12

The Evolution of Corporate Accountability for Climate Change

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From now on we will not be asking you to trust us. We will be showing that you can. And ultimately you will judge.

BP CEO Bernard Looney, February 2020.[1]

If you want to be a long-term relevant company that is on the right side of history, you have to be involved in this discussion, because it's the most important discussion of our time." Shell's pace of change "will be linked to the pace of change in society."

Ben van Beurden, October 2018.[2]

He who can but does not prevent, sins.

Antoine Loysel, 1607.

This chapter traces the evolution of thought on who is responsible for the climate crisis from the early science of the nineteenth century to today's Paris Agreement to oil and gas companies' commitments to reducing the carbon intensity of their supply chains. I discuss the science of attributing the lion's share of historical carbon dioxide emissions since 1750 to individual oil, gas, coal, and cement companies; the industry's climate denial, obfuscation, and greenwashing; and the emergence of litigation holding fossil fuel companies accountable for climate damages. I conclude that fossil fuel companies bear substantial responsibility for the severity of the climate crisis and the decades-long delay in effective action by nations, consumers, commerce, industry, and,

[1] Anamaria Deduleasa and Iain Esau "Winning Stakeholders' Trust a Key Challenge for Oil and Gas Players," *Upstream*, February 29, 2020, <https://www.upstreamonline.com/low-carbon/winning-stakeholders-trust-a-key-challenge-for-oil-and-gas-players/2-1-764770>.

[2] Adele Peters, "Is It Possible for an Oil Company to Help Fight Climate Change?," Fast Company, November 1, 2018, <https://www.fastcompany.com/90249937/is-it-possible-for-an-oil-company-to-help-fight-climate-change>.

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most of all, by oil, natural gas, and coal producers themselves to decarbonize at the scale and speed now required to avert dangerous interference with the climate system.

12.1 INTRODUCTION

The science of climate change grew primarily out of two strands of thought: one, the search for the mechanisms for the observed climate swings, sea level changes, stratigraphy, evolution of life, geologic history of the earth, and glaciations that were coming to light in the 1800s and two, the science of atmospheric physics, the behavior of gases, and the relationship between the atmosphere and the weathering of rocks.

The radiative properties of carbon dioxide (CO_2) were discovered by Eunice Foote in 1856, advanced by John Tyndall,[3] and studied by Svante Arrhenius in the 1890s.[4] Arrhenius, despite his careful work on calculating the atmospheric sensitivity of carbon dioxide, thought that fossil fuels (predominantly coal in the 1890s) had a minor role in CO_2 variability. He dismissed the idea that future fossil fuel use could double the atmospheric CO_2 content: there simply weren't enough recoverable carbon fuels in the world at the time, and that level of production and consumption was, in his day, unthinkable.

The science emerging in the 1900s on the importance of CO_2 was dismissed by the Royal Meteorological Society as having "no appreciable effect on the climate" – foreshadowing disbelief (still alive among climate denialists) that human activities could have any appreciable impacts on Mother Nature – but later confirmed by Guy Callendar in the 1930s.[5] Confirmation of the predominant role of human emission sources came later.

With respect to the causes of human-caused climate change, this chapter is primarily concerned with the sources of warming and the behavior of greenhouse gases, chiefly carbon dioxide and methane associated with fossil fuel combustion, and secondarily with humanity's impacts on the natural carbon cycle through, for example, deforestation, permafrost melting, ice loss, and albedo changes.

[3] Foote published a paper on the heating effect of carbon dioxide in 1856, although, erroneously, John Tyndall is typically credited with discovering the "greenhouse effect" in a series of experiments and papers starting in 1859.

[4] See Svante Arrhenius, "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground" (1896) 41 *Philosophical Magazine and Journal of Science* 237.

[5] See Charles C. Mann, "Meet the Amateur Scientist Who Discovered Climate Change," *Wired*, January 23, 2018; see also Spencer R. Weart, *The Discovery of Global Warming* (Cambridge, MA: Harvard University Press, 2008).

Early measurements of atmospheric carbon dioxide were sporadic and regional. Reliable global monitoring began in 1958 with Charles Keeling's continuous readings at the Mauna Loa volcano in Hawai'i.[6] The iconic "Keeling Curve" is one of the most significant scientific accomplishments of the twentieth century, and it helped raise scientific awareness of rising CO_2 concentrations, human impacts on the Earth's atmosphere, and the sensitivity of global temperatures to minor perturbations in the atmospheric concentration of CO_2. While CO_2 concentrations are low (0.04 percent of the atmosphere), the gas is the chief regulator of global temperatures and, once perturbed, is potent enough to awaken an "angry beast."[7]

12.2 SOURCES OF GREENHOUSE GASES

These "minor" perturbations in CO_2 concentration have involved large-scale mobilizations of resources, investment of trillions of dollars, the extraction and combustion of approximately 580 billion tons of fossil fuels since the mid-1700s, and trillion-ton terraforming visible from space for infrastructure, mining, and material movement. Cement production and energy-related carbon dioxide and methane comprise 72 percent of global anthropogenic emissions. Other sources include CO_2 from land use and deforestation (approximately 11 percent); methane from animal husbandry, agriculture, and decomposition of organic wastes (approximately 9 percent); nitrous oxide (approximately 6 percent); and fluorinated compounds (approximately 2 percent).

Now we know that the future Arrhenius couldn't fathom has come to pass: global fossil fuel production in the mid-1890s generated emissions of 1,535 million tons of carbon dioxide ($MtCO_2$), which by 2018 had risen twenty-two-fold to 33,730 $MtCO_2$.[8] Such an explosive expansion of fossil fuel

[6] See Charles D. Keeling, "The Concentration and Isotopic Abundances of Carbon Dioxide in the Atmosphere" (1960) 12 *Tellus* 200. Keeling also did readings in Antarctica in 1958 and in La Jolla from 1958 onward.

[7] Wallace S. Broecker, *Fossil Fuel CO_2 and the Angry Climate Beast* (New York: Eldigio Press, 2003).

[8] See Tom Boden, Bob Andres, and Gregg Marland, "Global CO_2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751–2014" (2017) US Department of Energy. Oil, gas, and coal emissions in 1896: 419 MtC (97 percent coal); 2018: 9,535 MtC. In 2018, cement totaled 1,507 $MtCO_2$. Updated using data from the Global Carbon Project. This "inconceivable" rise in fossil fuel use roughly parallels economic growth, though carbon emissions have gradually "decoupled" from global GDP growth. CO_2 decreased from 0.434 $kgCO_2$ per $GDP in 1990 to 0.328 $kgCO_2$ per $GDP in 2014. "$CO_2$ emissions," World Bank, <https://data.worldbank.org/indicator/EN.ATM.CO2E.PC> (kg per 2017 PPP $GDP).

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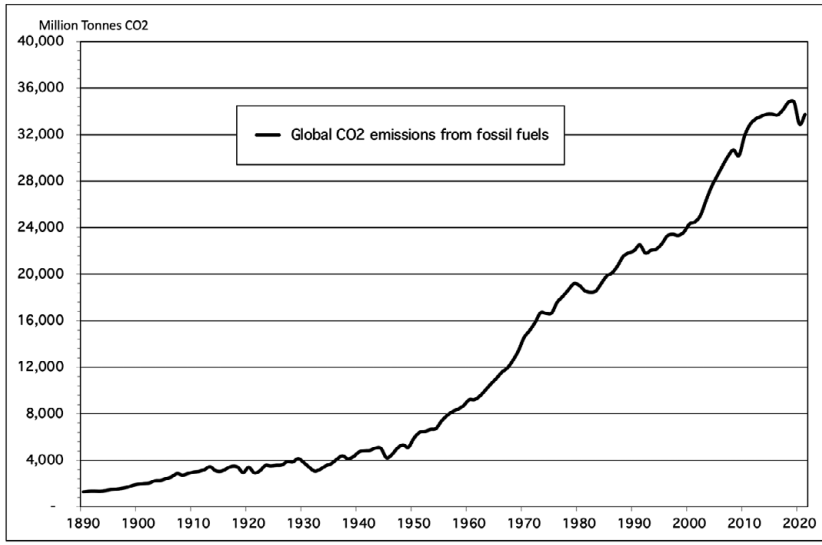

FIGURE 12.1 Global CO_2 emissions from fossil fuel use, cement production, and flaring, 1890

production brought unparalleled prosperity, allowed the global population to grow by 480 percent, and ultimately led per capita carbon emissions to rise from 0.95 tCO_2 in 1896 to 4.5 tCO_2 in 2018. This expansion of energy use vastly improved our access to basic necessities such as shelter, food, sanitation, and well-being. But it also perpetuated economic and racial inequality, environmental injustice, poverty, hunger, disease, and fossil fuel racism,[9] among a host of other problems (see Figure 12.1).

In the early carbon age, there was little concern for the environmental, societal, or climatic impacts of fossil fuel production and use. It wasn't until the 1950s that global industrialization and environmental change began to be recognized as imperiling humanity's prospects; Harrison Brown's *The Challenge of Man's Future* in 1954 and, later, Rachel Carson's *Silent Spring* (1962) and Club of Rome's *Limits to Growth* (1972) shed light on the clash between unrestrained growth and the planet's ability to sustainably provide food and materials without threatening the web of life on which humans depend. These concerns, which gained prominence in the 1960s, and the awareness of the dangers of unfettered industrialization led to the Earth Day

[9] See Nikayla Jefferson and Leah Stokes, "Our Racist Fossil Fuel Energy System," *Boston Globe*, July 13, 2020, <https://www.bostonglobe.com/2020/07/13/opinion/our-racist-fossil-fuel-energy-system/>.

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demonstrations of 1970 and emboldened President Nixon and Congress to pass environmental legislation and create the Environmental Protection Agency.

As Morris Udall (US Congressman from New Mexico) said in 1974, "far-sighted scientists, businessmen, economists, and public servants are beginning to realize that there is a better, safer way than blind, unlimited growth. And that is to limit growth now before the problem reaches crisis proportion."[10] Udall was speaking of US oil reserves and potential new discoveries and pointing out that exponential growth made the scale of our reserves irrelevant in the long run, chiefly because environmental impacts would limit growth. Indeed, fossil fuel reserves have far exceeded safe climate limits for decades.[11]

With respect to the threat of climate change, the scientific community as well as the petroleum industry began to issue early warnings in the 1950s. In 1959, Columbia University and the American Petroleum Institute (API) convened a meeting organized for the centennial of Edwin Drake's discovery of oil at Titusville, Pennsylvania in 1859. Physicist Edward Teller, best known for his role in the Manhattan Project and an "out of the box" thinker on the civilian use of atomic devices for energy production, was asked to comment on "energy patterns of the future." He warned the audience of 300 leading academics and oil industry executives that fossil fuels "contaminate the atmosphere" and that "when the temperature does rise by a few degrees over the whole globe, there is a possibility that the icecaps will start melting and the level of the oceans will begin to rise."[12] That seed of recognition of the consequences of fossil fuel use – that their continued use would threaten the viability of companies engaged in the production and distribution of carbon fuels – was thus planted decades ago.

Oil and gas company scientists and trade associations also researched the effects of carbon dioxide emissions and carbon uptake by the oceans. Company executives were duly warned that the continued use of fossil fuels would destabilize the global climate and pose an existential threat to fossil fuel producers. US and international Academies of Science weighed in with commissions and reports studying the severity of the threat of global warming, including, notably, the Charney report (1979), which were preceded and followed by scientific investigations, a warning to Congress by President

[10] For the source of the quotation, see Mason Inman, *The Oracle of Oil: A Maverick Geologist's Quest for a Sustainable Future* (New York: Norton, 2016).

[11] See Richard Heede, "A World Geography of Recoverable Carbon Resources in the Context of Possible Climate Change" (1983) National Center for Atmospheric Research 136.

[12] For the source of the quotation, see Ben Franta, "On Its 100th Birthday in 1959, Edward Teller Warned the Oil Industry about Global Warming," *The Guardian*, January 1, 2018.

Johnson's Science Advisory Committee, academic studies, international commissions, and so on.[13] (This is a bare summary; interested readers can follow the thread here.)[14]

As the science on the climate threat became incontrovertible, the world responded with the creation of the Intergovernmental Panel on Climate Change (IPCC) in 1988. Scientist Jim Hansen's riveting testimony before the Senate Energy and Natural Resources Committee in June 1988, cleverly timed by Senator Tim Wirth to coincide with a heat wave and conducted with the hearing room's cooling system turned off, finally brought the issue to public attention.[15]

12.3 INTERNATIONAL CLIMATE NEGOTIATIONS IN RESPONSE TO GLOBAL WARMING

As diplomats are wont to do with a global problem, an international effort to address climate change was launched in the late 1980s/early 1990s with climate negotiators, analysts, and scientists from most of the world's 196 nations, pursuant to the objectives of the UN Framework Convention on Climate Change (UNFCCC 1992) and focused on the responsibilities and obligations of national governments. This focus on controlling territorial consumption and emissions ignores the world's pan-national carbon producers, discussed below.[16]

The Framework Convention defines responsibility for climate change and the burden of mitigating the climate crisis "on the basis of equity and in

[13] See Jule G. Charney et al., "Carbon Dioxide and Climate: A Scientific Assessment" (1979) National Academy of Sciences 33, <https://www.bnl.gov/envsci/schwartz/charney_report1979.pdf>; see also President's Science Advisory Committee, "Restoring the Quality of Our Environment: Report of the Environmental Pollution Panel" (1965) White House 317; see also William H. Matthews, et al., *Study of Man's Impact on Climate* (Cambridge, MA: MIT Press, 1971), p. 308; see also Weart, *The Discovery of Global Warming*, above note 5.

[14] See, e.g., "Smoke & Fumes: The Legal and Evidentiary Basis for Holding Oil Companies Accountable for Climate Change" (2017) Center for International Environmental Law, < https://www.ciel.org/wp-content/uploads/2019/01/Smoke-Fumes.pdf>; see also Neela Banerjee et al., *Exxon: The Road Not Taken* (Brooklyn: Inside Climate News, 2015). And for the consummate history of climate deception and disinformation, see Naomi Oreskes and Erik Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming* (New York: Bloomsbury, 2010).

[15] See Philip Shabecoff, "Global Warming Has Begun, Expert Tells Senate," *New York Times*, June 24, 1988.

[16] Lee Raymond: "I'm not a U.S. company and I don't make decisions based on what's good for the U.S." Steve Coll, *Private Empire: ExxonMobil and American Power* (New York: Penguin, 2012).

accordance with their *common but differentiated responsibilities* and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof."[17] Responsibilities for ameliorating climate harms are thus chiefly accorded to the parties that benefited the most from historical fossil fuel use and emissions. The Framework Convention eventually led to the development of the 2015 Paris Agreement at the twenty-first meeting of the Conference of the Parties (COP). Signatories to the Paris Agreement agreed to submit plans for their Nationally Determined Contributions (NDCs), which would contain commitments to reduce national emissions in accordance with the global commitment to limit the global temperature increase to two degrees Celsius, and, if feasible, "well below" two degrees Celsius above pre-industrial surface temperature by mid-century.

This global initiative, along with the IPCC's Assessment Reports[18] and Special Report on 1.5°C,[19] are crucial to making progress on reducing still-increasing global emissions toward net zero by 2050, without significant overshoot.

Other analysts have pointed out that nations should take responsibility for consumption-based emissions that occur in countries from which they import goods, services, and energy commodities (whose operational emissions are attributed to the producer nation).[20] International agreements, while crucial, have thus far failed to curb emissions (it took a pandemic to peak emissions, if the downturn is sustainable).[21] The "emissions gap" remains wide, and NDC commitments are falling short of what is required to fulfil the objectives of the Paris Agreement.[22]

Can consumers, companies, or state and local governments fill the gap where nations fail?

[17] United Nations Framework Convention on Climate Change, Art. 3, Rio de Janeiro, May 9, 1992, 1771 UNTS.

[18] See "Climate Change 2014: Synthesis Report, Summary for Policymakers" (2014) IPCC 40.

[19] See "Special Report on Global Warming of 1.5°C: Summary for Policymakers of IPCC" (2018) IPCC.

[20] See Steven J. Davis et al., "Future CO_2 Emissions and Climate Change from Existing Energy Infrastructure" (2010) 329 *Science* 1330.

[21] See Corinne Le Quéré et al. "Temporary Reduction in Daily Global CO_2 Emissions during the COVID-19 Forced Confinement" (2020) 10 *Nature Climate Change* 647; International Energy Agency (2022) Global Energy Review: CO_2 Emissions in 2021: Global Emissions Rebound Sharply to Highest Ever Level, IEA, Paris, <https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2Climate/Emissions/IEA/IEAGlobalEnergyReviewCO2Mar22.pdf>

[22] See "The Emissions Gap Report 2019" (2019) United Nations Environment Programme 81.

12.4 NON-STATE ACTORS AND RESPONSIBILITY[23]

The concept of responsibility includes private parties as well as national governments.[24] Consumers have pursued emission reductions, cutting their consumption of carbon fuels and fossil-based electricity. Electric utilities, airlines, and large companies generate significant emissions of carbon dioxide, and most large public companies measure and report operational emissions using corporate inventory protocols.[25] Most Fortune 500 companies and thousands of mid-sized companies report direct and indirect operational emissions to platforms such as CDP and the Global Reporting Initiative, and most publish corporate sustainability reports. Nearly one thousand companies have committed to meet or exceed the Paris Agreement's "well-below 2°C" target and "to pursue efforts to limit warming to 1.5°C."[26] Thousands of cities have also committed to climate action. Yet emissions keep rising.[27]

The emphasis in the greenhouse gas protocol is to report on and thereby acknowledge a degree of responsibility for direct and indirect operational emissions (scope 1 and scope 2, respectively). For fossil fuel companies, in particular, emissions from oil, gas, and coal products sold to and emitted by their worldwide customers (scope 3) are reported voluntarily and, hence, without a commensurate sense of responsibility. Since their carbon fuel

[23] For brevity, this discussion ignores the rich literature on the nature and implications of responsibility for climate change and consequential burden of action by notable philosophers such as Simon Caney, John Broome, Kathleen Dean Moore, Stephen Gardiner, Dale Jamieson, John Nolt, James Garvey, Henry Shue, Steve Vanderheiden, Kristian Høyer Toft, and Sybille van den Hove. Most of this literature is focused on the individual vs. state moral responsibility, or on ancestral vs. current responsibility, and thus skirts discussion of corporate culpability in general and particularly the major carbon producers (with the exception of Shue and Toft).

[24] See Claire L. Fyson et al., "Fair-Share Carbon Dioxide Removal Increases Major Emitter Responsibility" (2020) 10 *Nature Climate Change* 836.

[25] See Pankaj Bhatia et al., "The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard" (2004) World Resources Institute & World Business Council for Sustainable Development.

[26] See Science Based Targets, < https://sciencebasedtargets.org/>; see also aspirational initiatives, e.g., ClimateAction100+, <https://www.climateaction100.org/>; CDP, <https://www.cdp.net/en>; Global Reporting Initiative, <https://www.globalreporting.org/>; see also financial reporting and corporate responsibility groups, e.g., CERES, <https://www.ceres.org/>; Task Force on Climate-Related Financial Disclosures, <https://www.fsb-tcfd.org/>. See also "Major Risk or Rosy Opportunity: Are Companies Ready for Climate Change?" (2019) CDP 47.

[27] See Jonathan Franzen, "What If We Stopped Pretending? The Climate Apocalypse Is Coming," *New Yorker*, September 8, 2019.

products are their largest source of attributed emissions, this, too, is changing, and fossil fuel companies are taking notice.

Corporations have stepped up their game in recent years,[28] pushed by the urgency of the IPPC's "1.5°C Report," the Task Force on Climate-Related Financial Disclosures, the keen interest of investors, the potential stranding of billion-dollar reserves, divestment campaigns, campaigns to keep carbon in the ground, virulent demonstrations, and the emergence of Greta Thunberg as humanity's climate conscience.

The fiduciary responsibility of corporations – previously limited to maximizing financial returns to shareholders – has been broadened by Business Roundtable's "Statement on the Purpose of a Corporation," investors such as BlackRock urging the full disclosure of climate-related risks and holding directors to account, the requirements of the Task Force on Climate-Related Financial Disclosures, the divestment decisions of Norway's Sovereign Wealth Fund, corporate reputational concerns, the need to preserve their social license to operate, and the threat of climate litigation, just to name a few of the motivating developments that have helped raise the pressure on oil and gas companies to align with the Paris Agreement.

Other companies, including electric utilities, have stepped up their ambition. What about the fossil fuel companies at the base of the global supply chain for carbon fuels? What responsibilities do they have?

12.5 THE RESPONSIBILITY OF FOSSIL FUEL PRODUCERS

By the mid-2010s, there was little choice for fossil fuel producers but to acknowledge their fundamental responsibilities for the impacts of their carbon fuels and the need to address the climate crisis largely caused by their products. Indeed, BP and Shell acknowledged as much in the 1990s.[29] (American companies, in contrast, invested millions of dollars to disinform Congress and the public[30] in order to delay action to curb production.) Whether any oil and gas company is fully prepared for the decarbonization of the world's energy economy remains to be seen, but Eni, TotalEnergies, BP, Shell, Repsol, Galp, and Equinor have made substantial commitments, in

[28] See David Kiron et al., "Corporate Sustainability at a Crossroads: Progress toward Our Common Future in Uncertain Times" (2020) MIT Sloan & Boston Consulting Group 31.

[29] See *Climate of Concern* (Royal Dutch Shell 1991) (28-minute film); see also "The Greenhouse Effect," Royal Dutch Shell (1988), p. 91; see also Robert Bradley, "Beyond Petroleum," BP, 2010; see also John Browne, Stanford University Speech (1997).

[30] See Robert J. Brulle, "The Climate Lobby: A Sectoral Analysis of Lobbying Spending on Climate Change in the USA, 2000 to 2016" (2018) 149 *Climatic Change* 289.

alignment with the Paris Agreement, to reduce operational and product-related emissions by mid-century.[31] Whether leading companies can be trusted to drive decarbonization remains to be seen.[32]

Fossil fuel companies extract, refine, and market the carbon fuels that, when used as intended, contribute the largest share (87 percent of all CO_2 from fuels, cement, and land use, and 62 percent overall) of all greenhouse gas emissions that drive atmospheric warming and climate change. Seven-eighths of emissions attributed to carbon producers result from the use of their products – gasoline, diesel, jet fuel, natural gas, and coal – and one-eighth from the extraction, refinement, and delivery of finished fuels.

Oil, natural gas, and coal companies have benefited for decades from hundreds of billions of dollars in government subsidies for fossil fuel development, as well as regulatory preferences such as lax pollution controls, favorable leasing terms for resource extraction on public lands, other taxpayer-funded costs, such as naval protection for shipping lanes, and health costs of energy-related pollution.[33] Fossil fuel companies are the beneficiaries of what economist Nicholas Stern has called the "greatest market failure the world has seen," whereby the profits have been privatized and the costs and damages have been externalized.

Fossil fuel and cement producers had early knowledge that their products would destabilize the climate and thus bear a moral responsibility to address the impacts caused by the use of their products. Rather than taking action to ameliorate the harms, these companies have continued to invest in additional reserves and production, funded campaigns to disinform the public in order to delay legislative action, and sought to perpetuate the carbon economy — as if the consequences didn't matter.[34]

12.6 THE CARBON MAJORS PROJECT: ATTRIBUTING EMISSIONS

On the theory that fossil fuel producers bear substantial responsibility for the adverse impacts of their products,[35] the Climate Accountability

[31] Simon Dietz, Dan Gardiner, Valentin Jahn, & Jolien Noels (2021) How ambitious are oil and gas companies' climate goals? Science, vol. 374:405–408.

[32] Dario Kenner and Richard Heede, "White Knights, or Horsemen of the Apocalypse? Prospects for Big Oil to Align Emissions with a 1.5°C Pathway" (2021) *Energy Research & Social Science* 79, art. no. 102049. <https://www.sciencedirect.com/science/article/pii/S2214629621001420>.

[33] Geoffrey Supran, Peter Erickson, Doug Koplow, Michael Lazarus, Peter Newell, Naomi Oreskes, & Harro van Asselt, "Fossil-Fuel Subsidies Must End," Scientific American, vol. 29 (3s), August 2020.

[34] See Benjamin Franta, "Early Oil Industry Knowledge of CO_2 and Global Warming" (2018) 8 *Nature Climate Change* 1024.

[35] See Peter Frumhoff et al., "The Climate Responsibilities of Industrial Carbon Producers" (2015) 132 *Climatic Change* 157.

Institute[36] began, in 2004, to investigate how much the largest oil, gas, and coal companies have contributed to global CO_2 and methane emissions and thus to climate change. An extensive database of each company's historical fossil fuel production was created, using company-declared production data, and a methodology to quantify atmospheric emissions was documented and peer-reviewed. The project quantified both direct operational emissions (scope 1) and product-related emissions (scope 3) from each entity's annual fossil fuel production, deducting for net non-energy uses such as petrochemicals, road oil, and lubricants. Initial results were published in 2014.[37] Results were then updated to 2017 when published in *The Guardian* and updated to include 2020 production data in Table 12.1.[38]

We found that the top twenty companies collectively produced the fuels that when used as intended dumped 493 billion tons of CO_2 and methane ($GtCO_2e$) into the atmosphere from 1965 to 2020, or 35 percent of all global fossil fuel emissions in that period (1.49 trillion tCO_2e, $TtCO_2e$). Table 12.1 shows company emissions as a percent of global fossil fuel and cement emissions over the same period.

The oil, gas, and coal companies, unsurprisingly, take a dim view of our perspective that they bear substantial responsibility for the climate impacts, costs, and damages caused by the use of their products. While they do not challenge the basic findings (the estimates are based primarily on their own production data, after all), their responses range from "we are fulfilling our customers demand for energy" and "we support climate action/we're reducing our own carbon footprint" to "people in developing countries should be allowed to have the benefits of clean fuels, too." What else can they say? That carbon fuels are legally sanctioned products and that they invested heavily in lobbying to perpetuate the carbon economy, restrain renewable energy development, and retain market share?

Suffice it to quote from seventeenth century legal scholar, Antoine Loysel: "He who can but does not prevent, sins."

[36] CAI is an independent research institute focusing on anthropogenic climate change, dangerous interference with the climate system, the contribution of fossil fuel producers' carbon production to atmospheric carbon dioxide, and the risk and disclosure requirements regarding past and future emissions of greenhouse gases. CAI was founded in 2011.

[37] See Richard Heede, "Tracing Anthropogenic CO2 and Methane Emissions to Fossil Fuel and Cement Producers 1854–2010" (2014) 122 *Climatic Change* 229; see also Richard Heede, *Carbon Majors: Accounting for Carbon and Methane Emissions 1854–2010 Methods & Results Report* (Sunnyvale: Lambert Academic, 2019), p. 148.

[38] See Matthew Taylor and Jonathan Watts, "Revealed: the 20 firms behind a third of all carbon emissions," *The Guardian*, October 9, 2019.

TABLE 12.1 *Operational and product emissions attributed to the top twenty major carbon producers, 1965–2020*

Entity		$MtCO_2e$[a]	% of global
1.	Saudi Aramco, Saudi Arabia	64,825	4.35%
2.	Gazprom, Russia	47,747	3.20%
3.	Chevron, USA	44,715	3.00%
4.	ExxonMobil, USA	43,649	2.93%
5.	National Iranian Oil Co.	39,168	2.63%
6.	BP, UK	35,646	2.39%
7.	Shell, UK	33,556	2.25%
8.	Coal India, India	26,737	1.79%
9.	Pemex, Mexico	23,731	1.59%
10.	PetroChina / China Natl Petroleum	16,783	1.13%
11.	Peabody Energy, USA	16,425	1.10%
12.	Petroleos de Venezuela	16,345	1.10%
13.	Abu Dhabi, United Arab Emirates	15,967	1.07%
14.	ConocoPhillips, USA	15,794	1.06%
15.	Kuwait Petroleum Corp., Kuwait	14,813	0.99%
16.	Iraq National Oil Co., Iraq	14,219	0.95%
17.	TotalEnergies, France	13,610	0.91%
18.	Sonatrach, Algeria	13,542	0.91%
19.	BHP, Australia	10,554	0.71%
20.	Occidental, USA	9,928	0.67%
	Top Twenty	517,743	34.73%
	Global, 1965–2020	1,490,872	100.00%

[a] $MtCO_2e$: million tonnes carbon dioxide-equivalent. Percent of global fossil fuel and cement emissions, 1965–2020

12.7 THE CARBON MAJORS: ATTRIBUTION AND LEGAL IMPLICATIONS

Attributing source emissions is the first crucial step in attributing climate impacts. In a co-authored 2017 paper, we modeled the rise in atmospheric CO_2 concentration, surface temperature, and sea level attributable to the emissions traced to the leading carbon producers.[39] In 2019, we modeled the

[39] See Brenda Ekwurzel et al., "The Rise in Global Atmospheric CO_2, Surface Temperature, and Sea Level from Emissions Traced to Major Carbon Producers" (2007) 144 *Climatic Change* 579.

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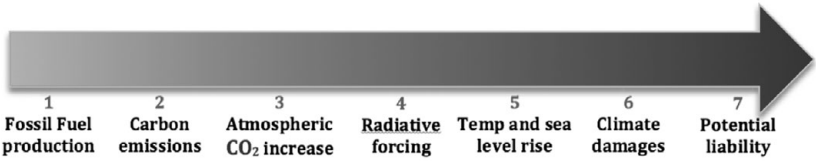

FIGURE 12.2 The arc of CAI's work from attributing emissions to carbon producers, modeling their impact on the global climate, and contributing to efforts to hold companies accountable for climate damages

major companies' impact on the acidification of the world's oceans and vulnerable fisheries.[40] These climate models account for non-anthropogenic greenhouse gases as well as emissions from other human sources, such as deforestation, carbon from soils, and non-energy sources of methane (rice cultivation, landfills, and animal husbandry) and nitrous oxide.

There are other ways of attributing climate impacts to major carbon producers. In preliminary research using a simple land inundation model, CAI estimated that of the 10,000 km² of land lost to sea level rise from 1980 to 2010, nearly 3,700 km² can be attributed to the twelve largest carbon producers. The largest land loss (approximately 600 km²) is attributed to Saudi Aramco; ExxonMobil's attributed land loss is approximately 380 km².[41] Most of this coastal inundation is in remote, sparsely populated areas, but the preponderance of economic damages are to low-lying buildings, industry, and infrastructure. We have not (yet) calculated the economic losses attributable to carbon producers (see Figure 12.2).

It is far more challenging to link the emissions traced to individual fossil fuel producers to anthropogenic climate damages.[42] It is not simply a proportional exercise in which each oil, gas, and coal company's historical emissions (e.g., Chevron's 3.0 percent of global CO_2 and CH_4 emissions since 1965) are used to allocate adaption costs or reparations (such as to an Atmospheric

[40] See Rachel Licker et al., "Attributing Ocean Acidification to Major Carbon Producers" (2019) 14 *Environmental Research Letters* 1.

[41] Preliminary calculations of estimated land loss attributed to emissions traced to major carbon producers. In the CIESIN database, global SLR of 1 m equates to 421,174 km² of inundated land; 1 mm equates to ~421 km². See Richard Heede, "Carbon Producers' Tar Pit: Dinosaurs Beware" (2017) Institute for New Economic Thinking 16, <https://www.ineteconomics.org/uploads/papers/Heede-PathToAccountability-18Oct17.pdf>.

[42] See Michael Burger and Jessica Wentz, "Holding Fossil Fuel Companies Accountable for Their Contribution to Climate Change: Where Does the Law Stand?" (2018) 74 *Bulletin of the Atomic Scientists* 397; see also Michael Burger et al., "The Law and Science of Climate Change Attribution" (2020) 45 *Columbia Journal of Environmental Law* 57.

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Recovery Trust Fund)[43] to fossil fuel companies. As discussed above, other parties contribute to emissions and thus bear some responsibility for climate change, including individual consumers (both living and dead)[44] as well as nations, airlines, corporations, and electric utilities, to name a few. Fossil fuel emissions are the major, but not the sole, contributor to anthropogenic climate change; deforestation, animal husbandry,[45] agriculture, soil loss, desertification, the thermal impacts of our cities and highways, and even albedo changes must be accounted for in considering how to allocate damages among contributing parties, whether defendants or not.

As a first step toward allocating climate damages to carbon producers, we analyze estimated global GDP losses from anthropogenic climate damages out to 2050 totaling $99 trillion and allocate climate reparations of $5.5 trillion to the twenty largest oil, gas, and coal producers based on their atmospheric CO_2 and methane contributions from 1988 to 2018, after accounting for non-energy contributions, other gases, and other responsible parties.[46]

These results are of interest to climate litigators, Loss & Damage proponents, human rights commissions, financial analysts, insurers and lenders, shareholders, regulators, scientists, and fossil fuel company executives and boards. CAI's work is cited in several climate lawsuits against major carbon producers in the United States and internationally, as well in human rights investigations.[47] The science of detection and attribution is improving rapidly,[48] and we can with increasing confidence link emissions to higher degrees of risk and higher incidences and degrees of damages. In other words, we can better link emissions to human interference with the climate system – the human fingerprint on rising climate damages.[49] For more on attribution science and climate litigation, see Michael Burger, Jessica Wentz, and Daniel Metzger's chapter in this volume (Chapter 11).

[43] As proposed by Mary Christina Wood and Dan Galpern, "Atmospheric Recovery Litigation: Making the Fossil Fuel Industry Pay for Damages to the Atmosphere from Carbon Pollution" (2015) 45 *Environmental Law* 259.

[44] See Henry Shue, "Responsible for What? Carbon Producer CO_2 Contributions and the Energy Transition" (2017) 144 *Climatic Change* 591.

[45] See Shefali Sharma, "Milking the Planet: How Big Dairy Is Heating up the Planet and Hollowing Rural Communities", IATP, June 29, 2020, <https://www.iatp.org/milking-planet>.

[46] Marco Grasso and Richard Heede, "Time to Pay the Piper: Fossil Fuel Companies' Reparations for Climate Damages: A Proposal" (in preparation).

[47] See Joanna Setzer and Rebecca Byrnes, "Global Trends in Climate Change Litigation: 2020 Snapshot" (2020) LSE 30. Isabella Kaminski "Indonesian islanders sue cement producer for climate damages," The Guardian, 20 July 2022. https://www.theguardian.com/world/2022/jul/20/indonesian-islanders-sue-cement-holcim-climate-damages?

[48] See Friederike Otto et al., "Towards an Inventory of the Impacts of Human-Induced Climate Change" (2020) *Bulletin of the American Meteorological Society*.

[49] See Kerry Emanuel, "Why It's Time to Stop Calling These Hurricane Disasters 'natural,'" *Washington Post*, September 19, 2017.

Fundamentally, however, fossil fuel producers have failed to "clean up their mess" and are morally obliged to limit future emissions and impacts in line with the science. As Henry Shue puts it:[50]

> Obviously, this responsibility to future generations does not fall on carbon producers any more than it does on anyone else. But it also does not fall on them any less. And more than most of us they have the political influence, the wealth, and the technical expertise to go beyond avoiding future harm and compensating for past harm and to make positive contributions to the creation of an energy regime that will be safe for people to live with. The time has come for the major carbon producers to face the reality of the unsafe products they persist in marketing and the safer world they could help to create. Otherwise, they risk turning themselves into enemies of humanity.

12.8 CONCLUSION

Some entities are more responsible than others, and it is my contention that oil and gas and coal producers bear substantial responsibility, not only for climate damages and adaption costs but also for a moral (and perhaps legal) mandate to accelerate the decarbonization of the global energy economy. Some companies are reacting positively to this challenge: Repsol, the Spanish oil and gas major, committed to net zero emissions by 2050 across its full supply chain[51] and other majors are moving in that direction, led by BP,[52] Royal Dutch Shell,[53] Eni, and Equinor.[54] Their ambitions, however, may not be sufficient.[55]

[50] Shue, "Responsible for What? Carbon Producer CO_2 Contributions and the Energy Transition," above note 43 at 591.

[51] See "Repsol 2050 Net Zero Emissions Commitment," Repsol, December 2, 2019, <www.repsol.com/en/press-room/press-releases/2019/repsol-will-be-a-net-zero-emissions-company-by-2050.cshtml>.

[52] See "BP Sets Ambition for Net Zero by 2050, Fundamentally Changing Organisation to Deliver," BP, February 6, 2020, p. 11; see also Mike Coffin, "BP's Net Zero Ambition: Deciphering the Code," Carbon Tracker Initiative, February 14, 2020, <https://carbontracker.org/bps-net-zero-ambition/>.

[53] See "Shell's Ambition to Be a Net-Zero Emissions Energy Business," Royal Dutch Shell, April 16, 2020, <www.shell.com/energy-and-innovation/the-energy-future/shells-ambition-to-be-a-net-zero-emissions-energy-business.html>; see also Katherine Dunn, "Shell Becomes the Largest Global Energy Company to Commit to a Net-Zero Emissions Goal by 2050," *Fortune*, April 16, 2020, <https://fortune.com/2020/04/16/net-zero-emissions-shell-oil-industry-gas/>; See also "Eni's strategy against climate change," *Eni*, <https://www.eni.com/en-IT/net-zero/strategy-climate-change.html>.

[54] See "Equinor's Climate Roadmap: Equinor Sets Ambition to Reduce Net Carbon Intensity by at Least 50% by 2050," *Equinor*, February 6, 2020, p. 23, <https://www.equinor.com/en/how-and-why/climate.html>.

[55] Dietz et al., "How Ambitious Are Oil and Gas Companies' Climate Goals?" *Science*, 2021, 374:405–408, above note 31; Kenner and Heede, "White Knights, or Horsemen of the Apocalypse?" note 32 above.

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The writing is on the wall. Carbon emissions must, if we are to preserve global civilization as we know it, decline rapidly to net zero by mid-century. This requires a massive transformation of the global energy system, the decommissioning of plants, drilling platforms, pipelines, refineries, mines, boilers, vehicles, aircraft – all manner of carbon infrastructure – and the creation and deployment of a new (though less massive) infrastructure to capture, store, transport, and permit the use of emerging renewable energy systems. It also requires the investment of trillions of dollars and the deployment of ingenious, efficient new systems.[56] This transition should not only be the burden of the nations of the world and their taxpayers but also, in substantial part, the fossil fuel companies that have willfully prolonged this transformation.

In this writer's view, this transition has been inevitable for decades,[57] and we have squandered precious time, skirted our responsibilities, and shifted the costs to our children. Major fossil fuel companies understand their role and the existential importance of leading the transition to a low-carbon economy. It is my hope that the companies – and countries – that lead will prosper and that the laggards will get out of the way.

[56] See Amory Lovins, "Reinventing Fire: Bold business solutions for the new energy era" (2011) Rocky Mountain Institute.

[57] See Myles Allen, "Liability for Climate Change"(2003) 421 *Nature* 419; see also Myles R. Allen et al., "The Case for Mandatory Sequestration" (2009) 2 *Nature Geoscience* 813.