

Urgency to update Germany's coal mine methane emission factor

This document provides an analysis on the potential underestimation of Germany's coal mine methane emissions, why this could be the case and the recommendations for how to rectify this major oversight on emissions reporting. This will be crucial in advance of the forthcoming EU Methane Regulation.

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About	2
Highlights	2
Introduction	3
Germany underestimates its coal mining emissions	3
Comparison of estimates	4
Ember update to GEM estimate	5
Addendum: Satellite sees Germany's CMM	7
CMM underreporting	9
The problem with Germany's current emission factor	9
Inadequacy of single emission factor	9
40-100 times lower than lignite coal from Poland	10
Rhine Basin cannot be assumed to be representative of all of Germany	10
Additional methane from the surrounding strata	11
Emission factor lacks verification	11
Conclusion	12
Recommendations	12
Best practice measurement for surface mines	12
Decommissioned surface mines	12
Verification	13
Reducing Methane Emissions	13
Avoid	13
Mitigate	13
EU Methane Regulation Opportunity	14
Supporting Materials	15
Methodology	15
Independent estimate by Global Energy Monitor	15
Independent estimate by Shen et al.	15
Emission factor lacks verification	16
About Ember	17
Acknowledgements	17

About

This report presents evidence of the underreporting of Germany's coal mine methane (CMM) emissions and highlights why the methane emission factor and methodology must be urgently updated. Ember compiled independent emission estimates and methane measurements from [Polish lignite](#), all of which indicate that the emission factor used by Germany underestimates CMM emissions. Finally, we present recommendations to improve Germany's monitoring, reporting and verification (MRV) framework.

Methane is the second most important greenhouse gas contributor to climate change and coal is the largest source of methane in the energy sector in the EU. Achieving the 1.5C pathway requires [global CMM emissions to be reduced by 75% by 2030](#). This can only be done with an accurate understanding of emissions, now even more important in the context of the new EU Methane Regulation.

Highlights

1%

Although Germany produced 44% of the EU's total lignite in 2022, it only reported active CMM emissions of 1.39 thousand tonnes, namely 1% of that reported by the EU.

220

Coal mine methane emitted by Germany could be 28 to 220 times as much as is officially reported.

40-100

Germany considers its lignite coal comparable to that of Poland. However, Germany's evaluation of the methane content of its coal is 40 to 100 times less than the measurements of Polish lignite.

Introduction

Germany underestimates its coal mining emissions

Ember assessed Germany's coal mine methane emission data and is concerned that the significant scale of emissions has not been adequately estimated or assessed.

In 2022, Germany mined [131 million tonnes](#) of lignite coal from surface mines, representing 44% of the 2022 [EU's total lignite coal production](#). However, Germany only reported active CMM emissions of 1.39 thousand tonnes, namely [1% of the total EU's reported](#) active surface CMM emissions in 2021.

Ember analysed methane measurements from [Polish lignite](#) and found that emissions could be **184 times higher** than Germany currently reports. **This would more than double Germany's 2021 methane emissions from the entire energy sector, representing a 14% increase in national methane emissions.** Germany cannot [claim to be a climate leader](#) whilst simultaneously underreporting their emissions.

Germany's current methods, which use a single emissions factor, are considered inadequate by EU standards. The upcoming [Methane Regulation](#) will require "deposit-specific coal mine methane emission factor" established "on a quarterly basis" and taking into account "methane emissions from surrounding strata".

As a [Global Methane Pledge](#) Champion, and the largest EU surface coal mine producer, Germany's oversight on measurements and verification must be rectified. Germany should set an example on "best practise" CMM MRV. To do this will require an overhaul of Germany's outdated and lax existing methodology.

By establishing a rigorous MRV standard, Germany has the potential to significantly enhance the effectiveness of emissions reductions from surface coal mines, both within the EU and globally, as the Methane Regulation mandates importers to attain MRV equivalence.

Ember highlights 3 recommendations which Germany can take:

1. **Measure:** Require surface mines to directly measure and model their current and future methane emissions, including after closure
2. **Avoid:** No coal mine expansions and phase out the gassiest mines first
3. **Mitigate:** Require methane mitigation at active and closed coal mines

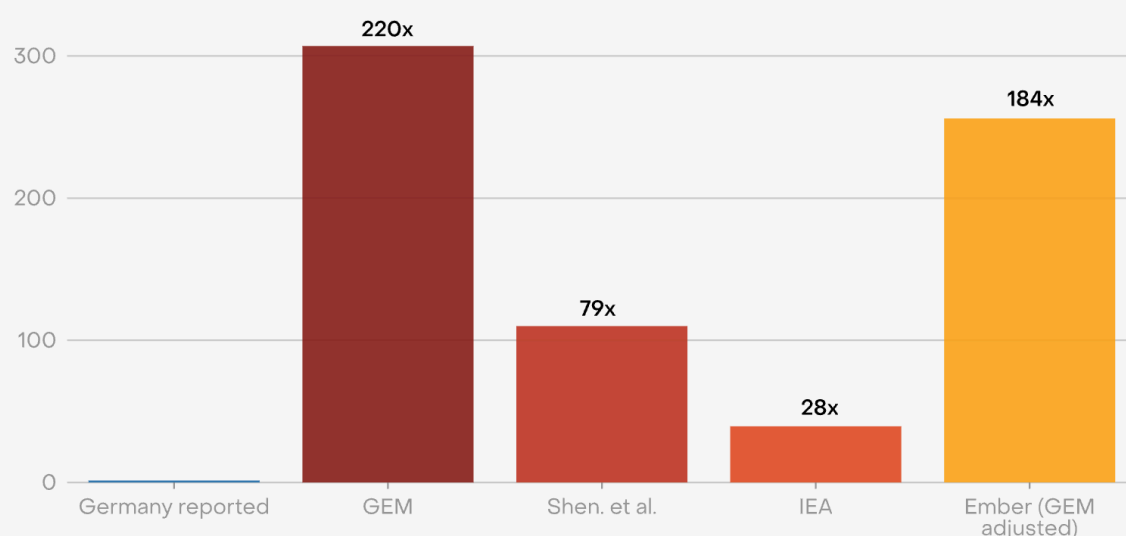
Comparison of estimates

Ember compared government-reported emissions to three independent estimates from the [International Energy Agency](#) (IEA), [Global Energy Monitor](#) (GEM) and [Shen et al. \(2023\)](#). The studies rely on bottom-up and top-down methods, described in the [Supporting Materials](#).

Findings from **all three studies agree that Germany is underreporting its CMM emissions**, although there are significant differences in the scale. [Ember's previous analysis found](#) that Germany was the country with the largest disparity between reported and independently estimated emission within the EU.

Germany's coal mine methane emissions estimated to be between 28 – 200 times larger than reported

Coal mine methane emissions (thousand tonnes)



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

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The studies indicate that Germany emits between 28 to 220 times as much as it officially reports from active coal mining operations. The largest estimates (by GEM) suggest Germany emits an additional 300,000 tonnes of methane emissions annually.

Using methane's short-term climate impact over 20 years ([GWP 20](#)), this would mean Germany's CMM emissions are between 3-25 million tonnes of CO₂e, equivalent to some of the [country's dirtiest coal power plants](#). Using methane's 100 year climate impact, CMM emissions would be equivalent to 1-9 million tonnes of CO₂e.

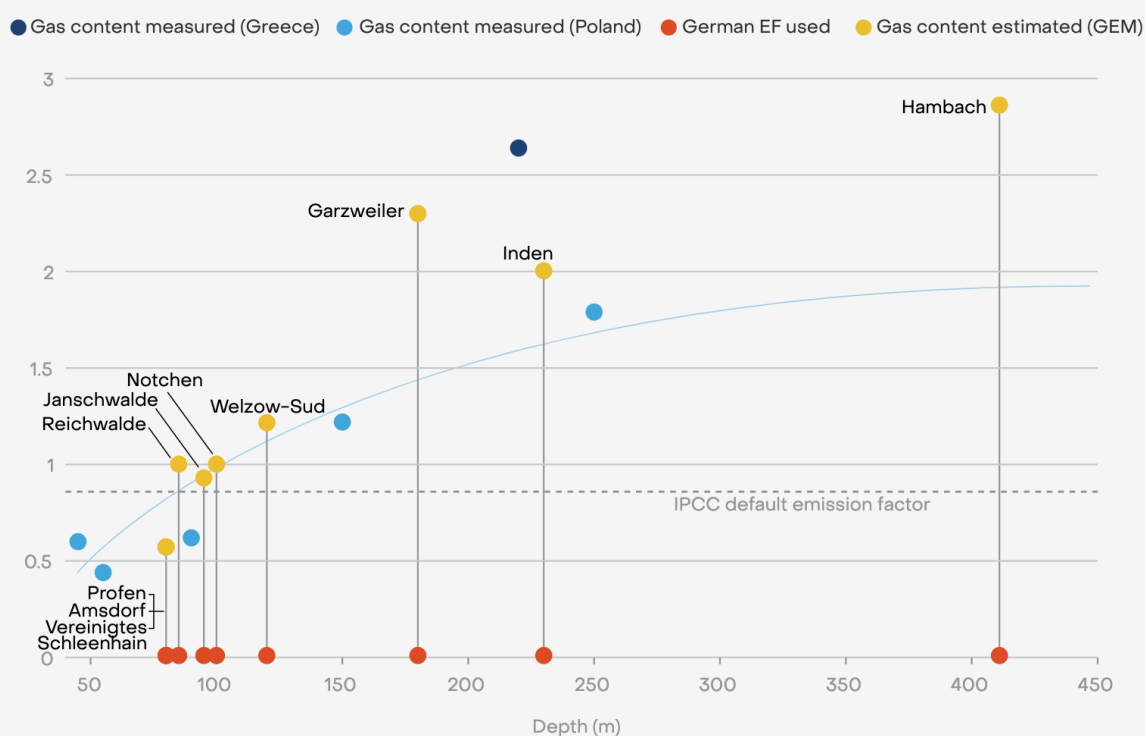
Ember update to GEM estimate

Ember estimated Germany's methane emissions, following the [peer-reviewed Model for Calculating Coal Mine Methane \(MC2M\) methodology](#), as used by GEM and described in the

[Supporting Materials](#). We compiled company data on coal production for the latest reported year (2022 when available, otherwise 2021), coal mine depth as described in company reports or academia, and [used data from Polish lignite samples](#) to estimate the gas content of German lignite at varying depths, as plotted below.

The German CMM emission factor is significantly lower than methane content measured in Polish lignite samples

Relationship between methane content of lignite coals and their depth in Europe (kg methane / tonne coal)



Source: Germany National Inventory Report (2023), Baran et al. Investigations of methane content in lignite coals, Vasiliadou et al. Extraction Study of Lignite Coalbed Methane as a Potential Supplement to Natural Gas for Enhancing Energy Security of Western Macedonia Region in Greece · Global Energy Monitor (GEM)

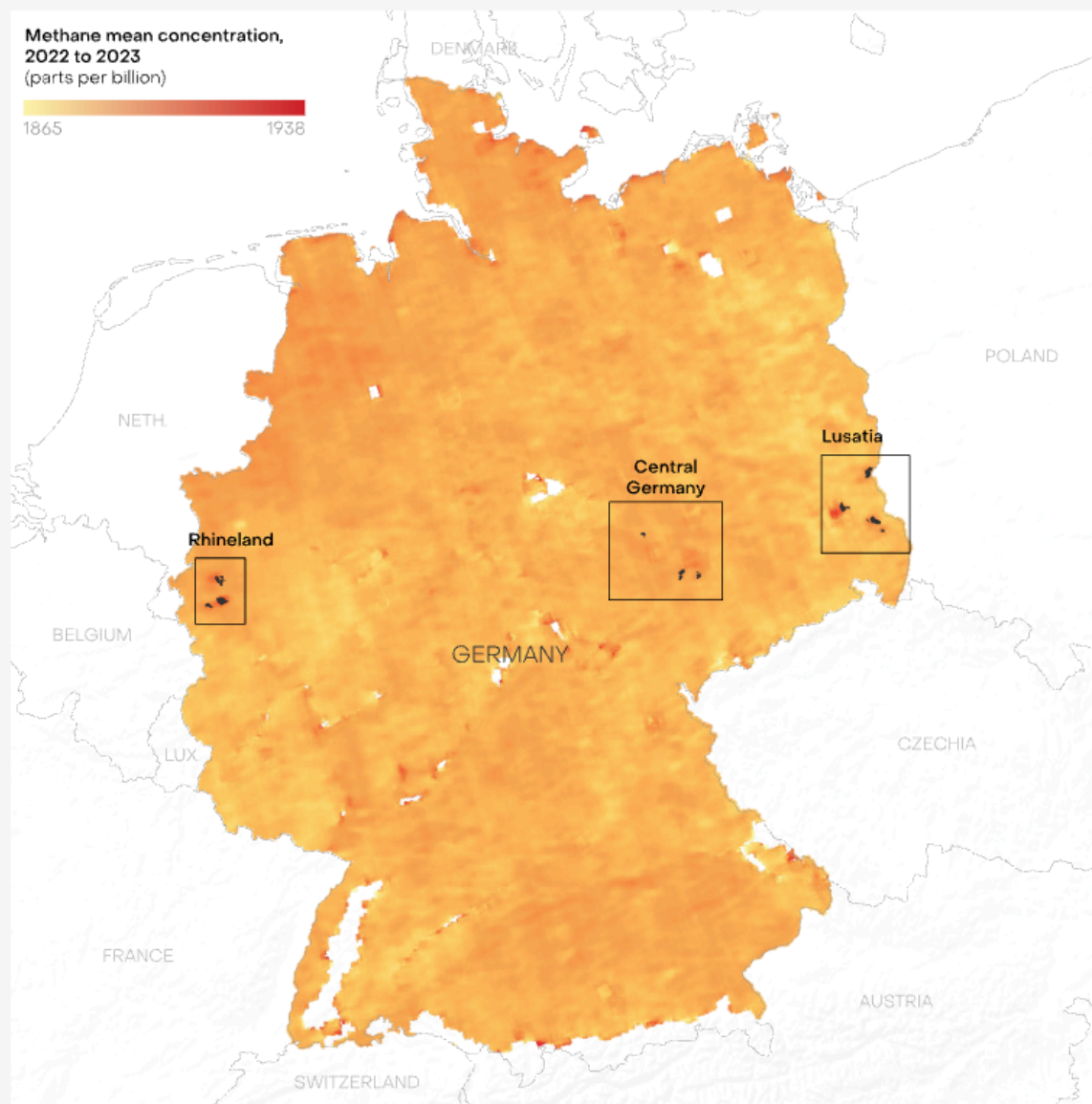
Applying this methodology, Ember estimated Germany's coal mine methane emissions at approximately 256,000 tonnes annually. While this figure aligns with the upper range of independent emission estimates, it remains within the uncertainty range established by Shen et al.'s analysis of Germany's CMM emissions from TROPOMI satellite data.

Addendum: Satellite sees Germany's CMM

The TROPOMI instrument onboard Sentinel-5P provides methane concentration measurements globally. Using [Google Earth Engine](#), Ember calculated average methane concentrations from 2022-2023 from repeat daily overpasses.

The TROPOMI data indicated strong methane enhancements over the lignite mines. Further analysis by the [SRON Netherlands Institute for Space Research](#) found that the enhancements are caused by high surface reflectivity and are not correlated with wind direction. Due to this limitation, we cannot conclude how much methane is present over the mines using the TROPOMI data. Observations from other satellite sensors and ground-based observations would help to quantify this.

Methane over Germany's coal mining regions



Source: Ember

CMM underreporting

The problem with Germany's current emission factor

Germany uses a single emission factor, measured in 1989, to calculate the methane emissions from all of its lignite coal mining operations throughout the country. This single emission factor lacks verification, is significantly different to lignite coal measured in Poland, and does not take into account methane emissions from surrounding strata. Here we highlight why the emission factor used by Germany is not adequate for estimating its coal mine methane emissions.

Inadequacy of single emission factor

A single emissions factor is insufficient for estimating surface coal mine emissions because the **methane intensity of coal mined is not constant in time**. Methane emissions are affected by factors such as the mines' location, depth, and change in the [permeability of coal seams](#) as overburden is removed. This level of variability is not captured with a single emission factor.

However, Germany currently relies on a single emission factor, based on a 1989 study by Rheinbraun AG, a lignite mining company. [The German Lignite Industry](#) (DEBRIV) states that methane content from borehole samples was measured, ranging from 0.00 m³/t to 0.05 m³/t, and that the average methane content was 0.015 m³/t.

Single emissions factors are not an appropriate starting point for effective methane measurement or management at surface mines. Awareness of this issue is increasing in other countries that mine coal. For example, this has also been highlighted by the [Australian Climate Change Authority](#), who have called for a review "with respect to sampling

requirements and standards estimation methodologies for fugitive methane emissions” when applied to surface coal mines “as a matter of urgency”.

40-100 times lower than lignite coal from Poland

Ember analysed the methane emission factor reported by Germany, and compared it to in-situ gas content, and depth measured from lignite samples in Europe (data was available for Poland and Greece, [see data here](#)).

Germany considers its lignite coal to be comparable to that from Poland, as stated in the [National Inventory Report](#) (NIR), and confirmed by [Betzenbichler et al. in 2016](#).

However, Germany evaluates the methane content of its coal as significantly lower. Depending on the depth of the coal sample, **Germany’s emission factor is anywhere between 40 to 100 times lower than in-situ measurements of Polish lignite.**

In general, a mine’s methane intensity will increase relative to the depth of the coal mined. Although there are exceptions to this rule as the methane intensity of coal can vary significantly between regions, basins and coal mines. Germany’s emission factor does not take into account variations in depth, or variations in coal geology throughout the country.

Rhine Basin cannot be assumed to be representative of all of Germany

In-situ gas contents can vary greatly within a country as there is often a large spatial variability of methane content of coals, even within a basin. In Poland, the Upper Silesian coal basin covers an area less than 2% the size of Germany but methane content varies significantly both vertically and horizontally. In shallow seams alone, the methane content can vary by a [factor of 100](#) (between 0.01 and 1 m³/t coal).

This raises the concern that the current emission factor, based only on samples from the Rhine basin, may not be representative for all of Germany's coal. The 2016 study by Betzenbichler et al. (referenced within Germany's NIR), highlights the same concern, and states that after requesting further information from DEBRIV, there were no further updates to the data.

Additional methane from the surrounding strata

During the excavation of coal at a surface mine, the methane within the mined coal seam will be released, **as well as methane within the surrounding (unmined) strata**. The IPCC guidelines state *"To account for the methane that migrates from surrounding strata, the assumed emissions factor should be based on measured variables such as gas content, and qualitative characteristics such as permeability"*.

To account for these additional emissions, the U.S. Environmental Protection Agency multiplies coal production by a gas content emission factor and a **150-percent emission factor** to account for emissions from over- and under-burden ([U.S. EPA, 2016](#)).

There is no indication that Germany has taken into account methane emissions from the surrounding strata within their emission factor estimates.

Emission factor lacks verification

Germany's [National Inventory Report](#) (NIR) claims that secondary references substantiate the findings of the 1989 Rheinbraun AG study, however, this is not the case. None of the references provide information to determine the applicability or robustness of the geological sampling program used. Information on the number of drill holes, sampling techniques, depth of samples, porosity, and methane content have not been publicly disclosed.

For more detail on the references included within the NIR, and why they do not substantiate the emission factor, see the [Supporting Materials](#).

Conclusion

Recommendations

Germany claims to be a [climate action champion](#). The country is also a signatory of the Global Methane Pledge and has therefore committed to measuring and reducing methane, but can only do this if it understands its emissions. It is up to the German government to implement a robust plan to measure and rapidly reduce its coal mine methane emissions. In doing so Germany has the opportunity to set an ambitious best-practise industry standard both within the EU and globally.

Ember recommends urgent changes that Germany should make to quickly get a grip on their methane emissions from surface mines, highlighting best practice measurement, and a pathway for how to avoid and mitigate future emissions.

Best practice measurement for surface mines

Best practice measurement for surface mines combines a number of technologies to generate a multi-input model. The approach should take into account methane variability, spatial and climatic factors, and changes to the permeability of the coal seam, as well as major pollution events.

In brief, Ember suggests the following should be considered:

- Measurements of geotechnical cores to establish the methane content across all the gas bearing strata, combined with field coal gas models, to derive a site-specific emission factor for surface operations, which are verified by an independent body;
- Complementary total site-level measurements should be conducted to ensure site-level reconciliation with source-specific measurements.

Decommissioned surface mines

Surface mines should be required to undertake direct measurements and model their emissions after closure, including reliable gas measurements from waters of pit lakes. [A 2017 study](#) at the pit-lake Vollert-Sued in Germany also found elevated methane

concentrations in the water. This is particularly important as pit-lakes can be [more susceptible to limnic eruptions](#), posing a serious safety risk.

Verification

Reporting entities should have a formal quality assurance program, including independent review of emission reports prior to submission, as stated in the upcoming EU Methane Regulation.

Satellites and drones are an emerging approach for the verification of national inventories, and regulators should consider the calibration of satellite observations with data from land-based monitoring systems.

Reducing Methane Emissions

Avoid

A clear pathway to avoiding methane emissions is for Germany to cease approving coal expansion projects, and focus on phasing out coal mining at the gassiest coal mines first.

For closed mines, Germany must reassess its legislation on the rehabilitation of surface coal mines via the creation of pit-lakes. Avoiding emissions from these sources can be done by utilising alternative rehabilitation methods.

Mitigate

Whilst existing mines continue to operate, there are methods available to mitigate methane emissions.

Best practice methane mitigation in surface coal mines is pre-mine drainage, as indicated in a recent [study from the University of Queensland](#). The method is widely used across the mining industry, and involves designing and implementing a series of planned wells to either flare or utilise the drained methane prior to mining. For the best possible mitigation results, this process begins months ahead of mining at a particular mining domain, and continues throughout the life of the mine.

This practice has a twenty year history in the mining industry, [especially in the USA](#), where surface mines are often found to have relatively lower gas content to those of underground mines.

At pit-lakes, [methane extraction and utilisation](#) could be considered as a mitigation option.

EU Methane Regulation Opportunity

As highlighted previously, in line with the upcoming EU Methane Regulation, Germany is required to update the current MRV methodology for surface mines. This means they must use the emissions factor based on coal deposit and specifically, the regulations state;

"As regards surface coal mines, mine operators shall use deposit-specific coal mine methane emission factors to quantify emissions resulting from mining operations. Mine operators shall establish those emission factors on a quarterly basis, in accordance with appropriate scientific standards and take into account methane emissions from surrounding strata. "

European standardisation organisations will be requested to draft harmonised standards for measurement and quantification of methane emissions from coal mines. **As the largest surface coal miner in the EU, it is Germany's responsibility to lead the effort to determine, and implement accurate MRV at surface mines.**

Although surface mines in Europe are exclusively for lignite coal, globally surface mining is commonly employed for methane-intensive hard coal, including coking coal. Improving MRV standards at surface mines in the EU can have a substantial positive impact globally, since imported coal must comply with the EU's MRV equivalence requirements.

Supporting Materials

Methodology

Independent estimate by Global Energy Monitor

Global Energy Monitor employs its Global Coal Mine Tracker to estimate methane emissions at individual mines worldwide, aggregating the data on national and global scales. They provide baseline estimates for coal mine methane emissions, which utilise mine-level activity data, such as production, operating depth, methane content at depth, and an emission factor to account for methane from over and under burden, following the [peer-reviewed Model for Calculating Coal Mine Methane \(MC2M\) methodology](#).

Using the MC2M methodology, GEM estimates that the emissions from Germany surface mines could be up to 307,000 tonnes per year. GEM applied gas content for “brown” coals in their calculations after a [Polish study showed](#) emissions of 2.5 dcm³/kg at a pressure of 10 bar for lignite. This estimate may therefore be overestimating Germany’s CMM emissions.

Independent estimate by Shen et al.

The study by Shen et al. estimated national and global CMM emissions using top-down methodology. The study used 22 months (May 2018-Feb 2020) of satellite observations from the TROPOMI instrument to better quantify national fossil fuel emissions worldwide.

The study estimated annual coal methane emissions from Germany to be 110,000 tonnes. The 95th percentile range is notably wide, ranging from 6,000 to 280,000 tonnes indicating a significant uncertainty of -95% to +155%. This considerable range underscores the uncertainty linked to methane emissions from the coal sector in Germany. In comparison, methane emissions from the oil and gas industry was estimated at 200,000 tonnes annually, with a more constrained 95th percentile range of 160,000 - 240,000 tonnes, showing a much smaller margin of +/- 20%.

Emission factor lacks verification

Not all studies references in Germany's NIR substantiate the CMM emission factor

Emissions and trend (1.B.1)

3.3.1.1 Underground mining – hard coal
Hard coal is no longer mined in Germany.

3.3.1.2 Open-pit mining – lignite

Gas	Method used	Source for the activity data	Emission factor used
CH ₄	Tier 2	AS	CS

3.3.1.2.1 Category description (open-pit mining – lignite)

Activity data

Table 96: Usable output of lignite, in millions of t.

1990	1995	2000	2005	2010	2015	2020	2021
356.5	292.7	167.7	177.9	169.4	178.1	107.4	126.3

(Statistik der Kohlewirtschaft, 2022)

Emission factors

In keeping with figures of the DEBRIV German lignite-industry association (DEBRIV, 2004), an average emission factor of 0.015 m³ CH₄/t (corresponds to 0.011 kg CH₄/t) is assumed for German lignite. This emission factor is based on a 1989 study of RWE Rheinbraun AG (DEBRIV, 2004) and has been substantiated by publications of the German Society for Petroleum and Coal Science and Technology (DGMK) (DGMK, 1992).

No lignite storage takes place; usage is "mine-mouth", i.e. extracted coal is moved directly to processing and to power stations.

241 of 974
14/04/2023

Source says:

In 1989 Rheinbraun AG measured methane content from boreholes ranging from 0 to 0.05 m³/t. The average methane content was 0.015 m³/t. Mentions the Öko-Institut measured a methane content of 0.02 m³/t. Source does not include any further measurements, data or evidence to support EF.

Source substantiates emission factor? **PARTLY**

Source says:

States the emission factor is 0.015 m³/t, but does not substantiate the emission factor with any further studies or information.

Source substantiates emission factor? **NO**

CLIMATE CHANGE National Inventory Report, Germany – 2023

Table 97: Emissions in category 1.B.1.a.ii – open-pit mining

Emission factors	m ³ CH ₄ /t	kg/t
CH ₄ from extraction	0.015	0.011

Emissions and trend

Table 98: Emissions in category 1.B.1.a.ii – open-pit mining

Gas	Total emissions	Trend	Remark			
	1990	2020	2021	Since 1990	With respect to the previous year	
Methane	3.9 kt	1.2 kt	1.4 kt	-64 %	17 %	The emissions have been decreasing as a result of reductions in lignite production.

3.3.1.2.2 Methods (open-pit mining – lignite)
The emissions from open-pit lignite mining are calculated with the Tier 2 method.

3.3.1.2.3 Uncertainties and time-series consistency (open-pit mining – lignite)
The emission factor used for calculating methane emissions from lignite production is based on maximum methane content levels and thus represents the upper limit of possible methane emissions. It thus already includes possible emissions from transport and storage. Numerous studies have shown that a negative uncertainty of - 33 % must be assumed (DEBRIV / DGMK research report / Forschungsbericht 448-2, DGMK (1992)).
For the emission factor and the activity data, a consistent source is used throughout the entire time series.

3.3.1.2.4 Category-specific quality assurance/control and verification (open-pit mining – lignite)
General and category-specific quality control, and quality assurance in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out by the Single National Entity.
In the framework of verification for the current report, various data sources for activity data in coal mining, and the relevant EF used, were compared with the corresponding sources and EF of other countries (cf. Table 99). A by-country comparison of specific emission factors for open-pit mining shows a broad range, with Germany in the lower part of the range, in a position comparable to that of Poland. The 2011 NIR (p. 103) noted that the Czech Republic uses the average IPCC default factor, in keeping with the fact that the coal mined in that country, in comparison to the coal mined in Poland and Germany, consists to a larger extent of sub-bituminous coal. The degree of coalification (rank) – and, thus, the methane content – of such coal is higher than that of the lignite found in Poland and Germany (sources: NaSE-Workshop (2004), personal communication of DEBRIV (2004)). This conclusion was also reached by a report prepared by VERICO (Betzenbichler et al., 2016b).

Source says:

Confirms that Germany is similar to Poland with respect to the type, and methane emissions of coal. Questions the representativeness of using the "old" 1989 study based in the Rhine Valley for the whole of Germany. State that after asking DEBRIV for more information, in fact, they have never pursue any update on EF.

Source substantiates emission factor? **NO**

Source: Germany National Inventory Report (NIR), DEBRIV. (2004, 15. September 2004) Mitteilung vom Deutscher Braunkohlen-Industrie-Verein e.V. an das IKP Stuttgart/Interviewer: I. Stuttgart. DEBRIV., DGMK. (1992). Ansatzpunkte und Potentiale zur Minderung des Treibhauseffektes aus Sicht der fossilen Energieträger Betzenbichler (2016b). Erarbeitung wissenschaftlich-methodischer Grundlagen zur Umsetzung der Empfehlungen aus den internationalen Inventarüberprüfungen – Verbesserung des Qualitätsmanagements und der Verifikation der deutschen Emissionsinventare.

About Ember

Ember is an independent, not-for-profit energy think tank that aims to shift the world to clean electricity using data. It gathers, curates and analyses data on the global power sector and its impact on the climate, using cutting edge technologies and making data and research as open as possible. It uses data-driven insights to shift the conversation towards high impact policies and empower other advocates to do the same. Founded in 2008 as Sandbag, it formerly focused on analysing, monitoring and reforming the EU carbon market, before rebranding as Ember in 2020. Its team of electricity analysts and other support staff are based around the world in Australia, the EU, UK, Turkey, India, China and Indonesia.

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