The Carbon Majors Database

Methodology Report 2017

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Summary

The Carbon Majors Database contains greenhouse gas (GHG) emissions data on the largest company-related sources of all time. Attributing operational and product-related carbon dioxide and methane emissions to 100 fossil fuel producers ('carbon majors'), the Database covers 52% of global industrial GHG emissions since the dawn of the industrial revolution (62% including non-extant companies). The novelty of the Database is that it presents a producer-side view of climate accountability and shows that significant contributions to anthropogenic climate change can be traced to a relatively small group of decisionmakers. It is also the most comprehensive database of corporate greenhouse gas emissions over time.

The methodology described herein was used to complete a dataset of fossil fuel producer emissions covering the period from 1988: the year in which human-induced climate change was officially acknowledged by the international community through the establishment of the Intergovernmental Panel on Climate Change (IPCC). The dataset shows that half of global industrial greenhouse gases released since then can be traced to just 25 fossil fuel producing entities. Two of the coal producing states – China and Russia – are represented as nation state producers though it is a future objective to split these entities into constituent companies. In 2015, after the breaking up of these large state producers, half of global greenhouse gas emissions can be traced to 50 companies.

1 Introduction

The Carbon Majors Database contains greenhouse gas emissions data on the largest company-related sources of all time. It originally contained 90 producers engaged in coal, oil and gas, and cement production dating back to 1854. These investor- and state-owned entities have contributed about two thirds of total historical industrial carbon dioxide and methane emissions worldwide.

The original Database was built by Richard Heede (2014a, 2014b) of the Climate Accountability Institute[1]. CDP is committed to keeping the database securely stored, updated, and accessible to the public. This report lays out the results and methodology behind this year's report. The database contains:

- 100 extant[2] fossil fuel producers ('Carbon Majors'): 41 public[3] investor-owned companies; 16 private investor-owned companies; 36 state-owned companies; and 7 state producers[4].
- 923 gigatonnes of carbon dioxide-equivalent ($GtCO_2e$) from direct operational and product-related carbon dioxide and methane emissions (1854-2015), representing 52% of global industrial GHG since the dawn of the industrial revolution (1751).
- A wider '2015 Sample' of 224 companies, representing 72% of annual global industrial GHG emissions.

The period focused on here is 1988-2015. In 1988 the IPCC was established by WMO and UNEP, signaling the official recognition of human-induced climate change by the international community. This methodology report is part of a package including:

- CDP Carbon Majors Report 2017 'The Carbon Majors Database': Introducing the Database and Reporting on its results and implications for investors and companies.
- CDP Methodology Report 2017: Reporting on the estimation methodology applied and data sources used.
- CDP Carbon Majors Database '2017 Dataset Release': Annual and cumulative direct operational (Scope 1) and product (Scope 3) emissions over the 1988-2015 period of 100 extant fossil fuel producers; top 100 list of fossil fuel producing companies in 2015 by Scope 1+3 emissions.

The present methodology builds on the peer reviewed methodology applied by Heede (2014a, 2014b). Emission estimations have been improved with newer emission factors and more granular activity data. A comprehensive threshold assessment has also been undertaken to increase the number of companies in the sample. It is intended that Carbon Majors will release new data on an annual basis. The methodology will be reviewed regularly for continuous improvement between editions. Feedback from companies and other interested stakeholders is welcomed.

[1] www.climateaccountability.org
[2] The Database also contains 8 significant non-extant producers raising total emissions to 1,090 GtCO2e, or 62% of global industrial GHG emissions since the dawn of the industrial revolution.
[3] Publicly invested, or traded, ownership excludes private sources of investment including: Individuals, venture capital, private equity firms, holding companies, insurance companies, and corporations.
[4] State producers are producing entities that are represented by national production.

2 Data sources

Before estimating company emissions, it is necessary to collect company activity data, product properties information, and emission factors. If the company reports Scope 1 emissions from fossil fuel extraction, then the reported figure is used and calculation data is not required (CDP 2016).

Oil, gas, and coal production data is principally obtained from publicly available sources: annual reports from company websites and the US Securities and Exchange Commission (SEC 2016). For some state-owned oil and gas enterprises, data is sourced from the OGJ lists of the *'Oil & Gas Journal'* (OGJ 1986-2016) or is estimated[5] from national statistics (EIA 2017, BP 2016, and OPEC 2016). For a small number of oil and gas companies, information from proprietary database *'Global Data Oil & Gas Upstream Analytics'* (GD 2016) is used to improve production granularity.

Russian and Chinese coal are represented by their nation states. Since the break-up of industry control, however, they are better represented by their constituent companies. This was achieved in the 2015 Sample, by collecting from company annual reports and articles from Chinese coal data service company sxcoal (2016).

Scope 3 emission factors for hydrocarbon solids, liquids, and gases are presented in sources as being specific to mass, volume, or energy (e.g. tCO_2e/tonne, tCO_2e/barrel, tCO_2e/TJ). These factors are found in API (2009), EPA (2014), and IPCC (2006a). Product non-energy use sequestration fractions and oxidation factors are sourced from national submissions to the UNFCCC (2016) '*Common Reporting Format'* and IPCC (2006a) respectively. Proportion fossil fuel products used in non-energy applications is informed from IEA (2016) statistical energy balances.

Scope 1 related emissions from venting, flaring, and fugitives is informed from UNFCCC (2016) and IPCC (2006). Typical Scope 1 emission factors relating to energy use in oil extraction are informed by the *'OPGEE'* model of the Oil Climate Index of the Carnegie Endowment for International Peace (CEIP 2014). Further information is sourced to determine Scope 1 emissions between different forms of oil (CEIP 2014 and IHS CERA 2012). Factors relating to energy related Scope 1 emissions from coal mining are distinguished for underground and surface mining, and are sourced from IPCC (2006a) and TIAX LLC (2007).

For comparison with global-level emissions, industrial emissions information was sourced from the Carbon Dioxide Information Analysis Center (CDIAC), the International Energy Agency (IEA), the Emission Database for Global Atmospheric Research (EDGAR), and other supplementary sources (CDIAC 2016a, CDIAC 2016b, IEA 2017, European Commission 2017, BP 2016, EIA 2017).

In the threshold assessments for potential entrants to the Carbon Majors Database, production data was collected from annual company filings and datasets from the Oil & Gas Journal (OGJ 1986-2016), Bloomberg (BB 2016), and GlobalData (GD 2016).

[5] For more information on the method used to estimate net production from these state companies refer to Heede (2014a)

3 Boundaries

Boundaries should be recognized to conform with corporate standards of emissions accounting, group companies, and give context to aggregated figures.

3.1 Organizational

Organizational boundaries refer to assets that fall inside the company inventory boundary and the attribution of emissions from those assets to the company. Company operations are variable in their legal and operational structures. Company operations may be wholly owned, incorporated or non-incorporated, joint ventures, subsidiaries, and so on. Consolidation of corporate GHG emissions is broadly split into three categories: equity share, operational control financial control. Most fossil fuel companies report on an operational control basis.

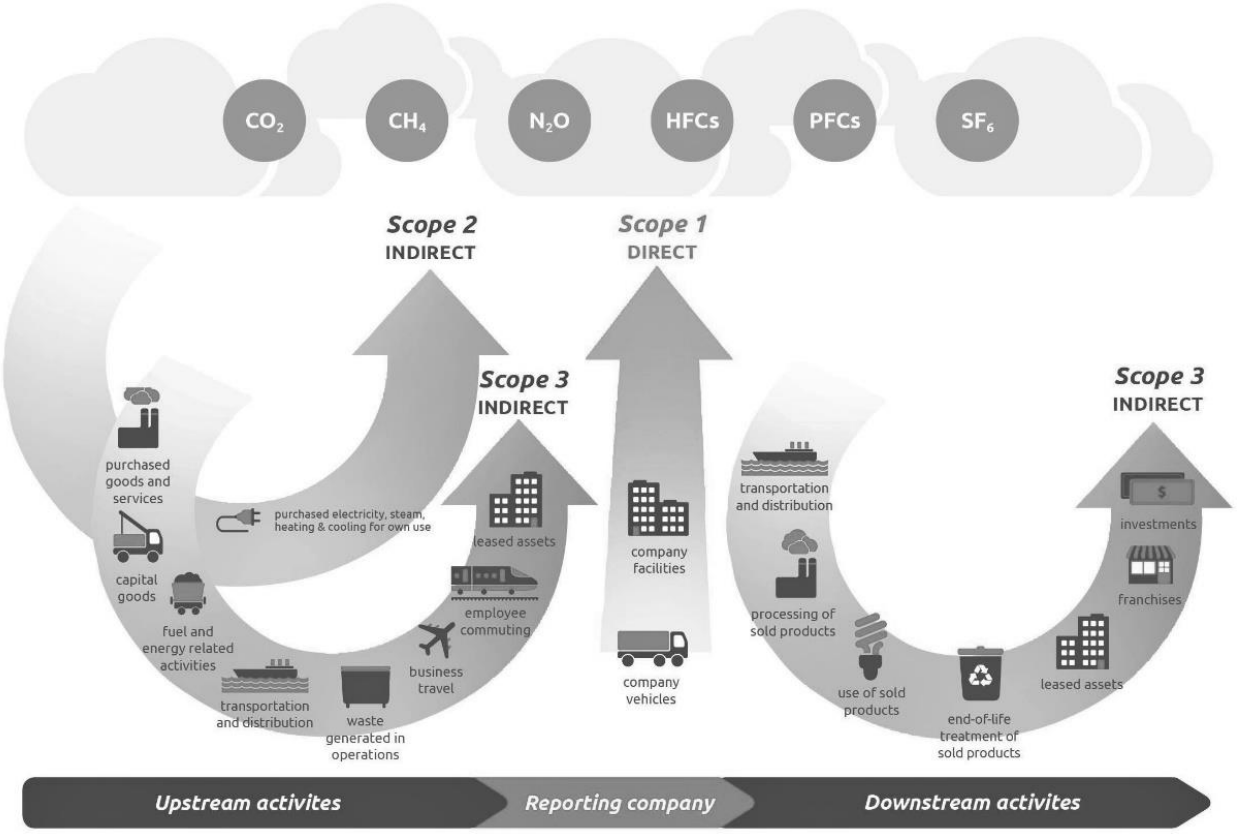

Figure 1: Value chain representation of company emissions (WRI/WBCSD 2011)

3.2 Operational

Operational boundaries refer to emission scopes and are categorized as direct or indirect relative to the organizational boundary. Emissions are categorized according to the *'Greenhouse Gas Protocol'* of the World Resources Institute and the World Business Council for Sustainable Development (WRI/WBCSD 2004, 2011). As illustrated in Figure 1, categories include direct company emissions (Scope 1), indirect emissions deriving from purchased energy carriers such as electricity (Scope 2), and value chain emissions (Scope 3). Scope 3 comprises 15 distinct categories of which Category 11 'use of sold products' typically accounts for over 90% of total (Scope 1+2+3) fossil fuel company emissions. To avoid double counting between companies, this project defines company emissions as the sum of Scope 1 and Scope 3 category 11, where Scope 1 covers only upstream activities associated with the extraction and production of fossil

fuels. Some of a company's own fuel use for extraction may be purchased from other companies, however the amount is assumed insignificant as this is more often a consumption of own production.

3.3 Global emissions

The principle boundary used for contextualizing fossil fuel emissions in the Database is 'industrial global greenhouse gas emissions'. Industrial greenhouse gas emissions include all anthropogenic greenhouse gasses except carbon dioxide relating to land-use change, and methane deriving from farming, landfills, and other non-industrial sources. Industrial sources of greenhouse gas unrelated to fossil fuels include: carbon dioxide from the processing of limestone in the cement sector and other industrial product- or process-related methane, nitrous oxide and F-gases. Fossil fuel related emissions account for about 90% of global industrial greenhouse gas emissions, and over 70% of total global anthropogenic emissions (CDIAC 2016a, CDIAC 2016b, IEA 2017, European Commission 2017, BP 2016, EIA 2017).

3.4 Company classification

Three broad definitions of entity are defined: Investor-owned company, State-owned company, State producer. Investor-owned company is broken down into public and private. Most classification undertaken is based on percentage ownership of ownership sources defined by Bloomberg (BB 2016). Sources of state-ownership include: Government and sovereign wealth fund. A public investor-ownership is defined after excluding private sources of investor-ownership. Sources of investor-ownership treated as private include: Individuals, venture capital, private equity firms, holding companies, insurance companies, and corporations. Companies not listed are identified through their website or other online sources. Though classification is on a majority basis, emissions are allocated in proportion to the percentage of investment from each ownership classification. The remaining entity, State producer, is represented by national production and includes 7 coal producing nations. Of these, Russia and China may be broken up further but lack of available data over time has prevented doing this outside of the 2015 Sample.

4 Methodology

The generalized methodological approach to estimating emissions is detailed in the IPCC (2006b) '*Guidelines for National Greenhouse Gas Inventories'* and is described by Equation (1). This equation expresses that activity data (e.g. barrels of production) is multiplied by a factor that has emissions specific to that activity (e.g. tonnes of CO_2e per barrel). There are often many activities and emission factors underpinning the estimation of a single company's emissions.

$$Emissions = Activity\ data \bullet Emission\ factor \quad (1)$$

The level of methodological complexity described in the guidelines is represented by three tiers: tier 1 (basic), tier 2 (intermediate), and tier 3 (advanced). Tier 1 is generally designed for the application of readily available, or aggregate, company activity data with default emission factors (e.g. IPCC 2006a). The estimation methodology used here can therefore be described as having tier 1 complexity.

4.1 Oil and gas emission estimation[6]

The calculation of Scope 1 emissions from oil and gas companies is described by Equation 2, where $E_{S1\text{-}OG}$ is oil and gas Scope 1 emissions, *EF* is emission factor, *P* is gross production, and subscripts fCO_2, fCH_4, *v*, *fl*, eS_1, and *p* denote fugitive carbon dioxide, fugitive methane, venting, flaring, Scope 1 energy, and hydrocarbon product respectively.

$$E_{S1\text{-}OG} = \sum_{p} \left(EF_{fCO_2\text{-}p} + EF_{fCH_4\text{-}p} + EF_{v\text{-}p} + EF_{fl\text{-}p} + EF_{eS1\text{-}p}\right) \bullet P_p \quad (2)$$

Because Scope 1 emissions are operational emissions, they relate to gross production. Gross production is commonly reported in company filings as deductions from reserves. In the case of gas, own consumption is estimated to be 3% the amount of net gas production on average. If gross gas production data is not available, it is calculated as the sum of net production and own use. Hydrocarbon products reported include: oil sands, bitumen, synthetic oil, heavy crude oil, crude oil, light crude oil, condensate, natural gas liquids (NGL), and natural gas. Where companies group liquids together in their reporting, proprietary production and field data is used to inform a split (GD 2016).

The difference in Scope 1 intensity between unconventional oils and conventional oils is informed by CEIP (2014) and IHS CERA (2012). The ratio of unconventional to conventional Scope 1 intensity is the defined here as the oil form factor (F) and is estimated at 2.1, where unconventional is represented by the average of a sample of US and Canadian oil sands. Equation 3 describes the calculation converting oil Scope 1 emissions ($E_{S1\text{-}O}$) to unconventional oil Scope 1 emissions ($E_{S1\text{-}UO}$) using this factor.

$$E_{S1\text{-}UO} = E_{S1\text{-}O} \bullet F \quad (3)$$

Methane is converted to carbon dioxide equivalent using a global warming potential[7] (GWP) factor of 28 (IPCC 2014, WRI/WBCSD 2016). This factor is for 100 years radiative forcing excluding climate feedbacks. The inclusion of climate feedbacks for methane is under review.

[6] For more detail on scope 3, including how to define it for integrated extraction and refining companies, see CDP's 'Guidance methodology for estimation of scope 3 category 11 emissions for oil and gas companies'.

[7] Most companies reporting to CDP use the outdated GWP factor 25, our next release will correct for this discrepancy.

The calculation of Scope 3 emissions from oil and gas companies is described by Equation 4, where $E_{S3.11\text{-}OG}$ is oil and gas Scope 3 category 11 emissions, *EF* is emission factor, *EO* is the effective oxidation rate, *P* is net production, and subscript *p* denotes hydrocarbon product.

$$E_{S3.11\text{-}OG} = \sum_{p} EF_p \bullet EO_p \bullet P_p \quad (4)$$

Net production is production that is net of losses, stock-changes, self-consumption, and royalties or entitlements to third parties. These deductions are independent of the company's organizational boundary[8]. Net production is chosen to represent Scope 3 category 11 'use of sold products' because sales data reported by companies can often include flows between entities inside the organizational boundary, which would lead to double counting.

Hydrocarbon products are not completely oxidized over their lifetime. Imperfect combustion is accounted for by the product's oxidation factor (OF), which is typically between 0.99 and 1. The OF is applied to the fraction of a product amount that is used for energy purposes. Within the non-energy use (NEU) fraction of a product amount, a proportion of carbon is expected to be sequestered. This proportion is accounted for by the product's storage factor (SF). Together these factors amount to a product's effective oxidation rate (EO). The EO is defined here as the ultimate proportion of a product that is emitted over its lifetime. Average global EO is about 0.9 for oil, 0.99 for gas, and 0.985 for coal. Equation 5 describes the calculation of EO using the factors described above, where *p* is the hydrocarbon product.

$$EO_p = OF_p \bullet (1 - NEU_p) + NEU_p \bullet (1 - SF_p) \quad (5)$$

4.2 Coal emission estimation[9]

The calculation of Scope 1 emissions from coal mining companies is described by Equation 6, where $E_{S1\text{-}C}$ is coal Scope 1 emissions, *EF* is emission factor, *P* is gross production, and subscripts fCO_2, fCH_4, *v*, *fl*, eS_1, and *m* denote fugitive carbon dioxide, fugitive methane, venting, flaring, Scope 1 energy, and mine type respectively.

$$E_{S1\text{-}C} = \sum_{m} (EF_{fCO_2\text{-}m} + EF_{fCH_4\text{-}m} + EF_{eS1\text{-}m}) \bullet P_m \quad (6)$$

Gross production of coal refers to the production of raw coal, or run-of-mine production. If this figure is not available, 5% on the net, or saleable, production of coal is added to represent gross production. Mine type can be underground or surface. There are significantly higher fugitives and energy demands associated with underground mines, which is why the activity data is split in this way.

The calculation of Scope 3 emissions from coal mining companies is described by Equation 7, where $E_{S3.11\text{-}C}$ is coal Scope 3 category 11 emissions, EF^e is the energy emission factor, HV is the heating value, *EO* is the effective oxidation rate, *P* is net production, and subscript *p* denotes coal product.

$$E_{S3.11\text{-}C} = \sum_{p} EF_p^e \bullet HV_p \bullet EO_p \bullet P_p \quad (7)$$

[8] Organizational boundary is commonly reported as either equity share, operational control, financial control.
[9] For more detail on scope 3, see CDP's 'Guidance methodology for estimation of scope 3 category 11 emissions for coal mining companies'.

Coal products are split by their grade or application field and include: anthracite, bituminous, subbituminous, lignite, metallurgical/coking, thermal. In contrast to Equation 4, the heating (calorific) value of the company's coal is sought and used in combination with emissions factors specific to energy. This approach is possible because coal companies commonly report heating value. This computation is more accurate because coal energy content has a stronger correlation with its carbon content, and therefore emissions, than has its mass. If heating value data is unavailable, then the calculation for coal Scope 3 category 11 emissions is analogous to Equation 4.

It is common for coal production data in the US to be given in short tons, as opposed to metric tons ('tonnes'). Furthermore, depending on the source, energy content can either be a 'higher heating value' (HHV) or a 'lower heating value' (LHV). To ensure alignment with emission factors, short tons are converted to tonnes with 1.1023 short tons to the tonne, and LHV is converted to HHV where LHV/HHV for coal is 0.95.

4.3 Threshold assessment

A new threshold assessment was undertaken to create a shortlist of potential oil and gas company entrants to the Carbon Majors Database. With this assessment, it was also possible to create a complete ranking of the top oil and gas companies by their emissions in 2015. The following procedure was undertaken for this assessment:

1. Collect historical production data from annual company filings and supplement with datasets including the Oil & Gas Journal (OGJ 1986-2016), Bloomberg (BB 2016), and GlobalData (GD 2016);
2. Identify historical mergers and acquisitions to attribute obsolete companies to extant;
3. Where there are gaps in emissions data over the period from 1988, interpolate from the most historical year of data (e.g. 2005) to the company's year of first extraction (e.g. 1978) and assume production is negligible in this year;
4. Where information is duplicated between sources, prioritize with the order: company filings, Bloomberg, Oil & Gas Journal, and GlobalData (noting that Bloomberg and the OGJ also source data from company filings);
5. Estimate cumulative Scope 1+3 emissions over the period 1988-2015;
6. For the 2015 Sample, repeat steps 1 and 4.

For coal companies, company filings and Bloomberg (BB 2016) were used with the largest coal companies each investigated for historical activities. Production in 2015 from the largest Chinese coal company groups was sourced from sxcoal (2016), but it was not possible to cover a reasonable period of years. The largest Russian coal companies were identified from analyses in company reports of SUEK (2017) and Mechel (SEC 2016). Historical data was collected for some of these companies but a wider reaching search will be required to fill data gaps.

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