

Supplementary materials

Richard Heede “Tracing anthropogenic CO₂ and methane....” *Climatic Change*, doi:10.1007/s10584-013-0986-y

METHODOLOGY

An initial threshold of ≥ 8 MtC/y was established for inclusion as a “carbon major” when this project started in 2005, yielding a list of 90 entities (not all entities met this threshold in 2010). The 8 MtC/y threshold was established in order to have a manageable number of entities—not too many, and not too few—capturing the principal entities but leaving out thousands of fossil fuel and cement companies operating around the world. Of these entities, 56 are oil & natural gas companies, 37 are coal producers (including coal subsidiaries of oil and gas companies), and 7 are cement producers. Fifty entities are investor-owned companies (including one privately-held company), 31 are state-owned enterprises, and 9 are current or former centrally planned states (Soviet Union, Russian Federation, China, Kazakhstan, Poland, Ukraine, Czechoslovakia, Czech Republic, and North Korea). Complete production histories were sought for each entity from its incorporation through 2010. In practice, these are often unavailable for the earliest years of an entity’s existence, or are available for oil production but not for natural gas. Production data gaps between reported years are interpolated.

Data sources

Annual production data on crude oil and natural gas liquids (NGLs), natural gas, coal, and cement were gathered from company annual reports, or were supplemented with data from company 10-K filings with the Securities and Exchange Commission, company histories (Bamberg 1994; Gibb & Knowlton 1956; Hidy & Hidy 1956; Howarth 1997), entity websites, annual compilations (e.g., *Oil & Gas Journal’s* OGI100 & OGI150), trade journals, publications from many nation-state governments, international agencies, and numerous other sources (Victor et al. 2012; World Bank 2008; Marcel 2006).

Net and gross production

Net or equity oil production (which excludes royalty or production due joint venture partners), and “natural gas available for sale,” and “produced coal” is used where such data is reported. In some cases the preferred data is not available; it was common practice by major oil companies to only report gross production of crude oil from the late 1950s to the early 1970s. This source of potential over-reporting was corrected by applying a net-to-gross ratio to gross production in order to estimate net production.

Acquisitions and divestitures

Historic production from major mergers and acquisitions are attributed to the extant acquiring entity. For example, Chevron is attributed the historic fossil fuel production of Unocal (acquired in 2005), and Texaco (merged in 2001), and the earlier acquisition of Mission, Skelly, Gulf, Getty, and SoCal by either Chevron or Texaco. Divestitures and disposition of assets: unlike acquisitions (in which production data for the acquired entity is not retroactively added to company-reported production in prior annual reports), if a company divests producing assets or subsidiaries, the subsequent annual reports will reflect the disposition of production assets.

Completeness

Production records are thus seldom complete but do capture the preponderance of annual oil, natural gas, and coal extraction for the carbon major companies. The U.S. DOE’s Oak Ridge National Laboratory Carbon Dioxide Information Analysis Center (CDIAC) has estimated cumulative industrial CO₂ emissions of 1,336 GtCO₂ dating back to 1751 (Marland et al. 2011). Global emissions between 1751 and 1930 are 10.4 percent of cumulative emissions to 2010 (Figure 1). From 1930 onwards fuel production data is relatively complete, and the lack of earlier data represents only a minor source of under-reporting.

Reporting units

Company production is reported in physical units—bbl of liquids, cubic feet of natural gas, and tonnes of coal—rather than in energy units. This complicates the process of estimating eventual emissions, particularly for coal, since carbon content and therefore emissions from the combustion of a tonne of coal is highly dependent on coal rank (see Supplementary Table 1); carbon content per unit of calorific heating value is better constrained. Coal rank, heating values, and mining method is noted when reported and applied to each coal entity’s worksheet. A generic term—such as “thermal coal” or “metallurgical coal”—is often reported by coal companies, in which cases the average carbon content for utility and industrial boiler coal and for coal prepared as coke for steelmaking are used. IPCC emission factors are used for fuel combustion emission estimates (IPCC 2006).

Supplementary Table 1. Combustion emissions factors

| Energy source | Carbon tC/unit | Carbon dioxide tCO ₂ /unit |
|----------------------|-------------------|--|
| Crude oil & NGLs | 101.4 kgC/bbl | 371.4 kgCO ₂ /bbl |
| Natural gas | 14.6 kgC/kcf | 53.4 kgCO ₂ /kcf |
| Lignite | 328.4 kgC/tonne | 1,203.5 kgCO ₂ /t |
| Subbituminous | 495.2 kgC/t | 1,814.4 kgCO ₂ /t |
| Bituminous | 665.6 kgC/t | 2,439.0 kgCO ₂ /t |
| Anthracite | 715.6 kgC/t | 2,621.9 kgCO ₂ /t |
| “Metallurgical coal” | 727.6 kgC/t | 2,665.9 kgCO ₂ /t |
| “Thermal coal” | 581.1 kgC/t | 2,129.3 kgCO ₂ /t |

Crude oil: prior to non-energy deduction & adjustment for NGLs: 115.7 kgC/bbl, 423.8 kgCO₂/bbl;
Gas: prior to non-energy deduction: 14.86 kgC/kcf, or 54.44 kgCO₂/kcf; (kcf = thousand cubic feet).

Attributed emissions of CO₂ from combustion of produced and marketed hydrocarbon fuels

Each carbon major entity is attributed the combustion emissions from marketed fuels (net of non-energy uses) based on self-reported annual production of crude oil and NGLs, natural gas, and coal using IPCC carbon content and emission factors (IPCC 2006). Documented emission rates representative of industry and international data sources are used (U.S. EPA 2012b; IPCC 2006; United Nations 2012; IEA 2005).

Cement emissions

The seven cement manufacturers (six investor-owned companies in Japan, Switzerland, France, Germany, Italy, & Mexico, plus China) contributed process emissions (thus excluding fossil fuel energy inputs to kilns and power plants) from the calcining of limestone ($\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$). The dataset is for 1990 to 2010 only, except for China, for which production data is available from 1928 (U.S. Bureau of Mines data). Calcining emissions are derived from industry data published by the World Business Council for Sustainable Development’s Cement Sustainability Initiative (WBCSD 2011).

Non-energy uses

Since the objective is to estimate potential emissions based on fuel produced and marketed by upstream producers, the net non-energy uses of petroleum, natural gas, and coal must be subtracted. The most comprehensive data on fuel disposition (including non-energy uses and short-term re-emission of the carbon in non-energy materials to the atmosphere) is for the United States, where 14.1 percent of all crude oil and NGLs supplied was used for road oil and asphalt, petrochemical feedstocks, waxes, lubricants, and other non-energy uses averaged over 1980 to 2010 (U.S. EPA 2012a, 2012b).

Per IPCC protocol, short-term re-emission of non-energy products such as oxidation of lubricants and waste-to-energy combustion of plastics are accounted for in calculating the final net storage factor for crude oil and NGLs, which reduces the final carbon storage rate to 9.34 percent of oil supply. This study averages the U.S. final net carbon storage rate (9.34 percent) and the CDIAC factor for non-combusted liquids of 6.7 percent (applied to all liquids production 1870-2010; the CDIAC factor of 1.5 percent for

non-oxidation at burner tips, which IPCC *Guidelines* sets at zero, is ignored) (Marland et al. 2011; IPCC 2006; Marland & Rotty 1984; Heede 2013). This study applies a final carbon storage factor of 8.02 percent for all crude oil and NGL production by carbon major entities.

Non-energy uses of natural gas for methanol used in petrochemicals and for fertilizer production gives a net carbon storage rate of 1.86 percent (the EPA is reviewing and may lower the net storage rates for non-energy uses of natural gas); for coal (used in steel production, chemicals, and carbon fibers) the net carbon storage factor is 0.016 percent. The net carbon storage factors are incorporated into the combustion emission factors for each fuel (Supplementary Table 1).

Additional methane and carbon dioxide emissions

Factors for additional emission sources such as vented carbon dioxide, flaring, and fugitive CO₂ and methane are taken from the IPCC *Guidelines for National Inventories* (IPCC, 2006). However, it is my assessment that the IPCC default methane emission rates from oil and natural gas are too high, and I instead base emission rates on U.S methane rates from petroleum and natural gas systems (U.S. EPA 2006, 2012a, 2012b). All of these factors are compared to and corroborated by World Bank data on flaring, European Commission’s Joint Research Centre’s EDGAR methane emission estimates, CDIAC flaring and methane estimates, EPA data, and other sources (World Bank 2012; IPCC 2006; European Commission 2011; Marland et al 2011; U.S. EPA 2012b; Stern & Kaufmann 1998).

These additional emission sources are, in the parlance of corporate greenhouse gas inventories, Scope 1 sources such as direct emissions from upstream production, transportation, and processing facilities, CO₂ emissions from flaring, sour gas (chiefly CO₂) vented from processing of raw gas, and fugitive methane from oil and gas operations and coal mining. (Note: Scope 2 emissions are from purchased electricity and steam, and are excluded from this study, since the fuels used by electric utilities and co-generators are accounted for by the primary producers.)

Supplementary Table 2 details the ancillary CO₂ and methane emission rates derived for this study and applied as additional emission factors on the basis of each entity’s attributed emissions from produced fuels. These factors exclude consideration of entity use of its own produced fuels prior to marketing.

Supplementary Table 2. Emission factors for vented, flared, and fugitive carbon dioxide and methane

| Entity | Combustion kgCO ₂ /tCO ₂ | Flaring kgCO ₂ /tCO ₂ | Vented kgCO ₂ /tCO ₂ | Methane kgCH ₄ /tCO ₂ | Methane kgCO ₂ e/tCO ₂ | Total kgCO ₂ e/tCO ₂ |
|------------------|---|--|---|--|---|---|
| Crude oil & NGLs | 1,000 | 15.94 | 3.83 | 1.92 | 40.39 | 1,060.2 |
| Natural gas | 1,000 | 1.74 | 28.53 | 9.88 | 207.44 | 1,237.7 |
| Coal | 1,000 | ne | ne | 4.03 | 84.73 | 1,084.7 |

ne: not estimated; see text for discussion. Excludes own fuel use of 59.24 kg CO₂/tCO₂ (natural gas only).

Own fuel use

Oil and gas companies use of their own fuels (particularly natural gas) at production sites, offshore platforms, refineries, processing plants, chemical plants, and in pipelines is estimated based on my analysis of eleven oil and gas companies’ GHG inventories submitted to the Carbon Disclosure Project (CDP). These include BP, Chevron, ConocoPhillips, ENI, ExxonMobil, Hess, Pemex, Petrobras, Royal Dutch Shell, Statoil, and Total. This analysis indicates that use of company-produced fuels result in emissions of 4.8 percent (Hess) to 15.7 percent (ENI SpA) relative to emissions from the combustion of marketed products, or, in CDP terminology, “use of sold products.”

The average additional factor for the eleven companies analyzed is 5.9 percent of natural “gas available for sale,” since oil and gas companies produce more gas than is marketed (this gas is used for re-pressuring reservoirs, flared, or used in company operations). The 5.9 percent factor is conservative; the International Petroleum Industry Environmental Conservation Association estimates that 9.5 to 10 percent of

combined oil and gas production is used in the oil and gas supply chain (IPIECA 2011). The present study excludes industry use of its own petroleum products in ground vehicles, construction and maintenance equipment, product tankers, and crude oil and liquefied natural gas (LNG) carriers insofar as the carbon in the reported production of liquid fuels is already fully accounted for.

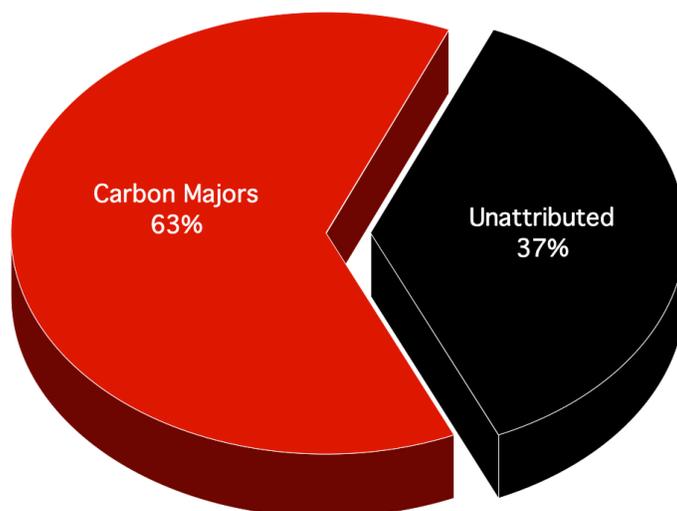
Cumulative and annual emissions

Cumulative emissions from marketed petroleum products, natural gas, and coal are summed for each entity. All oil companies also produce natural gas, and several multinational oil and gas companies have owned coal-producing assets or subsidiaries. Some oil and natural gas producers implicitly acknowledge the consequences of their products' intended ultimate use—their combustion in factories, airplanes, ships, vehicles, power plants, mines, and buildings—by estimating emissions from “use of sold products” under Scope 3 sources in materials submitted to the Carbon Disclosure Project.

Cumulative emissions attributed to the 90 carbon majors totals 914.3 GtCO₂e, equivalent to 63.0 percent of total industrial emissions since 1751 (Marland et al. 2011). Of total cumulative emissions attributed to 90 carbon majors, 815.4 GtCO₂ is from combustion of marketed oil, gas, and coal products, 13.2 GtCO₂ is from cement production (calcining emissions only), 6.0 GtCO₂ from flaring, 4.8 GtCO₂ from vented CO₂, 7.1 GtCO₂ from own fuel use, and 3.2 GtCH₄ (67.6 tCO₂e, at 21 x CO₂, 100-yr time horizon, per IPCC 1996) from fugitive methane from oil and natural gas systems and coal mines.

Of total emissions attributed to the 90 carbon majors for 2010 (27,946 MtCO₂e), 24,101 MtCO₂ is for combustion, 1,106 MtCO₂ cement, 144 MtCO₂ flaring, 155 MtCO₂ vented, 207 MtCO₂ from own fuel use, and 2,187 MtCO₂e fugitive methane from oil and natural gas systems and coal mines. Carbon majors emitted 78 percent of world industrial emissions of CO₂ and methane totaling 36,026 MtCO₂ in 2010 (Heede 2013).

Supplementary Fig. 1. Total historic CO₂ and CH₄ emissions attributed to Carbon Major entities as percent of global emissions 1751-2010.



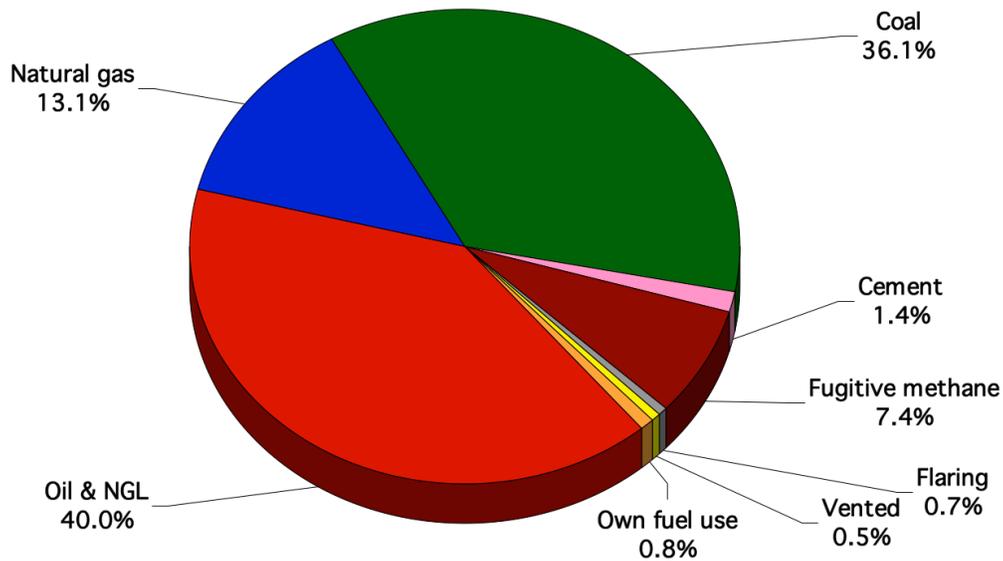
Global historic data from CDIAC, of which Carbon Majors contributed 63 percent (red), and emissions from all other entities (black) representing the hundreds of smaller producers of coal, oil, and gas as well as the many investor- or state-owned entities that are no longer extant, and thus not quantified.

Supplementary Table 3 summarizes cumulative emissions of carbon dioxide and methane attributed to all 90 carbon major entities from combustion of produced and marketed carbon fuels, from own fuel use, and vented, fugitive, and flared CO₂ and CH₄. Supplementary Tables 4, 5, and 6 detail 2010 and cumulative emissions attributed to the 50 investor-owned companies, 31 state-owned companies, and 9 nation-states included in the study, respectively.

Supplementary Figure 1 shows cumulative emissions from all sources of carbon dioxide and methane attributed to the 90 carbon major entities (63 percent) and the remaining unattributed (37 percent) from the hundreds of smaller producers of coal, oil, and gas as well as the many investor- or state-owned entities that are no longer extant, and thus not quantified. Supplementary Figure 2 shows the distribution of cumulative carbon major emissions by source. Supplementary Figure 3 shows the distribution of annual emissions by source from 1854 (the earliest production record) to 2010, and compares total emissions attributed to carbon majors to total global industrial emissions from 1850 to 2010.

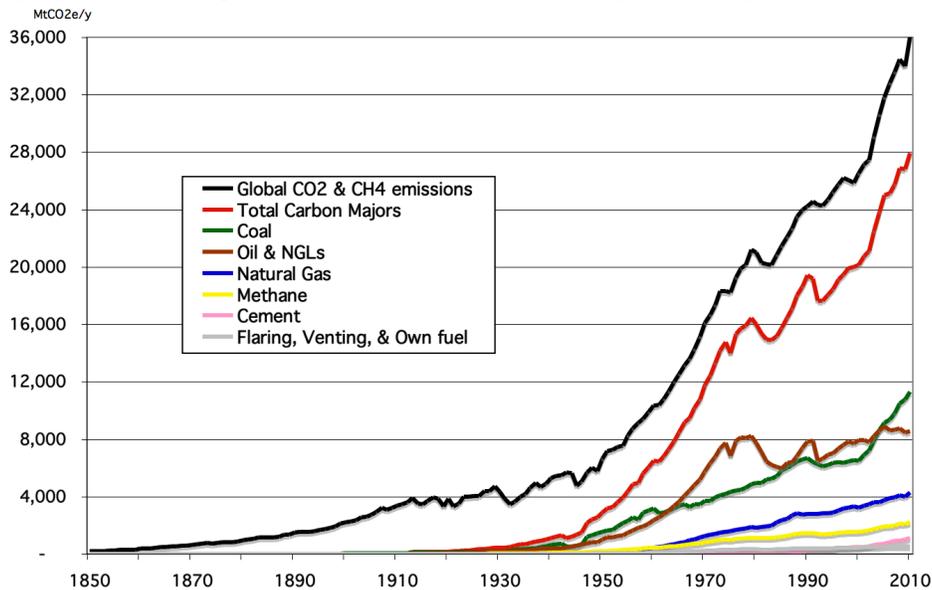
A full discussion of the methodology employed in this analysis is available in Heede 2013.

Supplementary Fig. 2. Cumulative CO₂ & CH₄ emissions attributed to Carbon Major entities by emission source.



Emission sources include combustion of marketed oil, natural gas, and coal products, cement production, own fuel use, vented CO₂, flared CO₂, and fugitive methane between 1854 and 2010.

Supplementary Fig. 3. Annual CO₂ & CH₄ emissions traced to carbon major entities by emission source, 1854 to 2010.



This chart compares emissions traced to all 90 carbon major entities by source to total global industrial emissions 1850-2010.

Supplementary Table 3. Cumulative emissions attributed to carbon major fossil fuel & cement producers, 1854-2010

| Entity | Production (fuels & cement) | Flaring, own fuel, vented CO ₂ | Fugitive methane | Total emissions | Percent of global 1751-2010 |
|---|--------------------------------|--|---------------------|---------------------|-----------------------------------|
| | GtCO ₂ | GtCO ₂ | GtCO ₂ e | GtCO ₂ e | |
| 1. Former Soviet Union,* (oil, gas, coal) | 116.88 | 2.31 | 10.53 | 129.72 | 8.94% |
| 2. China (coal & cement) | 115.11 | 0.00 | 8.98 | 124.09 | 8.56% |
| 3. ChevronTexaco, USA | 46.28 | 1.48 | 3.34 | 51.10 | 3.52% |
| 4. ExxonMobil, USA | 41.60 | 1.54 | 3.53 | 46.67 | 3.21% |
| 5. Saudi Aramco, Saudi Arabia | 42.82 | 1.03 | 2.18 | 46.03 | 3.17% |
| 6. BP, UK | 32.51 | 1.02 | 2.31 | 35.84 | 2.47% |
| 7. Gazprom, Russian Federation | 25.09 | 2.13 | 4.92 | 32.14 | 2.22% |
| 8. Royal Dutch Shell, The Netherlands | 27.57 | 0.99 | 2.19 | 30.75 | 2.12% |
| 9. National Iranian Oil Company | 26.71 | 0.76 | 1.62 | 29.08 | 2.01% |
| 10. Poland (coal) | 24.66 | 0.00 | 2.09 | 26.75 | 1.84% |
| 11. Pemex, Mexico | 18.14 | 0.59 | 1.29 | 20.03 | 1.38% |
| 12. British Coal Corp., UK * | 17.74 | 0.00 | 1.50 | 19.25 | 1.33% |
| 13. ConocoPhillips, USA | 14.70 | 0.67 | 1.50 | 16.87 | 1.16% |
| 14. Petroleos de Venezuela | 14.77 | 0.44 | 0.95 | 16.16 | 1.11% |
| 15. Coal India | 14.28 | 0.00 | 1.21 | 15.49 | 1.07% |
| 16. Peabody Energy, USA | 11.46 | 0.00 | 0.97 | 12.43 | 0.86% |
| 17. Total, France | 10.79 | 0.35 | 0.77 | 11.91 | 0.82% |
| 18. Russian Federation (coal) | 10.36 | 0.00 | 0.88 | 11.24 | 0.78% |
| 19. PetroChina, China | 9.67 | 0.28 | 0.61 | 10.56 | 0.73% |
| 20. Kuwait Petroleum Corp. | 9.80 | 0.23 | 0.48 | 10.50 | 0.72% |
| 21. Abu Dhabi NOC, UAE | 8.84 | 0.26 | 0.57 | 9.67 | 0.67% |
| 22. Sonatrach, Algeria | 7.96 | 0.40 | 0.91 | 9.26 | 0.64% |
| 23. Consol Energy, Inc., USA | 8.38 | 0.00 | 0.71 | 9.10 | 0.63% |
| 24. BHP Billiton, Australia | 6.97 | 0.06 | 0.58 | 7.61 | 0.52% |
| 25. Czechoslovakia, (coal) * | 6.77 | 0.00 | 0.57 | 7.35 | 0.51% |
| 26. Anglo American, UK | 6.68 | 0.00 | 0.57 | 7.24 | 0.50% |
| 27. Iraq National Oil Company | 6.70 | 0.14 | 0.29 | 7.14 | 0.49% |
| 28. RWE, Germany | 6.31 | 0.00 | 0.54 | 6.84 | 0.47% |
| 29. Pertamina, Indonesia | 6.16 | 0.21 | 0.46 | 6.83 | 0.47% |
| 30. Libya National Oil Corp. | 6.22 | 0.15 | 0.32 | 6.69 | 0.46% |
| 31. Nigerian National Petroleum | 6.06 | 0.15 | 0.33 | 6.54 | 0.45% |
| 32. Petrobras, Brazil | 5.49 | 0.16 | 0.34 | 5.99 | 0.41% |
| 33. ENI, Italy | 5.20 | 0.24 | 0.54 | 5.97 | 0.41% |
| 34. Rio Tinto, UK | 5.50 | 0.00 | 0.47 | 5.96 | 0.41% |
| 35. Arch Coal, USA | 5.43 | 0.00 | 0.46 | 5.89 | 0.41% |
| 36. Petronas, Malaysia | 4.56 | 0.22 | 0.50 | 5.27 | 0.36% |
| 37. Anadarko, USA | 4.56 | 0.18 | 0.46 | 5.20 | 0.36% |
| 38. Occidental, USA | 4.63 | 0.09 | 0.34 | 5.06 | 0.35% |
| 39. Kazakhstan (coal) | 4.09 | 0.00 | 0.35 | 4.44 | 0.31% |
| 40. Statoil, Norway | 3.89 | 0.15 | 0.33 | 4.37 | 0.30% |
| 41. Oil & Gas Corporation, India | 3.71 | 0.14 | 0.31 | 4.16 | 0.29% |
| 42. Lukoil, Russian Federation | 3.60 | 0.09 | 0.19 | 3.87 | 0.27% |
| 43. Sasol, South Africa | 3.24 | 0.00 | 0.27 | 3.52 | 0.24% |
| 44. Qatar Petroleum | 3.00 | 0.13 | 0.29 | 3.41 | 0.24% |
| 45. Repsol, Spain | 2.96 | 0.13 | 0.29 | 3.38 | 0.23% |
| 46. Ukraine (coal) | 3.11 | 0.00 | 0.26 | 3.37 | 0.23% |
| 47. Marathon, USA | 2.64 | 0.11 | 0.24 | 2.99 | 0.21% |
| 48. Yukos, Russian Federation* | 2.69 | 0.06 | 0.12 | 2.86 | 0.20% |
| 49. North Korea (coal) | 2.58 | 0.00 | 0.22 | 2.80 | 0.19% |
| 50. Egyptian General Petroleum | 2.48 | 0.09 | 0.20 | 2.77 | 0.19% |
| 51. Rosneft, Russian Federation | 2.50 | 0.07 | 0.15 | 2.72 | 0.19% |
| 52. Petroleum Development Oman | 2.40 | 0.08 | 0.18 | 2.66 | 0.18% |
| 53. Hess, USA | 2.09 | 0.08 | 0.19 | 2.36 | 0.16% |
| 54. Xstrata, Switzerland | 2.05 | 0.00 | 0.17 | 2.22 | 0.15% |
| 55. Massey Energy, USA | 2.03 | 0.00 | 0.17 | 2.20 | 0.15% |
| 56. Alpha Natural Resources, USA | 1.98 | 0.00 | 0.17 | 2.15 | 0.15% |

| | | | | | |
|---------------------------------------|-----------------|--------------|---------------|-----------------|---------------|
| 57. Czech Republic & Slovakia (coal) | 1.84 | 0.00 | 0.16 | 2.00 | 0.14% |
| 58. Singareni Collieries, India | 1.74 | 0.00 | 0.15 | 1.88 | 0.13% |
| 59. Ecopetrol, Colombia | 1.66 | 0.05 | 0.10 | 1.81 | 0.12% |
| 60. Sonangol, Angola | 1.69 | 0.03 | 0.07 | 1.79 | 0.12% |
| 61. Cyprus Amax, USA * | 1.61 | 0.00 | 0.14 | 1.75 | 0.12% |
| 62. EnCana, Canada | 1.40 | 0.09 | 0.20 | 1.69 | 0.12% |
| 63. Devon Energy, USA | 1.41 | 0.08 | 0.19 | 1.69 | 0.12% |
| 64. BG Group, UK | 1.24 | 0.09 | 0.21 | 1.54 | 0.11% |
| 65. Sinopec, China | 1.41 | 0.04 | 0.08 | 1.53 | 0.11% |
| 66. Westmoreland Mining, USA | 1.41 | 0.00 | 0.12 | 1.53 | 0.11% |
| 67. Suncor, Canada | 1.24 | 0.05 | 0.11 | 1.41 | 0.10% |
| 68. Syrian Petroleum | 1.29 | 0.04 | 0.08 | 1.40 | 0.10% |
| 69. Kiewit Mining, USA | 1.19 | 0.00 | 0.10 | 1.29 | 0.09% |
| 70. North American Coal, USA | 1.09 | 0.00 | 0.09 | 1.18 | 0.08% |
| 71. RAG, Germany | 1.05 | 0.00 | 0.09 | 1.14 | 0.08% |
| 72. China National Offshore Oil Co. | 1.03 | 0.03 | 0.06 | 1.12 | 0.08% |
| 73. Luminant, USA | 0.97 | 0.00 | 0.08 | 1.05 | 0.07% |
| 74. Lafarge, France | 1.04 | 0.00 | 0.00 | 1.04 | 0.07% |
| 75. Holcim, Switzerland | 1.01 | 0.00 | 0.00 | 1.01 | 0.07% |
| 76. Canadian Natural Resources | 0.83 | 0.04 | 0.09 | 0.96 | 0.07% |
| 77. Apache, USA | 0.81 | 0.04 | 0.10 | 0.95 | 0.07% |
| 78. Bahrain Petroleum | 0.78 | 0.05 | 0.11 | 0.93 | 0.06% |
| 79. Talisman, Canada | 0.79 | 0.04 | 0.09 | 0.92 | 0.06% |
| 80. Murray Coal, USA | 0.73 | 0.00 | 0.06 | 0.80 | 0.05% |
| 81. UK Coal, UK | 0.73 | 0.00 | 0.06 | 0.79 | 0.05% |
| 82. Husky Energy, Canada | 0.59 | 0.02 | 0.05 | 0.66 | 0.05% |
| 83. Nexen,** Canada | 0.59 | 0.02 | 0.04 | 0.65 | 0.04% |
| 84. HeidelbergCement, Germany | 0.59 | 0.00 | 0.00 | 0.59 | 0.04% |
| 85. Cemex, Mexico | 0.55 | 0.00 | 0.00 | 0.55 | 0.04% |
| 86. Polish Oil & Gas | 0.42 | 0.02 | 0.03 | 0.47 | 0.03% |
| 87. Italcementi, Italy | 0.46 | 0.00 | 0.00 | 0.46 | 0.03% |
| 88. Murphy Oil, USA | 0.37 | 0.02 | 0.03 | 0.42 | 0.03% |
| 89. Taiheiyo, Japan | 0.40 | 0.00 | 0.00 | 0.40 | 0.03% |
| 90. OMV Group, Austria | 0.30 | 0.01 | 0.03 | 0.35 | 0.02% |
| Total identified producers | 828.65 | 17.98 | 67.62 | 914.25 | 63.04% |
| Total CDIAC, 1751-2010 | 1,323.09 | na | 114.65 | 1,450.33 | |
| Carbon Majors percent of CDIAC | 62.63% | na | 58.98% | 63.04% | |

This table includes each entity's estimated emissions from fuel combustion (net of non-energy uses), flaring, own fuel use, and ancillary emissions of CO₂ and CH₄ (in CO₂e units). Emissions from cement manufacturing is listed under product emissions, but are vented process emissions from the calcination of calcium carbonate. * not extant; production and emission quantified for these entities but not attributed to extant entities. ** Nexen was acquired by CNOOC in 2012.

Supplementary Table 4. 2010 and cumulative CO₂ & CH₄ emissions attributed to investor-owned entities

| Investor-owned producers | 2010 emissions MtCO₂e | Cumulative 1854-2010 MtCO₂e | Percent of global 1751-2010 |
|-----------------------------------|---|---|--|
| 1. Chevron, USA | 423 | 51,096 | 3.52% |
| 2. ExxonMobil, USA | 655 | 46,672 | 3.22% |
| 3. BP, UK | 554 | 35,837 | 2.47% |
| 4. Royal Dutch Shell, Netherlands | 478 | 30,751 | 2.12% |
| 5. ConocoPhillips, USA | 359 | 16,866 | 1.16% |
| 6. Peabody Energy, USA | 519 | 12,432 | 0.86% |
| 7. Total, France | 398 | 11,911 | 0.82% |
| 8. Consol Energy, Inc., USA | 160 | 9,096 | 0.63% |
| 9. BHP Billiton, Australia | 320 | 7,606 | 0.52% |
| 10. Anglo American, UK | 242 | 7,242 | 0.50% |
| 11. RWE, Germany | 148 | 6,843 | 0.47% |
| 12. ENI, Italy | 258 | 5,973 | 0.41% |
| 13. Rio Tinto, UK | 161 | 5,961 | 0.41% |
| 14. Arch Coal, USA | 341 | 5,888 | 0.41% |
| 15. Anadarko, USA | 96 | 5,195 | 0.36% |
| 16. Occidental, USA | 109 | 5,063 | 0.35% |
| 17. Lukoil, Russian Federation | 322 | 3,873 | 0.27% |
| 18. Sasol, South Africa | 113 | 3,515 | 0.24% |
| 19. Repsol, Spain | 126 | 3,381 | 0.23% |
| 20. Marathon, USA | 59 | 2,985 | 0.21% |
| 21. Yukos | - | 2,858 | 0.20% |
| 22. Hess, USA | 61 | 2,364 | 0.16% |
| 23. Xstrata, Switzerland | 214 | 2,223 | 0.15% |
| 24. Massey Energy, USA | 91 | 2,199 | 0.15% |
| 25. Alpha Natural Resources, USA | 182 | 2,149 | 0.15% |
| 26. Cyprus Amax | - | 1,748 | 0.12% |
| 27. EnCana, Canada | 84 | 1,695 | 0.12% |
| 28. Devon Energy, USA | 93 | 1,690 | 0.12% |
| 29. BG Group, UK | 97 | 1,543 | 0.11% |
| 30. Westmoreland Mining, USA | 46 | 1,530 | 0.11% |
| 31. Suncor, Canada | 89 | 1,407 | 0.10% |
| 32. Kiewit Mining, USA | 59 | 1,295 | 0.09% |
| 33. North American Coal, USA | 40 | 1,181 | 0.08% |
| 34. Ruhrkohle AG, Germany | - | 1,138 | 0.08% |
| 35. Luminant, USA | 33 | 1,049 | 0.07% |
| 36. Lafarge, France | 61 | 1,044 | 0.07% |
| 37. Holcim, Switzerland | 62 | 1,008 | 0.07% |
| 38. Canadian Natural Resources | 93 | 958 | 0.07% |
| 39. Apache, USA | 97 | 951 | 0.07% |
| 40. Talisman, Canada | 62 | 925 | 0.06% |
| 41. Murray Coal, USA | 59 | 796 | 0.05% |
| 42. UK Coal, UK | 19 | 794 | 0.05% |
| 43. Husky Energy, Canada | 42 | 665 | 0.05% |
| 44. Nexen, Canada | 36 | 651 | 0.04% |
| 45. HeidelbergCement, Germany | 31 | 587 | 0.04% |
| 46. Cemex, Mexico | 27 | 551 | 0.04% |
| 47. Italcementi, Italy | 24 | 463 | 0.03% |
| 48. Murphy Oil, USA | 27 | 418 | 0.03% |
| 49. Taiheiyo, Japan | 10 | 402 | 0.03% |
| 50. OMV Group, Austria | 45 | 346 | 0.02% |
| Total: | 7,628 | 314,811 | 21.71% |

Right column shows each entity's cumulative emissions in percent of CDIAC's global emissions 1751-2010. Excludes Cyprus Amax, & Yukos, whose production and assets have not been attributed to extant companies.

Supplementary Table 5. 2010 and cumulative emissions attributed to state-owned producers

| State-owned producers | 2010 emissions MtCO₂e | Cumulative 1854-2010 MtCO₂e | Percent of global global, 1751-2010 |
|-------------------------------------|---|---|--|
| 1. Saudi Aramco, Saudi Arabia | 1,550 | 46,033 | 3.17% |
| 2. Gazprom, Russian Federation | 1,371 | 32,136 | 2.22% |
| 3. National Iranian Oil Company | 867 | 29,084 | 2.01% |
| 4. Pemex, Mexico | 602 | 20,025 | 1.38% |
| 5. British Coal, UK * | - | 19,245 | 1.33% |
| 6. Petroleos de Venezuela | 485 | 16,157 | 1.11% |
| 7. Coal India | 830 | 15,493 | 1.07% |
| 8. PetroChina, China | 614 | 10,564 | 0.73% |
| 9. Kuwait Petroleum Corp. | 322 | 10,503 | 0.72% |
| 10. Abu Dhabi NOC, UAE | 387 | 9,672 | 0.67% |
| 11. Sonatrach, Algeria | 386 | 9,263 | 0.64% |
| 12. Iraq National Oil Company | 220 | 7,137 | 0.49% |
| 13. Pertamina, Indonesia | 64 | 6,830 | 0.47% |
| 14. Libya National Oil Corp. | 219 | 6,693 | 0.46% |
| 15. Nigerian National Petroleum | 270 | 6,540 | 0.45% |
| 16. Petrobras, Brazil | 356 | 5,991 | 0.41% |
| 17. Petronas, Malaysia | 260 | 5,274 | 0.36% |
| 18. Statoil, Norway | 243 | 4,367 | 0.30% |
| 19. Oil & Gas Corporation, India | 164 | 4,163 | 0.29% |
| 20. Qatar Petroleum | 271 | 3,410 | 0.23% |
| 21. Egyptian General Petroleum | 129 | 2,768 | 0.19% |
| 22. Rosneft, Russian Federation | 364 | 2,723 | 0.19% |
| 23. Petroleum Development Oman | 124 | 2,663 | 0.18% |
| 24. Singareni Collieries, India | 99 | 1,882 | 0.13% |
| 25. Ecopetrol, Colombia | 89 | 1,809 | 0.12% |
| 26. Sonangol, Angola | 147 | 1,794 | 0.12% |
| 27. Sinopec, China | 160 | 1,532 | 0.11% |
| 28. Syrian Petroleum | 48 | 1,402 | 0.10% |
| 29. China National Offshore Oil Co. | 130 | 1,123 | 0.08% |
| 30. Bahrain Petroleum | 36 | 931 | 0.06% |
| 31. Polish Oil & Gas | 12 | 473 | 0.03% |
| Total: | 10,818 | 287,680 | 19.84% |

Right column shows each entity's cumulative emissions in percent of CDIAC's global emissions 1751-2010. * not extant; includes British Coal, whose assets were, in part, privatized through a merger with RJB Mining to form UK Coal in 1994-1997.

Supplementary Table 6. Cumulative & 2010 emissions of nation-state carbon producers

| Nation-state producers | 2010 emissions MtCO₂e | Cumulative 1854-2010 MtCO₂e | Percent of global global, 1751-2010 |
|---|---|---|--|
| 1. Former Soviet Union (coal, oil, gas) | - | 129,717 | 8.94% |
| 2. China (coal and cement) | 7,898 | 124,089 | 8.56% |
| 3. Poland (coal) | 294 | 26,750 | 1.84% |
| 4. Russian Federation (coal) | 695 | 11,243 | 0.78% |
| 5. Czechoslovakia (coal) | - | 7,347 | 0.51% |
| 6. Kazakhstan (coal) | 287 | 4,442 | 0.31% |
| 7. Ukraine (coal) | 145 | 3,370 | 0.23% |
| 8. North Korea (coal) | 88 | 2,802 | 0.19% |
| 9. Czech Republic (coal) | 92 | 2,000 | 0.14% |
| Total: | 9,500 | 311,760 | 21.50% |

Right column shows each entity's cumulative emissions in percent of CDIAC's global emissions 1751-2010.

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