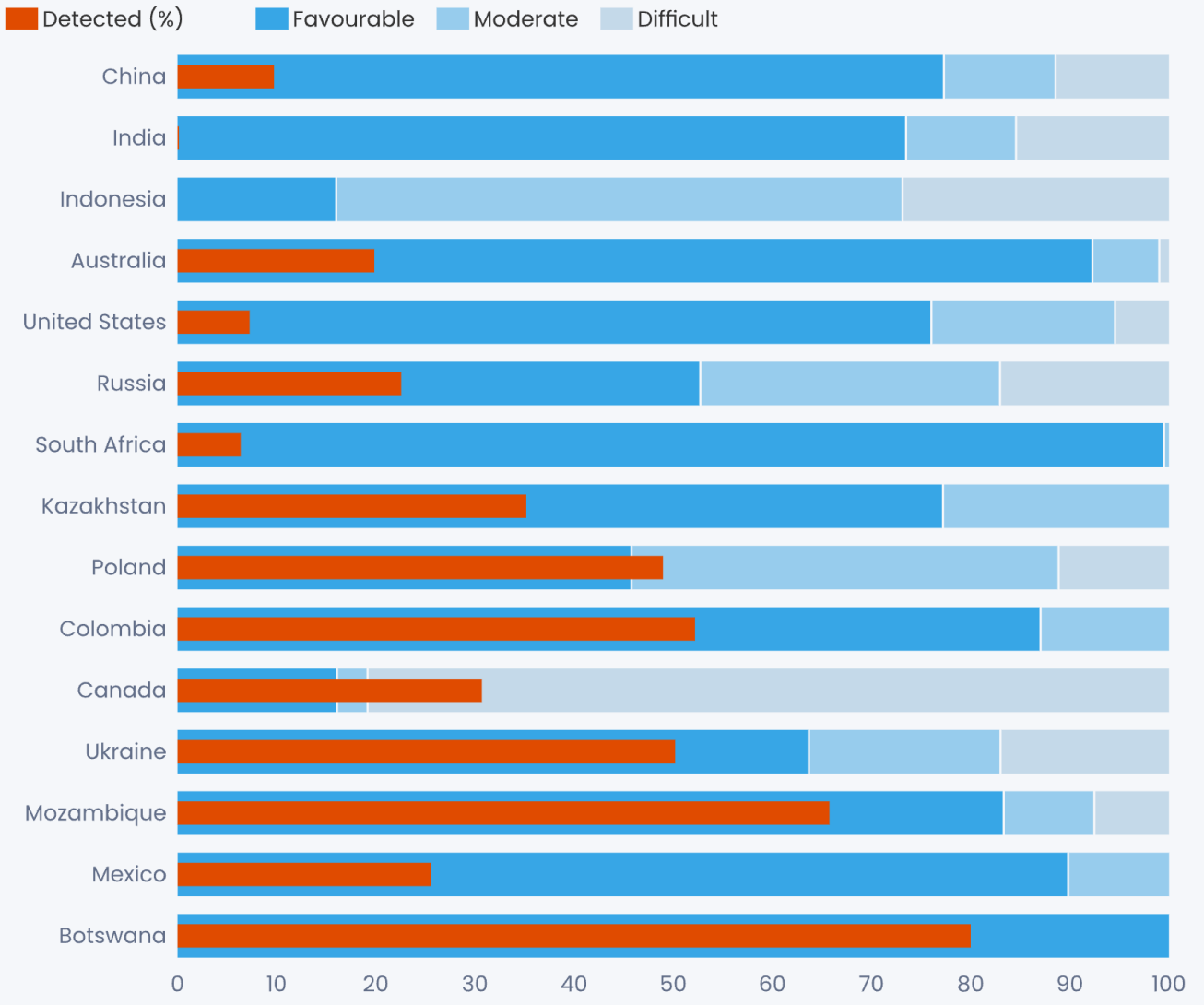
Source: Kayrros, IMEO MARS, CarbonMapper

3.2 Over 70% of hard coal production is in areas with favourable conditions for satellite monitoring

While the number of satellite observations of methane from coal mines is increasing, emissions can still go undetected due to unfavourable monitoring conditions or limited satellite coverage, as detections largely depend on routine observation footprints.

Most major coal producers have little to no satellite-observed emissions, even where conditions are favourable

Percentage of hard coal production with satellite plume as of 2024 (%)



Source: Global Energy Monitor, Ember's Coal Mine Methane Tracker

To assess how well coal-producing regions are covered by satellite observations, Ember compares the theoretical detectability of methane emissions, driven by local environmental conditions, with the frequency of detected plumes using data from GEM.

Using all publicly available high-resolution data, GEM associated a specific methane plume with 227 at approximately 5,000 active coal mines.

This analysis focuses on hard coal, which has higher gas content than lignite and is therefore both a greater source of methane emissions and more likely to produce detectable plumes from space.

The theoretical detectability classifications used throughout this section are based on Ember's previous analysis, which assessed how local environmental conditions affect the availability of satellite data across locations and seasons. Coal mines were classified as Favourable, Moderate or Difficult based on how challenging methane emissions are to observe in theory.

Ember analysis found that the majority (71%) of coal production is in favourable conditions for detection, 17% is located in regions with moderate conditions and 12% in difficult conditions.

Only 10% of hard coal production has been observed so far

When comparing the theoretical potential for satellite detection to the frequency of detected plumes, Ember found that only 10% of global hard coal production has been observed via satellite, defined here as having at least one attributed methane plume detected at a coal mine site.

This gap between theoretical detectability and actual detection rates points to factors beyond geography, such as satellite overpass frequency, instrument tasking priorities and the clustering of mining infrastructure. This determines whether emissions are captured in practice and represents a profound gap in understanding what is being emitted at most of the world's active coal mines.

Eight of the top nine CMM emitters still lack adequate satellite coverage

Eight of the top nine coal producers have fewer plumes detected than would be expected given favourable viewing conditions. South Africa and Australia's coal production is in 99.5% and 92% favourable conditions, respectively, yet only 7% and 20% of their hard coal production have had at least one plume attributed to them (see Methodology for full details).

Almost none of India's hard coal production has publicly available detections, even though 73% lies in regions classified as favourable for satellite observation.

Indonesia also records 0% detection, and only 16% of its coal production is in favourable monitoring conditions. The remainder is located in areas with persistent cloud cover and rugged terrain.

In Kazakhstan, 35% of hard coal production has been detected, while 77% is situated in favourable regions.

This discrepancy highlights that favourable geography alone is not enough, as limited satellite overpass frequency still leaves large emissions unseen.

Poland and Canada have exceptionally good coverage due to greater regulatory scrutiny

Satellites have the ability to detect methane plumes across a greater share of coal production than the proportion of mines considered favourable for detection suggests.

In Canada, only 16% of hard coal mines are classified as favourable, yet plumes are detected across 31% of the country's hard coal production. Similarly, in Poland, 46% of mines are deemed favourable, but plumes are detected across 49% of hard coal production.

Canada's higher detection rates are reinforced by high-resolution plume data from Carbon Mapper, a North America-based initiative that has prioritised systematic coverage of the region. In Poland, the EU Methane Regulation's stringent venting restrictions and mandatory reporting requirements have driven greater regulatory scrutiny of mine emissions, which in turn has led to more frequent and targeted satellite observations of Polish coal mines.

Chapter 4

Cutting CMM this decade is urgent and feasible

Large methane cuts this decade are urgent to reduce global methane emissions in line with the Global Methane Pledge and to avoid 0.2C of warming by 2050. Mitigating CMM is one of the opportunities to rapidly slow near-term global warming, given the availability of proven technologies with fast implementation times.

4.1 Reducing CMM could contribute to preventing over 180,000 deaths annually

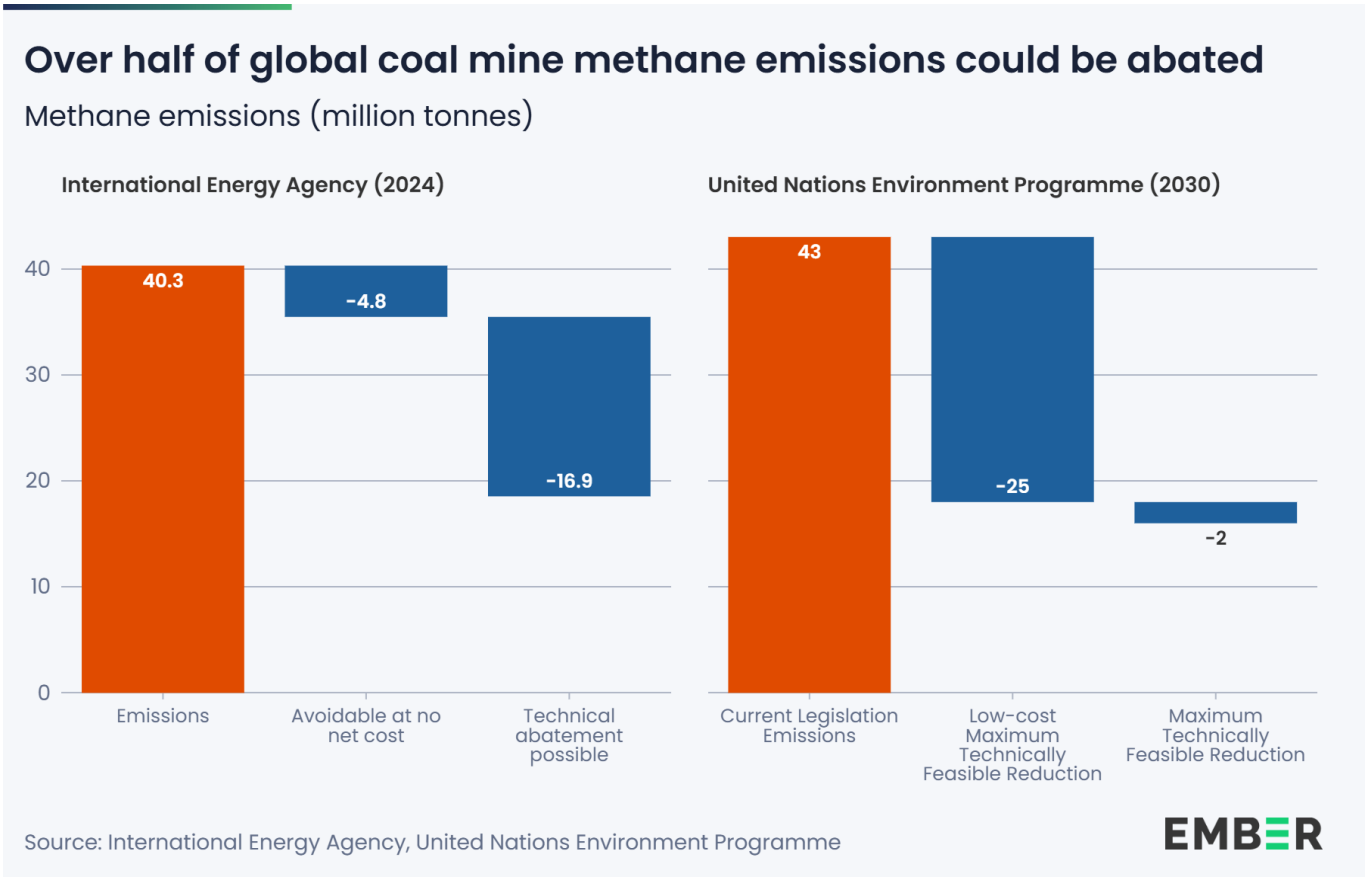
Achieving methane reduction targets also delivers immediate public health and climate benefits.

The Global Methane Status Report estimates that implementing all technically feasible methane mitigation measures could prevent over 180,000 premature deaths annually by 2030. In addition, it could avert nearly 19 million tonnes of crop losses each year and save nearly 53 billion hours of lost labour for outdoor workers due to extreme heat. The resulting monetised value of these benefits exceeds $330 billion USD per year, surpassing the estimated total annual implementation cost of $127 billion USD.

4.2 Proven technologies can slash coal mine methane by 54-63%

The IEA estimates that 54% of global CMM emissions in 2024 can be mitigated at an annual cost of $14.25 billion USD through to 2030. It also estimates that 12% could be mitigated at no net cost. Yet despite this clear economic case, uptake remains negligible: only 130 out of 1,800 active mines have reported a mitigation project to the Global Methane Initiative, underscoring the vast gap between mitigation potential and action on the ground.

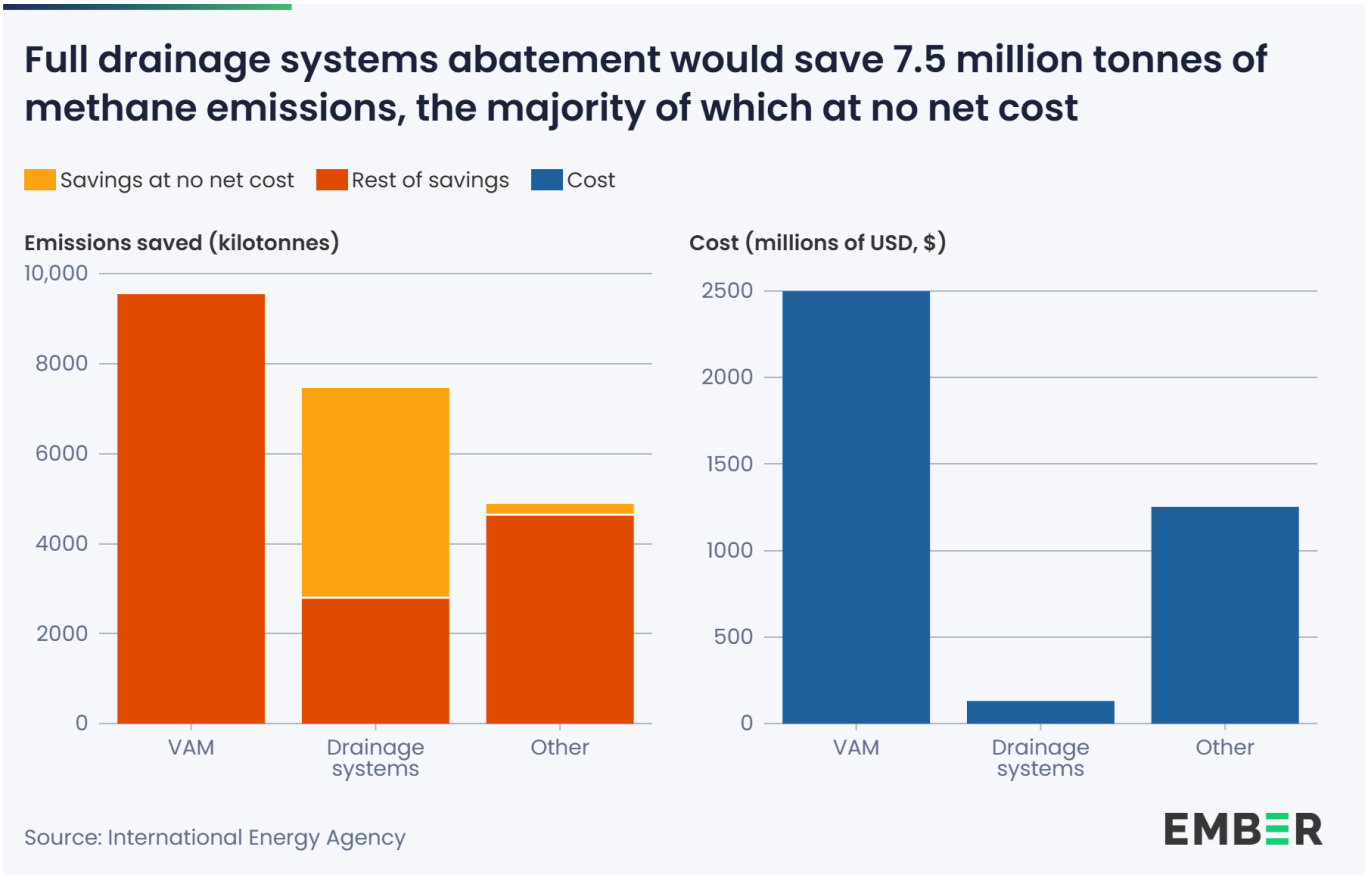
According to UNEP estimates, up to 63% of CMM could be mitigated, delivering 27 million tonnes of methane reductions in 2030, for $10.8 billion USD per year. Low-cost measures could deliver 25 million tonnes of these reductions at a total cost of $6 billion USD.



4.3 Cutting coal mine methane in half would cost just 16% of annual industry profits

Full abatement of coal mine methane would cost less than $4 billion USD, spread across ventilation air methane (VAM) oxidation, drainage systems and other measures.

Drainage systems stand out as the most cost-effective option, with the majority of their abatement potential available at no net cost. VAM oxidation requires the largest upfront investment but delivers the greatest overall emissions reductions.



VAM oxidation could cut nearly a quarter of CMM emissions

Most methane from underground coal mines comes from ventilation air, which can be captured and destroyed using proven technologies.

VAM mitigation is usually achieved by destroying methane using the most widely proven

technology: regenerative thermal oxidisers (RTOs). These oxidise methane at high temperature, and in some cases, it may be possible to recover part of the heat for electricity or steam generation.

Other emerging options include catalytic oxidisers, which operate at lower temperatures but are still under commercial development, and cryogenic or membrane separation systems that aim to capture methane for later use as fuel.

The IEA estimates that investing roughly $2.5 billion USD in VAM oxidation alone could cut CMM by 23.7% compared to 2024 emissions, reducing emissions by 9.5 million tonnes.

Early support and subsidies can make VAM projects financially viable. This aligns with research from the United Nations Economic Commission for Europe (UNECE), which states that backing VAM oxidation technologies with $20 USD per tonne of CO2 equivalent for four to five years can make projects investable.

Drainage station capture is often revenue-generating, making it the lowest cost abatement option

Methane captured from drainage stations before or after mining a coal seam is typically high enough in concentration to be used directly as fuel, meaning it can generate revenue to offset or exceed the cost of capture infrastructure.

According to the IEA, drainage systems offer around 7,460 kilotonnes of abatement potential globally. Crucially, around 62% is available at negative net cost, meaning capture and utilisation generates more revenue than it costs to implement.

This accounts for 95% of all negative cost abatement opportunities across the entire coal mine methane sector.

The economics of pre-mining degasification are illustrated by Anglo American's Queensland metallurgical coal mines, where the company has spent around $100 million USD per year on gas mitigation infrastructure (equivalent to roughly $20 per tonne of CO2 equivalent), capturing gas before and during mining and abating approximately 60% of reported methane emissions in 2023, rising to 70% in 2024 with improved sealing practices.

Chapter 5

Recommendations

Mitigating CMM presents a major near-term climate win, yet current policies still miss the scale of abatement opportunities. Strengthening measurement, verification and reporting to address data inconsistencies, alongside clearer methane targets and incentivised mitigation, can unlock crucial emissions reductions.

5.1 Improve understanding of CMM emissions by updating monitoring, verification and reporting methods

Governments: require direct measurement and reporting for all coal mines
Implementing continuous (or near-continuous) measurement at every coal mine, including surface, underground and decommissioned sites allows for a clearer understanding of emissions and abatement potential, improving methane management and lowering explosion risk for workers in underground mines.

For underground mines, Ember recommends MRV requirements to Level 5, as specified by the United Nations International Methane Emissions Observatory (UN IMEO), covered in their technical documents on drainage methane and ventilation air methane.

For surface mines, Ember strongly recommends against the use of emission factors if used

without frequent, direct measurement verification. This includes mine-specific emission factors which were recently found to exhibit significant, systematic differences from airborne quantifications.

Major improvements to currently accepted "best-practice" methodologies used to estimate mine-specific emission factors are required, including coal core gas sampling procedures, borehole spatial distribution requirements and gas content modelling approaches.

Ember recommends that mine-by-mine methane emissions should be made publicly available annually to promote transparency in emissions and allow for third-party verification.

Governments and regulators: integrate independent data and satellite verification into methane inventories

National CMM monitoring and reporting systems should integrate independent data sources to verify asset-level reported emissions. This includes data such as satellite observations, aerial surveys and third-party ground measurements.

Regularly comparing bottom-up mine-level estimates with top-down atmospheric measurements helps identify and resolve any reporting inconsistencies.

Ember recommends that governments track CMM super-emitters via available data platforms. Publicly available platforms include IMEO MARS, Carbon Mapper and Kayrros. Several super-emitter tracking mechanisms are available for seamless uptake. These include Carbon Mapper's super-emitter alert feature which provides daily, weekly or monthly updates on specific areas of interest. Similarly, IMEO MARS provides a notification system of detected super-emitter events based on dedicated focal points. Governments should embrace available CMM super-emitter tracking platforms and leverage their emission notification tools.

Platform	Data type	Satellites	Access
IMEO MARS	Area flux mapper & Point source	TROPOMI, PRISMA, EnMAP, EMIT	Link
Carbon Mapper	Point source	Tanager-1, EMIT	Link
Kayrros	Area flux mapper & Point source	TROPOMI, EMIT	Link
GEM	Area flux mapper & Point source	TROPOMI, PRISMA, EnMAP, EMIT, Sentinel-2	Link

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Satellite operators: expand targeted coverage over major coal-producing regions
Satellite operators and data providers should prioritise tasking high-resolution point-source imagers over the world's largest coal-producing regions, particularly where theoretical detectability is favourable but observed detection rates remain low, such as India, South Africa and Australia.

Examples such as Poland and Canada demonstrate that focused satellite attention, driven by regulatory requirements or dedicated regional programmes, can substantially increase detection rates beyond what random overpass frequency alone achieves. Targeted tasking of instruments such as Carbon Mapper's Tanager-1 over high-priority mines, combined with regular revisit schedules, would help close the gap between regions with favourable conditions and those where emissions remain hidden.

Extending the operational lifetime of existing missions, such as EMIT, which has already proven highly effective at identifying methane super-emitters, should also be supported to maintain continuity of observation and fill gaps where newer instruments have limited coverage.

5.2 Quick win: example policies for governments to kick-start emissions reductions

Given that low-cost CMM abatement technologies are already available, embedding mitigation into national legislation can achieve substantial emissions cuts, maximising emissions reductions per dollar spent.

This section highlights the strengths of selected regulations aimed at reducing CMM emissions, and outlines recommendations to enhance their effectiveness.

Ban venting from drainage systems at active and closed underground mines - as the EU Methane Regulation does

Adopted in 2024, the EU Methane Regulation mandates MRV at both operating and closed coal mines. To mitigate CMM emissions, the regulation bans venting from drainage systems at active mines and from closed or abandoned mines. For methane from ventilation air shafts, it sets limits on the methane intensity of coal.

Strengths: The ban on venting of drainage methane from both active and non-active underground mines targets the most easily avoidable emission sources. By restricting high-concentration methane releases, the regulation creates a strong incentive for methane capture and utilisation. For example, Poland's coking coal company JSW aims to achieve capturing 50% of its methane emissions in the drainage systems, and use 95% of this, demonstrating the technical feasibility of such approaches.

Gaps: The regulation leaves implementation, verification and enforcement – including penalties for non-compliance – to individual Member States. To ensure mine operators fully comply with requirements, a robust and harmonised verification and penalty framework should apply.

Hold large emitting operators accountable through binding reduction requirements - as Australia's Safeguard Mechanism does

Australia's Safeguard Mechanism launched in 2016 and updated in 2023, covers the country's largest emitters, requiring them to progressively reduce emissions towards 2030 or offset any excess through the purchase of carbon credits. This approach creates accountability for large emitters and encourages reductions to meet national targets. In 2026, it continues to operate with declining baselines while the government assesses future settings.

Strengths: The regulation covers around 31% of national emissions from high-emitting facilities, ensuring that major emitters are directly accountable for emissions reduction efforts. The regulation introduces a declining emissions limit (baseline), which aligns with the

country's climate goals and provides a clear pathway for the company's long-term investment in low-emissions technologies.

Gaps: The regulation does not fully address potential underreporting issues of coal mine methane emissions, undermining the true mitigation potentials from large emitters. In addition, the flexibility to meet obligations through carbon offsets can weaken incentives for on-site abatement, especially for non-CO2 greenhouse gas emissions, such as methane.

Establish incentive mechanisms for mitigating VAM - as China's CCER does

In January 2024, China relaunched its voluntary carbon market, China Certified Emission Reduction (CCER), which, as of January 2025, allows for the generation of carbon offset credits from the use of coal mine gas with a methane volume concentration below 8%.

Strengths: The inclusion of low-concentration methane within CCER methodologies provides a formal pathway for crediting VAM mitigation, making China one of the few jurisdictions where such projects are explicitly recognised within a carbon crediting framework. The CCER scheme justifies its financial support for low-concentration methane mitigation as the solutions are seen as capital-intensive, therefore creating an additional revenue stream for emissions reductions. According to the Global Methane Initiative, there are currently 10 VAM mitigation projects active in China, and early uptake under CCER is beginning to materialise, with at least three low-concentration coal mine methane projects submitted for registration, including two in Shanxi province and one in Shaanxi province.

Gaps: VAM mitigation projects remain limited in practice. This is likely due to the very low methane concentrations in VAM, higher abatement costs and relatively low credit revenues, which have limited the uptake of VAM projects under CCER. A dedicated VAM methodology, carbon price support, streamlined MRV and stronger integration with China's ETS could improve viability and demand.

Phasing down coal

Phasing down coal use is the most effective way to curb CMM emissions. The International Energy Agency's Net Zero by 2050 report shows that no new coal mines or extensions should be approved after 2022.

For example, The Government of Canada has passed regulations to accelerate the phase out of unabated coal-fired electricity by 2030, which is expected to cut carbon pollution by approximately 13 Mt in 2030.

By linking coal phase-down targets with CMM reduction objectives, governments can enable early action at the highest-emitting mines.

Mine-closure requirements

Requiring coal companies to submit closure and transition plans that include specific methane abatement measures, clear timelines and post-closure monitoring commitments prevents ongoing emissions from decommissioned sites.

5.3 Industry requires mine-level MRV and abatement

Coal remains central to major industries, with steel being the largest industrial coal user. In 2024, global crude steel production reached 1,885 million tonnes, with around 70% still produced via the blast oxygen furnace route using coal-derived coke. While low-emissions alternatives are emerging, progress is not yet aligned with net zero. Methane from coking coal mining adds at least 27% to steel's warming impact, but is largely absent from Scope 3 disclosures despite being one of the quickest and most affordable decarbonisation opportunities available before 2030.

Ember recommends that industry, in particular steelmakers, require mine-level measurement, transparent reporting, verified abatement in procurement and transition planning.

Glossary

Emission factor (EF)
Emission Factor = Methane Emissions (t) / Coal Production (kt)

This metric represents the emissions efficiency of the coal industry in a specific year.

UNFCCC-derived data
Coal mine methane emissions calculated using the emission factors in years when national emission inventories have been reported to the UNFCCC.

Area Flux Mappers vs Point Source Imagers
Satellite observations rely on two complementary sensing methods.

Area flux mappers, such as the TROPOMI instrument, observe large areas but can detect only the highest emissions. TROPOMI provides daily global coverage for methane monitoring, offering a consistent picture of total emissions across large areas. Point source imagers, by contrast, provide very fine-resolution estimates of smaller emissions over a limited area.

Together, these satellites reveal both the overall scale of methane emissions (via area flux mappers) and the specific sources requiring monitoring (via point-source imagers), helping to link the broader issue to concrete mitigation actions.

Abandoned Mine Methane (AMM)
Emission changes can be complicated by AMM, which differs fundamentally from emissions at active mines. Once a mine closes, ventilation ceases and methane accumulates and migrates to the surface through old shafts, fractures and surrounding geology.

Ventilation Air Methane (VAM)

This is methane released from underground coal mines when large volumes of ambient air are pumped through the mine to keep the atmosphere safe for workers. The air contains only a very small fraction of methane – typically between 0.1% and 1% – but because flow rates can reach up to one million cubic metres per hour, VAM emissions generally make up the majority of emissions from underground coal mines.

Methodology

Global coal mine methane emissions

Ember creates a complete national time series of coal mine methane emissions from 1990 by gap-filling reported data. Emissions reported by Annex I and non-Annex I countries to the United Nations Framework Convention on Climate Change (UNFCCC) are merged into a single dataset and combined with historical coal production data from the United States Energy Information Administration (EIA). Where both production and reported emissions exist, a methane Emission Factor (EF) is calculated.

Missing intensity values are filled for each country using the last known valid intensity value for a country and carrying it forward through subsequent years. This handles gaps that occur after a period of reporting. After the forward fill, a backward fill is performed. This uses the next known intensity value to fill in any remaining gaps, which is crucial for countries that started reporting recently, leaving their early years blank. For each year, reported UNFCCC values are prioritised where available, with gap-filled values used otherwise and classified accordingly.

Future methane emissions are estimated by applying emissions intensity factors to coal production forecasts from the International Energy Agency (IEA). Ember produces three forecast series: one that applies each country's final historical UNFCCC-based intensity to future production, one that applies a single intensity derived from 2024 IEA emissions and production, and one that applies an intensity derived from the latest Global Energy Monitor (GEM) emissions data and reported production.

This report's national-level analysis excludes emissions from closed or abandoned mines. Reporting for this methane source covers only a subset of countries and lacks comprehensive data.

Comparison to independent estimates

GEM estimates methane emissions for individual mines across the globe using nuanced assumptions for coal extraction volumes, method, coal rank and depth. Their bottom-up method estimates active CMM emissions at 55.7 million tonnes in 2024.

However, GEM does not account for methane mitigation activity, meaning its estimates will be higher than actual emissions in countries where capture and utilisation is practised. For this reason, GEM figures in this report are only compared to UNFCCC-derived estimates for countries where there is little to no known CMM mitigation — specifically India, Indonesia and South Africa.

The IEA uses similar assumptions as GEM, with additional constraints provided by atmospheric inversions and satellite data. It estimates that emissions from active coal mines amounted to 35.7 million tonnes in 2024.

East et al. (2025) provide a further independent estimate using TROPOMI satellite observations inverted against UNFCCC prior estimates at up to 25 km grid resolution for 2023. Unlike purely bottom-up methods, this approach is directly constrained by atmospheric observations, though results in some regions — particularly Indonesia and Kazakhstan — are limited by sparse satellite coverage.

Afghanistan and Nigeria emission data

When constructing the global emission factors, we screened emissions per country for implausible outliers. Countries with implied emission factors greater than 100 kt emissions per Mt of coal produced or changing by more than an order of magnitude from one year to the next were flagged as inconsistent with the rest of the dataset and with independent estimates. Under this criterion, UNFCCC estimated emissions for Afghanistan prior to 2004 and Nigeria prior to 2017 were treated as outliers and excluded from the aggregation of global emission factors.

Getting the percentage of underground versus surface coal mines

When determining the percentage of coal production that is sourced underground for each country, we first look for this statistic in the National Communication documents submitted to the UNFCCC. If a value is not available in these reports, the methodology defaults to using the corresponding figure from the GEM dataset.

Calculation of the Ember confidence score

The confidence score ranges from 0 (low confidence in coal mine methane reporting) to 6 (high confidence in coal mine methane reporting) and is based on a combined assessment of three key categories:

1. Recency of reporting to the UNFCCC (United Nations Framework Convention on Climate Change)
2. Similarity to other independent estimates
3. Robustness of the methods used to estimate emissions (tier of estimation used when reporting to UNFCCC)

Each category is scored from 0-2, the highest number being the best. The confidence score is the sum total of the three sub-scores.

Methodology: Coal Mine Methane Data Tracker

Acquiring the number of satellite observations and their emission intensity

The number of satellite observations and emission data used in this analysis were based on satellite data collected via API calls from three main platforms (Kayrros, IMEO MARS and Carbon Mapper). The collected data was treated for duplicates and missing values.

Calculating the percentage of national coal production that has an attributable satellite plume

We estimate the proportion of coal mines with detectable satellite plumes by aggregating site-level data from GEM Global Coal Mine Tracker (GCMT) and Global Methane Emitters Tracker (GMET). The number of coal mines per country is first counted from the GCMT dataset, which provides comprehensive mine-level information. We then identify the number of unique mining infrastructures with at least one attributed plume using the GMET dataset. This approach provides an estimate of the prevalence of detectable emissions across coal mine operations on a national level globally.

The GMET includes 66 mines flagged under the "auto attribution for edge cases" category. These are mines located near a detected plume where adjacent mines were also present, making attribution to a specific mine unclear. These plumes are nonetheless likely of CMM origin and are included in our national-level counts.

227 of all coal mines are reasonably associated with a satellite methane plume. Plume data is up-to-date as of July/August 2025.

Calculation of coal mining profits

We estimate global annual coal mining profits by aggregating the net profit figures reported for the 131 most profitable coal-mining companies in Bullfincher's ranking, which lists each company's market capitalisation and profit data. The total of these profit values is taken as a proxy for worldwide coal mining earnings, representing a lower-bound estimate that captures the largest publicly listed operators.

Supplementary Materials

Mission extensions are filling critical methane blind spots

The Earth Surface Mineral Dust Source Investigation (EMIT) mission has proven highly effective in identifying methane super-emitters. This unexpected ability to spot large methane plumes demonstrates that targeted satellite observations can uncover significant emission sources that were previously invisible to routine monitoring.

Originally, EMIT was designed to study mineral dust and map global mineral dust sources between 2022 and 2024. However, its success in methane detection led to its extension and refocus for broader scientific applications. This highlights how adapting and expanding satellite missions can fill important blind spots in global methane tracking.

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Cover image

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