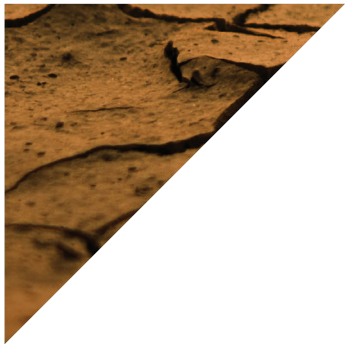
The Carbon Majors Database

CDP Carbon Majors Report 2017

100 fossil fuel producers and nearly 1 trillion tonnes of greenhouse gas emissions



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About this report

The Carbon Majors Database stores greenhouse gas (GHG) emissions data on the largest company-related sources of all time. CDP's Carbon Majors Report 2017 is the first in an ongoing series of publications aimed at using this Database – the most comprehensive available – to highlight the role that corporations can play in driving the global energy transition.

Large-scale GHG emissions data has traditionally been collected at the country-level. In fact, these emissions can be traced to a smaller group of commercial decision makers. The Carbon Majors Database was established in 2013 by Richard Heede of the Climate Accountability Institute (CAI) to show how these emissions are linked to companies, or 'Carbon Majors'. Now CDP works in collaboration with the CAI to maintain the Database and share its important data and insights with all stakeholders.

This report looks at industrial carbon dioxide and methane emissions deriving from fossil fuel producers in the past, present, and future. In 1988, human-induced climate change was officially recognized through the establishment of the Intergovernmental Panel on Climate Change (IPCC). Since this time, the fossil fuel industry has doubled its contribution to global warming by emitting as much greenhouse gas in 28 years as in the 237 years between 1988 and the birth of the industrial revolution. Since 1988, more than half of global industrial GHGs can be traced to just 25 corporate and state producers.

In 2015, a fifth of global industrial GHG emissions was backed by publicly listed investment. The scale of emissions signals the importance and potential of investor engagement in the fossil fuel industry. Many oil and gas majors are already developing scenarios to comprehend their potential role in the future energy system. The Carbon Majors Database is also projected out to 2100 to illustrate 'contraction and convergence' theory at the company-level. Setting science-based targets is an initial step for companies to take in navigating themselves through this global transition.

This report is aimed at investors wishing to better understand the amount of carbon associated with their fossil fuel holdings. Further, it is intended that this output will improve transparency from fossil fuel companies, particularly around product-related (Scope 3) emissions, as well as providing them with contextual information regarding their share of global emissions. The Database can also be useful to policy analysts and academics for developing further insights in this area of research.

Companies included in the Database are invited to share updated GHG emissions figures where estimates have been employed. Other stakeholders are also welcome to share their views and data use stories. All enquiries can be directed to datacheck@cdp.net.

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CDP foreword
Pedro Faria, Technical Director, CDP

Climate action is no longer confined to the direction given by policy makers — it is now a social movement, commanded by both economic and ethical imperatives and supported by growing amounts of data.

A fresh angle to an old debate.

I ran into Rick Heede at COP20 in Lima, where we spoke about our most recent accomplishments over several cups of coffee. He went into details about his 'Carbon Majors' project, explaining the painstaking process of tracing cumulative emissions from the highest emitting companies back to the 1850s. I was utterly impressed and slightly envious – what a laborious and amazing piece of work!

This was a new and powerful perspective on climate accountability, different from the dichotomies Parties adopted about future responsibility and that led to stalemate for an agreement in the Copenhagen summit: developed vs. developing, North vs. South, historical emitters vs. future emitters, etc.

'Carbon Majors' offers insight into responsibility from the perspective of the producers of hydrocarbons; those companies that have made astonishing returns over decades through the extraction and production of greenhouse gas emitting products.

From Lima we moved to Paris, where there was a very smart shift to expand the remit of climate action beyond the Parties, welcoming investors, banks, companies, NGOs, civil society organizations, and citizens, among others. This was the milestone for when we were officially empowered to take collective responsibility for our climate. With this necessarily comes the responsibility to act on it: A call to action for collective stewardship.

This 2017 report and dataset release mark the first in an ongoing series of updates to Rick's pioneering work. It is the first output of an ongoing collaboration between CAI and CDP that started in Lima. It highlights several important aspects: historical corporate emissions, the present view, and the path forward. Its novelty lies in its comprehensiveness and the fact that it's the only available data source to paint GHG emissions responsibility from the producer-side. The segmentation by hydrocarbon type not only facilitates improved emission estimations, but also provides useful information for those working in or with the energy sector. It is the result of laborious data collection, but also of methodological improvements on GHG indirect emissions accounting.

The publication of this seminal report comes shortly after the US' announcement of withdrawal from the Paris Accord – the first global agreement to reduce greenhouse gas emissions. While an unfortunate decision, we have witnessed a resurgence in the energy and commitment to GHG emission reductions from non-state actors, including cities, states, regions and companies. They have reaffirmed what we already know: the transition is already underway and is irreversible. Climate action is no longer confined to the direction given by policy makers; it is now a social movement, commanded by both economic and ethical imperatives and supported by growing amounts of data. Those that ignore this reality do so at their own peril.

Fossil fuel companies are also going to have to demonstrate leadership as part of this transition. They owe it to the millions of clients they serve that are already feeling the effects of climate change, and to the many millions more that require energy for the comfort of their daily lives but are looking for alternatives to their products. We should all be conscious of our shared responsibility, which implies learning from the past while keeping our eyes on the future, internalizing our stewardship responsibilities, and acting upon them together to ensure a more sustainable world.

Pedro Faria
Technical Director,
CDP

Introducing the Carbon Majors Database

The Carbon Majors Database brings a fresh perspective to global greenhouse gas (GHG) emissions by attributing them to companies.

The Carbon Majors Database in its original form was completed in 2013 by Richard Heede, Director of the Climate Accountability Institute (CAI). CDP began its relationship with the CAI in 2014 and is committed to keeping the Database securely stored, updated, and accessible to all stakeholders. CDP has also been growing the sample of companies contained within the Database, which presently consists of:

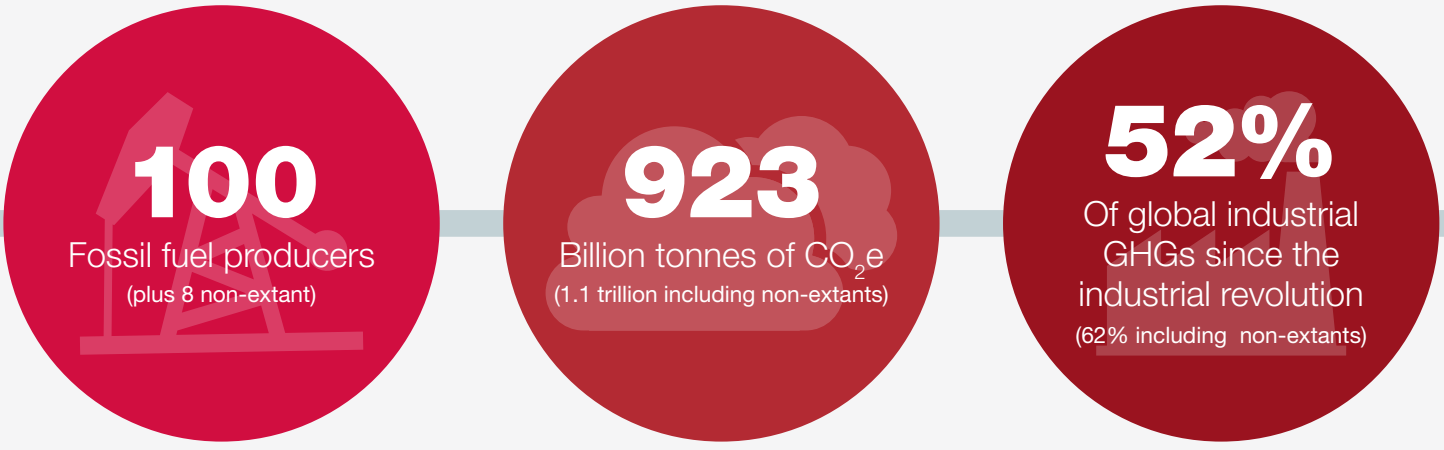
- 100 extant[1] fossil fuel producers ('Carbon Majors'): 41 public[2] investor-owned companies; 16 private investor-owned companies; 36 state-owned companies; and 7 state producers[3].
- 923 gigatonnes of carbon dioxide-equivalent[4] ($GtCO_2e$) from direct operational and product-related carbon dioxide and methane emissions (1854-2015), representing over half (52%[5]) 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 in 2015.

Direct operational emissions (Scope 1[6]) and emissions from the use of sold products (Scope 3: Category 11) are attributed to the extraction and production of oil, gas, and coal. Scope 1 emissions arise from the self-consumption of fuel, flaring, and venting or fugitive releases of methane.

Scope 3 emissions account for 90% of total company emissions and result from the downstream combustion of coal, oil, and gas for energy purposes. A small fraction of fossil fuel production is used in non-energy applications which sequester carbon.

Emissions of this scale have traditionally been collected and accounted from the national-level by organizations such as the International Energy Agency (IEA). This is the first and only database containing global-scale emissions, past and present, at the company-level.

Alongside this report, CDP have released a dataset[7], extracted from the Database, of emissions from all 100 producers over the period 1988-2015 and the top 100 companies of the 2015 Sample.



1. The Database also contains 8 significant non-extant producers raising total emissions to 1,090 $GtCO_2e$, or 62% of global industrial GHG emissions since the dawn of the industrial revolution.
2. Publicly invested, or traded, ownership excludes private sources of investment including: Individuals, venture capital, private equity firms, holding companies, insurance companies, and corporations.
3. State producers are producing entities that are represented by national production.
4. All data in this report relating to fossil fuel producers is taken from the Carbon Majors Database.
5. All emissions figures relating to the fossil fuel industry as a whole, and to global emissions, were collected or calculated using the formula expressed on page 6. Data from the Carbon Dioxide Information Analysis Center (CDIAC), the International Energy Agency (IEA), the Emission Database for Global Atmospheric Research (EDGAR), and others are used to provide a full picture of global GHG emissions. For more detailed information on sources, refer to the CDP 'Carbon Majors Database: Methodology Report 2017'.
6. Greenhouse gas emissions accounting 'Scopes' as defined by the Greenhouse Gas Protocol of the World Resources Institute (WRI).
7. CDP (2017) The Carbon Majors Database: 2017 Dataset. CDP, London.

Transparency is at the heart of the approach, which relies on company reported activity data and follows a simple, reproducible methodology for estimating emissions.

Where possible, Scope 1 emissions from upstream activities are sourced from company responses to the CDP Climate Change information request. Scope 1 emissions of non-responders and all of Scope 3 emissions are estimated. The estimation method follows the IPCC 'Guidelines for National Greenhouse Gas Inventories'[8].

$$Emissions = \sum_{p} EF_p \cdot P_p$$

The general form of calculation is expressed by the equation above. This equation states that activity data (e.g. barrels of oil) is multiplied by a factor which defines the emissions specific to that activity (e.g. tonnes of CO_2e per barrel of oil). In this case, P is production, EF is the emission factor, and subscript p is the product.

Nearly all activity data is collected from sources available in the public domain, most of which are found in company annual reports and securities filings. For Scope 3 Category 11 'use of sold products', net production is used over sales because of data availability, and because this eliminates the chance of double-counting from resales.

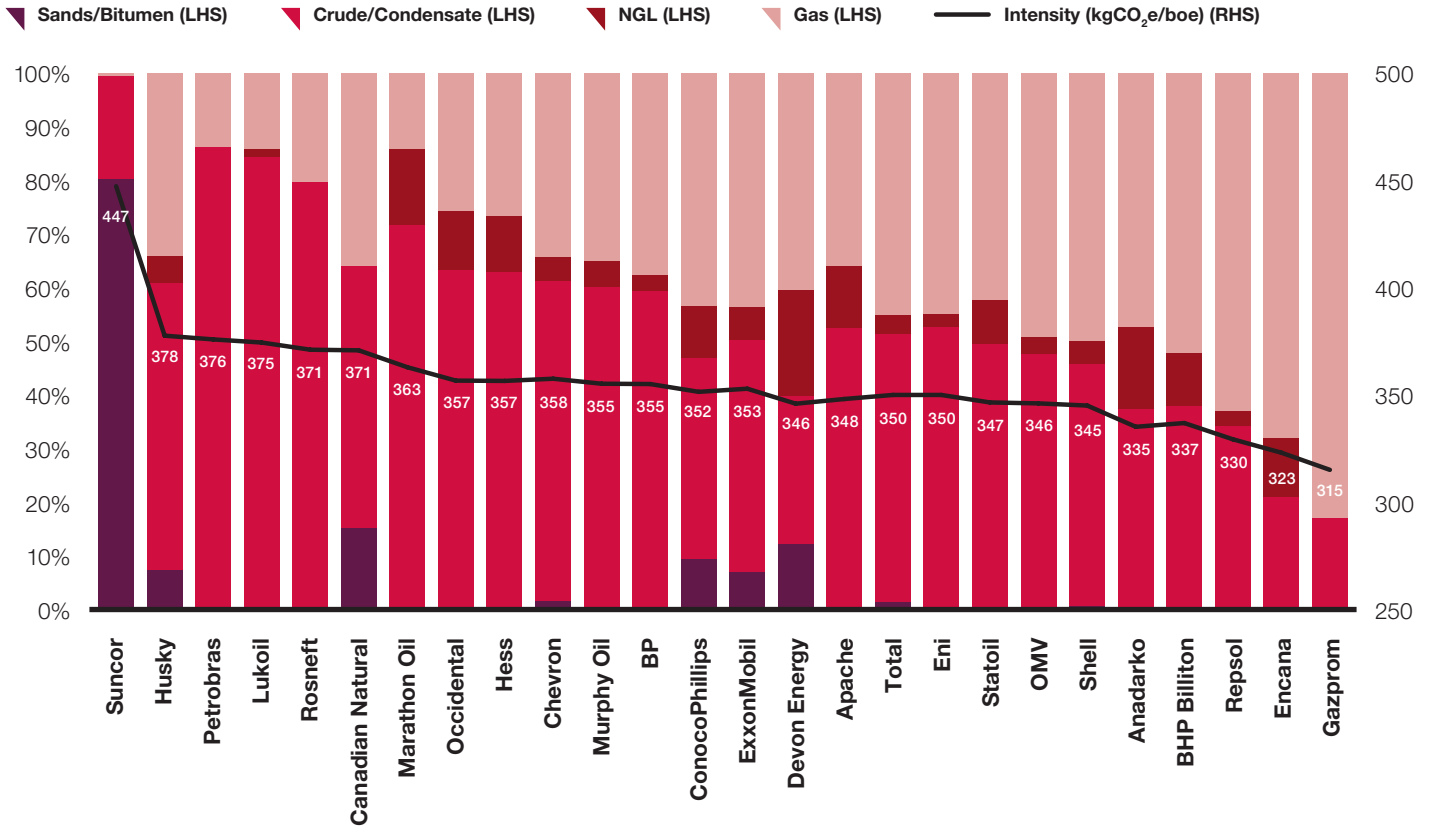
To improve estimation accuracy, liquid hydrocarbons are split into crude oils, natural gas liquids, and bitumen. Coal production is split by grade, such as bituminous and lignite, or by application, such as thermal and metallurgical. The variation in Scope 3 emission factor for oil and gas production is illustrated in Figure 1.

Many fossil fuel companies do not disclose Scope 3 'use of sold product' emissions. One intention of the Database is that it will incentivize greater transparency from fossil fuel extraction companies in this area.

For a more detailed description of the methodological approach, please refer to the CDP 'Carbon Majors Database: Methodology Report 2017'[9].

8. IPCC (2006) 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1: General Guidance and Reporting', IGES, Japan.
9. CDP (2017) The Carbon Majors Database: Methodology Report 2017. CDP, London.

Figure 1: Oil and gas company product portfolio mix and GHG emissions intensity



A huge acceleration in the extraction of fossil fuels has doubled their contribution to global warming since 1988.

In 1988, the IPCC was established and, as such, the effects of human activities on the climate were officially recognized. Despite this landmark, the fossil fuel industry has expanded prodigiously since 1988 and has become more carbon-intensive:

- **The contribution of fossil fuels to global warming has doubled:** 833 $GtCO_2e$ was emitted in just 28 years since 1988, compared with 820 $GtCO_2e$ in the 237 years between 1988 and the birth of the industrial revolution.
- **Coal makes up a larger share of fossil fuels.** The chart on the right depicting the independent contributions to emissions from oil, gas, and coal show that, despite an increase in the share of gas (a less carbon-intensive fuel), the vast expansion of coal production over the past 15 years has led the overall emissions intensity of fossil fuels since 1988 to increase (by 2.4%).
- **Large ventures into carbon-intensive 'unconventional oils' have emerged.** Companies[10] such as Suncor, ExxonMobil, Chevron, Shell, and ConocoPhillips have invested in the extraction of oil sands, tight oil, heavy oils and other forms which carry a larger environmental impact than conventional crude oil[11].

Fossil fuels are the largest source of anthropogenic greenhouse gas emissions in the world. The fossil fuel industry and its products accounted for 91% of global industrial GHGs in 2015, and about 70% of all anthropogenic GHG emissions[12]. If the trend in fossil fuel extraction continues over the next 28 years as it has over the previous 28, then global average temperatures would be on course to rise around 4ºC above preindustrial levels by the end of the century[13]. This would entail substantial species extinction, large risks of regional and global food scarcity, and could cross multiple tipping points in the Earth's climate system, leading to even more severe consequences[14].

Figure 2: Fossil Fuel product emissions contribution indices, 1988-2015

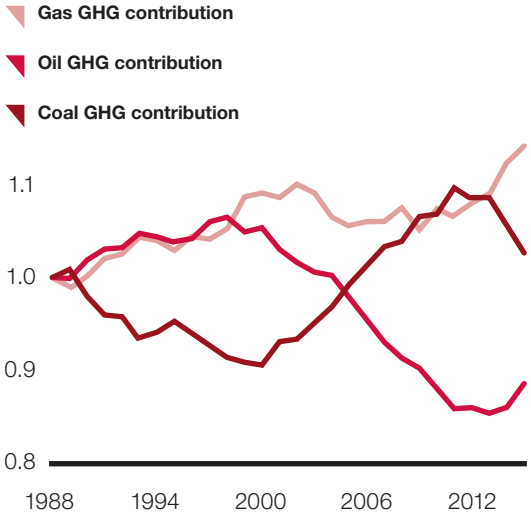
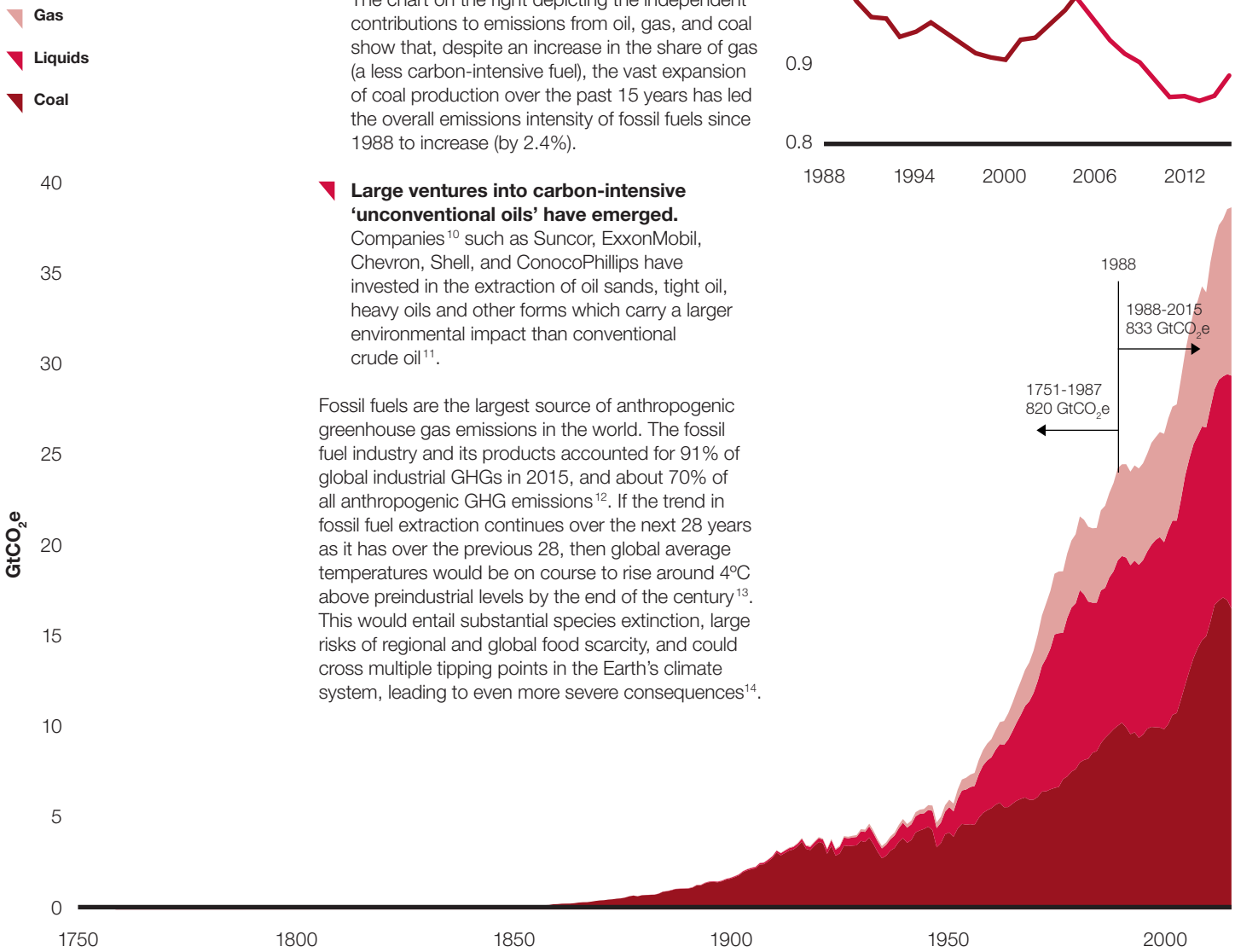


Figure 3: Fossil fuel sector operational and product GHG emissions, 1750-2015



10. The CDP investor-focused report 'In the Pipeline' ranks oil and gas companies on a range of environmental indicators.
11. The Oil Climate Index of the Carnegie Endowment for International Peace benchmarks lifecycle emissions conventional and unconventional oils.
12. Other industrial GHGs include process carbon dioxide from cement manufacturing and other industrial product- or process-related methane, nitrous oxide and F-gases. Non-industrial GHG emissions consist of carbon dioxide relating to land-use change, and methane from sources such as farming and landfills.
13. Based on comparison with the IEA 6DS scenario which projects an almost 4ºC temperature rise by the end of the century, and 5.5ºC in the long-term.
14. Based on the IPCC (2014) AR5 WGII 'Impacts, Adaption, and Vulnerability' report commentary on some of the impacts associated with a 4ºC rise.

Past accountability

Over half of global industrial emissions since human-induced climate change was officially recognized can be traced to just 25 corporate and state producing entities.

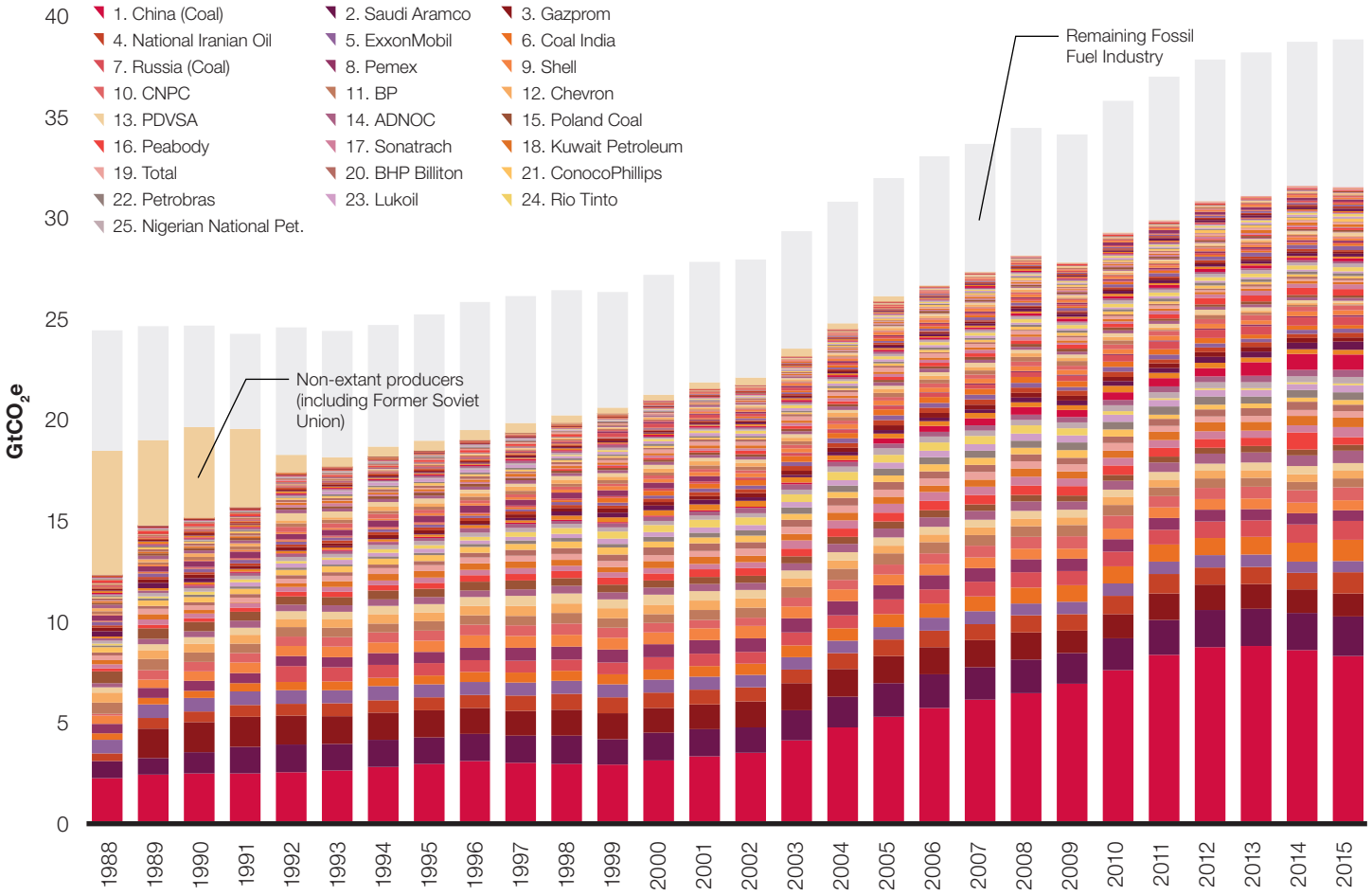
By 1988, fossil fuel companies knew, or should have known, of the destabilizing effects of their products on the environment. Nonetheless, most companies have expanded extraction activities significantly in the time since, while non-carbon primary energy sources, such as renewables, have seen relatively very little investment. Observing the period since 1988:

- **Investors own a great legacy of GHG emissions:** Of the 635 $GtCO_2e$ of operational and product GHG emissions from the 100 active fossil fuel producers, 32% is public investor-owned, 9% is private investor-owned, and 59% is state-owned.
- **The distribution of emissions is concentrated:** 25 corporate and state producing entities account for 51% of global industrial GHG emissions. All 100 producers account for 71% of global industrial GHG emissions.

The **highest emitting companies since 1988** that are investor-owned include: ExxonMobil, Shell, BP, Chevron, Peabody, Total, and BHP Billiton. Key state-owned companies include Saudi Aramco, Gazprom, National Iranian Oil, Coal India, Pemex, and CNPC (PetroChina). Coal emissions from China are represented by the state, in which key state-owned producers include Shenhua Group, Datong Coal Mine Group, and China National Coal Group.

Attributing operational and product GHG emissions since 1988 paints, for the first time, a producer-side view of climate accountability. The scale of historical emissions associated with these producers is large enough to have contributed significantly to climate change. It follows that the actions of these producers over the medium-long term can, and should, play a pivotal role in the global energy transition. Directly or indirectly, these companies are most affected by the prospect of climate change regulation, which presents myriad **risks and opportunities** to their future prosperity.

Figure 4: Operational and product GHG emissions of 100 active fossil fuel producing entities, 1988-2015



State entities

The Carbon Majors Database represents some state producers with the use of national statistics. National data statistics, which are compiled by organizations such as the International Energy Agency (IEA), the Energy Information Administration (EIA), BP, and the Organization of the Petroleum Exporting Countries (OPEC), were used in place of, or to supplement, missing or partial state company data. For state oil and gas producers, the Oil and Gas Journal's OGJ100 was also a useful data source. Data from these sources was utilized for 13 active and historical state oil and gas producers with shares of domestic production from multinational oil and gas corporations deducted[15]. For 7 state coal producers, national production was considered representative. Of these coal producers, China and Russia are treated as single producers, though they have come to comprise a reasonable number of constituent companies as production was privatized, or joint state- and investor-owned companies were established. Options for obtaining historical data will be explored so that past emissions from top Chinese and Russian coal companies can be accounted for in future updates.

Chinese Coal

Since the turn of the millennium, growth in Chinese coal production has tripled to nearly 4 billion tonnes, representing half of global output. Most of this expansion has occurred in the provinces of Shanxi, Shaanxi, and Inner Mongolia. Companies such as Shenhua, Datong, and China Coal Energy are key players in these regions.

Coal production in China is broken down into state-owned industry groups, which may partially own one or a number of listed subsidiaries. According to the Chinese-based data service company sxcoal, production from the top 50 coal company groups in 2015 amounted to 71% of national production. Half of Chinese coal production in 2015 came from 15 company groups, and one third of national production from just 7 companies: Shenhua Group, Datong Coal Mine Group, China National Coal Group, Shandong Energy Group, Shaanxi Coal Chemical Industry, Shanxi Coking Coal Group, and the Yankuang Group. Key listed subsidiaries of these groups include: Shenhua, Datong Coal Industry, China Coal Energy, Shaanxi Coal Industry, Shanxi Xishan Coal & Electricity, and Yanzhou Coal Mining.

Figure 5: Top 15 Chinese Coal Companies (50%), Mt coal

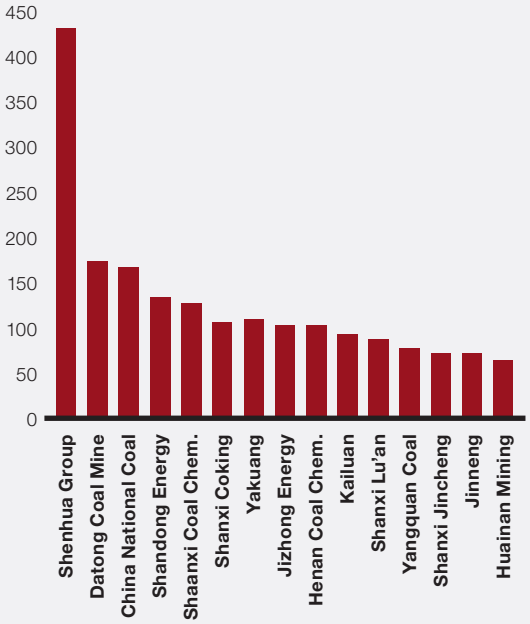
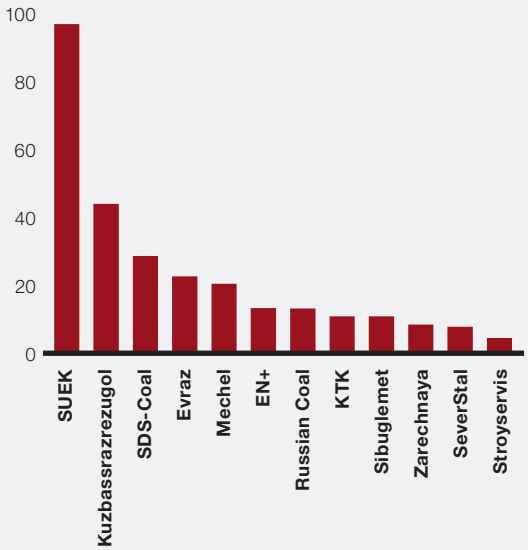


Figure 6: Top 12 Russian Coal Companies (76%), Mt coal



Russian Coal

Russia is the world's 6th largest coal producing nation and has seen production increase by 70% since the late 1990s to 373 million tonnes in 2015. This growth has been driven largely by an expansion in the Kemerovo region, Southwest Siberia, in which the Kuznetsk, or 'Kuzbass', coal basin is located.

The coal mining industry in Russia remained in state-hands for most of the 1990s, during which it underwent restructuring for private investment. By the end of 2002, the Russian coal industry had been fully broken-up and privatized. The Siberian Coal Energy Company (SUEK) is one outcome of this transition. SUEK was founded in 2001 through the affiliation of companies in the Irkutsk and Chita regions, and the Republic of Buryatia. It soon expanded assets rapidly in numerous other areas, including the Kuzbass basin. Three quarters of Russian coal production in 2015 was shared between 12 companies and half of production came from just 4 companies: SUEK, Kuzbassrazrezugol, SDS-Coal, and Evraz.

15. For more detail on this approach, refer to: Heede, R. (2014), 'Carbon Majors: Accounting for carbon and methane emissions 1854-2010. Methods & Results Report', Climate Mitigation Services, Colorado.

Investors in fossil fuel companies carry influence over one fifth of industrial greenhouse gas emissions worldwide.

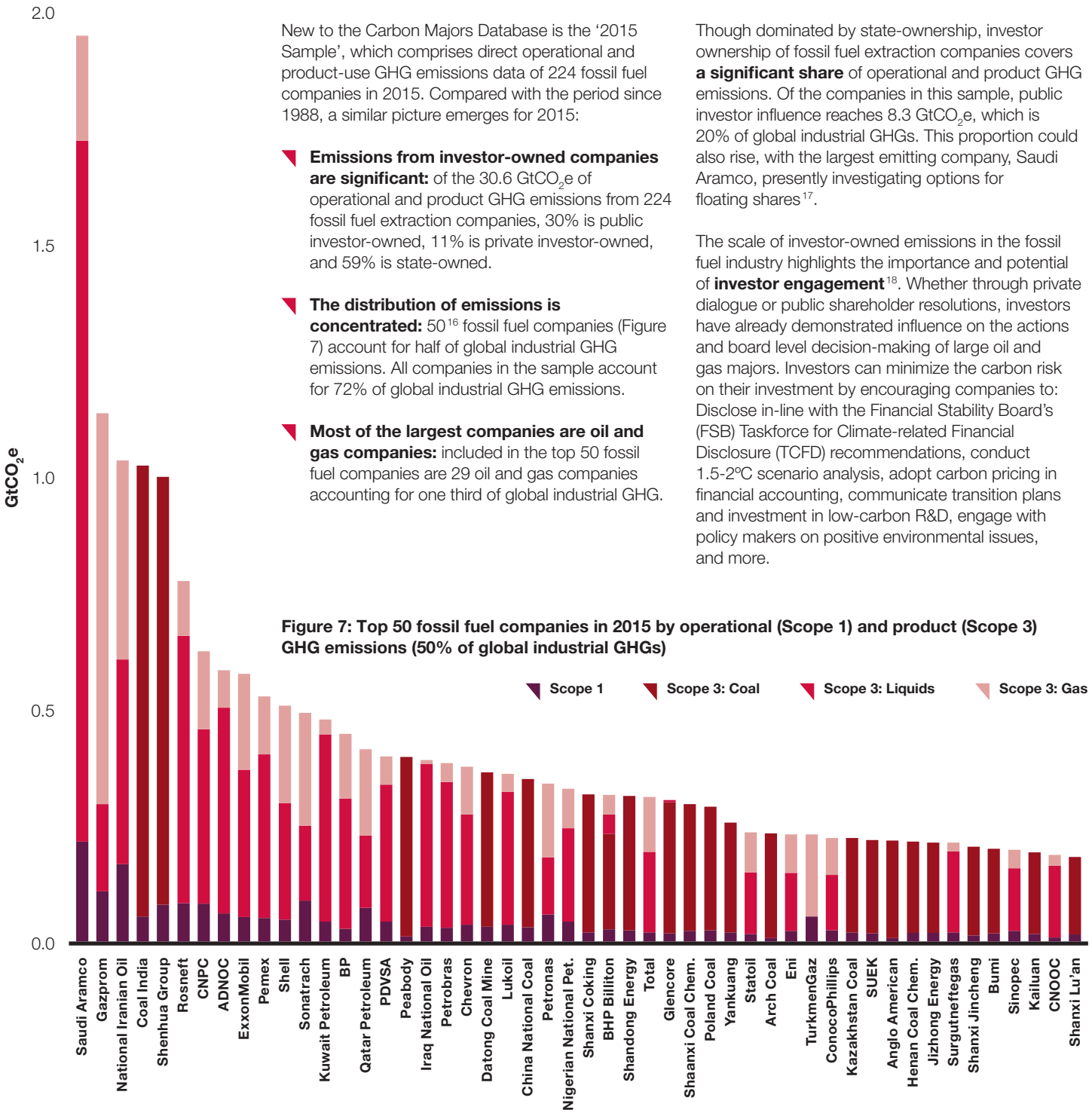
New to the Carbon Majors Database is the '2015 Sample', which comprises direct operational and product-use GHG emissions data of 224 fossil fuel companies in 2015. Compared with the period since 1988, a similar picture emerges for 2015:

- **Emissions from investor-owned companies are significant:** of the 30.6 $GtCO_2e$ of operational and product GHG emissions from 224 fossil fuel extraction companies, 30% is public investor-owned, 11% is private investor-owned, and 59% is state-owned.
- **The distribution of emissions is concentrated:** 50[16] fossil fuel companies (Figure 7) account for half of global industrial GHG emissions. All companies in the sample account for 72% of global industrial GHG emissions.
- **Most of the largest companies are oil and gas companies:** included in the top 50 fossil fuel companies are 29 oil and gas companies accounting for one third of global industrial GHG.

Though dominated by state-ownership, investor ownership of fossil fuel extraction companies covers **a significant share** of operational and product GHG emissions. Of the companies in this sample, public investor influence reaches 8.3 $GtCO_2e$, which is 20% of global industrial GHGs. This proportion could also rise, with the largest emitting company, Saudi Aramco, presently investigating options for floating shares[17].

The scale of investor-owned emissions in the fossil fuel industry highlights the importance and potential of **investor engagement**[18]. Whether through private dialogue or public shareholder resolutions, investors have already demonstrated influence on the actions and board level decision-making of large oil and gas majors. Investors can minimize the carbon risk on their investment by encouraging companies to: Disclose in-line with the Financial Stability Board's (FSB) Taskforce for Climate-related Financial Disclosure (TCFD) recommendations, conduct 1.5-2ºC scenario analysis, adopt carbon pricing in financial accounting, communicate transition plans and investment in low-carbon R&D, engage with policy makers on positive environmental issues, and more.

Figure 7: Top 50 fossil fuel companies in 2015 by operational (Scope 1) and product (Scope 3) GHG emissions (50% of global industrial GHGs)



16. This is more than the 25 corporate and state producing entities emitting over half of global industrial GHG emissions since 1988 (page 8) because coal emissions from Russia and China are split into their constituent companies. For more detail on this representation, refer to page 9.
17. The Economist (2016) 'The Big Float', 28 April 2016.
18. For a guide on how investors have influenced, and can influence, oil and gas majors, refer to the CDP collaborated report 'Investor Climate Compass: Oil and Gas'.

Fossil fuel extraction companies will need to plan their future in the context of a radical transformation of the global energy system.

Futures modelling was undertaken by fossil fuel companies long before the climate change era to cost and manage reserves. Oil and gas companies are now analyzing **scenarios** in which global emissions are constrained to avoid dangerous climate change. In so doing, these companies are better positioned to understand and define their potential role in a transforming industry.

The next step for a company is to design a **transition plan** that will minimize the physical and transition risks imposed by climate change. A transition plan begins with the setting of an emissions target. The **Science Based Targets Initiative** was established in 2015 to guide companies in this area and set the corporate standard for alignment with a 2ºC limit in the rise of global average temperature above the pre-industrial level.

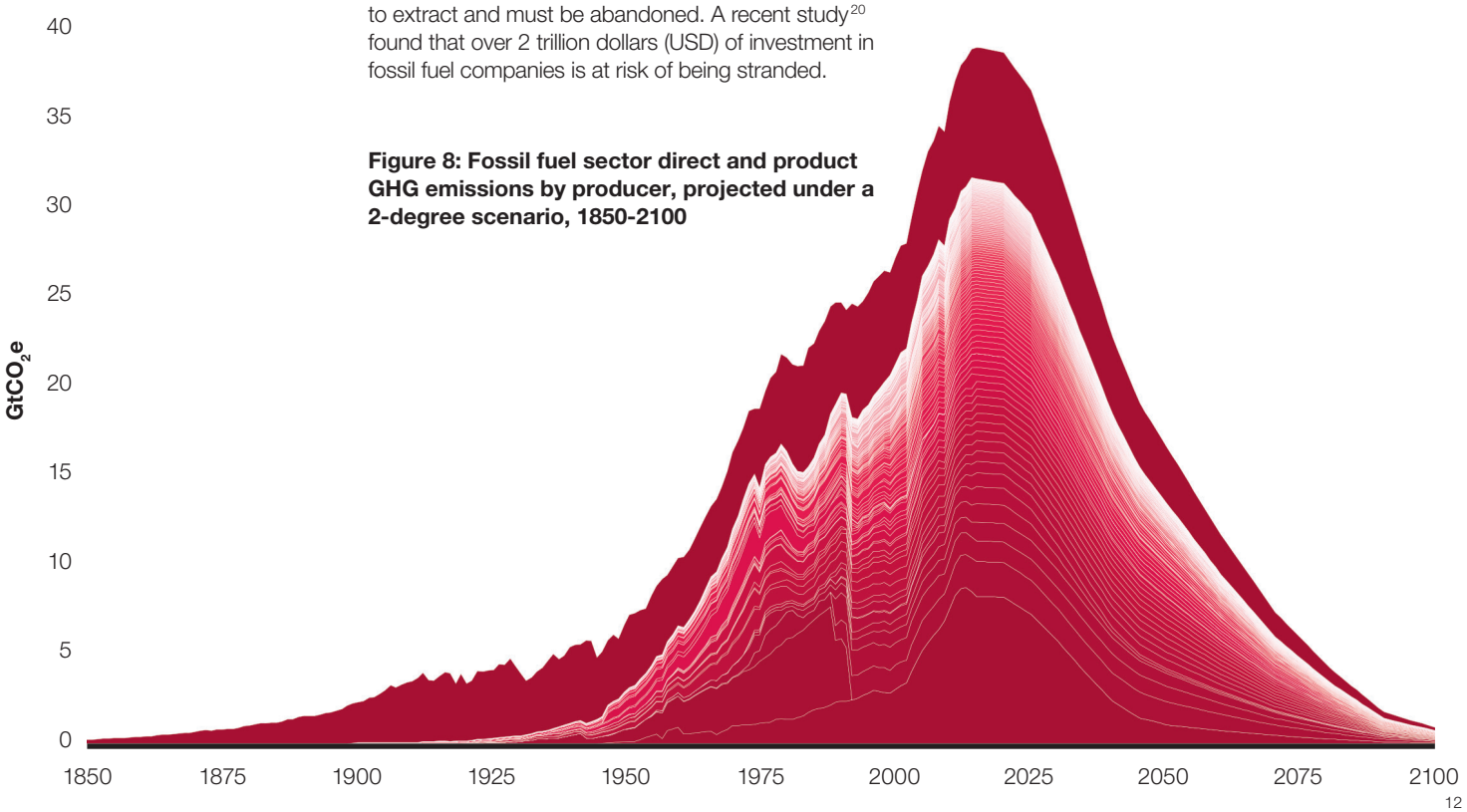
The implication of a temperature limit is a cap in global GHG emissions which, in turn, places a cap on the extraction of fossil fuels. In 2009, Malte Meinshausen et al. quantified proven fossil fuel reserves against a global carbon budget for the first time[19]. It showed that existing reserves of fossil fuels contain locked-in emissions far above the carbon budget required for a 2°C limit. This truth confirms the risk of **stranded assets**: When reserves become financially unviable to extract and must be abandoned. A recent study[20] found that over 2 trillion dollars (USD) of investment in fossil fuel companies is at risk of being stranded.

Figure 8 is a chart illustrating the '**contraction and convergence**'[21] GHG profile of the Fossil Fuel sector and its 'Carbon Majors' out to 2100. The reduction in emissions would be mostly driven by a decline in production (in-step with a decline in global fossil fuel demand), the rate of which is somewhat dependent on the dissemination of carbon, capture, utilization and storage (CCUS): a breakthrough technology that sequesters CO_2 emissions through applications or underground storage, though without any scalable examples to-date. Meanwhile, population growth will push the world's demand for primary energy up. The gap in supply and demand will be closed by growth in zero-carbon sources of energy such as nuclear, solar, wind, hydro, and biomass.

Fossil fuel companies can contribute to the transition by reducing operational emissions, shifting to lighter fossil fuels, engaging in the deployment of CCUS and other carbon-offset options, and diversifying their portfolio of primary energy products to encompass renewables. These measures all contribute to a **decoupling of growth and emissions**, which will maximize the growth achievable by a company under an emissions cap.

19. Meinshausen, M., Meinshausen, N., Hare, W., Raper, S., Frieler, K., Knutti, R., Frame, D., and Allen, M. (2009) Greenhouse-gas emission targets for limiting global warming to 2°C, Nature, 458:1158-1162.
20. Carbon Tracker (2015) 'The $2 trillion stranded assets danger zone.'
21. Contraction and convergence is a widely-accepted framework for global GHG emissions mitigation conceived by the Global Commons Institute.

Figure 8: Fossil fuel sector direct and product GHG emissions by producer, projected under a 2-degree scenario, 1850-2100



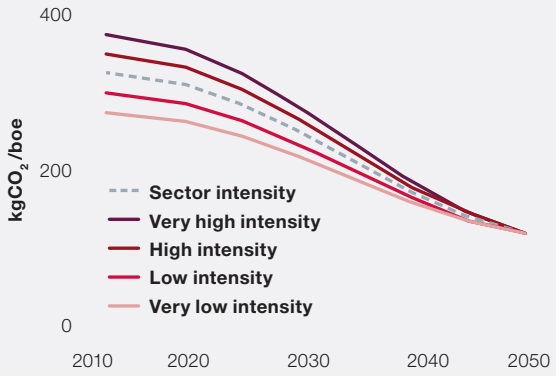
Science-based targets

In response to the disparity between the private sector's current emissions trajectory and the trajectory required by internationally-agreed-upon targets, CDP, the World Resources Institute (WRI), and the World Wildlife Fund (WWF) formed the Science Based Targets Initiative to increase the level of ambition of emission reduction targets in the corporate sector. The Sectoral Decarbonization Approach (SDA) was developed by the Initiative by building on existing approaches: It allocates a carbon budget to companies based on their contribution to the economy. The SDA methodology was unveiled in 2015 as the Initiative's first major publication[22]. Sector modeling for the SDA method was built on the 2-degree scenario (2DS) developed by the International Energy Agency (IEA) as part of its 2014 Energy Technology Perspectives (ETP) outlook. The choice of this scenario is not a pre-requisite of the SDA, but was chosen because it is the most suitable scenario for articulating the method.

The Primary Energy Sector

Work is underway to define a methodology that coal, oil, and gas extraction companies can use to set Scope 1 and Scope 3 (use of sold products) science-based targets. The Fossil Fuel industry is a subset of the Primary Energy sector, which includes production of all primary forms of energy: Fossil fuels, biomass, nuclear, hydro, wind, solar, and other renewables. The company's primary energy product portfolio defines its sector and, in the SDA, the sector is the basis on which the benchmark for setting science-based targets is defined. For example, if a company's operations are weighted towards natural gas production, then the benchmark will more closely reflect the scenario's emissions projection for natural gas.

Figure 9: Emissions intensity convergence mechanism for primary energy sector

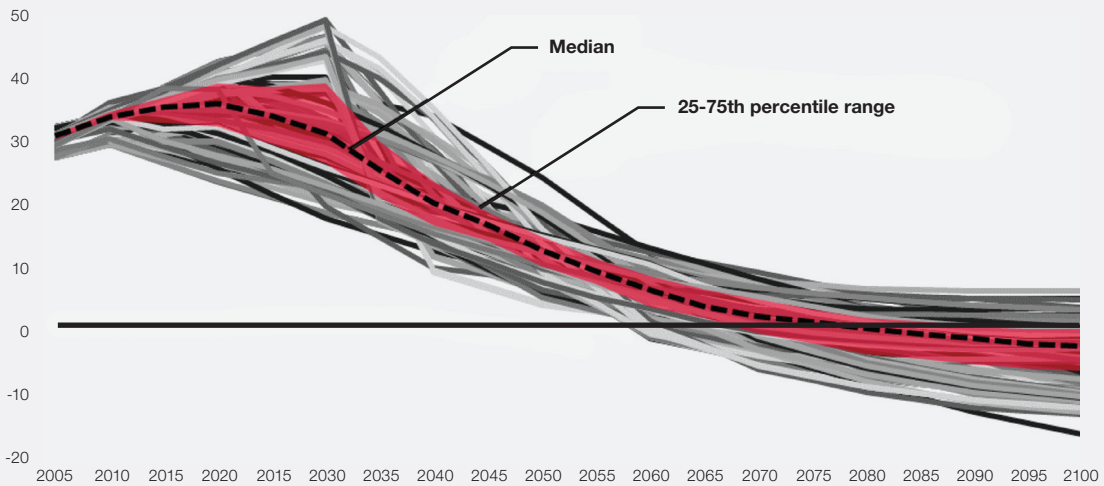


Once the company's sector is defined, the benchmark is set in terms of absolute emissions or emissions intensity. To translate a sector benchmark to a company target, 'allocation mechanisms' are applied. Figure 9 illustrates the 'convergence' allocation mechanism, which is used to set emissions intensity targets. The intensity target is defined by converging the company's intensity in the base year to the sector's intensity in 2050. Companies starting from a higher intensity have a steeper intensity reduction path, whereas companies that have already taken steps to reduce intensity have a shallower path.

Scenarios

The SDA does not specify the use of any one emissions scenario. Work is now being carried out to define an envelope within which a scenario may be deemed acceptable. Figure 10 is an illustration of the envelope concept. The approach and data is borrowed from the IPCC Fifth Assessment Report[23] (AR5) and the AR5 scenarios database[24]. The link between emissions and temperature is made using the Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC). In this way, it is possible distinguish scenarios by their probability of achieving climate goals. Further work investigating scenarios compliant with the 'well-below 2-degree' ambition of the Paris Agreement will also be undertaken.

Figure 10: Envelope concept applied to emissions scenarios with 50-66% probability of achieving a 2ºC global temperature limit



22. SBTi (2015) 'Sectoral Decarbonization Approach (SDA): A method for setting corporate emission reduction targets in line with climate science. CDP, WRI, WWF.
23. IPCC (2014), 'Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change' [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
24. AR5 Scenario Database Version 1.0.2.

Appendix I
Cumulative emissions 1988-2015

Producer	Cumulative 1988-2015 Scope 1[25] GHG, $MtCO_2e$	Cumulative 1988-2015 Scope 3[26] GHG, $MtCO_2e$	Cumulative 1988-2015 Scope 1+3 GHG, $MtCO_2e$	Cumulative 1988-2015 Scope 1+3 of global industrial GHG, %
China (Coal)	9,622	119,312	128,933	14.3
Saudi Arabian Oil Company (Aramco)	4,263	36,298	40,561	4.5
Gazprom OAO	4,652	30,569	35,221	3.9
National Iranian Oil Co	2,468	18,037	20,505	2.3
ExxonMobil Corp	1,833	15,952	17,785	2.0
Coal India	892	15,950	16,842	1.9
Petroleos Mexicanos (Pemex)	2,055	14,749	16,804	1.9
Russia (Coal)	1,216	15,524	16,740	1.9
Royal Dutch Shell PLC	1,212	13,805	15,017	1.7
China National Petroleum Corp (CNPC)	1,479	12,564	14,042	1.6
BP PLC	1,072	12,719	13,791	1.5
Chevron Corp	1,215	10,608	11,823	1.3
Petroleos de Venezuela SA (PDVSA)	1,108	9,971	11,079	1.2
Abu Dhabi National Oil Co	1,135	9,635	10,769	1.2
Poland Coal	884	9,596	10,480	1.2
Peabody Energy Corp	266	10,098	10,364	1.2
Sonatrach SPA	1,490	7,507	8,997	1.0
Kuwait Petroleum Corp	767	8,194	8,961	1.0
Total SA	778	7,762	8,541	0.9
BHP Billiton Ltd	588	7,595	8,183	0.9
ConocoPhillips	654	6,809	7,463	0.9
Petroleo Brasileiro SA (Petrobras)	533	6,375	6,907	0.8
Lukoil OAO	557	6,193	6,750	0.8
Rio Tinto	297	6,445	6,743	0.7
Nigerian National Petroleum Corp	643	5,848	6,491	0.7
Petroliam Nasional Berhad (Petronas)	995	5,190	6,185	0.7
Rosneft OAO	571	5,295	5,866	0.7
Arch Coal Inc	182	5,514	5,696	0.6
Iraq National Oil Co	435	4,927	5,362	0.6
Eni SPA	672	4,647	5,319	0.6
Anglo American	114	5,173	5,287	0.6
Surgutneftegas OAO	482	4,653	5,135	0.6
Alpha Natural Resources Inc	343	4,561	4,904	0.5
Qatar Petroleum Corp	798	4,103	4,901	0.5
PT Pertamina	602	4,254	4,857	0.5
Kazakhstan Coal	418	4,317	4,735	0.5
Statoil ASA	198	4,497	4,695	0.5
National Oil Corporation of Libya	425	4,101	4,526	0.5
Consol Energy Inc	515	3,979	4,495	0.5
Ukraine Coal	286	4,143	4,429	0.5
RWE AG	499	3,701	4,201	0.5
Oil & Natural Gas Corp Ltd	193	3,367	3,560	0.4
Glencore PLC	228	3,159	3,387	0.4
TurkmenGaz	746	2,471	3,217	0.4
Sasol Ltd	259	2,936	3,195	0.4
Repsol SA	224	2,773	2,996	0.3
Anadarko Petroleum Corp	201	2,790	2,991	0.3
Egyptian General Petroleum Corp	383	2,444	2,827	0.3
Petroleum Development Oman LLC	372	2,397	2,769	0.3
Czech Republic Coal	277	2,430	2,706	0.3
Remaining 50 producers in sample	6,232	60,569	66,800	7.4
Total sample (100 producers)	**58,328**	**576,506**	**634,835**	**70.6**

25. Note that Scope 1 and Scope 3 cover only fossil fuel industry related activities; total Scope 1 and Scope 3 emissions for some producers may be higher.
26. Scope 3 refers specifically to Scope 3 Category 11 'use of sold products'.

Appendix II
2015 Sample emissions

Producer	2015 Scope 1[27] GHG, $MtCO_2e$	2015 Scope 3[28] GHG, $MtCO_2e$	2015 Scope 1+3 GHG, $MtCO_2e$	2015 Scope 1+3 of global industrial GHG, %
Saudi Arabian Oil Company (Aramco)	215	1,735	1,951	4.6
Gazprom OAO	108	1,030	1,138	2.7
National Iranian Oil Co	166	870	1,036	2.4
Coal India	54	971	1,025	2.4
Shenhua Group Corp Ltd	79	922	1,001	2.4
Rosneft OAO	83	694	777	1.8
China National Petroleum Corp (CNPC)	81	544	625	1.5
Abu Dhabi National Oil Co	61	523	584	1.4
ExxonMobil Corp	54	523	577	1.4
Petroleos Mexicanos (Pemex)	53	477	530	1.3
Royal Dutch Shell PLC	48	460	508	1.2
Sonatrach SPA	89	404	492	1.2
Kuwait Petroleum Corp	43	435	478	1.1
BP PLC	28	420	448	1.1
Qatar Petroleum Corp	73	341	414	1.0
Petroleos de Venezuela SA (PDVSA)	42	356	398	0.9
Peabody Energy Corp	10	387	397	0.9
Iraq National Oil Co	31	360	391	0.9
Petroleo Brasileiro SA (Petrobras)	27	355	382	0.9
Chevron Corp	36	341	377	0.9
Datong Coal Mine Group Co Ltd	32	333	365	0.9
China National Coal Group Co Ltd	30	320	350	0.8
Petroliam Nasional Berhad (Petronas)	59	281	340	0.8
Nigerian National Petroleum Corp	42	287	329	0.8
Lukoil OAO	3	325	328	0.8
Glencore PLC	35	287	322	0.8
BHP Billiton Ltd	27	290	317	0.7
Shanxi Coking Coal Group Co Ltd	19	298	317	0.7
Shandong Energy Group Co Ltd	24	290	314	0.7
Total SA	20	292	311	0.7
Shaanxi Coal Chemical Industry Group Co Ltd	23	273	296	0.7
Poland Coal	25	266	291	0.7
Yankuang Group Co Ltd	20	236	256	0.6
Arch Coal Inc	7	225	232	0.5
Eni SPA	23	208	231	0.5
Statoil ASA	12	219	231	0.5
TurkmenGaz	53	177	230	0.5
ConocoPhillips	24	199	224	0.5
Kazakhstan Coal	20	203	222	0.5
SUEK Ltd	18	200	218	0.5
Henan Coal Chemical Industry Group Co Ltd	18	197	215	0.5
Anglo American	5	210	215	0.5
Jizhong Energy Group Co Ltd	19	194	213	0.5
Surgutneftegas OAO	20	193	212	0.5
Shanxi Jincheng Anthracite Coal Mining Group Co Ltd	13	191	204	0.5
Bumi Resources	18	182	200	0.5
China Petrochemical Corp (Sinopec)	23	174	197	0.5
Kailuan Group Co Ltd	17	175	192	0.5
China National Offshore Oil Corp Ltd (CNOOC)	8	178	187	0.4
Shanxi Lu'an Mining Group Co Ltd	16	166	181	0.4
Remaining 174 companies in sample	902	8,392	9,294	21.9
Total sample (224 companies)	**2,955**	**27,610**	**30,565**	**72.1**

27. Note that Scope 1 and Scope 3 cover only fossil fuel industry related activities; total Scope 1 and Scope 3 emissions for some companies may be higher.
28. Scope 3 refers specifically to Scope 3 Category 11 'use of sold products'.

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