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IN THE CIRCUIT COURT OF THE STATE OF OREGON  
FOR THE COUNTY OF MULTNOMAH

COUNTY OF MULTNOMAH,

Case No. 23CV25164

Plaintiff,

**DECLARATION OF  
RICHARD HEEDE**

v.

Hon. Benjamin Souede

EXXON MOBIL CORP., SHELL PLC,  
F.K.A. ROYAL DUTCH SHELL PLC,  
SHELL U.S.A., INC., EQUILON  
ENTERPRISES LLC DBA SHELL OIL  
PRODUCTS US, BP PLC, BP AMERICA,  
INC., BP PRODUCTS NORTH AMERICA,  
INC., CHEVRON CORP., CHEVRON  
U.S.A., INC., CONOCOPHILLIPS,  
MOTIVA ENTERPRISES, LLC,  
OCCIDENTAL PETROLEUM F.K.A.  
ANADARKO PETROLEUM CORP.,  
SPACE AGE FUEL, INC., VALERO  
ENERGY CORP., TOTALENERGIES  
MARKETING USA F.K.A. TOTAL  
SPECIALTIES USA, INC., MARATHON  
OIL COMPANY, MARATHON OIL CORP.,  
MARATHON PETROLEUM CORP., KOCH  
INDUSTRIES, INC., AMERICAN  
PETROLEUM INSTITUTE, WESTERN  
STATES PETROLEUM ASSOCIATION,  
MCKINSEY & COMPANY, INC.,  
MCKINSEY HOLDINGS, INC., NW  
NATURAL F.K.A. NORTHWEST  
NATURAL GAS COMPANY, OREGON  
INSTITUTE OF SCIENCE AND MEDICINE  
and DOES 1-250 INCLUSIVE,

Defendants.

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I, Richard Heede, hereby declare under penalty of perjury the following:

1. I am over the age of 21 and am competent to be a witness in this action.

2. My name is Richard Heede. I am a climate scientist, Director and Co-Founder of the Climate Accountability Institute. I also serve as the principal investigator for the Climate Accountability Institute's widely-cited "Carbon Majors" project, which traces historical CO2 emissions to oil, natural gas, and coal companies. I have authored/co-authored several papers on the climate responsibilities of fossil fuel producers.

3. I co-founded CAI in 2011 to provide the scientific basis for leveraging climate stewardship by carbon producers. I published my thesis *A Geography of Carbon* with the National Center for Atmospheric Research in 1984. I worked on energy and climate solutions with the Rocky Mountain Institute 1984-2002 and founded Climate Mitigation Services in 2003. My passive-solar rammed-earth home cuts carbon emissions by two-thirds. I have not been convicted of a felony. I have specific knowledge and experience that qualifies me to provide expert opinions in this matter.

4. I have prepared the following report, *Extraction, refining, & sales: Comparing emissions of CO2 and methane of selected oil, gas, and coal companies from 1950 to 2022*, for use in this above captioned matter. A true and correct copy of my April 11, 2025, report, which includes my opinions, is attached hereto as Exhibit 1.

5. I hereby adopt and incorporate my report into this declaration as though it was set forth in full herein. My professional services have been performed using the degree of care and skill ordinarily exercised. All opinions in this report are my opinions to a reasonable degree of scientific certainty.

1 I hereby declare that the above statement is true to the best of my knowledge and  
2 belief, and that I understand it is made for use as evidence in court and is subject to penalty  
3 for perjury.  
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6 Richard Heede

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# **EXHIBIT 1**

# *Extraction, refining, & sales:* *Comparing emissions of CO<sub>2</sub> and methane of selected oil, gas, and coal companies from 1950 to 2022*



**By Richard Heede**  
Climate Accountability Institute  
11 April 2025



## Climate Accountability Institute

Principal Investigator: Richard Heede

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NASA image



**Note on units:** International SI units are used throughout, except where reporting is in bbl of oil, cubic feet of natural gas, or (short) tons of coal. Emissions of methane are expressed in CH<sub>4</sub> or in CO<sub>2</sub>-equivalent terms (CO<sub>2</sub>e; AR4: 100-y, 28xCO<sub>2</sub>).

Cover: earth edge; BP platform Thunderhorse; laying pipe; Exxon refinery in the UK; gas flaring; Exxon adrift.

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## Introduction

This report presents the results of a source attribution effort that is focused on selected oil, gas, and coal companies and their production, refinery output, and petroleum product sales over the period from 1965 to 2022, using to the fullest extent possible company-reported data from sources such as their Annual Reports and SEC Form 10-Ks (for US companies, or 20-F for Canadian companies and 40-F for foreign companies). Company-reported data sets are substantially but not fully complete, due to gaps or incompleteness in their reporting or from our inability to discover original pre-digital reports. The acquisition and analysis of complete data sets from each of the companies that refined and/or sold petroleum products from 1965 onwards would enable a comprehensive comparison between the three methodologies.

The objective, within the context of responsibility for atmospheric change, is to quantify emissions of carbon dioxide and methane attributable to selected fossil fuel producers from three perspectives:

1. Each company's *net equity extraction* of crude oil, natural gas, and coal and the estimated emissions from the use of their carbon fuels (Carbon Majors approach);
2. Each company's *refinery output* of petroleum products, plus processed natural gas and coal, if applicable (Refining approach). In practice, most companies report refinery *inputs*;
3. Each company's *sale of petroleum products*, plus processed natural gas and coal, if applicable (Product sales approach).

The companies whose production, refinery output, and product sales are documented and emissions are estimated in this report are:

1. BP Plc.;
2. Chevron Corp.;
3. ConocoPhillips;
4. ExxonMobil Corp.;
5. Koch Industries Inc.;
6. Marathon Oil, Marathon Petroleum
7. Motiva Enterprises LLC;
8. Northwest Natural;
9. Occidental Petroleum (incl Anadarko);
10. Shell Plc.;
11. Space Age Fuel Inc.;
12. TotalEnergies USA;
13. Valero Energy Corp.

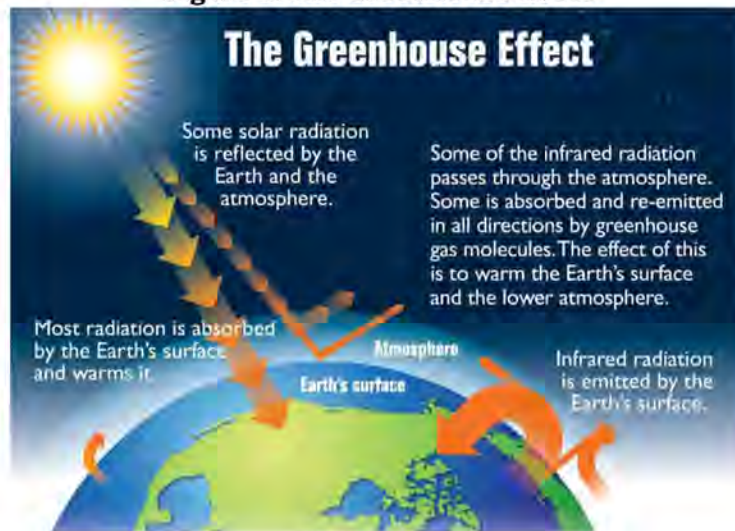
Company-reported data for oil, gas, and coal *extraction* are relatively complete for the period from 1950 to 2022 for the thirteen analyzed companies, whereas company reporting of refinery output (or throughput) and of petroleum product sales are more limited in time — several major companies have not published, or if published we have not found the publications (having searched through hundreds of annual reports and SEC filings) detailed data on refining and product sales.

The three datasets analyzed here are relatively complete for the year 2000 forward, and for those years most of the investigated companies *sell* considerably more petroleum product than they either produce or refine. This indicates substantial procurement of refined products from third parties for sale through each company's supply chain. The oil and gas industry is deeply complex and interwoven, and this analysis has barely begun to illuminate the data and the methodology of how to quantify emissions and attribute responsibility for the climate impacts thereof to these thirteen selected companies.

## Definitions and global context

**Greenhouse Gases** (GHGs) are atmospheric gases that increase the surface temperature of the planet by preventing some of the longwave radiation from the surface to escape into space, instead reflecting the radiation back to the surface. GHG gases include water vapor (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), and F-gases (chloro-fluorocarbons, hydrofluorocarbons, etc.). These heat-trapping gases increase the surface temperatures of the earth, most especially in high latitudes.

**Figure 1. The Greenhouse Effect**



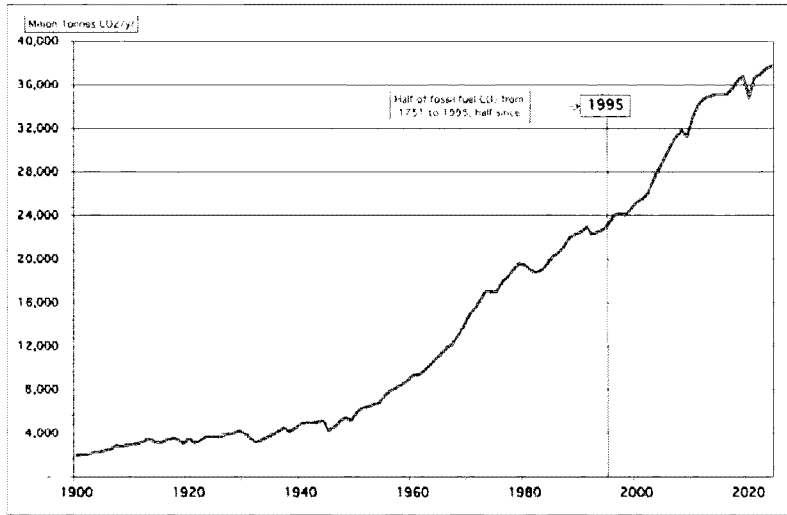
US EPA (2012).

**Anthropogenic climate change** — or global warming (or global weirding) — refers to humanity's interference with the natural cycles of climate. While the Earth's climate is naturally variable and also involve changes in atmospheric composition, especially of methane and carbon dioxide, human alteration of the atmosphere is the primary cause of global warming. Other human activities influence climate, such as deforestation for agriculture and animal husbandry, and building highways and cities, which change the albedo of the land surface, or rice cultivation and landfills, which release methane. Deforestation also lowers the rate of carbon dioxide absorption by forested areas, agricultural practices release soil carbon, and so on. The main cause of anthropogenic climate change is our increasing use of fossil fuels and release of CO<sub>2</sub> and methane.

Emissions from fossil fuel use and cement production (see definition below) have doubled since 1977, and fully half of fossil fuel CO<sub>2</sub> emissions have occurred since 1994. (Fig. 2)

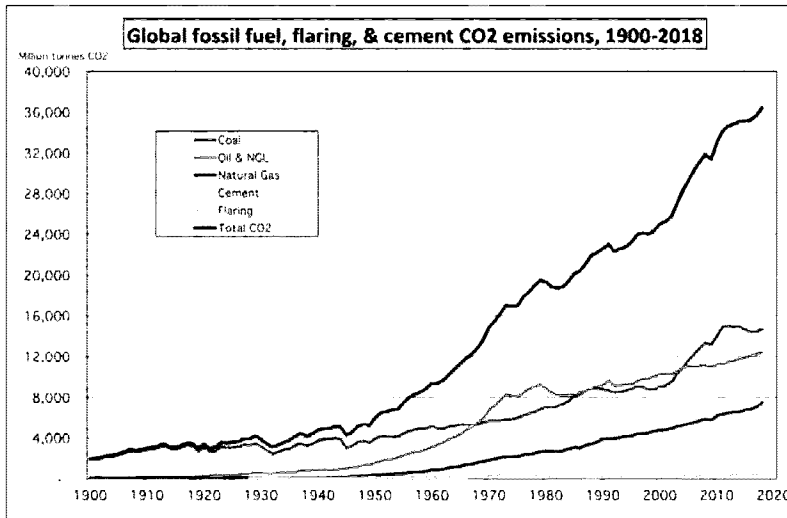
The accepted **Global Warming Potential** (GWP) of CO<sub>2</sub> is defined as 1.0. Other gases are expressed in relation of CO<sub>2</sub> so that emissions can be compared in a rational manner. Over a 100-year time horizon methane has a GWP of 28 x CO<sub>2</sub>. IPCC (2013). Other researchers express methane over a 20-year horizon at a value of 82 x CO<sub>2</sub> (since methane decays to CO<sub>2</sub> relatively quickly in the atmosphere). The accepted metric in national and corporate inventories is typically 28 x CO<sub>2</sub>, which we adopt in the current work.

**Figure 2. Half of Fossil Fuel and Cement emissions have occurred since 1995.**



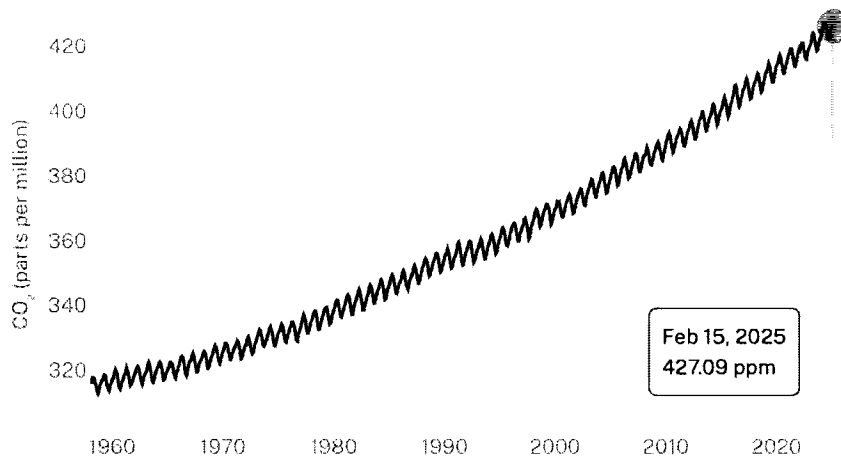
Climate Accountability Institute. Data from Global Carbon Project & CDIAC.

**Figure 3. Emissions of CO<sub>2</sub> from fossil fuel combustion, cement production, and flaring 1900-**



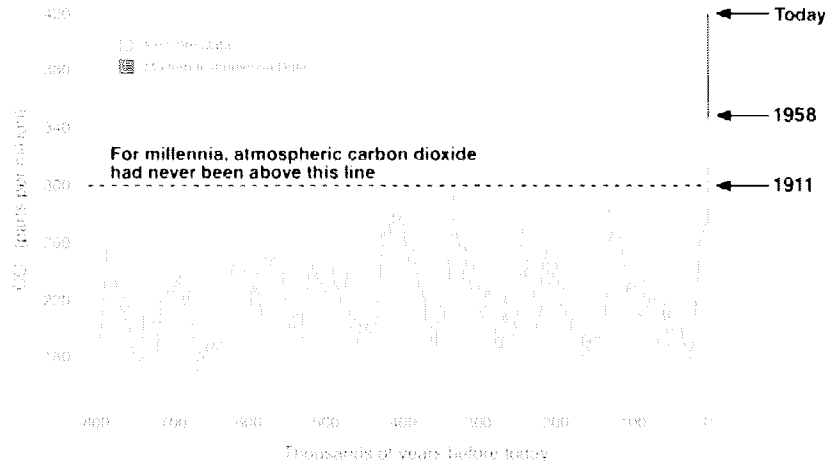
Climate Accountability Institute. Data from Global Carbon Project & CDIAC.

**Figure 4. Measured CO<sub>2</sub> concentration since 1950. 2025: 427 ppm.**



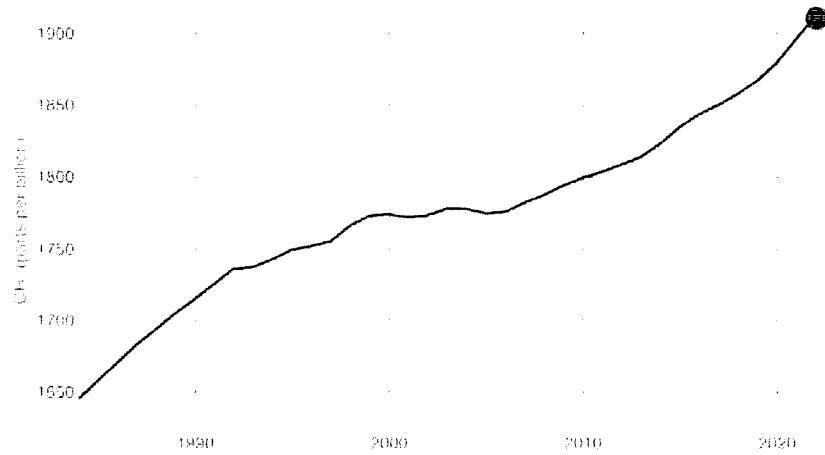
<https://climate.nasa.gov/vital-signs/carbon-dioxide/>

**Figure 5. Ice core measurements of CO<sub>2</sub> concentration over the last 800,000 yrs.**



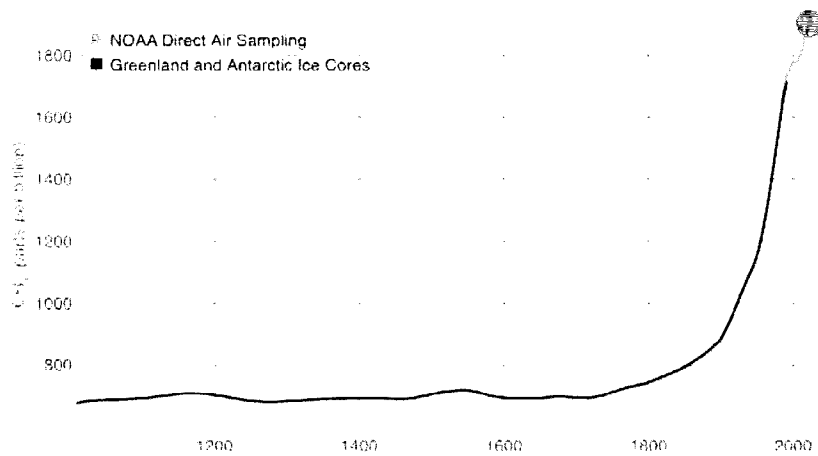
Data source: Reconstruction from ice cores. Credit: NOAA. <https://climate.nasa.gov/vital-signs/carbon-dioxide/>

**Figure 6. Measured methane concentration since 1985. 2022: 1,912 ppb.**



Etheridge et al., 1998 and NOAA Global Monitoring Laboratory. <https://climate.nasa.gov/vital-signs/methane/>

**Figure 7. Estimated methane concentration since ~1,000 AD.**



Etheridge et al., 1998 and NOAA Global Monitoring Laboratory. <https://climate.nasa.gov/vital-signs/methane/>

**Carbon Majors** refers to a dataset of historical emissions of CO<sub>2</sub> and methane attributed to fossil fuel and cement producers since as early as 1854. The database was developed by Climate Accountability Institute over a period of twenty years, and now encompasses

emissions attributed to 108 entities on the basis of each entity’s reported production of oil, natural gas, and coal by year and the carbon content of each barrel of oil, cubic foot of natural gas, or ton of coal. The Carbon Majors methodology estimates emissions from extraction to final combustion of petroleum products, including their refining, and not simply emissions from “upstream” production activities. As such, the methodology encompasses the full value chain of emissions from extraction to consumption. The other two methodologies examined in this report — emissions from refining, and emissions from petroleum product sales (see below) — *cannot be added* to production-based emissions.

Note: the updating of the Carbon Majors database has been transferred to InfluenceMap in London, which released the latest update in March 2025. The dataset has been expanded to 180 entities, significantly due to the addition of individual coal producing companies in China and the Russian Federation; previously aggregated under China coal and Russia coal.

Carbon Majors adopts the World Resources Institute’s *Corporate GHG Protocol*. We account for scope 1 direct emissions of CO<sub>2</sub> and methane, and scope 3 emissions of CO<sub>2</sub> from combustion of petroleum products (such as jet fuel, gasoline, diesel, and bunker fuel) and marketed natural gas. We base our calculations on net equity extraction of fossil fuels for each company, and, importantly, deduct for typical net non-energy uses of petroleum, such as for petrochemical feedstocks, lubricants, road oil, etc. in order to realistically estimate atmospheric emissions of CO<sub>2</sub> by combustion of carbon fuels used by global consumers *as intended*. The methodology excludes scope 2 from indirect operational sources — primarily emissions from electricity generation and delivery — in order to avoid double-counting carbon fuels produced by database entities. Vertically-integrated oil and gas companies report emissions from petroleum product sales, which often exceed emissions from production-based accounting methodology. Explanation of each of these methodologies is discussed below.

Alternative accounting metrics also used in this analysis:

**Refinery output:** oil & gas companies, particularly vertically-integrated companies, often own refineries or share ownership in refineries in order to provide petroleum products to its supply chains or to third party companies such as jet fuel, home heating oil, or gasoline wholesalers. As investigated in this report, oil and gas companies inconsistently publish data on refinery output (or refinery outturn) either in aggregate, or more usefully, by each of several commonly-reported categories of finished petroleum fuels. The major categories include gasoline, diesel (or distillate fuel), heavy oils (or heating oil, sometimes including bunker fuel), jet fuel, and the like. Company-reporting is inconsistent over time, for many years only total product sales are reported, definitions are neither clear nor comparable to other company’s categories — nor even to the same company’s later or earlier categories. Furthermore, the category often entitled “other, or specialty products” is generally poorly or variably defined and often contain combustion products (such as propane, or jet fuel, or petroleum coke<sup>1</sup>) in addition to non-combustion products such as petrochemical feedstocks, road oil, and lubricants that typically sequester the carbon in those products.<sup>2</sup> Depending on the quality of the reported refinery output data it is straightforward to

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<sup>1</sup> Petroleum coke (“green coke”) is used for combustion in powerplants or cement kilns, whereas calcined coke is used in aluminum, glass, and brick firing. A minor amount is used in the production of TiO<sub>2</sub> as pigment in paints, sunscreens, etc.

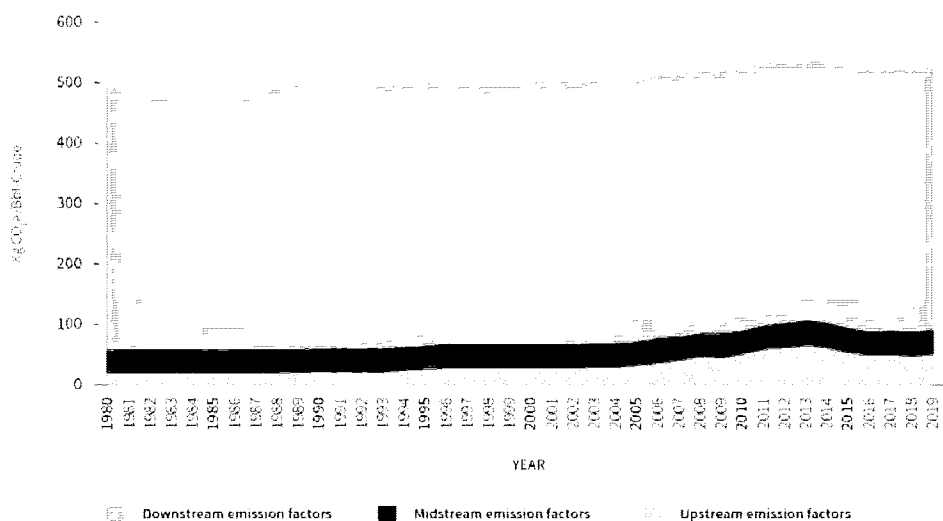
<sup>2</sup> The Carbon Majors methodology nets in proportions of “non-energy” products if, for example, lubricants or plastics are combusted in waste-to-energy plants or cement kilns.

quantify CO<sub>2</sub> emissions from their combustion using well-documented emission factors per million bbl (Mb) of each product. Minor emissions of methane associated with the storage and distribution of refined products are ignored in this analysis.

**Petroleum Product Sales:** integrated oil & gas companies typically sell finished petroleum products through their own supply chains (such as retail gasoline stations, both branded and non-branded) as well as to consumers through third party wholesalers, such as home heating oil or jet fuel distributors. Company reporting of petroleum product sales are also inconsistent, incomplete, or variously or unclearly defined. Reporting of petroleum product sales is typically in thousand barrels per day (kbpd), which we convert to million bbl (Mb) per year, and calculate emissions by applying peer-reviewed emissions factors for each product category.

A detailed analysis of emissions from refining and petroleum product sales was published by Columbia Center for Sustainable Investment.<sup>3</sup> Figure 8 shows the gradual increase in overall emissions in kgCO<sub>2</sub>e/bbl of crude oil since 1980, of which “downstream” emissions (chiefly from combusting petroleum products: ~430 kgCO<sub>2</sub>e/bbl) is the largest component; “midstream” (mostly refining) emissions are ~40 kgCO<sub>2</sub>e/bbl, and “upstream” emissions, which have changed the most since 1980, are ~50 kgCO<sub>2</sub>e/bbl.

**Figure 8. Life-Cycle emission factors by sectors weighted average by oil consumption**



Columbia CSI 2022, page 35.

**Carbon accounting** is a non-technical term that generally refers to providing an inventory of greenhouse gas emissions attributable to a corporate entity and typically using a protocol such as the WRI *GHG Protocol* or similar. The boundary of the entity must first be defined (e.g., should emissions from owned facilities, buildings, and equipment be included, or leased assets as well; should third-party gasoline stations’ fuel sales be accounted for; should bunker fuel emissions from crude oil tankers not owned by the company be included, etc.), which scopes should be included (only direct and indirect operational emissions, scope 1 and scope 2, respectively, or are scope 3 source to be included, and if so,

<sup>3</sup> Columbia Center on Sustainable Investment (2022) *How Much Have the Oil Supermajors Contributed to Climate Change? Estimating the Carbon Footprint of the Oil Refining and Petroleum Products Sales Sectors*, By Jiarui Chen, Perrine Toledano, & Martin Dietrich Brauch, CSI, March, 82 pp.

which of scope 3 fifteen categories? A better technical term is greenhouse gas accounting, insofar as methane and other greenhouse gases are often included. In our analysis, only energy-related methane is accounted for. We ignore nitrous oxide, non-energy methane, and halocarbons that are not material to the fossil fuel industry.

**Allocation (of greenhouse gases)** refers to the “boundary setting rules and norms that assign responsibility for emissions to an accounting subject—such as a company, country, city, or facility—when applying physical allocational accounting methods (e.g., emission inventories). ... When we set the GHG inventory accounting boundaries for a company we are choosing what emissions that company will be allocated *responsibility for*.”<sup>4</sup>

In this report I have allocated full responsibility for emissions—whether production-based, refinery output, or petroleum products sales, plus natural gas and coal—to the named companies that extracted, refined, and/or distributed carbon fuels with knowledge of their potential climate harms. This allocation is subject to change. Other analyses have allocated responsibility for emissions differently; Grasso & Heede (2023) allocated equal one-third responsibility to fossil fuel producers, governments (for their actions or failures to act), and consumers who used the harmful products as intended.<sup>5</sup> As did Schleussner et al. (2024).<sup>6</sup>

**Carbon Footprint** is a popular term for a Greenhouse Gas emissions inventory, be that of an entire company or aggregates of companies as discussed here or a community or a supply chain or an individual building or facility, or even a product (such as a household toaster over its life) or a single event (such as a five-minute shower), and can focus on emissions of CO<sub>2</sub> only, or include methane and any other greenhouse gas.

**Fossil Fuel Extraction** refers to extraction or production of any of the primary fossil fuels: crude oil (including condensate and natural gas liquids (NGLs)), natural gas, and coal. Carbon Majors uses net equity production reported by each company, and take note of the carbon content of various fossil fuels, which is especially important for ranks of coal. We use production data published by companies in their annual reports and/or SEC form 10-Ks. Companies have reported on their equity production of crude oil and natural gas and related fossil fuels since the passage of the Securities Act in 1933 and 1934, or, for some companies, even earlier in annual reports to shareholders or company histories.<sup>7</sup>

**Units:** We use metric units in our analysis and reporting, such as million tonnes of CO<sub>2</sub> (MtCO<sub>2</sub>) per year. Data inputs, however, are typically in US units, as typically reported by fossil fuel companies, such as thousand barrels of oil per day (converted to million bbl/yr: Mb/yr), or million cubic feet of gas production per day (converted to billion cubic feet per year: Bcf/yr). Many companies report in SI units such as cubic meters and tonnes.

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<sup>4</sup> Gillenwater, Michael (2023) *What Is Greenhouse Gas Accounting? Part 3: Allocation Rules*, 11 October.

<sup>5</sup> Grasso, Marco, & Richard Heede (2023) Time to pay the piper: fossil fuel companies' reparations for climate damages, *One Earth*, online 19 May. [https://www.cell.com/one-earth/fulltext/S2590-3322\(23\)00198-7](https://www.cell.com/one-earth/fulltext/S2590-3322(23)00198-7)

<sup>6</sup> Schleussner, Carl-Friedrich, Marina Andrijevic, Jarmo Kikstra, Richard Heede, Joeri Rogelj, Holly Simpkin, & Sylvia Schmidt (2023) *Carbon majors' trillion-dollar damages: The case for contributions from fossil wealth to loss and damage finance*, Climate Analytics, Berlin, 36 pp. <https://climateanalytics.org/publications/carbon-majors-trillion-dollar-damages>

<sup>7</sup> Company reporting of what it produced or sold in the previous fiscal year was required by the legislation establishing the U.S. Securities and Exchange Commission and associated reporting rules in 1933 and 1934. Rules proposed by the SEC to require reporting of scope 3 emissions were not approved by Congress.

## Extraction-based, refinery output, & product sales emissions

This report presents the results of my analysis of CO<sub>2</sub> and methane emissions attributable to selected companies from three different approaches: net equity production of carbon fuels, refinery output (or input), and petroleum product sales. The analysis relies on company-reported production, refinery output, and product sales for each year from 1965 to 2022 or earlier, if available, and on robust methodologies for each case using established emission factors per bbl of crude oil, cubic foot of natural gas, and tonne of coal.

This analysis, and its methodology and results, are subject to change in response to peer-reviews and as additional information becomes available.

Companies report similar but variable categories of petroleum products (whether reported as refinery output or as petroleum product sales). Jet fuel, for example is sometimes reported as a line item or included in “other or specialty products.” The latter are often poorly defined and include both non-combustion products such as road oil, lubricants, and petrochemical feedstocks as well as combustion products such as propane, jet fuel, and petroleum coke. I have, as a conservatism, excluded all products listed as “other” from estimated emissions, since quantification of unknown “other” products is not possible, even though “other” can comprise a significant proportion of all reported petroleum products refined or sold, and typically range from 5% to 20% of total products, depending on what is included and whether the company has a large chemical business.

Part of the following analysis compares respective emissions from petroleum only, after which we add emissions from each company’s natural gas production, processing, and delivery to consumers, reported as “gas available for sale.” I also quantify emissions for the companies that owned coal-producing assets at any point from 1965 to 2022.

Emission factors per bbl of oil (or finished petroleum products), cubic feet of natural gas, or tonne of coal (by coal rank) are listed in Appendix B.

### **Methodology #1: emissions based on fossil fuel production (Carbon Majors)**

The peer-reviewed Carbon Majors methodology estimates emissions attributable to each company’s oil, natural gas, and coal production. The methodology accounts for sequestered carbon by deducting net non-energy use of crude oil & natural gas liquids as feedstocks for road oil, lubricants, and petrochemicals in order to realistically estimate emissions to the atmosphere. Direct operational emissions, known as Scope 1 sources, such as CO<sub>2</sub> vented in gas processing, CO<sub>2</sub> from flaring and own fuel used in refineries, pipelines, and production fields and offshore platforms, and, importantly, also estimates vented and fugitive methane (CH<sub>4</sub>) from oil and gas production, processing, transportation, storage, and end use. The Carbon Majors methodology excludes Scope 2 emissions in order to avoid double-counting emissions. Several inventory protocols have been developed, though most companies use the WRI *Greenhouse Gas Protocol*, API’s *Compendium*, or proprietary software.<sup>8</sup>

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<sup>8</sup> World Resources Institute & World Business Council for Sustainable Development (2004) *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*, Revised Edition, March, 112 pp. Also: American Petroleum Institute (2009) *Compendium of Greenhouse Gas emissions Methodologies for the Oil and Gas Industry*, API, Washington, 807 pp.

## Methodology #2: emissions based on refinery output (or throughput)

The analysis relies on company-reported refinery yield (or output, or outturn) as the basis for quantifying emissions of CO<sub>2</sub> attributable to each company's refining of finished carbon fuels intended for combustion by its global customers. Most refinery output is in the form of petroleum products intended for combustion — typically reported as gasolines, diesel (or gas oil or middle distillates), residual fuel oil (or heavy oil or bunker fuel), jet fuel (or kerosine), and "other petroleum products." Each company may use slightly differing categories or definitions of refined fuel. Furthermore, "other specialty products" are typically poorly defined or variable over the years.

**Note on data availability:** every company whose data I have sought may have reported complete and detailed data for every year since 1965. I have used my archival data sources for each company covering decades of company reporting including hundreds of annual reports, and found numerous data gaps and inconsistent reporting, but this does not definitively mean that the companies have not reported comprehensive data. I have only used the data I have found, and based my analysis thereon. See Table 1 for data ranges.

**Figure 9. Chevron reporting of refinery production for 2022-2024.**

Refinery and bio-refinery production of refined products Thousands of barrels per day	2024	2023	2022
<b>United States</b>			
Gasoline	435	437	428
Jet fuel	228	234	201
Diesel/Gas oil	184	200	205
Other	131	128	102
<b>Total United States</b>	<b>978</b>	<b>999</b>	<b>936</b>
<b>International</b>			
Gasoline	44	40	42
Jet fuel	18	18	11
Diesel/Gas oil	66	60	70
Other	48	51	38
<b>Total International</b>	<b>176</b>	<b>169</b>	<b>161</b>
<b>Worldwide</b>			
Gasoline	479	477	470
Jet fuel	246	252	212
Diesel/Gas oil*	250	260	275
Other	179	179	140
<b>Worldwide Consolidated</b>	<b>1,154</b>	<b>1,168</b>	<b>1,067</b>
<b>Worldwide Equity Share of Affiliates</b>	<b>591</b>	<b>592</b>	<b>592</b>
<b>Total Worldwide</b>	<b>1,745</b>	<b>1,760</b>	<b>1,689</b>
* Includes renewable diesel and bio-diesel	25	27	30

Chevron Corporation 2024 Supplement to the Annual Report, page 23.

**Figure 10. BP reporting of refinery throughputs for 2020-2022.**

Refinery throughputs <sup>a, b</sup>	thousand barrels per day		
	2022	2021	2020
US	678	719	693
Europe	804	787	742
Rest of world	22	88	192
<b>Total</b>	<b>1,504</b>	<b>1,594</b>	<b>1,627</b>
			%
Refining availability <sup>c</sup>	94.5	94.8	96.0

<sup>a</sup> This does not include bp's interest in Pan American Energy Group.

<sup>b</sup> Refinery throughputs reflect crude oil and other feedstock volumes.

BP Annual Report 2022, page 368. No detail on refined products by type.

### Methodology #3: emissions based on petroleum product sales

Similarly, I apply EPA emission factors to company-reported petroleum product sales (see Appendix Table B-1 for emission factors). Data reporting is variable and incomplete, except for detailed reporting by ExxonMobil from 1965 to 2022 (we sum Exxon and Mobil product sales data 1965-1999);<sup>9</sup> Shell also provides a relatively complete record of petroleum sales.

### The companies

Table 1 shows the companies included in this analysis and the years for which I have collected and analyzed company-reported data.

**Table 1. Data reported and used in this analysis and data availability by range of years.**

Company	Production-based MtCO <sub>2</sub>	Refinery output MtCO <sub>2</sub>	Product sales MtCO <sub>2</sub>
BP	1965-2022	1971-2022	1984-2022
Chevron	1965-2022	1990-2022	1990-2022
ConocoPhillips	1965-2022	na	1970-2022
ExxonMobil	1965-2022	1965-2022	1965-2022
Koch Industries	na	2000-2022	2000-2022
Marathon	1965-2022	1965-2022	1965-2022
Motiva	na	1989-2022	1989-2022
Northwest Natural	1997-2022		1997-2022
Occidental (incl Anadarko)	1965-2022	na	na
Shell	1965-2022	1965-2022	1965-2022
Space Age Fuel			2010-2022
TotalEnergies	1965-2022	1999-2022	1999-2022
Valero	na	2000-2022	2000-2022

Note that Chevron refining and products sales data from 1990; TotalEnergies from 1999. Mobil Corp refining data interpolated 1971-1984. Data ranges in yellow indicate significant data gaps and thus under-reporting.

**Table 2. Emissions attributed to companies from crude oil production, refining, & sales**

Company	Production-based MtCO <sub>2</sub>	Refinery output MtCO <sub>2</sub>	Product sales MtCO <sub>2</sub>
BP	24,255	11,450	16,752
Chevron	30,352	7,321	10,971
ConocoPhillips <sup>10</sup>	9,157	na	11,956
ExxonMobil	25,233	46,297	52,392
Koch Industries	na	2,284	2,284
Marathon	1,948	7,008	8,705
Motiva	na	1,263	1,263
Northwest Natural (gas only)	na	na	na
Occidental (incl. Anadarko)	5,791	na	na
Shell	19,143	26,212	39,612
Space Age Fuels	na	na	8
TotalEnergies	9,662	5,700	7,461
Valero	na	6,918	6,918
<b>Total selected companies</b>	<b>125,541</b>	<b>114,452</b>	<b>158,322</b>

Calculations by Climate Accountability Institute, based on data reported by each company. XOM includes Mobil <1999.

<sup>9</sup> Standard Oil of New Jersey [SONJ], aka Esso {"SO"}, later Exxon] and Standard Oil of New York [SOCONY, later Mobil Oil], both successor companies to the Standard Oil Trust upon the 1911 Supreme Court order breaking up of the company, merged in 1999. Chevron has over its history merged or acquired several predecessor companies, e.g. Getty, Gulf, Texaco.

<sup>10</sup> Product sales emissions for ConocoPhillips are subject to change, i.e., a reduction, since Phillips 66 was spun off in 2012.

### Comparing production-based emissions to refining and product sales emissions

The result of our analysis is shown in Table 2. Over the period from 1965 to 2022, ExxonMobil, ConocoPhillips, Marathon, and Shell are estimated to emit more CO<sub>2</sub> from product sales than from their extraction of crude oil and NGLs, whereas BP, Chevron, and TotalEnergies are attributed smaller amounts from product sales than from production. This is largely a consequence of limited data range for product sales data vs production (see Table 1). For nearly every company analyzed product sales of petroleum products exceed their petroleum-production in comparative years, as shown in Figures 11-18.

In this accounting, *excluding natural gas and coal*, the total for all companies analyzed is 125.5 billion tonnes of CO<sub>2</sub> (GtCO<sub>2</sub>) for the production-based methodology, 114.5 GtCO<sub>2</sub> for refinery output, and 158.3 GtCO<sub>2</sub> for petroleum product sales. Having access to complete datasets for each company engaged in petroleum product sales would increase this category's emissions. Having more complete data on company refining output is not likely to affect its ranking.

### Adding emissions from each company's production and sale of natural gas and coal

If we look at the complete record of company production of fossil fuels from 1965 to 2022 and the resulting attributed emissions from scope 3 product-related emissions plus scope 1 operational emissions (vented CO<sub>2</sub> and methane, flaring, own fuel use, etc.), then we get totals as shown in table 3.

**Table 3. Emissions attributed to selected companies from oil, natural gas, and coal production, (Carbon Majors), Scope 1 and scope 3, 1965-2022**

Company	Crude oil & NGLs MtCO <sub>2</sub> e	Natural gas MtCO <sub>2</sub> e	Coal MtCO <sub>2</sub> e	Sum MtCO <sub>2</sub> e
BP	26,041	9,490	975	36,506
Chevron	32,587	11,844	1,208	45,639
ConocoPhillips	9,831	6,745	na	16,576
ExxonMobil	27,091	16,215	1,466	44,772
Koch Industries	na	na	na	na
Marathon	2,091	1,226	na	3,317
Motiva	na	na	na	na
Northwest Natural	na	na	na	na
Occidental (incl Anadarko)	6,218	3,492	1,419	11,129
Shell	20,553	12,827	1,089	34,469
Space Age Fuel	na	na	na	na
TotalEnergies	10,374	4,828	198	15,399
Valero	na	na	na	na
<b>Total selected companies</b>	<b>134,785</b>	<b>66,667</b>	<b>6,355</b>	<b>207,807</b>

Calculations by Climate Accountability Institute, based on data reported by each company. Note that Koch and Valero do not produce crude oil, natural gas, or coal, but do refine and sell petroleum products. NWN sells natural gas (Oregon data).

### Adding natural gas and coal emissions to production, refining, and product sales

Table 4 adds emissions from each company's "natural gas available for sale" and emission from produced and sold coal to the petroleum emissions in Table 2. This is the overarching comparison of the three methodologies, given the data available, totaling attributable emissions from production of oil, gas, and coal (Carbon Majors) to the emissions from refinery output (oil only) to product sales of petroleum products plus natural gas "available for sale" and coal emissions.

In this comparison we see that the sum of petroleum product sales plus natural gas and coal exceed estimated emissions for the Carbon Majors production-based approach for ConocoPhillips, ExxonMobil, Marathon, and Shell. Note that ConocoPhillips' attributed product sales results may be revised down (once we have resolved the issue of CP divesting its refining and marketing emissions to Phillips 66 in 2012). The combination of Marathon Oil (E&P) and Marathon Petroleum (refining and marketing) also needs to be resolved.

Note: Acquiring and analyzing longer historical product sales reporting by BP (pre-1984), Chevron (pre-1990), TotalEnergies (pre-1999), and Valero (pre-2000) will increase total estimated emissions attributable to the thirteen companies.

Neither the refining nor the product sales approach account for mid-stream & downstream emissions of methane or other operational sources such as use of its own natural gas or petroleum products in refining and distribution, which can be substantial in natural gas and coal production, transportation, and processing. The majority of methane from the crude oil, natural gas, and coal sectors occur in upstream production.<sup>11</sup>

Note that the production-based methodology includes associated methane emissions and other scope 1 operational sources. See Table 4.

**Table 4. Emissions attributed to companies from production, refining and product sales, adding natural gas and coal to each entity**

<b>Company</b>	<b>Production-based (oil, gas, coal, S1+3) MtCO<sub>2e</sub></b>	<b>Refinery output (oil S3 only) MtCO<sub>2</sub></b>	<b>Product sales (oil, gas &amp; coal S3) MtCO<sub>2</sub></b>
BP	36,506	11,450	24,585
Chevron	45,639	7,321	20,739
ConocoPhillips	16,576	na	16,901
ExxonMobil	44,772	46,297	65,596
Koch Industries	na	2,284	2,284
Marathon	3,317	7,008	9,603
Motiva	na	1,263	1,263
Northwest Natural	na	na	150
Occidental	11,129	na	3,835
Shell	34,469	26,212	49,993
Space Age Fuels	na	na	8
TotalEnergies	15,399	5,700	11,178
Valero	na	6,918	6,918
<b>Total selected companies</b>	<b>207,807</b>	<b>114,452</b>	<b>213,054</b>

Calculations by Climate Accountability Institute, based on data reported by each company.

### Visualizing each company's emissions 1950-2022

Illustrations of each company's attributed emissions from production, refining, and product sales are shown in the following eight Figures, each showing data from 1950 to 2022. Note that scales vary, and nearly all datasets for refining and product sales are far shorter than the data on production (Carbon Majors).

Note also that these charts compare emissions from crude oil and its refining and product sales only, and *do not* add each company's emissions from "natural gas available for sale" or emissions from coal production and combustion. Detailed data and results by company,

<sup>11</sup> U.S. EPA (2022) *Inventory*, tables 3-1 and 3-2. PDF page 135.

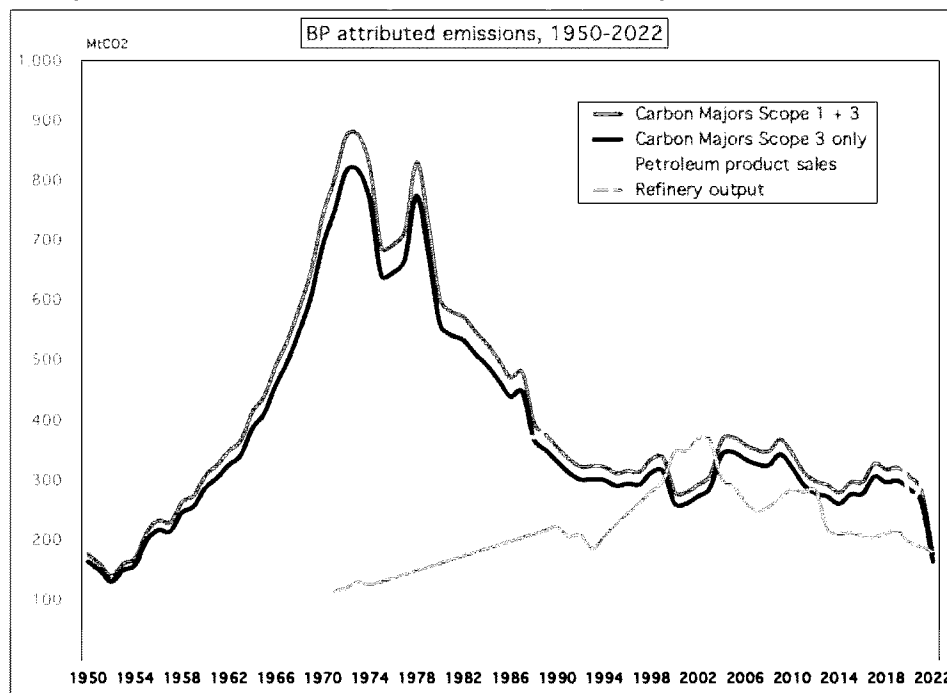
year, scope, and source are all available, but here I only compare the petroleum results for each of the three methodologies.

Each of the figures show estimated production-based (Carbon Majors) for crude oil and natural gas liquids, crude oil refining, and petroleum product sales, again: excluding each company's attributed emissions from natural gas and coal. See Figure 21 for combined petroleum product sales plus natural gas plus coal combustion.

Also note that each company's data set for refinery output and petroleum product sales are truncated due to incomplete historical data on refinery inputs (or outputs) and product sales in million bbl per year. Future research, or the companies making such data available, will help complete the analysis. Refer to table 1 for dataset ranges. BP, for example, shows lack of refinery data 1950-1970, and petroleum product sales 1950-1983.

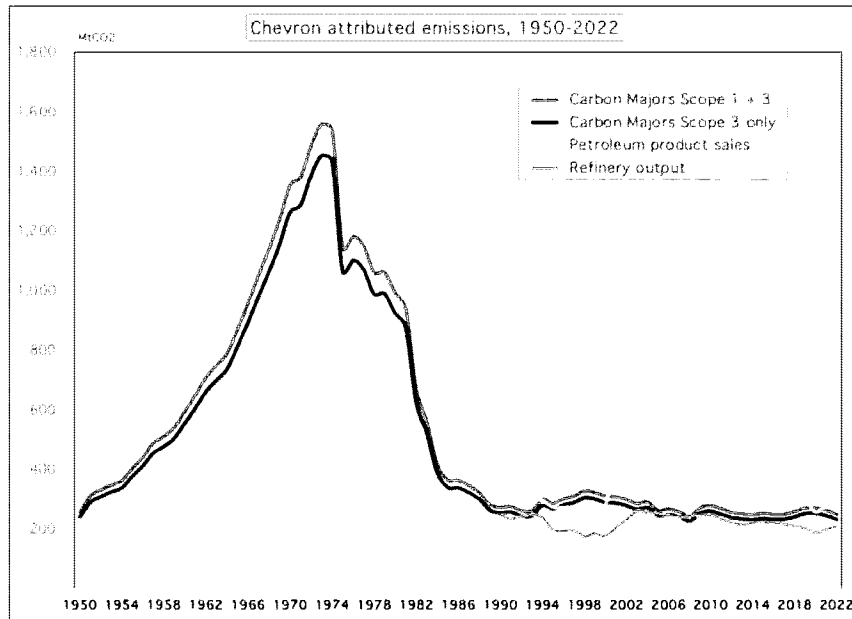
**BP:** According to the Annual Reports and 10-K filings we have for BP, the company does not report reliable data on refinery output prior to 1990, nor on petroleum product sales prior to 1982. Documented refinery production of 26.3 Gb since 1989 equates to emissions of 8.6 GtCO<sub>2</sub>. Petroleum product sales 1989-2022 total 42.4 Gb and associated emissions of 16.8 GtCO<sub>2</sub>. Emissions based on the company's net equity production of crude oil and NGLs from 1965 to 2022 total 24.3 GtCO<sub>2</sub>e; partial data on refinery output emissions total 8.4 GtCO<sub>2</sub>, and for petroleum product sales total 17.0 GtCO<sub>2</sub>.

**Figure 11. BP, 1950-2022, production, refining, and product sales**



**Chevron** data on refinery output is scattered and incomplete. Note: this assessment is, as always, “as far as we know and have found” in our search of company documents and *not* a definitive statement that the company has not published comprehensive data; we have not found it if published. See “Oil&GasData.xls” worksheet for details. In Chevron’s case, we have detailed data by refined product categories for 2009-2013 and 2020-2022, and aggregated refinery input data (thus a conservatism, given typical processing gains) from 1990-2000 and 2003-2004 and 2007-2008 (2001-2002 and 2005-2006 are interpolated).

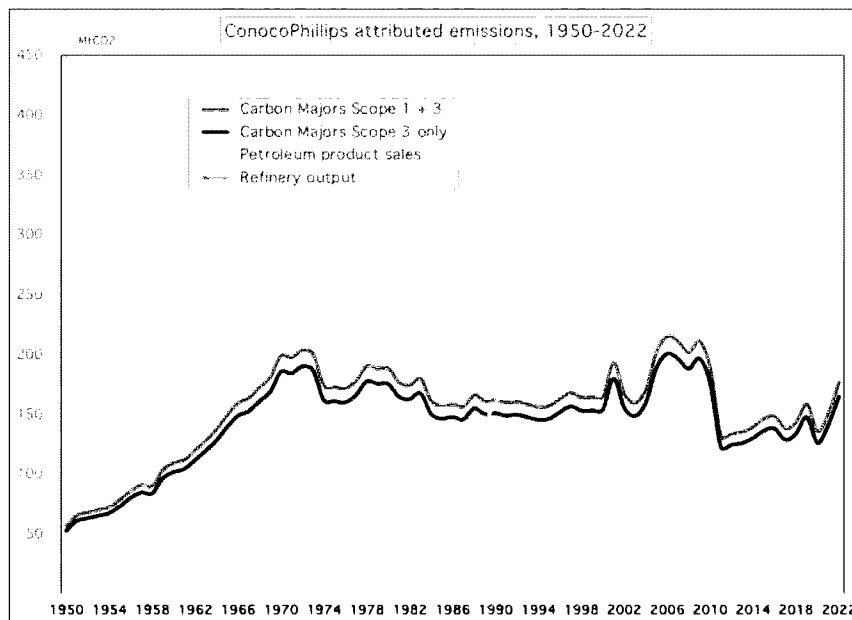
**Figure 12. Chevron, 1950-2022, production, refining, and product sales**



Chevron’s petroleum product sales data is also incomplete prior to year 2000, but data 2001-2022 is detailed by product category. However, we do not have data on Texaco’s product sales prior to its merger with Chevron in 2001, nor Gulf Oil’s sales prior to its acquisition by SoCal in 1984 (the company became Chevron in 1984). This lack of data represents a large but unquantified undercount of refinery sales emissions in all years prior to 2001.

Chevron data on refinery output 1990-2022 totals 20.5 Gb, with associated emissions of 7.3 GtCO<sub>2</sub>. Chevron’s product sales 1990-2022 totaled 30.8 Gb, with emissions of 11.0 GtCO<sub>2</sub>. Production-based emissions for the full period from 1965-2022 total 81.7 Gb, with attributed emissions of 30.4 GtCO<sub>2</sub>e.

**Figure 13. ConocoPhillips, 1950-2022, production, refining, and product sales**

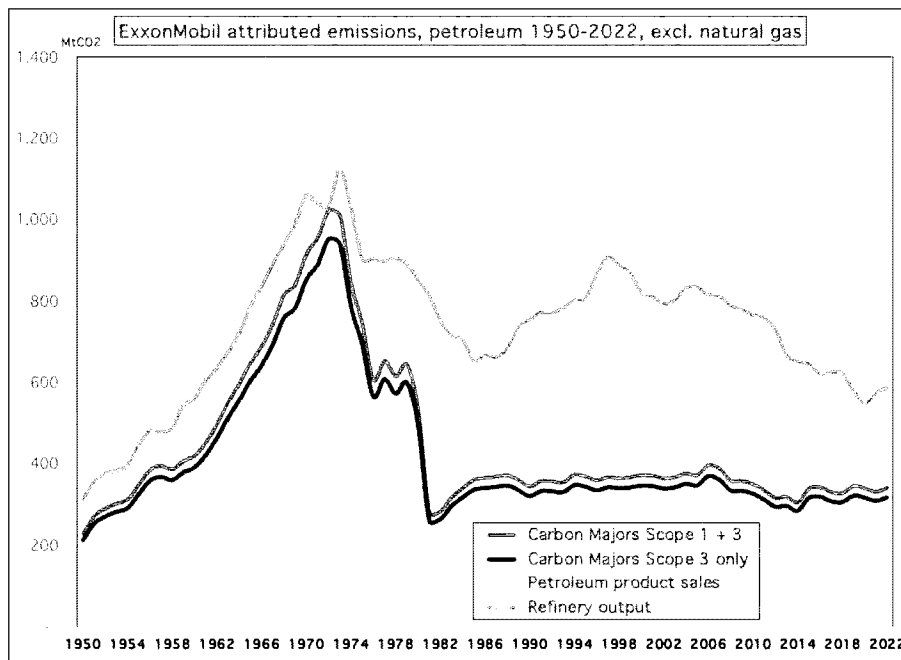


**Conoco** became an independent company after the 1913 Supreme Court decision to dissolve Standard Oil. The company merged with Phillips Petroleum in 2002, and spun off its refining and retail sales to its Phillips 66 subsidiary in 2012. ConocoPhillips continues as an upstream exploration and production company and produces crude oil natural gas liquids, natural gas, and bitumen in 15 countries (49% in the US).

We have Phillips 66 data on refinery output 2010-2022 (11.1 Gb) and data on petroleum product sales for Conoco and Phillips from 1970-1984 and 2003-2011 with partial data on sales by product type. Note: interpolated from 1985-2002. Figure 13 includes emissions from Phillips 66 product sales 2012-2022, which we may eliminate upon further review, since ConocoPhillips spun off its downstream division to Phillips 66 in 2012.

**Standard Oil of New Jersey (SONJ)** became **Exxon** in 1972 and merged with **Mobil** (previously known as Standard Oil of New York, SOCONY) in 1999. We have a complete data set on both companies from 1951 to the present for refinery output, albeit only in total and not by product category.

**Figure 14. ExxonMobil, 1950-2022, petroleum production, refining, and product sales**

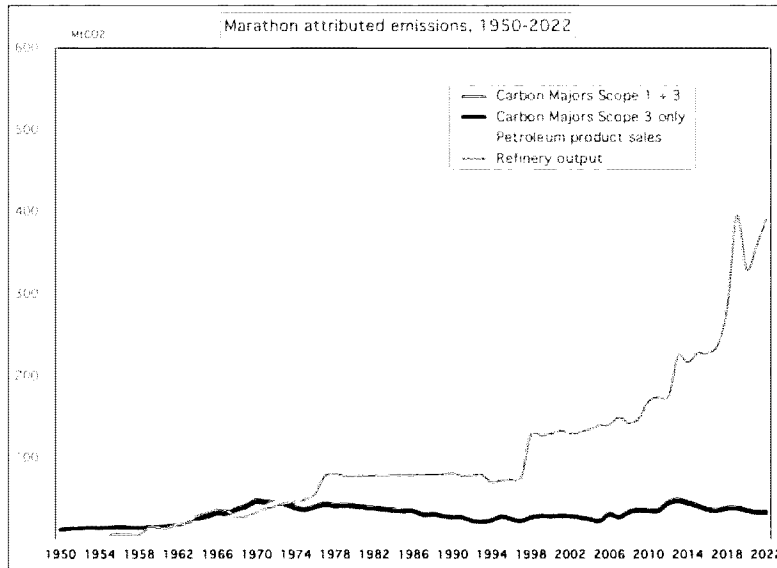


**ExxonMobil’s** reported petroleum product sales data is relatively complete — including sales by product type — totaling 129.6 Gb since 1965, excluding “lubricants, specialty, and other petroleum products,” per our methodology, with associated emissions of 45.6 GtCO<sub>2</sub>.

The Carbon Majors data on crude oil production 1965-2022 total 67.6 Gb, with estimated supply chain emissions of 25.2 GtCO<sub>2</sub>e (27.1 GtCO<sub>2</sub>e if scope 1 emissions are added).

**Marathon Petroleum** (Marathon’s refining division) has published data on total “crude oil refined for US and Canada plus Outside North America” for 1955-2006, plus detail on refinery production by fuel category for 2007-2022. Refinery output since 1955: 18.5 Gb. Petroleum product sales reported in aggregate for 1955-1988, plus product categories 1989-2022. Total product sales 1965-2022: 22.7 Gb.

**Figure 15. Marathon, 1950-2022, production, refining, and product sales**

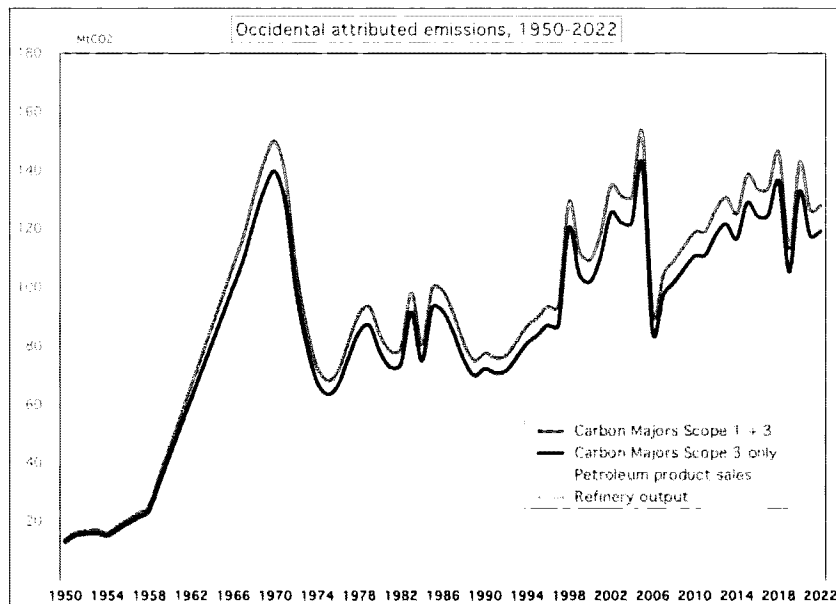


**Marathon Oil** (its exploration and production division, E&P), shown in the black and red lines below, are relatively modest, totaling 5.2 Gb from 1965-2022.

Note: Marathon Petroleum was a wholly-owned subsidiary of Marathon Oil until the company was spun off in 2011. We may, upon review, separate these companies, or exclude attributed emissions from product sales post-2011.

**Occidental Petroleum** is an exploration and production company, and owns chemical production assets (OxyChem), but does not own, jointly own, or lease refineries, and does not sell or procure and re-sell petroleum products through retail or wholesale channels, according to available information. The company does not report on refinery output or product sales. Being a large producer of both oil and natural gas, the company does sell its crude, NGLs, and gas commodities to other refiners and downstream business segments.

**Figure 16. Occidental, 1950-2022, production, refining, and product sales**

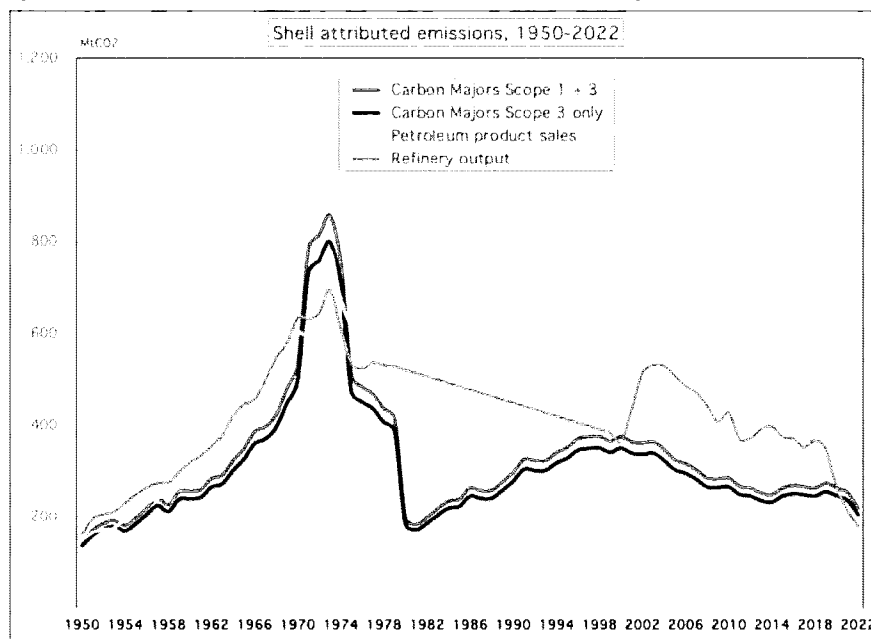


**Anadarko**, acquired by Occidental in 2019, did not report refining or product sales data, and marketed its crude oil, NGLs, natural gas, and, for a time, LNG (liquefied natural gas) to third-parties and pipeline companies.

The emissions attributed to Occidental shows production-based emissions (Carbon Majors) for both Occidental and Anadarko for 1965-2022 on the basis of 15.6 Gb of oil production, with associated emissions of 5.8 GtCO<sub>2</sub> (6.2 GtCO<sub>2</sub>e if scope 1 emissions are added). Combined gas production of 48 Tcf yields emissions of 2.6 GtCO<sub>2</sub>, or 3.5 GtCO<sub>2</sub>e with scope 1 emissions added. Anadarko’s ownership of Island Coal Group’s production of 807 Mt coal 1965-1996 adds 1.9 GtCO<sub>2</sub>e.

**Shell plc** (previously Royal Dutch Shell) has reported “crude oil processed” from 1950 to 1979 (annual total only), plus “refinery processing intake” 1993-2000, plus detail on refinery output by fuel category from 2001 to 2022. “Other” refinery output, ranging from 13 to 16% of total, is excluded from emissions calculations, per our protocol. See Annex A. Emissions from refinery output 1965-2022 of 67 Gb totaled 26.2 GtCO<sub>2</sub>.

**Figure 17. Shell, 1950-2022, production, refining, and product sales**



**Shell** reports comprehensive data on total petroleum product sales from 1950 or earlier, and by product category since 1966, except lacking product detail 1980-1992 (which we interpolate). We exclude Shell’s substantial marketing of crude oil and “other” products, which range from 10 to 19% of total products supplied.

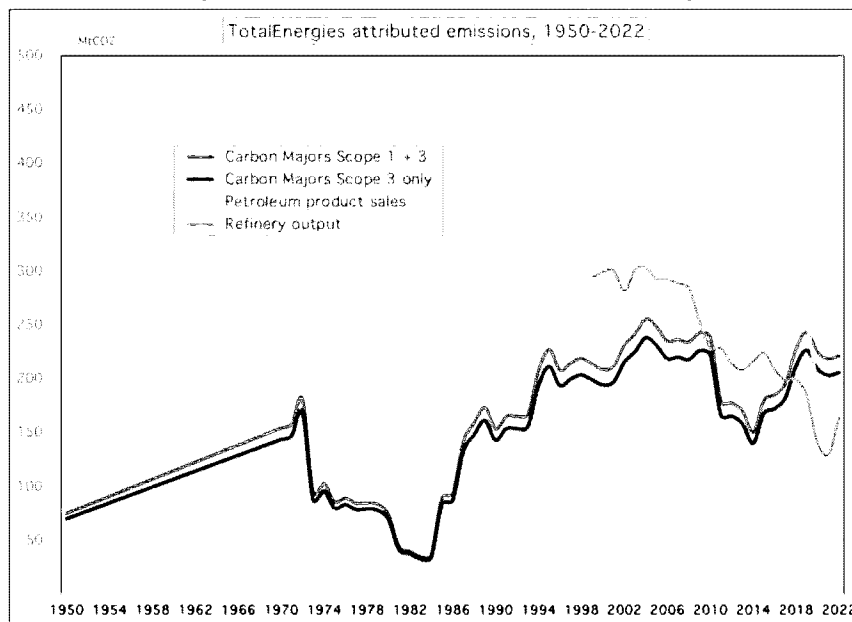
Shell product sales dropped precipitously from 2,394 Mb in 2019 to 914 Mb in 2022. Shell sales totaled 101.9 Gb (excluding “other”), with associated emissions totaling 39.6 GtCO<sub>2</sub>.

**TotalEnergies** reported refinery output data from 1999-2022, with detail on refinery production by category. Refinery production since 1999 totaled 14 Gb, excluding 3 Gb of “other” products, which are excluded (“other” products range from 15% to 30% of total refinery output 1999-2022). Emissions from refinery output since 1999 totaled 5.7 GtCO<sub>2</sub> on refinery output of 14 Gb.

TotalEnergies' petroleum product sales data are also reported 1999-2022, based on total sales 1999-2009 and detailed by product category 2010-2022. Sales totaled 19.7 Gb, with associated emissions of 7.5 GtCO<sub>2</sub>.

The production-based methodology total emissions of 9.0 GtCO<sub>2</sub> from 1965 to 2022 (liquids production only; gas production adds 3.5 GtCO<sub>2</sub>).

**Figure 18. TotalEnergies, 1950-2022, production, refining, and product sales**



**Koch Industries** and **Valero** are not fossil fuel producers. Koch is privately held, and as such is not required to disclose refining data. We base our estimate on Koch's published 2006 refinery capacity of 880,000 bbl per day (bpd), which we multiply by an assumed and typical utilization factor of 90% (Koch's may vary) and multiplied by 89.5% production of combustion products (Koch's product slate may differ) and thus 10.5% is excluded for non-combustion products. Koch's daily refinery yield of combustion products is  $880 \text{ kbpd} \times 0.9 \times 0.895 = 709 \text{ kbpd}$ , times 365 days per year = 259 million bbl per year, and 6.0 Gb 2000-2022. Emissions, based on the distribution of combustion products, totals 101 MtCO<sub>2</sub> per year and 2.3 GtCO<sub>2</sub> since 2000. We assume Koch's refining has been unchanged from 2000 to 2022. Complete data supplied by Koch Industries will be used to revise this estimate, and attribute emissions earlier than our assumed horizon of 2000. Koch Industries and its predecessors (e.g., Wood River Oil and Refining Company, renamed Koch Industries in 1968, and which had a 35% interest in Great Northern Oil Company, which in turn owned the Pine Bend Refinery) has owned refining assets since the 1940s.

Note: I may be able to extend the refinery capacity and estimated refinery output and thus attributed emissions with the discovery of reliable data on Koch's expanding refinery capacity since 1968 (then only 25,000 bpd) and its acquisition of refineries in Corpus Christi from Sunoco in 1981 and Kerr-McGee in 1994. Note also that Koch/Flint Hills product slate may have higher fractions of asphalt, aromatics, and petrochemical feedstocks than assumed in this analysis. Full data from Koch Industries will improve the accuracy of refinery output and emissions estimates.

**Valero** procures its refinery inputs from other sources in California, Texas, Oklahoma, Tennessee, Louisiana, Quebec, and UK. Valero, unlike Koch, is an investor-owned company and does publish data on refinery throughput by year, though not by product category. We apply the same utilization and combustion-product factors, and reduce refinery capacity according to its published data (the earliest 10-K is for 2010: 2,640 kbpd, rising to 3,150 kbpd in 2022); we assume an annual capacity decrease of -4% per year in back-casting refinery yields back to 2000. Lastly, we assume that the refinery yields of combustion products are all sold through company supply chains or sold to wholesalers.

## Summary and Recommendations

In this report we have analyzed company-reported data on the fossil fuel production of eleven leading oil, natural gas, and coal companies and applied a robust and peer-reviewed methodology to estimate the emissions of CO<sub>2</sub> and methane to the atmosphere attributable to each of these companies from 1965 to 2022. We have applied three approaches: net equity production of carbon fuels, refinery output, and petroleum product sales.

Most of these companies sell more petroleum products than they extract or refine, often procuring finished fuels for distribution through their supply chains to gas stations, home heating oil distributors, and jet fuel vendors. Refer to Table 4 and figures 11-18 for details.

**Table 4. Emissions attributed to companies from production, refining and product sales, adding natural gas and coal to each entity**

Company	Production-based (oil, gas, coal, S1+3) MtCO <sub>2e</sub>	Refinery output (oil S3 only) MtCO <sub>2</sub>	Product sales (oil, gas & coal S3) MtCO <sub>2</sub>
BP	36,506	11,450	24,585
Chevron	45,639	7,321	20,739
ConocoPhillips	16,576	na	16,901
ExxonMobil	44,772	46,297	65,596
Koch Industries	na	2,284	2,284
Marathon	3,317	7,008	9,603
Motiva	na	1,263	1,263
Northwest Natural	na	na	150
Occidental	11,129	na	3,835
Shell	34,469	26,212	49,993
Space Age Fuels	na	na	8
TotalEnergies	15,399	5,700	11,178
Valero	na	6,918	6,918
<b>Total selected companies</b>	<b>207,807</b>	<b>114,452</b>	<b>213,054</b>

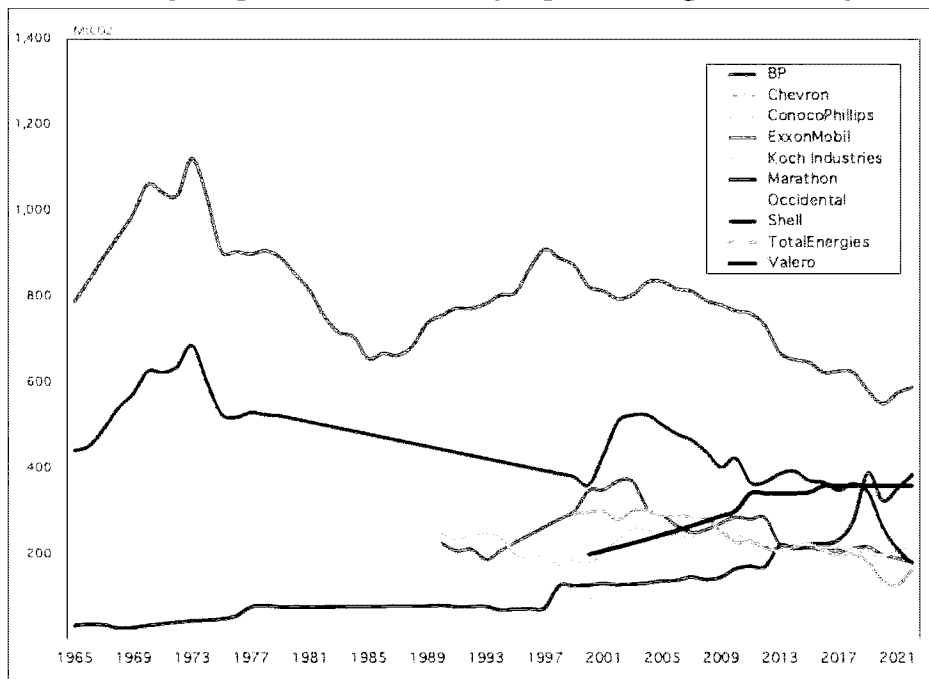
Calculations by Climate Accountability Institute, based on data reported by each company.

Data on fossil fuel production are complete, reliable, and based on company-reported data for each of the eight oil & gas and the single coal company we evaluate in this study. (Valero and Koch Industries are petroleum refiners and sell petroleum products, but are not oil producers.) I apply a peer-reviewed methodology that accounts for net non-energy crude oil and industry-standard emission factors, and I have high confidence in the estimated emissions. There are variables and uncertainties in these estimates, based on our use of default factors for scope 1 emission sources such as CO<sub>2</sub> from flaring, venting, own fuel use, and fugitive methane — each company's practice will vary — but these are variances within the scope 1 estimates, which average 12% of each oil and gas company's total emissions of scope 1 plus scope 3 emissions. Further discussion can be found in Heede (2014a, 2014b, 2019).

In contrast, the data on refinery output and petroleum product sales are incomplete and variable, the reported carbon fuel categories are often poorly defined, and data, if reported at all, might aggregate all refinery output or product sales. I have assembled and analyzed

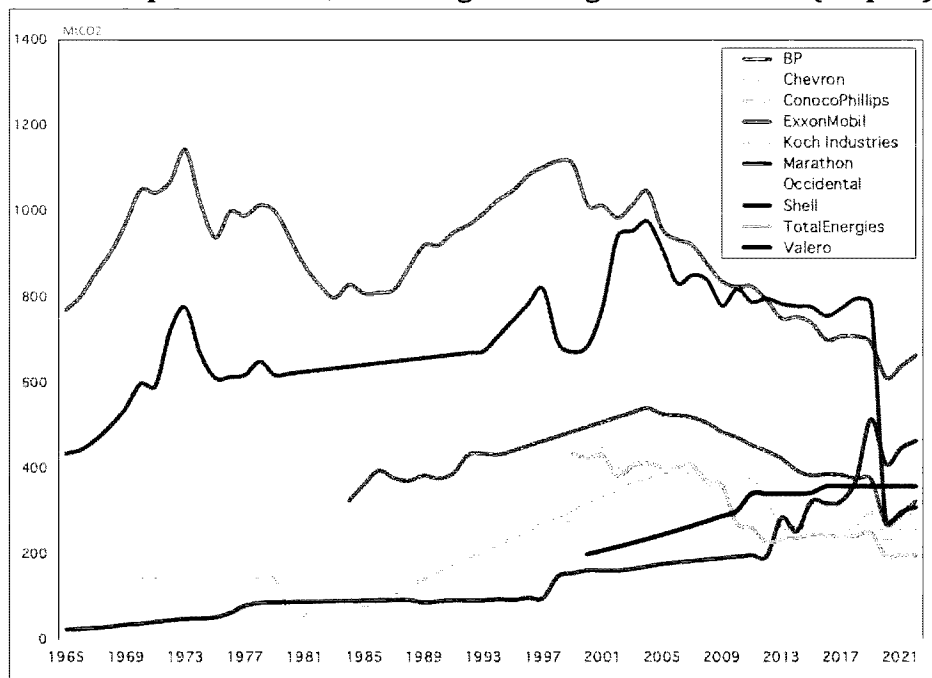
the data available in hundreds of annual reports and SEC Form 10-Ks in order to cobble together a partial but indicative record of each company's refinery output and product sales. Table 1 and figures 19 and 20 show the data availability for the companies whose output and associated attributed emissions are quantified.

**Figure 19. Refinery output and emissions (scope 3; excl. gas and coal), 1965-2022**

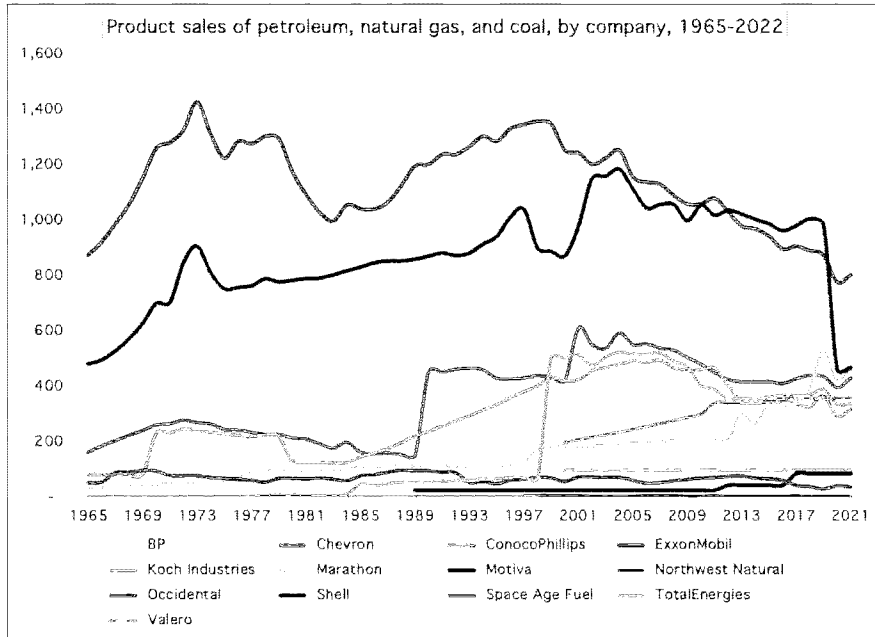


A timeline of each company's attributed emissions from refinery output (Figure 19) and petroleum product sales (Figure 20) show that most companies sell more petroleum products than they refine themselves, — especially ExxonMobil and Shell.

**Figure 20. Petroleum product sales, excluding natural gas and coal CO<sub>2</sub> (scope 3), 1965-2022**



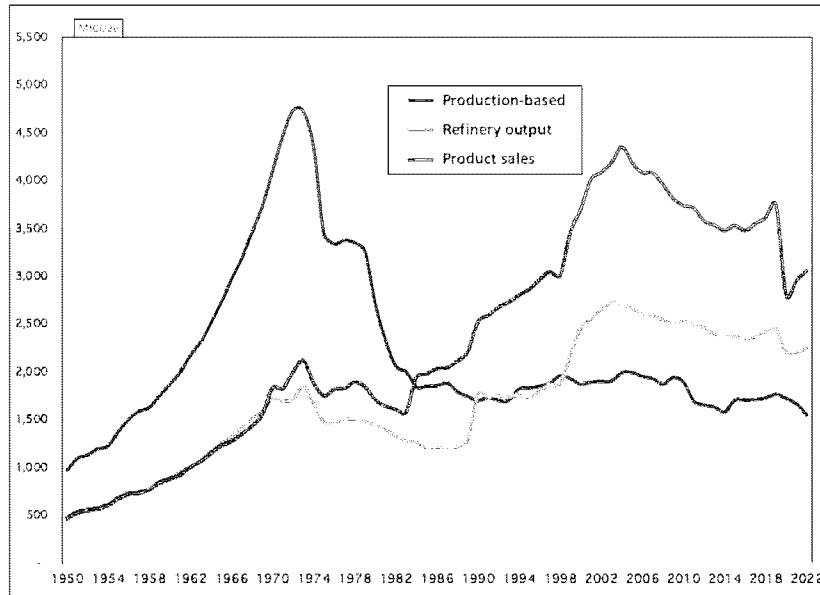
**Figure 21. Petroleum product sales plus natural gas plus coal CO<sub>2</sub> (scope 3), 1965-2022**



Note also that I have compared my results of emissions from petroleum product sales to the results in the Columbia CSI report (see Appendix A), and find the latter estimates tend to be moderately to much higher than my results. I do not have the raw data from CSI so I cannot trace the reason for the apparent discrepancy. I use a direct approach — calculating emissions from reported product sales times emission factors for finished petroleum fuels.

Aggregating attributed emissions for oil-related output for the companies assessed (Koch and Valero are added to both refinery output and product sales) in Figure 21 shows steeply rising emissions from product sales 1990-forward, and a later rise in refinery output emissions. Product-related emissions, in contrast, was higher in the 1960s, and continued declining in response to the rise of OPEC production in the early 1970s.

**Figure 22. Comparing production-based (S1+S3), refinery output (S3), and petroleum product sales (S3), oil only, 1950-2022**



**Figure 23. Comparing production-based (S1+S3), refinery output (S3), and petroleum product sales (S3), oil only, cumulative 1965-2022**

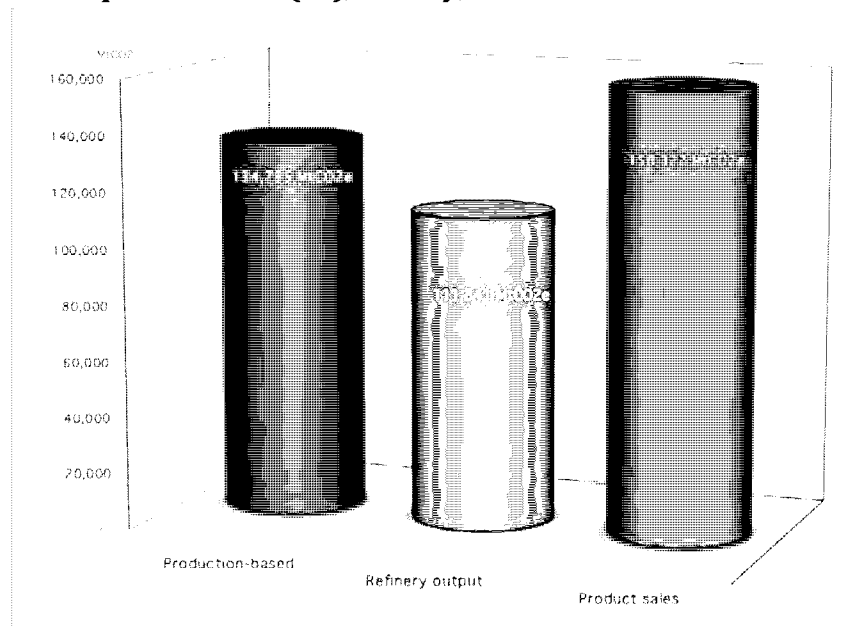
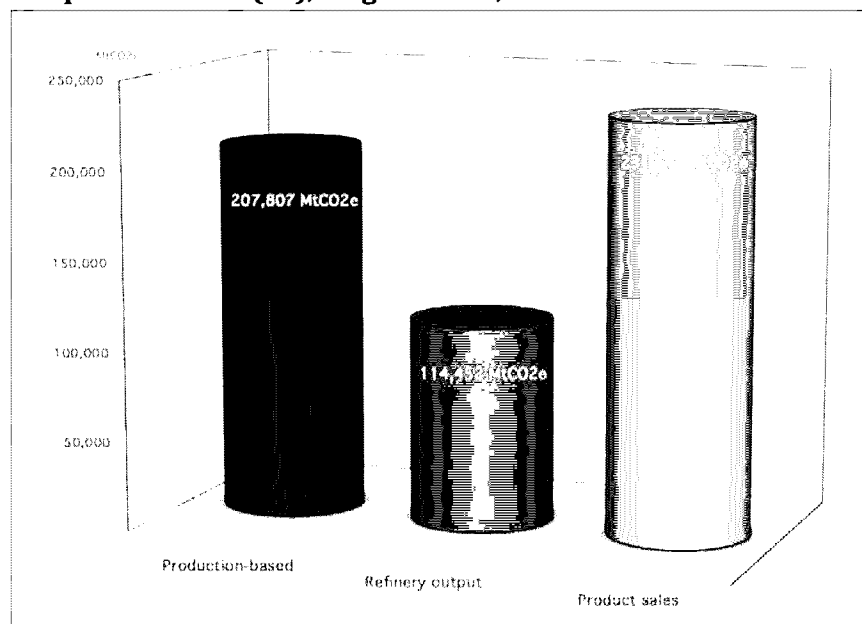


Figure 22 compares attributed emissions on the basis of the three methodologies — production, refining, and product sales — for crude oil only. Figure 23 adds quantified emissions from each company’s production of “natural gas available for sale” and for coal production (which is assumed to be used as intended by industry and power generation). See Tables 3 and 4.

Given the completeness of the production-based data and associated emissions and the partial data so far acquired on both refinery output and petroleum product sales, both of these latter sources will grow larger with acquisition and analysis of complete data sets.

**Figure 24. Comparing production-based (S1+S3), refinery output (S3), and petroleum product sales (S3), oil gas & coal, cumulative 1965-2022**



**Table 5. Emissions from attributed petroleum product sales, incl. natural gas and coal, and percent of global fossil fuel CO<sub>2</sub> 1950-2022 and 1965-2022.**

Company	Product sales	Percent of global	Product sales	Percent of global
	1950-2022 MtCO <sub>2</sub>	fossil fuel emissions %	1965-2022 MtCO <sub>2</sub>	fossil fuel emissions %
BP	25,092	1.68%	24,585	1.79%
Chevron	21,807	1.46%	20,739	1.51%
ConocoPhillips	17,833	1.19%	16,901	1.23%
ExxonMobil	74,036	4.96%	65,596	4.78%
Koch Industries	2,284	0.15%	2,284	0.17%
Marathon	9,803	0.66%	9,603	0.70%
Motiva	1,263	0.08%	1,263	0.09%
Occidental	4,241	0.28%	3,835	0.28%
Shell	54,086	3.63%	49,993	3.64%
TotalEnergies	11,178	0.75%	11,178	0.81%
Valero	6,918	0.46%	6,918	0.50%
<b>Total selected companies</b>	<b>228,540</b>	<b>15.31%</b>	<b>212,896</b>	<b>15.51%</b>
<b>Global fossil fuel emissions</b>	<b>1,493,015</b>		<b>1,372,459</b>	

Calculations by Climate Accountability Institute, based on data reported by each company. Global fossil fuel emissions data from Global Carbon Budget (oil, gas, coal, flaring, excludes cement).

In order to put regional companies Northwest Natural and Space Age Fuel in context of Oregon in-state emissions I used sales and emissions data reported by fuel and natural gas suppliers to the Oregon Dept. of Environmental Quality. Table 6 shows the liquid fuel suppliers whose emissions exceed 4 MtCO<sub>2</sub>e from 2010 to 2022. Space Age Fuel is eighth of 128 reporting companies for 2010-2022.<sup>12</sup>

**Table 6. Top nine company emissions from Oregon fuel suppliers 2010-2022.**

Company	Fuel suppliers	Percent of Oregon
	MtCO <sub>2</sub>	fuels, %
Phillips 66	50.44	16.84%
Marathon Petroleum	46.23	15.44%
BP West Coast Products	44.44	14.84%
Equilon Enterprises	42.09	14.06%
Chevron Products	35.51	11.86%
Vitol Inc.	17.73	5.92%
BP Products	9.77	3.26%
Space Age Fuel	8.19	2.74%
Carson Oil	4.08	1.36%
<b>Total nine companies</b>	<b>258.50</b>	<b>86.32%</b>
<b>Other 119 companies</b>	<b>40.95</b>	<b>13.68%</b>
<b>Total reported fuel suppliers</b>	<b>299.45</b>	<b>100.00%</b>

Calculations by Climate Accountability Institute, based on data reported by each company to Oregon Dept of Environmental Quality exceeding 4.0 MtCO<sub>2</sub>e for 2010-2022. DEQ data is summed for each company as percent of total reported emissions from Oregon fuel suppliers 2010-2022. A total of 148 companies are listed on DEQ's fuel supplier list, twenty of which report no emissions, or do not report. The 128 companies that do report, show from 1 tCO<sub>2</sub>e (Shell Trading) to 3.35 MtCO<sub>2</sub>e (McCall Oil & Chemical).

Note: ExxonMobil fuel sales are not included in DEQ data, insofar as the company does not own the fuel as it is imported into Oregon and thus the company's fuel sales through its ~36 in-state gasoline stations are not recorded in DEQ sales and emissions data. A ballpark estimate goes as follows: ExxonMobil reported gasoline and diesel sales of 822 Mb of gasoline (and naphthas) and 646 Mb of diesel (and heating oil, and kerosene) in 2024; of which I assume 90% are gasoline and

<sup>12</sup> Greenhouse Gas Emissions Reported to DEQ: <https://www.oregon.gov/deq/ghgp/Pages/GHG-Emissions.aspx>

diesel sales. There are an estimated 11,892 Exxon and Mobil service stations in the United States,<sup>13</sup> thus each sells an average of 2.6 million gallons of gasoline and 2.1 million gallons of diesel per year. Multiplying by the emission factor for each fuel, I estimate that the average branded service station in Oregon sells fuel that causes the emission of 43,700 tCO<sub>2</sub> per year; multiplied by the company's 36 branded service stations gives 1.57 MtCO<sub>2</sub> (in 2024).

For regional natural gas suppliers, we used emissions data reported by companies operating in Oregon, and that reported emissions for the period from 2010 to 2022. The five companies listed in Table 7 provide 98.3% of natural gas consumed in Oregon, led by Northwest Natural at 40.8%.

**Table 7. Top 5 company emissions from Oregon natural gas suppliers, 2010-2022.**

<b>Company</b>	<b>Natural gas suppliers MtCO<sub>2</sub></b>	<b>Percent of Oregon natural gas, %</b>
Northwest Natural	72.15	40.84%
Gas Transmission Northwest	55.03	31.15%
Cascade Natural Gas	22.45	12.71%
Kelso-Beaver Pipeline	15.38	8.71%
Avista (NatGas)	8.64	4.89%
<b>Total five leading companies</b>	<b>173.65</b>	<b>98.29%</b>
<b>Total reported natural gas</b>	<b>176.68</b>	<b>100.00%</b>

Calculations by Climate Accountability Institute, based on data reported by each company to Oregon Dept of Environmental Quality exceeding 4.0 MtCO<sub>2</sub>e for 2010 to 2022. DEQ data is summed for each company as percent of total reported emissions from Oregon natural gas suppliers 2010-2022.

Note: I have not incorporated natural gas leaks reported to DEQ for 2020-2023, averaging 0.06 MtCO<sub>2</sub>e per year for Northwest Natural, and smaller quantities for Avista and Cascade Natural Gas.

Table 8 combines all suppliers of liquid fuels and natural gas (see Table 6 and 7) and shows the percent of total fuels and natural gas for each of the fourteen companies listed.

**Table 8. Top 14 Oregon company emissions from fuel & natural gas suppliers 2010-2022.**

<b>Company</b>	<b>Fuel &amp; Nat Gas MtCO<sub>2</sub>e</b>	<b>Percent of Oregon Fuel &amp; Natural Gas, %</b>
Northwest Natural (gas)	72.15	10.20%
Gas Transmission Northwest (gas)	55.03	7.78%
Phillips 66 (fuels)	50.44	7.13%
Marathon Petroleum (fuels)	46.23	6.54%
BP West Coast Products (fuels)	44.44	6.28%
Equilon Enterprises (fuels)	42.09	5.95%
Chevron Products (fuels)	35.51	5.02%
Cascade Natural Gas (gas)	22.45	3.17%
Vitol Inc. (fuels)	17.73	2.51%
Kelso-Beaver Pipeline (gas)	15.38	2.18%
BP Products (fuels)	9.77	1.38%
Avista (gas)	8.64	1.22%
Space Age Fuel (fuels)	8.19	1.16%
Carson Oil (fuels)	4.08	0.58%
<b>Total selected companies</b>	<b>432.14</b>	<b>90.76%</b>
<b>Oregon fuels + natural gas</b>	<b>476.12</b>	<b>100.00%</b>

Calculations by Climate Accountability Institute, based on data reported by each company to Oregon Dept of Environmental Quality exceeding 4 MtCO<sub>2</sub>e for 2010 to 2022. DEQ data is summed for each company as percent of total reported emissions from Oregon fuel and natural gas suppliers 2010-2022. This represents 90.8% of Oregon's combined emissions from fuels and natural gas.

<sup>13</sup> ScrapeHero.com, at: <https://brilliantmaps.com/us-locations/exxon-mobil-locations-us/>

## Recommendations

Given the partial data gathered and analyzed for this study on refinery output and petroleum product sales I recommend that each company be asked to supply complete records of refinery output and petroleum product sales covering the period from 1965 to 2022. This should include detail, to the degree available, on carbon fuels refined and/or sold by clearly defined and reasonably granular categories of fuels, e.g., including distillates, kerosine, jet fuel, propane (LPG), and gasoline, as well as documenting products reported under “specialty or other products” that are intended for combustion, such as propane, jet fuel (if not reported separately), petroleum coke, and so on. Note: The Carbon Majors methodology parses non-energy uses of crude oil and NGLs and accounts for petrochemical feedstocks that are emitted to the atmosphere rather than sequestered through combustion in waste-to-energy plants, cement kilns, and the like.

While I can provide a breakdown of which years and for which companies, I have acquired sufficient documentation of refinery output and petroleum product sales (these can be seen in the worksheets and workbooks discussed in Appendix), I advise that we request full documentation for the period 1965 to 2022 in order to facilitate reporting on the same consistent basis over the entire period from 1965. At minimum, companies should provide documentation of refinery data and petroleum product sales covering the data gaps identified in this analysis. In addition, a complete record of scope 1 emission sources for both CO<sub>2</sub> and methane from each company’s in-house monitoring and/or published data from its earliest records.

In addition, as I have done for the Carbon Majors, companies should also document both refinery output and product sales for the extant company as well as mergers and acquisitions since 1965. That, in brief, should include Chevron’s M&A of Gulf Oil (1984), Getty Oil (acquired by Texaco in 1984), Texaco (2001), Unocal (2005), Noble Energy (2020), and the proposed acquisition of Hess Corp., if it goes through (Exxon is challenging it in court) And Occidental’s acquisition of Anadarko (2019), Exxon and Mobil merger (1999), and, if pertinent to the chosen timeline, ExxonMobil’s acquisition of Pioneer Natural Resources in May 2024.

I have sufficient documentation on each company’s production of and “natural gas available for sale” and associated emissions as well as coal production data on coal assets owned by the companies in this survey. See Table 3.

Scope 1 operational emissions are estimated in the Carbon Majors database, based on robust and peer-reviewed global industry data. Inasmuch as oil and gas companies have only reported on scope 1 emissions and sources since approximately 2000 or later, Carbon Majors elected to apply global factors. It would help improve accuracy of scope 1 reporting if we had access to comprehensive historical reporting of such emissions that we could apply to our accounting, if proven reliable; there is considerable doubt over the veracity of company-reporting on leaked and fugitive methane, for example.

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# Appendix A

## Company data

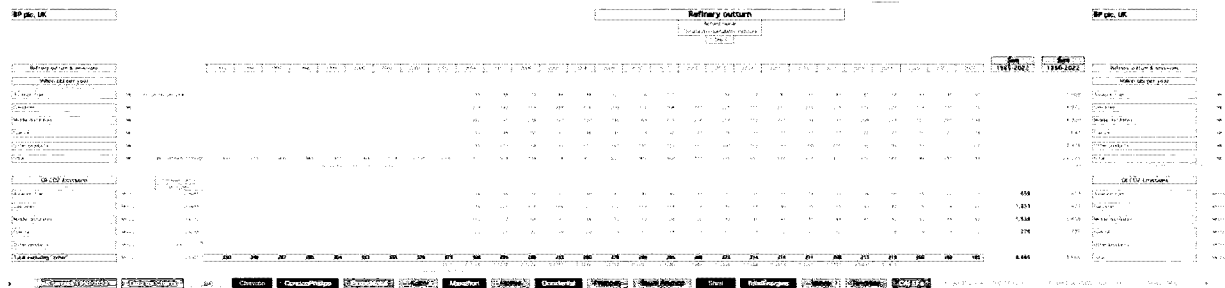
### Brief discussion of each oil, natural gas, and coal company included in our analysis

**BP** has produced 65 billion bbls (Gb) of crude oil and natural gas liquids (NGLs) and 130 billion cubic feet (Bcf) of gas since 1965. We have quantified and attributed emissions to BP from 1965 to 2022 totaling 36.4 billion tonnes CO<sub>2</sub>e (GtCO<sub>2</sub>e) under the Carbon Majors methodology (including crude oil, natural gas, and coal, and estimating both scope 1 and scope 3 sources), or 26 GtCO<sub>2</sub> for crude oil and NGL production. Emissions attributable to refinery output is 11.4 GtCO<sub>2</sub>, and 16.8 GtCO<sub>2</sub> using the product sales methodology. See Tables 2 and 4 for details. Fig. 11 shows BP’s emissions from crude oil production (Carbon Majors), from refinery output, and from petroleum product sales. Note that data availability limits our analysis of refinery output and product sales. Note that the scales vary for each figure.

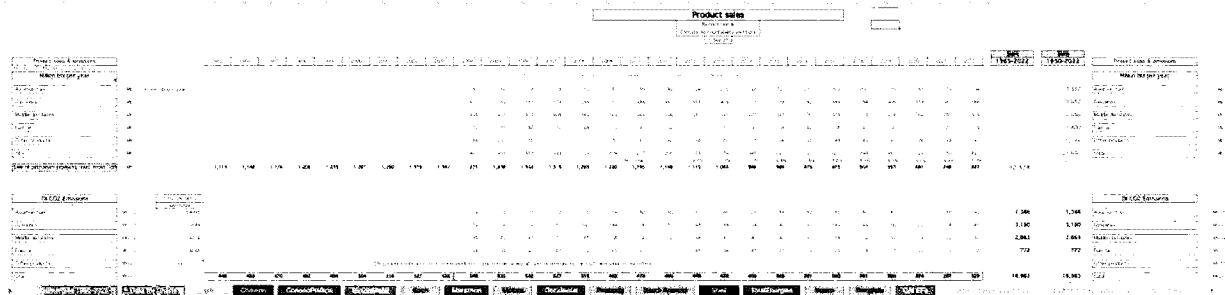
The Carbon Majors database has BP-reported production since 1913, and we cite crude oil and natural gas production and emissions for 1965-2022 here. BP also owned coal-mining assets from at least 1960 to 1989, and we include coal emissions in the total. See Table 4.

Figures A-1 and A-2 shows our worksheets on BP data on refinery outturn and petroleum product sales from 1995 to 2022. These are illustrative only, showing the lack of detailed reporting prior to 2004 and summaries prior to 1989 and 1984, respectively.

**Figure A-1. BP refinery yield, 1995-2022**



**Figure A-2. BP petroleum product sales, 1995-2022**

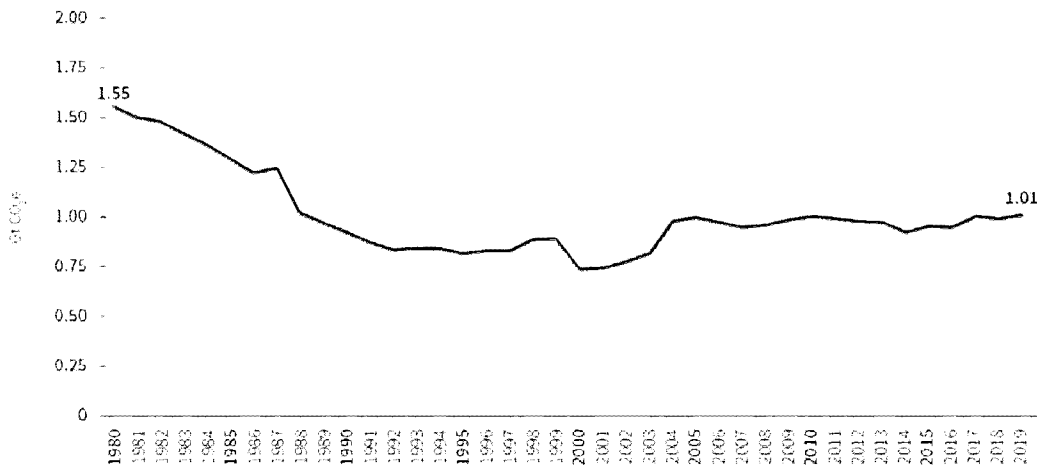


We have data on refinery yield (or output) from 2004 to 2022 by type of petroleum product, and total refinery yield (lacking product type) from 1990 to 2003. First of all, we exclude “other” mostly unspecified products (such as lubricants, petrochemical feedstocks,

but also, undisclosed propane (LPG) and jet fuel). Likewise, for petroleum products, we have disaggregated data by product type – and therefore the emissions per bbl sold – for BP from 2004 to 2022, and total “refined petroleum products” from 1984 to 2003.

Comparing my results to CCSI report on BP’s product sales emissions shows the CCSI study estimates far higher emissions from product sales than my analysis. Bear in mind my study uses BP-reported refinery output and petroleum product sales by fuel category (from 2004-2022, with aggregated sales 1984-2003 and *peaks* at 540 MtCO<sub>2</sub> in 2004 compared to CCSI’s results of nearly twice as high at ~1,000 MtCO<sub>2</sub>e in 2004. Verify that the difference is largely attributable to CCSI’s inclusion of crude oil commodity trading, not simply end use products for sale. Note also that I exclude “other products,” per our methodology.

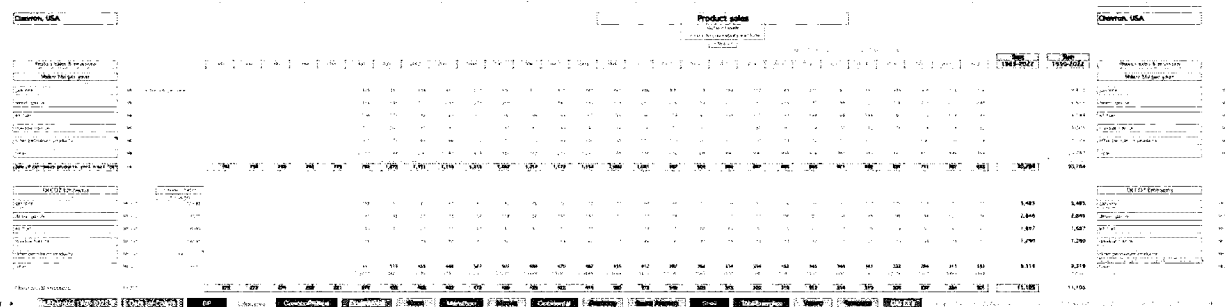
**Figure A-3. Columbia CSI Carbon Footprint of BP’s petroleum product sales, 1980-2019.**



Columbia CSI 2022, Fig. 18, page 42.

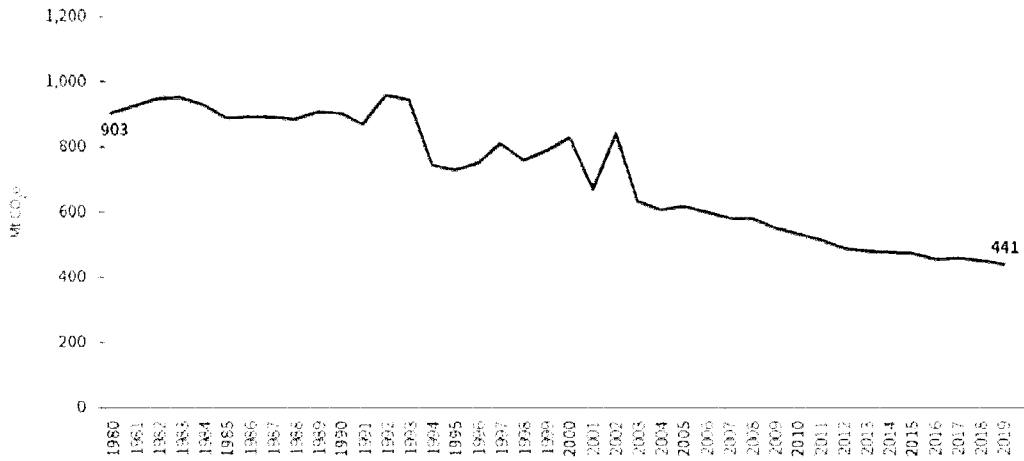
**Chevron** has produced 82 Gb of crude oil and natural gas liquids (NGLs) and 162 Bcf of gas since 1965. The Carbon Majors database has Chevron-reported production data since 1912. We have quantified and attributed emissions to Chevron from 1965 to 2022 totaling 45.5 GtCO<sub>2</sub>e under the Carbon Majors methodology (including crude oil, natural gas, and coal, and estimating both scope 1 and scope 3 sources), or 30.4 GtCO<sub>2</sub> for crude oil and NGL production. Emissions attributable to refinery output is 7.3 GtCO<sub>2</sub>, and 20.7 GtCO<sub>2</sub> using the product sales methodology. See Tables 2 and 3 for details. Figure 2 compares Chevron’s emissions from crude oil production (Carbon Majors), from refinery output, and from petroleum product sales. Note that data availability limits our analysis of refinery output and product sales. Note that the scales vary at each figure.

**Figure A-4. Chevron petroleum product sales, 1995-2022**



Our product sales data and emission calculation for Chevron petroleum product sales peak at 468 MtCO<sub>2</sub> in 2004. The Columbia analysis is ~600 MtCO<sub>2</sub>e in the same year, and for 2019 shows 441 MtCO<sub>2</sub>e compared to our result of 296 MtCO<sub>2</sub>. Compare Figure 12.

**Figure A-5. Columbia CSI Carbon Footprint of Chevron’s petroleum product sales, 1980-2019**



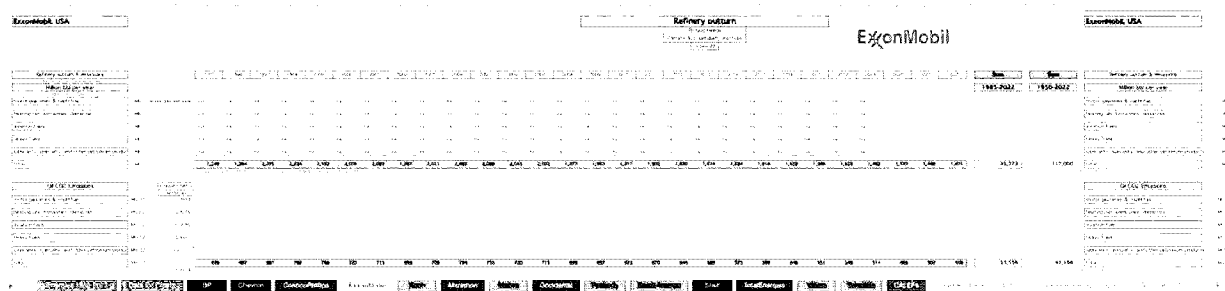
Columbia CSI 2022, Fig 20, page 44.

**ExxonMobil** reports aggregate refinery output from 1965 to 2022, totaling 116 Gb and associated emissions of 46.3 GtCO<sub>2</sub>. Petroleum product sales of 130 Gb (after excluding “lubricants, specialty, and other petroleum products”) are reported in detail from 1965 to 2022, and I calculate emissions totaling 52.4 GtCO<sub>2</sub> since 1965.

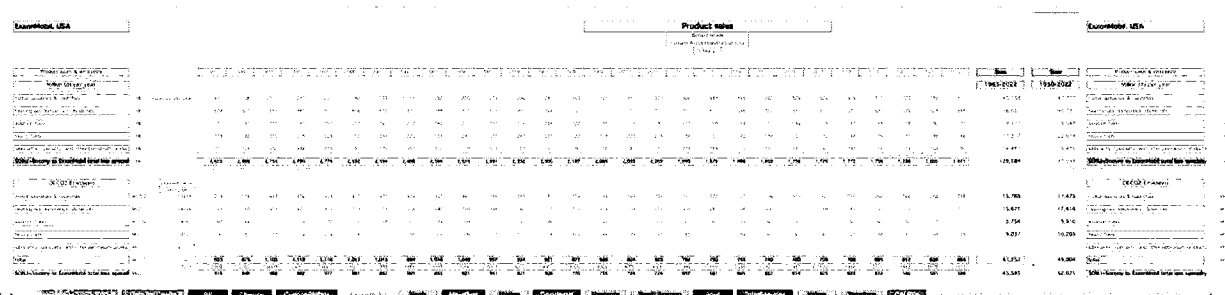
ExxonMobil reports comprehensive and detailed petroleum products sales by fuel category since 1950.

My calculations show product sales emissions of 693 MtCO<sub>2</sub> in 2019, whereas the Columbia analysis shows 930 MtCO<sub>2</sub>e and a differing curve of emissions in Figure 14 in the main text.

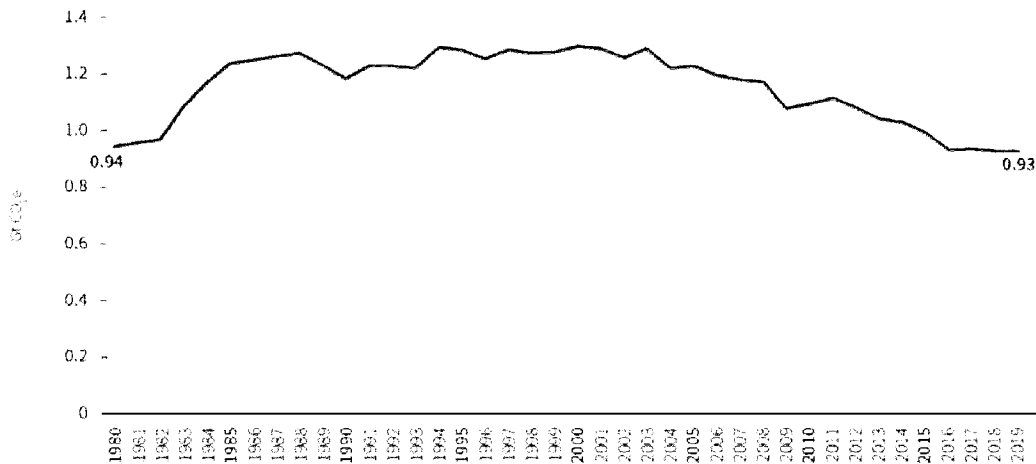
**Figure A-6. ExxonMobil refinery yield, 1995-2022**



**Figure A-7. ExxonMobil petroleum product sales, 1995-2022**



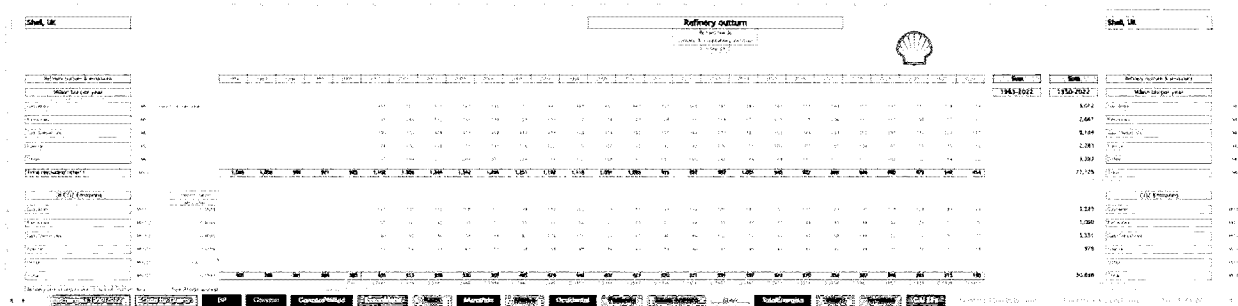
**Figure A-8. CSI Annual Carbon Footprint of ExxonMobil petroleum product sales, 1980-2019**



Columbia CSI 2022, Fig 24, page 48.

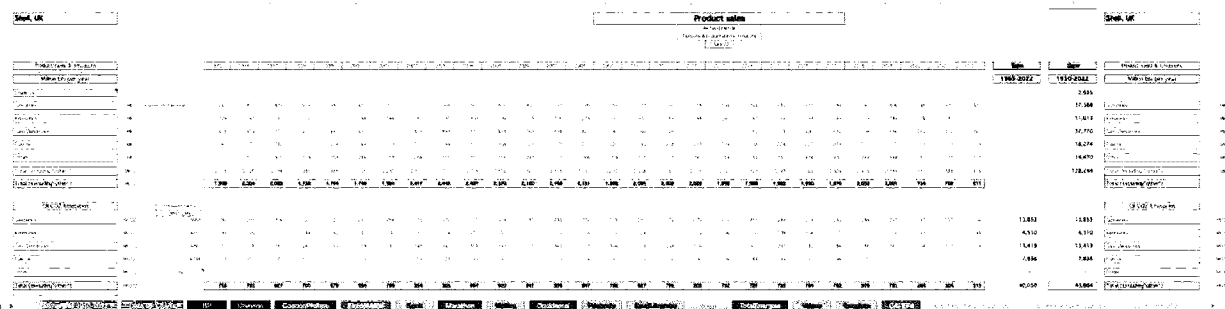
**Shell** reports detailed data on refinery output from 2001 onwards, and aggregate output from 1950 to 2000. Refinery output 1965-2022 totals 67.2 Mb and associated emissions of 26.2 GtCO<sub>2</sub>. Sale of petroleum products is reported in detail by fuel category since 1950; totaling 101 Gb from 1965 to 2022 (excluding “lubricants and specialty products”) and estimated emissions of 39.6 GtCO<sub>2</sub>.

**Figure A-9. Shell’s refinery output and emissions, 1995-2022**

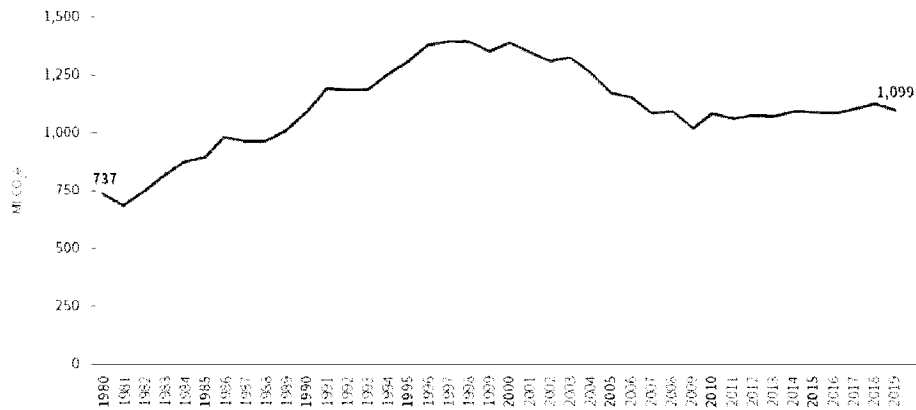


Columbia CSI report shows 2019 petroleum product emissions of 1,099 MtCO<sub>2</sub>e, compared to my result of 781 MtCO<sub>2</sub> in 2019. Compare main text Figure 17 with Figure A-11. As with BP, Chevron, and ExxonMobil, we cannot explain these substantial discrepancies in results, whether Columbia includes emissions from crude oil and product commodity marketing (not product sales) or some other reason, such as regional transportation, refining emissions, or other factors.

**Figure A-10. Shell petroleum product sales and emissions, 1995-2022**



**Figure A-11. CSI Annual Carbon Footprint of Shell's petroleum product sales, 1980-2019**

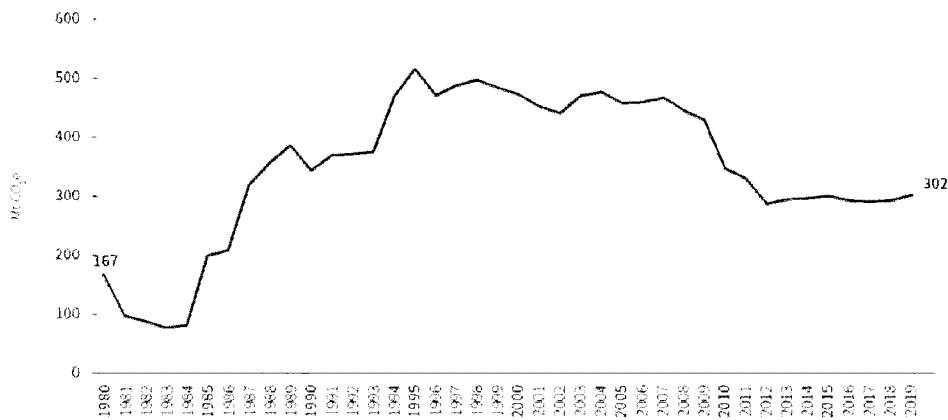


Columbia CSI 2022, Fig 26, page 50.

TotalEnergies reports refinery output by fuel categories from 1999 to 2022 totaling 14 Gb and associated emissions of 5.7 GtCO<sub>2</sub>, and none (that we have found) prior to 1999. The company also reports sale of petroleum products from 2010 to 2022, also by fuel type, and in aggregate from 1999 forward totaling 19.7 Gb and emissions of 7.5 GtCO<sub>2</sub>.

Columbia CSI estimates product sale emissions of 303 MtCO<sub>2</sub>e, compared to our estimate of 248 MtCO<sub>2</sub>. Compare Figures 18 and A-12.

**Figure A-12. CSI Annual Carbon Footprint of TotalEnergies' petroleum product sales, 1980-2019**



Columbia CSI 2022, Fig 28, page 52.

## Appendix B

### Emission factors

I use the following emission factors in my analysis. Table B-1 is used to estimate emissions from both refinery output and petroleum product sales. Table B-2 shows emission factors used in the Carbon Majors methodology based on production of crude oil, natural gas, and coal (by coal rank), and accounting for net non-energy uses of petroleum, gas, and coal. Table B-3 shows relative factors comparing crude oil & NGLs, natural gas, and coal for scope 3 combustion emissions to scope 1 operational sources such as flaring, vented CO<sub>2</sub>, and vented or fugitive methane.

**Table B-1. EPA emission factors applied to refinery output and petroleum product sales** <sup>14</sup>

Fuel	tCO <sub>2</sub> /bbl
Propane	0.2402
Aviation gasoline	0.3490
Motor gasoline	0.3688
Jet Fuel	0.4095
Distillate fuel oil #1	0.4276
Distillate fuel oil #2	0.4288
Distillate fuel oil #4	0.4603
Crude oil	0.4322
Lubricants	0.4490
Petroleum coke	0.6149

Calculated by CAI from US EPA (2024)

**Table B-2. Combustion emissions factors for Carbon Majors** <sup>15</sup>

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

Crude oil prior to non-energy deduction & adjustment for NGLs: 115.7 kgC/bbl, 423.8 kgCO<sub>2</sub>/bbl;

Gas prior to non-energy deduction: 14.86 kgC/kcf, or 54.44 kgCO<sub>2</sub>/kcf; (kcf = thousand cubic feet).

**Table B-3. Emission factors for vented, flared, and fugitive carbon dioxide and methane**

Entity	Combustion kgCO <sub>2</sub> /tCO <sub>2</sub>	Flaring kgCO <sub>2</sub> /tCO <sub>2</sub>	Vented kgCO <sub>2</sub> /tCO <sub>2</sub>	Methane kgCH <sub>4</sub> /tCO <sub>2</sub>	Methane kgCO <sub>2</sub> e/tCO <sub>2</sub>	Total kgCO <sub>2</sub> e/tCO <sub>2</sub>
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. Excludes own fuel use of 59.24 kg CO<sub>2</sub>/tCO<sub>2</sub> (natural gas only).

<sup>14</sup> U.S. EPA Climate Leaders (2021) *Emission Factors for Greenhouse Gas Inventories*, EPA, Washington, DC, April. <https://www.epa.gov/climateleadership/ghg-emission-factors-hub>

<sup>15</sup> Heede, Richard (2014) Tracing anthropogenic CO<sub>2</sub> and methane emissions to fossil fuel and cement producers 1854-2010, *Climatic Change*, vol. 122(1): 229-241; <http://link.springer.com/article/10.1007/s10584-013-0986-y?view=classic>

**Table B-4: US EPA Emission Factor Hub**

15 January 2025

<https://www.epa.gov/climateleadership/ghg-emission-factors-hub>

Fuel Type	Heat Content (HHV)	CO <sub>2</sub> Factor	CH <sub>4</sub> Factor	N <sub>2</sub> O Factor	CO <sub>2</sub> Factor	CH <sub>4</sub> Factor	N <sub>2</sub> O Factor
	mmBtu per short ton	kg CO <sub>2</sub> per mmBtu	g CH <sub>4</sub> per mmBtu	g N <sub>2</sub> O per mmBtu	kg CO <sub>2</sub> per short ton	g CH <sub>4</sub> per short ton	g N <sub>2</sub> O per short ton
<b>Coal and Coke</b>							
Anthracite	25.05	103.69	11	1.5	2,562	276	40
Bituminous	24.93	93.28	11	1.6	2,326	274	40
Subbituminous	17.25	97.17	11	1.6	1,678	190	28
Lignite	14.21	97.72	11	1.6	1,380	166	23
Mixed (Commercial Sector)	21.39	94.27	11	1.5	2,016	235	34
Mixed (Electric Power Sector)	19.73	95.52	11	1.6	1,885	217	32
Mixed (Industrial Coking)	29.28	93.00	11	1.6	2,498	280	42
Mixed (Industrial Sector)	22.35	94.87	11	1.6	2,136	246	36
Local Coke	24.80	113.67	11	1.6	2,319	273	40
<b>Other Fuels - Solid</b>							
Municipal Solid Waste	9.95	99.79	32	4.2	192	318	42
Petroleum Coke (Solid)	39.00	102.41	32	4.2	3,072	180	126
Plastics	31.00	25.00	32	4.2	2,850	1,216	109
Tires	28.00	85.97	32	4.2	2,402	886	118
<b>Biomass Fuels - Solid</b>							
Agricultural Byproducts	8.25	118.17	32	4.2	175	284	39
Peat	8.00	111.84	32	4.2	805	256	34
Solid Byproducts	10.30	106.51	32	4.2	1,096	332	44
Wood and Wood Residues	17.48	93.80	12	3.6	1,649	126	63
<b>Natural Gas</b>							
Natural Gas	0.001026	5.06	1.0	0.10	0.02444	0.00103	0.00010
<b>Other Fuels - Gaseous</b>							
Black Furnace Gas	0.000022	274.32	0.022	0.10	0.02624	0.00002	0.000009
Dryer Combustion Gas	0.000500	46.85	5.43	0.10	0.02006	0.00020	0.000060
Fuel Gas	0.001383	59.00	3.9	0.60	0.00189	0.004164	0.000813
Propane Gas	0.002519	81.46	3.9	0.60	0.1463	0.002548	0.001510
<b>Biomass Fuels - Gaseous</b>							
Landfill Gas	0.000495	52.07	3.2	0.63	0.02424	0.001552	0.000396
Other Biomass Gases	0.000665	52.07	3.2	0.63	0.034106	0.002206	0.000413
<b>Petroleum Products</b>							
Asphalt and Road Oil	0.150	75.36	3.0	0.60	11.81	0.47	0.03
Aviation Gasoline	0.120	69.25	3.0	0.60	8.33	0.36	0.02
Bitumen	0.103	64.77	3.0	0.60	6.67	0.31	0.06
Butylene	0.105	68.72	3.0	0.60	7.22	0.32	0.06
Crude Oil	0.130	74.54	3.0	0.60	10.29	0.41	0.01
Gasoline Fuel Oil No. 1	0.120	73.25	3.0	0.60	10.18	0.42	0.08
Gasoline Fuel Oil No. 2	0.128	73.96	3.0	0.60	10.21	0.41	0.08
Gasoline Fuel Oil No. 4	0.140	74.04	3.0	0.60	10.96	0.34	0.09
Kerosene	0.090	50.68	3.0	0.60	4.85	0.20	0.04
Ethylene	0.050	65.96	3.0	0.60	1.83	0.12	0.03
Heavy Gas Oils	0.148	74.92	3.0	0.60	11.68	0.43	0.09
Isobutane	0.099	64.84	3.0	0.60	6.43	0.30	0.06
Isobutylene	0.105	68.86	3.0	0.60	7.06	0.31	0.06
Kerosene	0.135	75.29	3.0	0.60	10.15	0.41	0.08
Kerosene Type Jet Fuel	0.135	72.22	3.0	0.60	9.75	0.41	0.08
Liquefied Petroleum Gases (LPG)	0.092	61.21	3.0	0.60	5.63	0.28	0.09
Lubricants	0.144	74.27	3.0	0.60	10.69	0.43	0.09
Motor Gasoline	0.125	70.22	3.0	0.60	8.28	0.38	0.08
Naphtha (<401 deg F)	0.125	68.02	3.0	0.60	9.50	0.38	0.09
Natural Gasoline	0.110	66.88	3.0	0.60	7.36	0.33	0.07
Other Oils (>401 deg F)	0.138	75.22	3.0	0.60	10.59	0.42	0.08
Paraffins Plus	0.110	70.02	3.0	0.60	7.70	0.33	0.07
Petrochemical Feedstocks	0.125	71.02	3.0	0.60	8.88	0.38	0.08
Propane	0.091	62.87	3.0	0.60	5.72	0.27	0.05
Propylene	0.091	67.77	3.0	0.60	6.17	0.27	0.05
Residual Fuel Oil No. 5	0.140	72.93	3.0	0.60	10.21	0.42	0.08
Residual Fuel Oil No. 6	0.150	75.10	3.0	0.60	11.27	0.45	0.09
Special Naphtha	0.125	72.54	3.0	0.60	9.04	0.38	0.08
Unfinished Oil	0.139	74.64	3.0	0.60	10.30	0.42	0.08
Used Oil	0.138	74.00	3.0	0.60	10.21	0.41	0.08
<b>Biomass Fuels - Liquid</b>							
Methanol (100%)	0.128	73.84	1.1	0.11	9.45	0.14	0.01
Ethanol (100%)	0.084	68.43	1.1	0.11	5.75	0.09	0.01
Ruminant Animal Fat	0.125	71.06	1.1	0.11	8.88	0.14	0.01
Vegetable Oil	0.120	81.55	1.1	0.11	9.78	0.13	0.01

# Appendix C

## Caveats

### Caveats

Reporting of refinery output (or outturn, or sometimes reported instead as input) varies in range of years reported. In some cases, covering many years, only total refinery output or product sales are reported. In addition, I do not have access to a complete record of every company's annual report or 10-K/20-F. Therefore, I quantify emissions from refining and sales over differing range of years for each company. Overall, I cover the years from 1965 to 2022 for each of the three methodologies, and also report 1950-2022 when available.

Definitions of categories of petroleum fuels vary from company to company. CAI has reviewed several dozen annual reports and 10-Ks for the selected companies going back to as early as the 1950s in order to glean relevant information on refinery output and/or petroleum product sales.<sup>16</sup> Each company's record therefore varies and seldom covers the full period from 1965 to 2022, unlike the complete record of each company's reporting of net equity production of crude oil and NGLs and natural gas based on the peer-reviewed methodology established in CAI's "Carbon Majors" work.<sup>17</sup> See the descriptions of each company, and the coverage illustrated in each company's graphic in Figures 11 to 18 as well as in Table 1. Note that scales vary.

While I have assembled large quantities of company-reported data, and carefully entered the data on excel worksheets, it would be prudent to request complete refinery output and petroleum product sales data from each company to complete the dataset and to correct any errors in reporting or data entry. The methodology for calculating emissions is straightforward, relies on company-reported data, employs verified emission factors (see Appendix B), and is conservative in its approach.

Since we have partial records for most companies – ExxonMobil, Marathon, and Shell have presented the most complete records — it is given, therefore, that I have underestimated attributable emissions for those companies with incomplete reporting (or for which we simply don't have the pertinent Annual reports or 10-Ks).

Included in this dataset are estimates for two companies that are not fossil fuel producers, but that do refine crude oil and liquids and, I reasonably assume, sell those refined products through their own or their customers' supply chains. One of these companies — Koch Industries — is privately held (Koch by Charles Koch and related trusts) — is not required to publish annual reports or divulge much of anything.

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<sup>16</sup> CAI has historical archives of photocopied Annual Reports for all Carbon Major companies, including the selected companies analyzed here. We do not, however, have AR sets covering all years for all companies, and, since the Carbon Majors project is primarily focused on reported production of oil, natural gas, and coal, our selected photocopies may have excluded data on refining and sales.

<sup>17</sup> Heede, Richard (2014) Tracing anthropogenic CO<sub>2</sub> and methane emissions to fossil fuel and cement producers 1854-2010, *Climatic Change*, vol. 122(1): 229-241. <http://link.springer.com/article/10.1007/s10584-013-0986-y?view=classic>  
Heede, Richard (2019) *Carbon Majors: Accounting for carbon and methane emissions 1854-2010 Methods & Results Report*, ISBN 978-3-659-57841-0, re-issued 2014 Rpt, OmniScriptum, Riga, 148 pp.

The focus is on quantifying emissions from oil production, refining, and petroleum product sales. I have, however, also added emissions from natural gas production and processing, in the form reported as “natural gas available for sale.”

Vertically integrated oil companies also owned coal mining assets for several years, typically from the 1970s to 1990s. See table 1 and 3 for details on ownership years, quantities of coal mined, and associated emissions of CO<sub>2</sub> and methane.

I have made a best-effort to quantify emissions reliably and conservatively using established methodologies and emission factors. Any errors in data entry, methodology, calculations, or results are the responsibility of the author.

## Appendix D

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