# Fossil Fuel Operations Sector: Coal Mining Emissions

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## 1. Introduction

The underground, geological process that produces coal also produces greenhouse gas emissions (GHGs), primarily carbon dioxide ($CO_2$) and methane ($CH_4$). These gases remain trapped in the underground coal seams until the coal is mined. During the process of extracting coal, these gases can be released into the atmosphere. For this reason, coal mine emissions are classified by the Intergovernmental Panel on Climate Change (IPCC) under *1.B Fugitive Emissions from Fuels.* Even after active mining is complete, methane may continue to be released from these abandoned mines [1].

Climate TRACE utilized coal mine data from Global Energy Monitor's Global Coal Mine Tracker, which includes production and capacity data for 3,788 coal mines globally. Using methane gas content from the tracker, and capacity factors from literature, Climate TRACE was able to estimate annual emissions from these mines. Note, In Climate TRACE's 2024 release of source level data, only active mines had methane emissions estimated and abandoned coal mines and $CO_2$ emissions were not included.

## 2. Dataset

The main dataset employed for this work was from The Global Energy Monitor in their Global Coal Mine Tracker (GCMT; https://globalenergymonitor.org/projects/global-coal-mine-tracker/). Global Energy Monitor's $CH_4$ as a worldwide dataset of coal mines and proposed projects. The tracker is updated annually and provides source level details on ownership structure, development stage and status, coal type, production at operating mines, capacity at proposed mines, workforce size, reserves and resources, geolocation, and other categories.

The tracker gathers data from publicly available sources: (1) government data, including national energy and resource plans, environmental permits and applications; and national datasets; (2) reports by state-owned and private mining companies, including quarterly and annual reports; (3) news and media reports, including local, international, and trade outlets; (4) local non-governmental organizations (NGOS) monitoring companies, mining activity, and developments; (5) on the ground contacts who can provide first-hand information.

The information was collected by an international team of researchers, with fluencies in Chinese, Russian, Spanish, and Turkish. Wherever possible, Global Energy Monitor circulates data for vetting and review to researchers familiar with local mining conditions. Input data from this tracker was used to estimate emissions, described in the sections below.

## 3. Input data

The following metadata was used to estimate emission factors and methane emissions for coal mines.

*Coal mine data*

Coal mine location, name, country, and owner are all based on the dataset provided by Global Energy Monitor in their Global Coal Mine Tracker (GCMT; https://globalenergymonitor.org/projects/global-coal-mine-tracker/). In order to create a temporally comprehensive dataset (2015-2023), GEM collected historical production data for 1,886 mines. For mines where historical production was not available, Climate TRACE back filled the earliest production estimate available. These datasets were used to identify mines that were open previously, and closed, or to identify past activity for mines that are currently open.

*Capacity Factor*

Capacity factor values were gathered from relevant literature for specific regions in China and the U.S. For all remaining regions, a global average capacity factor was used based on China and the U.S.

China: Yangpin Ju, et al. (2019) used a stochastic model to estimate the regional capacity utilization for 15 years in China [5]. Climate TRACE utilized these capacity factors for Chinese mines using the following rules:

1. If a mine was in a state provided in the paper above, and we were estimating emissions for a year provided in the paper above, the exact capacity factor was used.
2. If a mine was in a state provided in the paper above, and we were estimating emissions for a year not provided in the table, the mean across all 15 years for that state was used.
3. If a mine was not in a state provided, but we were estimating for a year provided, the mean across all states for that year was used.
4. Finally, if a mine was not in a state, and we were not estimating emissions for a year in the table, the mean of the entire table was used.

USA: The U.S. Energy and Information Administration (EIA) provides state level, annual capacity factors for coal mines in the U.S [6]. Climate TRACE utilized these capacity factors for US mines using the following rules:

1. If a mine was in a state provided in the paper above, and we were estimating emissions for a year provided in the paper above, the exact capacity factor was used.
2. If a mine was in a state provided in the paper above, and we were estimating emissions for a year not provided in the table, the mean across all 15 years for that state was used.
3. If a mine was not in a state provided, but we were estimating for a year provided, the mean across all states for that year was used.
4. Finally, if a mine was not in a state, and we were not estimating emissions for a year in the table, the mean of the entire table was used.

All other locations: For all other coal mine locations and years, an average of all U.S. and Chinese capacity factors was applied.

*Activity*
GEM's 2023 GCMT provided either production or capacity information for each mine (https://globalenergymonitor.org/projects/global-coal-mine-tracker/). In some cases, both were provided. If both were available, Climate TRACE used production, and calculated capacity using the capacity factors listed above. GEM recently released historical production data (back to 2017) for almost half of the operating coal mines. Climate TRACE used these historical data where it was available. Where it was not available, activity was backfilled using the earliest estimate available.

For mines where only capacity was available, activity was calculated using the capacity factors described above.

*Capacity*
For mines where only capacity was provided, Climate TRACE used the capacity as provided. If activity was provided in GEM's GCMT, capacity was calculated by dividing the activity by the capacity factors described above. Capacity values were backfilled to the year that the mine opened.

*Emissions Factor*
The emissions factor for each mine is a function of two things: the *methane gas content* of each mine, and the *emission factor coefficient*.

Methane gas content: The gas content of a coal isotherm is dependent on the depth of the mine, and GEM estimated the methane gas content of each mine using the approach laid out in *Global methane emissions from coal mining to continue growing even with declining coal production* [2]. Climate TRACE utilized the methane gas content provided by GEM for each mine. GEM provided the value in cubic meters per tonne ($M^3$/tonne) of coal produced, and Climate TRACE applied a conversion factor provided by the EPA to convert the methane gas content to tonnes of $CH_4$ [3] .

Emission factor coefficient: In order to convert the $CH_4$ gas content into an emissions factor, the emission factor coefficient must be applied. This is due to emissions from coal pillars and methane in coal seams that are in the surrounding area. Ju et al. (2016) reported that this coefficient is in the range 1.3 to 2.0. For this work, Climate TRACE used an average of 1.65 [4].

The two values described above are combined as in Equation 1 in order to produce the emissions factor for each mine.

$$Emission\ factor(mine) \ = \ (Methane\ Gas\ Content(mine)\ /\ 1.4703e3)\ *\ 1.65 \qquad \text{(Eq.1)}$$

## 4. Model

Once the metadata above was determined, calculating emissions used Equation 2. Climate TRACE combined $CH_4$ emissions factor (in tonnes $CH_4$ per tonne of coal) with activity (in tonnes of coal) to derive tonnes of $CH_4$ emissions per mine per year.

$$CH4\ Emissions\ (mine) \ = \ CH4\ Emissions\ Factor \ * \ Activity \qquad \text{(Eq.2)}$$

Equation 2 was applied to 3,788 coal mines globally to estimate their methane emissions for years 2015 to 2023. To convert annual values to monthly values, refer to the Climate TRACE methodology "*Temporal Disaggregation of Emissions Data for the Climate TRACE Inventory*" in the GitHub repository Post Processing for Global Emissions and Metadata Completeness.

## 5. Reporting of emissions on Climate TRACE

Coal mining emissions data for this sector is hosted in the Climate TRACE website: https://climatetrace.org/. This emissions sector is equivalent to the United Nations Framework Convention on Climate Change (UNFCCC) sector "Fossil Fuel Operations 1.B.1.a - Coal Mining and Handling". Climate TRACE default emissions values were reported as $CH_4$, and $CO_2$ equivalent 20- and 100-year global warming potential ($CO_2$e 20yr and 100yr GWP).

## 6. Supplementary Metadata

This dataset provides emissions estimates for active coal mines. Metadata information is provided in the tables below.

**Table S1:** *General dataset information*

| General Description | Definition |
|---|---|
| **Sector definition** | *Fugitive methane emissions from coal mining, and post-mining activities of commercially operating mines and carbon dioxide emissions from on-site fuel combustion for coal extraction, handling, and logistics.* |
| **UNFCCC sector equivalent** | *1.B.1.a Coal Mining and Handling* |
| **Temporal Coverage** | *2015 – 2023* |
| **Temporal Resolution** | *Annual* |
| **Data format(s)** | *CSV* |
| **Coordinate Reference System** | *EPSG:4326, decimal degrees* |
| **Number of assets/countries available for download** | *3,788 assets* |
| **Total emissions for 2023** | *1,873,073,233 tonnes $CO_2e$* |
| **Ownership** | *We used permit data and research to identify ownership information* |
| **What emission factors were used?** | *Industry emission factors* |
| **What is the difference between a "NULL / none / nan" versus "0" data field?** | *"0" values are for true non-existent emissions. If we know that the sector has emissions for that specific gas, but the gas was not modeled, this is represented by "NULL/none/nan"* |
| **total_CO2e_100yrGWP and total_CO2e_20yrGWP conversions** | Climate TRACE uses IPCC AR6 $CO_2$e GWPs. $CO_2$e conversion guidelines are here:[https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_FullReport_small.pdf](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_FullReport_small.pdf) |

**Table S2:** *Asset level metadata description*

| Data attribute | Definition |
|---|---|
| **sector** | Fossil Fuel Operations |
| **asset_sub-sector_name** | N/A |
| **asset definition** | N/A |
| **start_date** | Start date for time period of emissions estimation (YYYY-MM-DD format) |
| **end_date** | End date for time period of emissions estimation (YYYY-MM-DD format) |
| **asset_identifier** | Internal, unique ID for mining asset and mineral type |
| **asset_name** | Mining asset |
| **iso3_country** | ISO 3166-1 alpha-3 country code for asset location |
| **location** | Well-known text (WKT) MultiPolygon of approximate mine centre |
| **type** | Coal Mine classification |
| **capacity_description** | Coal Mine Capacity |
| **capacity_units** | Tonnes |
| **capacity_factor_description** | Proportion of capacity accounted for by activity |
| **capacity_factor_units** | N/A |
| **activity_description** | t Coal extracted |
| **activity_units** | Tonnes |
| **CO2_emissions_factor** | N/A |
| **CH4_emissions_factor** | Tonnes $CH_4$/ Tonne coal |
| **N2O_emissions_factor** | N/A |
| **other_gas_emissions_factor** | N/A |

| Data attribute | Definition |
|---|---|
| **CO2_emissions** | N/A |
| **CH4_emissions** | Tonnes $CH_4$ |
| **N2O_emissions** | N/A |
| **other_gas_emissions** | N/A |
| **total_CO2e_100yrGWP** | Tonnes $CO_2$e |
| **total_CO2e_20yrGWP** | Tonnes $CO_2$e |
| **other1_description** | Coal Type |
| **other1_units** | N/A |
| **other2_description** | Coal Grade |
| **other2_units** | N/A |
| **other3_description** | Total Reserves (Proven and Probable) |
| **other3_units** | Million Tonnes |
| **other4_description** | Total Resource (inferred, indicated, measured) |
| **other4_units** | Million Tonnes |
| **other5_description** | Primary Consumer, Destination |
| **other5_units** | N/A |
| **other6_description** | Coal Plant, Steel Plant, Terminal |
| **other6_units** | N/A |
| **other7_description** | Mine Depth |
| **other7_units** | m |
| **other8_description** | Mine Size |
| **other8_units** | km^2 |
| **other9_description** | N/A |
| **other9_units** | N/A |
| **other10_description** | N/A |
| **other10_units** | N/A |



**Data citation format:** Lewis, C., Tate, R.D., and Mei, D.L. (2024). *Fossil Fuel Operations Sector- Coal Mining Emissions.* WattTime and Global Energy Monitor, USA, Climate TRACE Emissions Inventory. https://climatetrace.org [Accessed date]

**Geographic boundaries and names (iso3_country data attribute):** The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents, and databases on Climate TRACE are generated from the Global Administrative Areas (GADM) project (Version 4.1 released on 16 July 2022) along with their corresponding ISO3 codes, and with the following adaptations:

- HKG (China, Hong Kong Special Administrative Region) and MAC (China, Macao Special Administrative Region) are reported at GADM level 0 (country/national);
- Kosovo has been assigned the ISO3 code 'XKX';
- XCA (Caspian Sea) has been removed from GADM level 0 and the area assigned to countries based on the extent of their territorial waters;
- XAD (Akrotiri and Dhekelia), XCL (Clipperton Island), XPI (Paracel Islands) and XSP (Spratly Islands) are not included in the Climate TRACE dataset;
- ZNC name changed to 'Turkish Republic of Northern Cyprus' at GADM level 0;
- The borders between India, Pakistan and China have been assigned to these countries based on GADM codes Z01 to Z09.

The above usage is not warranted to be error free and does not imply the expression of any opinion whatsoever on the part of Climate TRACE Coalition and its partners concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its borders.

**Disclaimer:** The emissions provided for this sector are our current best estimates of emissions, and we are committed to continually increasing the accuracy of the models on all levels. Please review our terms of use and the sector-specific methodology documentation before using the data. If you identify an error or would like to participate in our data validation process, please contact us.

**References**


1) https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/2_Volume2/19R_V2_4_Ch04_Fugitive_Emissions.pdf
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6) EIA, 2023. *Annual Coal Report.* Available at: https://www.eia.gov/coal/annual/. Accessed 01 October 2023.