The Carbon Majors Database

Dataset 1.0 Methodology and Results

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Summary

Just 8 companies account for over a third of emissions from oil and gas since the world acknowledged man-made climate change.

CDP's new Carbon Majors dataset contains historical emissions data from 50 of the world's largest oil and gas producers (Figure 1). Since the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988, three quarters of greenhouse gas emissions from oil and gas can be traced to these companies, and over a third is linked to just 8 companies: Saudi Aramco, Gazprom, National Iranian Oil, ExxonMobil, Pemex, BP, PetroChina and Royal Dutch Shell.

The Carbon Majors Database was originally constructed by Richard Heede of the Climate Accountability Institute. It covers coal, oil and gas, and cement company emissions dating back to 1854. In this version, CDP has updated oil and gas company emissions to 2015 and widened the sample of companies to rank the largest emitting oil and gas companies of 2015. The next version will provide a complete ranking of fossil fuel companies, including coal.

Greenhouse gas emissions of this scale have traditionally been analyzed at the level of nation states. In fact, they can be traced upstream to a smaller group of commercial decision-makers. Therefore, this dataset highlights the central role that corporations can play in driving the transition away from fossil fuels and towards a low-carbon energy system.

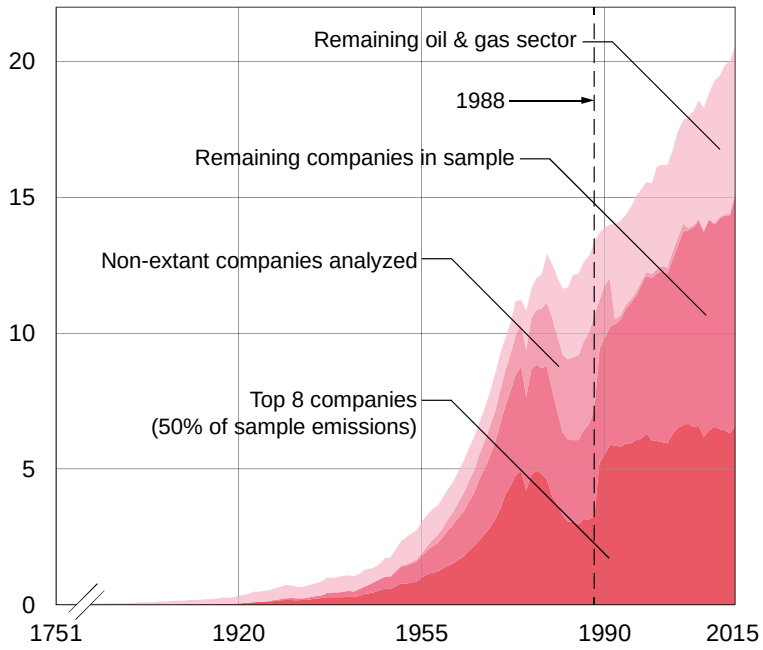

Figure 1. Historical greenhouse gas emissions of oil and gas majors, $GtCO_2e$

Share of gas is increasing but product emissions intensity remains over twice the amount needed to avoid dangerous climate change.

Well over half of greenhouse gases emitted from oil and gas since the industrial revolution have occurred after the world officially acknowledged anthropogenic climate change (Figure 2). Notwithstanding this, the proportion of natural gas in oil and gas production from the 50 companies assessed has been slowly increasing in recent times. Because natural gas is a cleaner fossil fuel than oil, this increase has equated to a reduction in overall product emissions intensity. However there is a long way to go; intensity is still more than double that of the IEA's two degree (2DS) primary energy scenario in 2050.

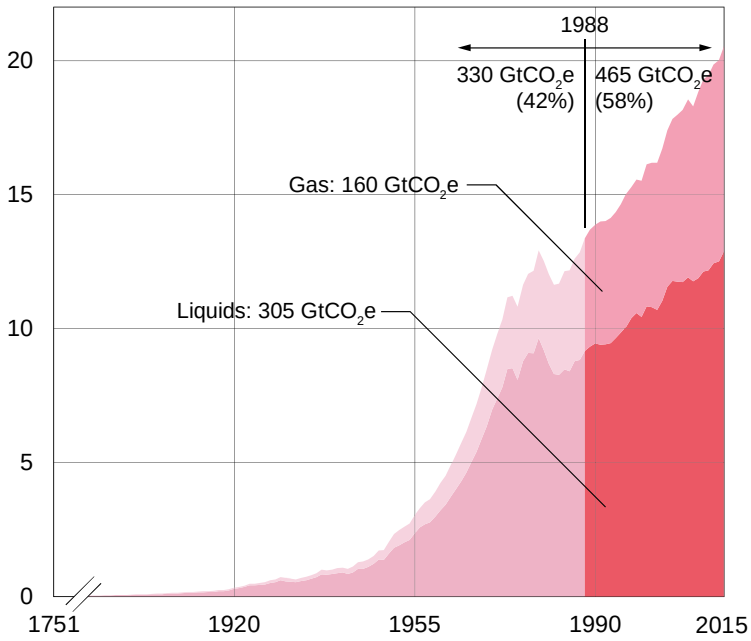

Figure 2. Historical greenhouse gas emissions from oil and gas production, $GtCO_2e$

Of the 50 companies assessed, about half are investor influenced and half are state entities. Figure 3 shows the product split and emissions intensity of the 26 investor companies analyzed. There exists a varied range in product mix over the sample, with the less intensive companies demonstrating the viability of producing higher proportions of gas.

The Paris Agreement highlighted the role of non-state actors in the road to two degrees and the Carbon Majors dataset, in which emissions may be viewed through the lens of historical accountability, further underlines their role. As we move towards 2050, oil and gas companies will need to demonstrate diversification into other sources of primary energy, such as renewables. The most recent CDP Investor Report 'In the Pipeline'[1] analyzed which publicly listed companies are best placed to transition and minimize carbon risk.

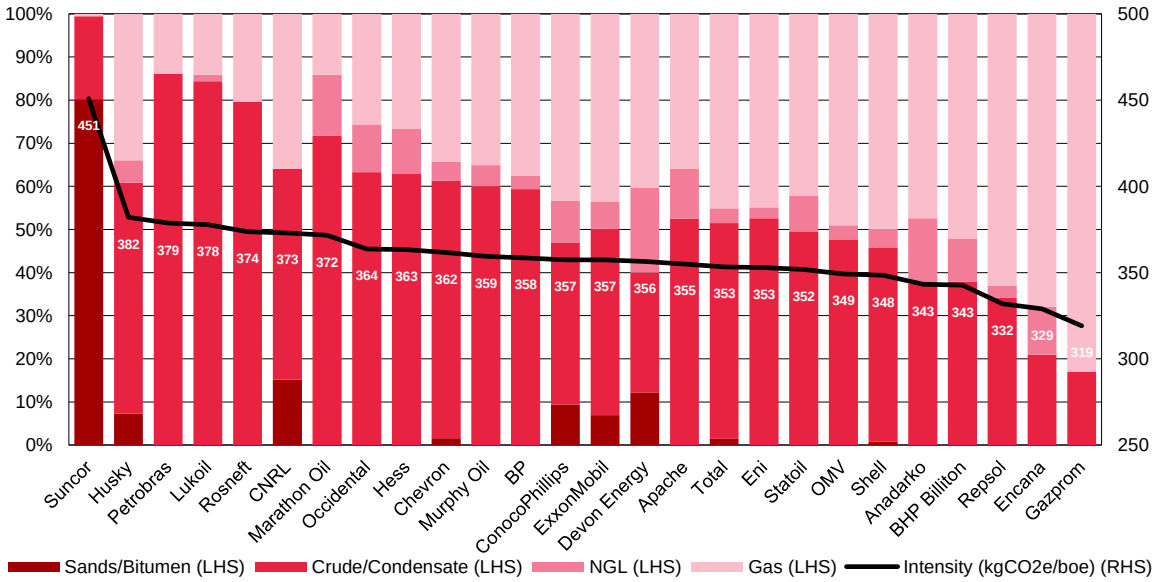

Figure 3. Product emissions intensity of publicly listed oil and gas majors in 2015

[1] This report can be accessed from CDP at cdp.net/en/investor/sector-research

1 Introduction

The Carbon Majors Database houses annual emissions data concerning the largest greenhouse gas emitting companies since the dawn of the industrial revolution. It originally contained 90 companies engaged in coal, oil and gas, and cement production dating back to 1854. These investor-owned, state-owned and government-run organizations have contributed about two thirds of total historical industrial carbon dioxide and methane emissions worldwide.

The original Database[2] was built by Richard Heede (2014a, 2014b) of the Climate Accountability Institute. CDP are committed to keeping the database is securely stored, updated, and accessible to the public. This report lays out the results and methodology behind its first update: Dataset 1.0.

Dataset 1.0 is focused on the oil and gas sector since 1988. This was the year in which the IPCC was established and after which prominent scientists had stated publicly the significance of anthropogenic climate change. Accompanying this report is an Excel workbook 'Carbon Majors Dataset 1.0', which contains the following information:

- Direct operational (Scope 1) and product (Scope 3) emissions over the period 1988-2015 of 50 extant oil and gas producing companies
- Top 50 list of oil and gas 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. Dataset 2.0 will be released later this year and include a wider sample of companies and emissions from coal production. It is intended that the data will support analyses in the three spheres of academia, policy, and investment.

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 oil and gas extraction, then the reported figure is used and calculation data is not required (CDP 2016).

Oil and gas production data is principally obtained from publicly available sources: annual reports from company websites and the US Securities Exchange Commission (SEC 2016). For some state-owned enterprises, data is sourced from the OGJ lists of the *'Oil & Gas Journal'* (OGJ 1986-2016) or is estimated[3] from national statistics (EIA 2017, BP 2016, and OPEC 2016). For a small number of companies, information from proprietary database *'Global Data Oil & Gas Upstream Analytics'* (GD 2016) is used to improve production granularity.

Scope 3 emission factors of hydrocarbon liquids and gases are presented in different 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). Venting, flaring, and fugitive emission and oxidation factors are sourced from national submissions to the UNFCCC (2016) '*Common Reporting Format'* and IPCC (2006a). Typical Scope 1 emission factors relating to energy use 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).

For comparison with global level emissions, industrial emissions information was sourced from the Carbon Dioxide Information Analysis Center (CDIAC) and other supplementary sources (CDIAC 2016a, CDIAC 2016b, BP 2016, EIA 2017, IEA 2017, European Commission 2017).

[2] Original activity data 1854-2010 and methodology can be found at carbonmajors.org
[3] For more information on the method used to estimate net production from these state companies refer to Heede (2014a)

In the threshold assessment for potential entrants to the Carbon Majors Database, liquids and gas 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).

3 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.

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). 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 sold products' typically accounts for over 90% of total (Scope 1+2+3) oil and gas company emissions. To avoid double counting between companies, this project defines company emissions as the sum of Scope 1 and Scope 3 category 11. Some of a company's own fuel use for extraction may be purchased from other companies, however this is amount is assumed insignificant.

3.1 Oil and gas emission estimation[4]

The calculation of Scope 1 emissions from oil and gas companies is described by Equation (2), where E_{S1} is 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.

$$E_{S1} = \sum_{p=1}^{N} \left(EF_{fCO_2\text{-}p} + EF_{fCH_4\text{-}p} + EF_{v\text{-}p} + EF_{fl\text{-}p} + EF_{eS1\text{-}p}\right) \bullet P_p \quad (2)$$

Because Scope 1 emissions are operational emissions, they relate to gross production. Gross production is commonly reported in company filings as deductions from reserves. 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 of unconventional oil Scope 1 emissions ($E_{S1\text{-}U}$) using this factor.

[4] 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'.

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

Methane is converted to carbon dioxide equivalent using a global warming potential[5] (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.

The calculation of Scope 3 emissions from oil and gas companies is described by Equation (4), where $E_{S3.11}$ is 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.

$$E_{S3.11} = \sum_{p=1}^{N} EF_p \bullet EO_p \bullet P_p \quad (4)$$

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[6]. 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.

Oil and gas 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 and 0.99 for gas. Equation (5) describes the calculation of EO using the factors described above, where *p* is the hydrocarbon product.

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

3.2 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 50 oil and gas companies by their emissions in 2015. The following procedure was undertaken for this assessment:

- 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);
- Identify historical mergers and acquisitions to attributed obsolete companies to extant;
- 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;
- Where information is duplicated between sources, prioritize with the order: company filings, Oil & Gas Journal, Bloomberg, and GlobalData;
- Estimate cumulative Scope 1+3 emissions over the period 1988-2015, and in 2015 for the 2015 list, and rank.

[5] Most companies reporting to CDP use the outdated GWP factor 25, our next release will correct for this discrepancy.
[6] Organizational boundary is commonly reported as either equity share, operational control, financial control.

4 Results

Shown in Table 1 are the cumulative Scope 1+3 emissions from oil and gas extraction over the study period. Total emissions from the sample are 343 $GtCO_2e$. This is three quarters of the 465 $GtCO_2e$ arising from the sector during that time, and more than the 330 $GtCO_2e$ emitted by the sector in all years prior. Of global industrial[7] emissions over the period (832 $GtCO_2e$), the sample accounts for about 40%. Emissions from state companies are two thirds of the sample total and half of sector emissions, whereas investor influenced emissions make a third of the sample and a quarter of sector emissions.

Rank	Company	Allocated ownership status[8]	Scope 1+3 emissions 1988-2015, $GtCO_2e$	Of sector emissions 1988-2015	Of global industrial emissions 1988-2015
1	Saudi Arabian Oil Company (Aramco)	State	40.0	8.6%	4.8%
2	Gazprom OAO	Mixed	35.3	7.6%	4.2%
3	National Iranian Oil Co	State	19.4	4.2%	2.3%
4	ExxonMobil Corp	Investor	17.3	3.7%	2.1%
5	Petroleos Mexicanos (Pemex)	State	17.0	3.7%	2.0%
6	Royal Dutch Shell PLC	Investor	15.0	3.2%	1.8%
7	BP PLC	Investor	13.8	3.0%	1.7%
8	China National Petroleum Corp (PetroChina)	State	13.6	2.9%	1.6%
9	Chevron Corp	Investor	11.9	2.6%	1.4%
10	Petroleos de Venezuela SA (PDVSA)	State	10.6	2.3%	1.3%
11	Abu Dhabi National Oil Co	State	10.3	2.2%	1.2%
12	Kuwait Petroleum Corp	State	8.7	1.9%	1.0%
13	Total SA	Investor	8.6	1.9%	1.0%
14	Sonatrach SPA	State	8.4	1.8%	1.0%
15	ConocoPhillips	Investor	8.4	1.8%	1.0%
16	Petroleo Brasileiro SA (Petrobras)	Mixed	7.0	1.5%	0.8%
17	Nigerian National Petroleum Corp	State	6.2	1.3%	0.7%
18	Petroliam Nasional Berhad (Petronas)	State	5.7	1.2%	0.7%
19	Rosneft OAO	Mixed	5.7	1.2%	0.7%
20	Lukoil OAO	Mixed	5.7	1.2%	0.7%
21	Eni SPA	Mixed	5.4	1.2%	0.6%
22	Iraq National Oil Co	State	5.2	1.1%	0.6%
23	Statoil ASA	Mixed	4.8	1.0%	0.6%
24	Qatar Petroleum Corp	State	4.7	1.0%	0.6%
25	PT Pertamina	State	4.6	1.0%	0.6%
-	Other 25 companies	-	50	10.7%	6.0%
-	Total	-	343	74%	41%
-	Of which are State owned	-	227	49%	27%
-	Of which are Investor owned	-	116	25%	14%

Table 1. Top 25 Oil and Gas companies ranked by cumulative oil and gas related emissions, 1988-2015

Figure 4 shows sector and sample emissions over time. Such is the degree of production growth since 1988, the 50 companies analyzed have emitted more than the entire oil and gas sector in all the years prior to 1988. Though there has been a trend towards higher natural gas as a proportion of oil and gas production, the effect on product emissions intensity is marginal at this stage. Furthermore, the change may be unrelated to company commitments to reduce greenhouse gas emissions. Median product intensity of the sample in 2015 is 357 $ktCO_2e$/boe, which is more than double the 154 $ktCO_2e$/boe associated with the global mix of primary energy supply in 2050 under the IEA (2016) 2DS scenario.

[7] This excludes greenhouse gases from agriculture and deforestation.
[8] Where there is evidence of shared influence from state and investors over a company, the company is classified here as 'mixed' and emissions are allocated to according to percentage ownership.

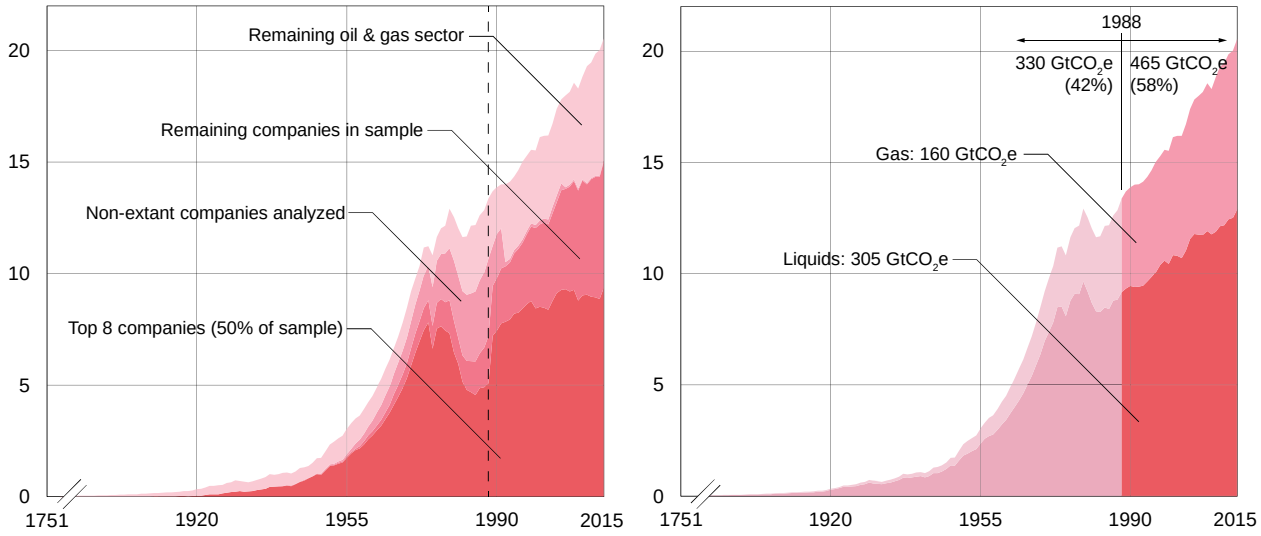

Figure 4. Historical greenhouse gas emissions from oil and gas production, $GtCO_2e$

Resulting from the threshold analysis undertaken for the sector, a short list of ten potential entrants to the Carbon Majors Database is displayed in Table 2. If all of these are included in the the next dataset, then approximately 90% of oil and gas sector emissions since 1988 will be represented. Other companies worth mentioning include Dubai Petroleum Co, EOG Resources Inc, Naftogaz of Ukraine, BASF SE, PTT E&P Co Ltd, and Chesapeake Energy Corp. Ten of the sixteen companies highlighted here appear in the top 50 list of 2015.

Name	Country	Established[9]	Ownership Status
Surgutneftegas OAO	Russia	1993	Mixed
Petoro AS[10]	Norway	2001	State
YPF SA	Argentina	1922	State
Petroleos del Ecuador	Ecuador	1989	State
KazMunayGas	Kazakhstan	2002	State
Inpex Corporation	Japan	1966	Investor
TurkmenGaz	Turkmenistan	1997	State
A.P. Moller - Maersk	Denmark	1904	Investor
Novatek OAO	Russia	1994	Mixed
Tatneft OAO	Russia	2000	Mixed

Table 2. Shortlist of potential entrants to the Carbon Majors Database

[9] Emissions that are historical to this year could potentially be attributed to the present entity. For example, KazMunayGas was formed in 2002 from a merger of Kazakhoil and Oil & Gas Transportation.
[10] Petoro AS manages Norway's Government portfolio and does not operate or directly own licences to any oil fields. They are considered here as representative of production (excluding Statoil) under ownership of the Norwegian Government.

5 Next steps

Dataset 1.0 is the first output of a continuing commitment to maintain and maximize the usefulness of the Carbon Majors Database to academics, policy analysts and investors. Feedback from stakeholders within these spheres is welcomed and may be submitted to the corresponding author. As of this time the following next steps are in the pipeline:

- Include enough companies to represent 90% of oil and gas sector emissions since 1988;
- Conduct a new threshold analysis of coal producers for potential new entrants;
- Cover all fossil fuels by incorporating emissions from coal producers since 1988;
- Review cement companies for inclusion.

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