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Greenhouse Suppliers 100: A ranking of corporate producers of greenhouse gas precursors in the USA

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ABSTRACT

This paper presents the first comprehensive database of corporate suppliers of fossil fuels and greenhouse gas supply stocks in the U.S. economy. The database is a publicly available resource that adds value to existing information sources in two ways. First, we combine several high-quality public data sources, including the US Environmental Protection Agency (EPA) Greenhouse Gas Reporting Program (GHGRP), which reports on most products that would result in GHG emissions if those products were released, combusted, or oxidized, with the notable exception of coal, and data on coal from the US Energy Information Administration and the US Mine Safety and Health Administration. In this paper, we discuss the importance of coal as a GHG source and describe its exclusion from coverage by the GHGRP. Second, we aggregate facility-level data (on individual mines, wellheads, refineries, pipelines, and import facilities) to the corporate level, with the corporate final parent as the unit of analysis. While the data collection of the EPA focuses on individual facilities as the reporting units, the analysis of corporate ownership shifts attention to control and responsibility. Here we use these data to explore the corporate concentration of GHG activity, and we compare the degree of concentration between GHG supply and emissions, and between the facility level and the corporate level. Finally, we discuss current and potential applications and possible extensions, such as the development of environmental-justice metrics for fossil-fuel suppliers.

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Introduction

The United States emits 5–6 billion mt of CO_2-e per year, representing slightly <15 percent of the global total (Ritchie 2022). The supply of fossil fuels into the U.S. economy therefore is an important location for consideration of responsibility for and intervention against climate change. Figure 1 reports the carbon dioxide emissions for US energy-related activity by fuel source.

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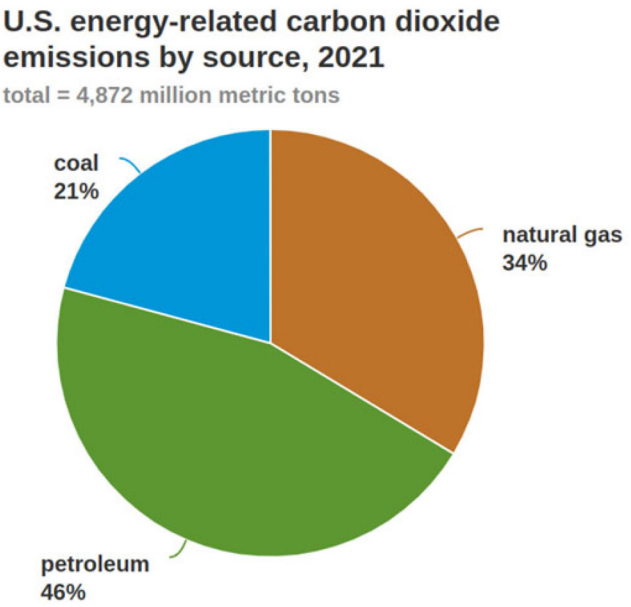

Figure 1. U.S. energy-related carbon dioxide emissions by fuel.
Source: U.S. Department of Energy.

Supply is a particularly important potential site of policy intervention because the number of suppliers is much smaller than the number of emitters, which includes the automotive and residential heating emissions of roughly one hundred million households as well as thousands of industrial facilities and electrical generation facilities.

We provide careful documentation of facilities contributing to the US supply of fossil fuels and of the companies, or final parents, that own these facilities. This analysis draws on the U.S. Environmental Protection Agency's Greenhouse Gas Reporting Program (GHGRP; US Environmental Protection Agency Office of Atmospheric Protection n.d.) for supplier data on facilities, together with a newly synthesized dataset of estimated greenhouse gas emissions attributable to coal suppliers using data from the Energy Information Administration of the U.S. Department of Energy, the Mine Safety and Health Administration of the U.S. Department of Labor, along with original research on the ownership of fossil-fuel supplying facilities by companies, or final parents.

The U.S. Congressional Budget Office (2001) analyzed several alternative structures for carbon permitting or taxation. The report observed the enormous difficulty in collecting at the point of emission and instead recommended upstream regulation for permitting or collection of carbon taxes. As Boyce and Riddle (2007) note, "Carbon revenues would be most easily collected "upstream," at the mine heads, oil refineries, natural gas

pipelines, and ports where fossil fuels enter the U.S. economy. Nationwide there would be roughly 2000 such collection points."[1]

Our analysis of the suppliers of GHG sources in the U.S. economy suggests that substantially fewer than 2000 entities are responsible for the vast majority of the source of US greenhouse gas emissions. Once the sites of physical entry—wellheads, oil refineries, mine mouths, pipelines, and ports—are further collapsed to the firms that own them, the list of parties responsible for the vast majority of the fossil fuel supply becomes very short, with fewer than 25 corporations being responsible for supplying fuel that accounts for more than 50 percent of all US GHG emissions (including non-combustion emissions).

The phenomenon of disproportionality, or the responsibility of a small number of entities for a large share of activity, is a common feature in pollution and other forms of environmental degradation (Collins et al. 2020; Robertson Galli and Collins 2019; Collins 2011; Freudenburg 2005). Our analysis indicates a substantial degree of disproportionality in the ownership of the fossil-fuel supply. The implications of this concentration for enforcement, liability, and responsibility are important. Implementation of supply controls, which are essential for climate mitigation (Boyce et al., 2023), is facilitated, and the financial and distributional consequences of supply interventions (Semieniuk et al. 2022, 2023) are concentrated. Pollin (2022) has proposed a buyout of a controlling share of the commanding heights of the fossil-fuel supply, and the concentration analysis presented here bears on the needed scale and scope of such proposals.

Right-to-know and the corporate toxics information project

The Corporate Toxics Information Project (CTIP) of the Political Economy Research Institute at the University of Massachusetts Amherst uses publicly available right-to-know data and other data from U.S. government agencies to analyze and disseminate information on corporate releases of pollutants, including greenhouse-gas emissions, air pollution, and water pollution, and on the consequences for communities. CTIP aims to help community-based activists, socially responsible investors, and public regulators themselves to translate the right to know into the right to clean air and water (Corporate Toxics Information Project 2022a, 2022b). In particular, CTIP aggregates the unit of analysis from the individual facility (plant, mine, etc.), which is the focus of most US regulatory and reporting systems, to the corporation, which is the decision-making and financially responsible entity. Puchalsky, Michael, and Boyce (2021) discusses the methods and the challenges in connecting the facility data to final parent ownership information.

Right-to-know regulation aims to bring about policy or market-based changes through improved public information. Right-to-know mandates the disclosure of various types of information. Notable examples of mandated public information include pollution data, residential water quality, energy efficiency ratings for cars and consumer goods, disclosure of financial asset risks and loan details for investors and consumers, lending performance of banks with a focus on racial equity, standardized test scores for schools, and performance indicators for healthcare providers. Right-to-know regulation often arises as a compromise between public demand for more specific regulations and industry resistance to direct regulation. Fung et al. (2007) survey and analyze various areas of regulation through disclosure. As Puchalsky, Michael, and Boyce (2021) observe, translating right-to-know data into tangible progress toward a clean and safe environment necessitates not just access to the information for stakeholders but also the ability to understand it, along with the capacity and motivation to act upon it (see also Hersh 2006). Intermediating institutions can play a vital role in this translation.

In the case of the Greenhouse Gas Reporting Program (GHGRP), the analysis by the Corporate Toxics Information Project (CTIP) of the Political Economy Research Institute at the University of Massachusetts Amherst began with the Greenhouse 100 Emitters publication which catalogs point-source emissions of greenhouse gases. As with the earlier and ongoing CTIP Toxic 100 Polluters publications, the emphasis is on corporate responsibility for pollutant emissions.[2] The analysis of emissions directly assesses contributions to the buildup of GHG in the atmosphere from industrial facilities but covers only the portion of US GHG emissions that come from industrial and electricity generation point sources.

The GHGRP also provides data on suppliers of fossil fuels. Rather than direct emissions, suppliers report the quantity of GHGs that would be emitted when the fuels or other compounds that they produce, import, or export are combusted, released, or oxidized. The emissions ultimately associated with these fuels and industrial gases do not occur at the supplier's facility, nor do they necessarily occur in the year in which the fuels are introduced into the economy. That is, the associated emissions occur throughout the United States and, in the case of exported fuels, elsewhere in the world, and only when the combustion, release, or oxidation occurs.

A supplier database is of interest for a range of policy reasons. The concentration of supply, which we will document below, makes the point at which fossil fuels first enter the economy an efficient location for carbon permitting or taxation. A supplier database provides a tool for assessment of responsibility, liability, and the potential incidence of losses that would be incurred as a result of aggressive climate change mitigation policies. The Climate

Accountability Institute and Heede (2014) provide a historical accountability analysis based on a variety of sources in a period before the availability of the GHGRP. Semieniuk et al. (2022, 2023) and Hansen (2022) discuss the magnitude, distribution, and political economy of potential stranded assets in the fossil-fuel sector. Hansen finds, for example, that "fossil fuel reserves will suffer a devaluation of 37–50 percent , amounting to $13–$17 trillion … Over half (51–63 percent) of the reserve devaluation stems not from fuels left in the ground but from price decreases for fuels that will still be extracted and sold during climate stabilization." The supplier analysis can also provide data to assess potential policies such as Pollin's recent proposal to nationalize majority control of leading fossil fuel producers.

There are several other projects that track the supply or emission of carbon in the U.S. or world economies. Some are private data products that often are prohibitively expensive and involve non-published methods and data. Two important publicly accessible projects are the Carbon Majors Project (Heede 2014) and the Global Energy Monitor (GEM 2022).[3] The Carbon Majors Project comprises a web-accessible database and analysis of major global companies based on their cumulative historical emissions (Heede 2019). The Global Energy Monitor (GEM) is a publicly accessible source on fossil fuel suppliers, again with global coverage, that began as an informal group of journalists and environmental advocates called CoalSwarm in 2007, became a project of the Earth Island Institute in 2008, and became an independent nonprofit group in 2017. GEM's mission is to develop and share information in support of the worldwide movement for clean energy. In pursuit of this mission, it tracks both fossil fuel suppliers and large plants that burn fossil fuels. Its suppliers databases include the Global Coal Mine Tracker, which covers operating mines producing 1 million tons per year or more, the Global Oil and Gas Extraction Tracker, which includes information on discovered, in-development, and operating oil and gas units worldwide, and various databases of oil and gas pipelines and other infrastructure (GEM 2022).

While these are valuable resources and have the advantage of global coverage, the datasets have unavoidable lags in updates, cannot rely on publicly mandated data sources, and depend on methods of combining data from a range of sources of varying quality and reliability. The legal mandate of the US EPA Greenhouse Gas Reporting Program, in contrast, ensures the availability of current, uniform, and, in principle, audited and validated data backed by Federal enforcement.

The US EPA regulates emissions and collects data (US Environmental Protection Agency n.d.) with the facility as the fundamental unit of analysis. The Corporate Toxics Information Project (CTIP) not only brings the lens of corporate ownership to the analysis of fossil fuel introduction and

production, but also advances interlinkages among datasets, making available links to GHG emissions, toxic releases to air and water, public subsidies, and regulatory and legal violations by the companies associated with the GHG supply.

Although many EPA reporting instruments include a field for the corporate parent, the data gathered are often of low quality. Apart from missing or incomplete data entries, they may list companies that are subsidiaries of other companies thereby failing to establish the ultimate owner or owners, and may not update changes in ownership due to mergers, acquisitions, spin-offs, and divestitures. The CTIP maintains a unique open-source database of final parent ownership of facilities implicated by right-to-know environmental databases including the U.S. EPA's Toxics Release Inventory, Risk Screening Environmental Indicators, and Greenhouse Gas Reporting Program, and also the EIA-7A data of the US Energy Information Administration and the MSHA coal mining data of the U.S. Department of Labor.

The Greenhouse Suppliers 100 Polluters Index (first issued in 2022 based on 2020 data) combines data from EPA's GHGRP Suppliers database and a dataset compiled by PERI on US coal mines as described below. The top 100 list derived from this database ranks companies by the CO_2-equivalent GHG emissions when the products they supply are released, combusted, or oxidized. The Greenhouse 100 Suppliers is distinct from the CTIP's Greenhouse 100 which ranks companies based on their direct releases of GHG emissions.

The US EPA Greenhouse Gas Reporting Program

The Greenhouse Gas Reporting Program database (GHGRP), compiled by the U.S. Environmental Protection Agency (EPA) in response to the FY2008 Consolidated Appropriations Act (H.R. 2764; Public Law 110–161), annually reports the weight (in metric tons) of greenhouse gases from both large direct emission sources and from suppliers of fossil fuels. From an EPA page about the program, facilities are required to report as suppliers if "supply of certain products would result in over 25,000 metric tons CO_2e of GHG emissions if those products were released, combusted, or oxidized." Annual data have been reported since 2010; here we use the 2020 data.

We obtained the GHGRP Suppliers data from the Envirofacts Customized Search Summary Subjects on May 10, 2022. Sectors with facilities that report to GHGRP as suppliers include: for natural gas, natural gas distribution companies, and natural gas liquids fractionaters; for petroleum, refiners, importers, and exporters; for greenhouse gases used in non-fuel

industrial processes, producers, importers, and exporters; for coal-based liquid fuel (which is distinct from coal itself), producers, importers, and exporters; and finally, importers and exporters of equipment pre-charged with fluorinated GHGs.

Some of these sectors have facilities that are also direct emitters: for instance, refineries emit GHGs as part of the process of refining, apart from the GHGs released when their petroleum products are burned as fuel. Coal mines, excluded from the GHGRP Suppliers data, are mandated to report emissions of methane from the mining activity itself. The direct emissions by supplying facilities are included in the Greenhouse 100 (emitters) database rather than the Greenhouse 100 Suppliers database.

It is important to note that EPA treats CO_2 quantities from suppliers as confidential if the supplying facility only produces one fossil fuel product and converting back from CO_2 emissions would let the public figure out the production amount of the fossil fuel when this is judged by EPA to be a trade secret. We cannot determine the value of these confidential amounts and have treated them as zeroes throughout. EPA has not to our knowledge released a supplier's CO_2 total that includes the confidential amounts. Users of the Greenhouse Suppliers 100 thus should be aware that any totals derived from EPA GHGRP Suppliers data represent a lower bound. That said, it is clear from comparison with emissions data that the GHGRP suppliers data covers the vast majority of fossil fuels entering the U.S. economy.

The continuing relevance of coal in the US energy mix

Coal combustion remains an important source of GHG emissions in the United States, accounting for about 20 percent of US energy-related GHG emissions (U.S. EIA). As shown in Figure 2, the electric power sector is by far the largest user of coal, with coke plants (for the steel industry) and other industrial processes as the next largest users. (The use of coal in transportation, commercial, or residential activity has essentially disappeared.) Coal is of particular interest as a fuel. First, in its role as a thermal source of electric power, coal is more than twice as carbon-intensive (in terms of kg of CO_2-e emissions per kWh electricity) than natural gas. Although the use of coal has declined sharply over the past decades, it remains a major source of fuel for electric power generation, representing roughly 35 percent of fossil-fuel electricity generation and well over half of the CO_2 emissions from electricity generation (U.S. EIA).

Second, coal is substantially dirtier and unhealthier in terms of local pollutants per unit of energy released than natural gas. In addition to GHG,

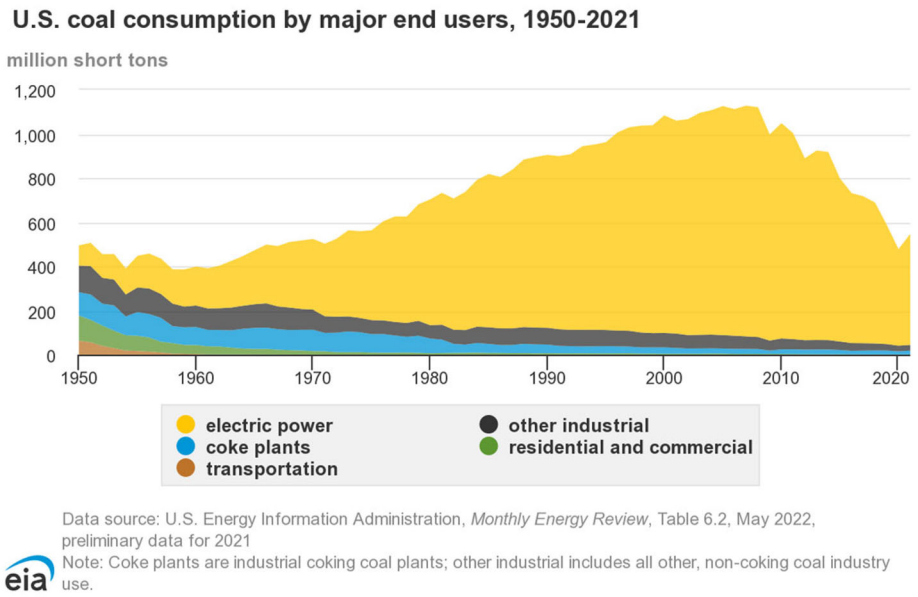

Figure 2. U.S. coal consumption by end-use sector.
Source: U.S. Energy Information Administration.

coal combustion releases a set of dangerous local pollutants including sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulates, which are precursors for acid rain and smog and cause significant respiratory harms; mercury and other heavy metals with high human and ecosystem toxicity; and fly ash and bottom ash which pose containment challenges and dangers to air and water (US Energy Information Administration n.d.). The harms of coal are well documented and are highly unequally distributed with low-income communities (Diana, Ash, and Boyce 2023), people of color (Henneman et al. 2023), and coal-mining communities (Wishart and Pierce 2023) at especially high risk.

The GHGRP coal exclusion and coal data sources

The draft regulations for the Greenhouse Gas Reporting Program included coal suppliers among the covered entities (as Subpart KK of the draft regulations). Corporate mobilization in the period for comments on the draft derailed this proposed subpart of the agency rules. Corporate and trade organization comments emphasized the reporting burden and the redundancy of including coal supply data because other reporting systems, including the Energy Information Administration of the U.S. Department of Energy and the Mine Safety and Health Administration of the U.S. Department of Labor already collect data on mine output.

> "Proposed Subpart KK—Suppliers of Coal" in the draft Greenhouse Gas Reporting Rules was dropped from the final reporting rules. When issuing the final rules, EPA reported, "EPA has made a final decision to not include reporting requirements for suppliers of coal as a Subpart in 40 CFR Part 98 at this time because EPA's near-term needs for information on GHG emissions from coal consumption can be met through existing reporting requirements under 40 CFR Part 98, as well as other readily available and existing data sources."

It is interesting to note the affiliation of commenters opposing and supporting GHG reporting for coal suppliers.

Most of the opponents were mining companies or trade associations of mining companies. Commenters opposing GHG reporting for coal suppliers were: Rio Tinto Services, Inc.; Texas Mining and Reclamation Association (TMRA); Association of Electric Companies of Texas (AECT); Luminant; North American Coal Corporation (NAC); Koch Carbon LLC; Lignite Energy Council (LEC); LyondellBasell Industries; Texas Mining and Reclamation Association (TMRA); National Petrochemical and Refiners Association; West Virginia Chamber of Commerce; Murray Energy Corporation. Among the commenters, the National Mining Association (NMA) provided four distinct comments against the proposed rule; Peabody Energy, the largest coal producer in the U.S. with 104.8 million short tons of coal produced in 2020 (which would yield some 187.6 metric tons of CO_2) thoughtfully provided comments on behalf of small producers potentially burdened by the rule, "As EPA recognizes, there are more than 1300 coal suppliers who will be required to report under the rule, and many of these are small businesses, and some are very small indeed." A public agency, the Small Business Administration (SBA) commented to protect the small mining businesses in their ambit, "The great majority of the coal mines in the United States are operated by small businesses; 48 percent of U.S. mines produce 100,000 tons of coal or less per year. The National Mining Association has informed Advocacy that it expects GHG reporting requirements to add $7.00 per ton (on the order of 7–14 percent) to the cost of small mining operations (or as much as $700,000 per year) and small communities (e.g., municipal utilities)."

The EPA received fewer comments supporting the draft requirement of GHG reporting for coal suppliers. These included the environmental advocacy organization, the Sierra Club, which quoted a Federal agency, the US Forest Service, with respect to the variation in coal types, "It is impossible to quantify emissions related to coal that is burned at coal-fired power plants with regard to the coal in [a proposed federal coal] lease modification as it will be mixed with other less compliant coals all over the United States to meet air quality standards." Other supporters of coal reporting included a researcher at Drexel University, the World Resources Institute, and a natural-gas oriented energy company,

MidAmerican Energy Holdings Company, whose parent company is Berkshire Hathaway.

The decision in the final rule was to exclude the draft Subpart KK—Suppliers of Coal. Suppliers of coal-based liquid fuel were not exempted from the reporting and methane releases from coal mining activity are included in the emitters reporting. The ultimate decision of US EPA to exclude coal itself from the final rules with the reason given that the data could be collected from "readily available and existing data sources" had the effect of making the GHGRP data less than comprehensive in tracking the introduction of GHG-creating fuels into the U.S. economy.

A comprehensive synthesis of data on GHG suppliers

The CTIP Greenhouse 100 Suppliers database has remedied the omission of coal by integrating the US EPA GHGRP Suppliers database with data from the Energy Information Administration (EIA) in the US Department of Energy and the Mine Safety and Health Administration (MSHA) in the US Department of Labor. To fix the data gap, PERI collected data on U.S. operating coal mines from the Department of Energy's EIA-7A survey, augmented by information from MSHA. The survey includes all US coal mines with production of over 25,000 short tons in a year, plus anthracite mines with production of over 10,000 short tons in a year. Mines are classified as Underground, Surface, or Refuse mines, and if a single mine has both an underground and a surface component it will have two records in this file. Unlike the GHGRP Suppliers data, the EIA-7A database includes production amounts of the fossil fuel (coal). PERI multiplied these amounts by EIA conversion factors to compute the amount of CO_2 released when the coal is combusted. Note that the coal data are not strictly the same as the GHGRP Suppliers data in that the coal data includes only coal mines (producers) while the GHGRP Suppliers data includes producers, importers, and exporters.

Using information on company ownership of facilities from the GHGRP, EIA, and MSHA reports, company websites, the CrocTail database of SEC filings, and news reports, we matched each facility to its parent company. Each facility was assigned either one or two parents. If more than 50 percent of a facility was controlled by a single parent, that parent was assumed to have final control over the facility's operations and was assigned full responsibility for the facility's pollution. If two companies each controlled 50 percent of a facility (i.e. it was a 50/50 joint venture), then its pollution was divided between the two companies. If a single company controlled 50 percent of a facility and no other single entity controlled the other 50 percent, that company was considered to be the parent of the facility. If no

parent-controlled 50 percent of a facility, the facility was considered to be its own parent. The GHGRP database includes detailed ownership percentages of facilities by multiple parents, and we could have used these to assign each facility's pollution to multiple parents instead of one or two. However, these percentages reported within the GHGRP are percentages of ownership, not percentages of emissions. It is possible for power plants to have multiple generating units owned by different companies in which the percentage of ownership of the facility as a whole does not match the percentage of the facility's emissions from each set of generating units. Partly for this reason, we consider that assigning pollution by corporate majority ownership better reflects the data.

For the current versions (available in July 2023 at toxic100.org), the baseline corporate ownership of GHGRP-reporting facilities is as reported to the GHGRP on December 31, 2020. In some cases, we updated parent companies according to mergers, acquisitions, and corporate name changes that took place through mid-2022, under the principle that when one company acquires another, it takes responsibility for that company's past pollution. We also combined some U.S. subsidiaries of common foreign companies together. The data on coal mines had information on ownership that we similarly converted to ultimate parent companies as of mid-2022.

PERI released the coal data in June 2020 as a separate database.[4] This database contains additional data fields, not only the coal data that have been incorporated into the Greenhouse Suppliers 100.

Both the GHGRP Suppliers database and the coal database convert other gases to CO_2 equivalents (CO_2-e) using GWPs from IPCC's AR4 with a 100-year time horizon. We estimated how much CO_2 would be released into the atmosphere if all coal that a mine produced in 2020 was burned. To do this, we multiplied coal production by EIA emissions factors. There is substantial variation among coal types with an average of about 1800 kg of CO_2 per short to (2000 pounds) of coal.[5] The type of coal reported to the EIA-7A survey determined the emission factor for each mine.

Unlike the Toxic 100 Air, Toxic 100 Water, or Greenhouse 100 lists, which provide environmental justice (EJ) analysis based on proximity and plume models of pollutant (or in the case of the Greenhouse 100, co-pollutant) dispersion around the point of release, the Greenhouse Suppliers 100 list does not have a natural EJ component. This is because the fossil fuels produced or imported are sent to multiple locations to be burned, so there is no single geographic location that suffers from the co-pollutants released by the combustion of these fuels. In some cases, however, the extractive, refinement, or storage activity by the supply entities creates local harms. Future analysis of these harms is warranted.

Results

The full data from the integrated suppliers list (Greenhouse 100 Suppliers) and the coal-mining list (U.S. Coal Producers and Greenhouse Gas Emissions 2020) are available at www.toxic100.org from the Corporate Toxics Information Project of the Political Economy Research Institute at the University of Massachusetts Amherst. The Greenhouse Suppliers 100 list was created by ranking the 100 largest GHG suppliers final-parent companies. In addition to listing the 100 largest companies, the website provides online access to the complete database of supplier companies and offers the open-source data for download for further analysis.

The Greenhouse Suppliers 100 list and application also report data from the individual facilities owned by each parent company. For each parent company, the percentage of the company's total emissions that are from a single facility is displayed. This helps to identify companies whose overall emissions are dominated by fossil fuel from a single source.

Tables 1 and 2 report the top ten GHG-supplying companies ranked by CO_2-e emissions. Table 1 reports the overall results, with the share from each company reported as a share of the total U.S. supply. Total U.S. emissions from all sectors, including those releasing GHG from sources other than fossil fuels, are also reported in the final row. It can be seen that supply is highly concentrated: the top ten suppliers are responsible for 42 percent of all supply (and for 36 percent of all U.S. emissions from all sources).

Table 2 reports emissions by sector. The three panels report results for coal mining, petroleum (including companies that also supply natural gas), and natural gas (excluding companies that also supply petroleum). All three source stocks are highly concentrated in ownership, with petroleum the most

Table 1. Top 10 GHG-supplying companies ranked by CO_2-e emissions, overall.

Parent corporation	CO_2-e emissions (mt)	Share of supply (%)	Activity
Marathon Petroleum	401,574,105	7.9	Petroleum refineries, natural gas extraction
Phillips 66	300,637,006	5.9	Petroleum refineries, natural gas extraction
Valero energy	298,505,939	5.9	Petroleum refineries and wholesale
Exxon Mobil	281,458,143	5.6	Petroleum refineries and extraction, natural gas extraction
Peabody energy	187,589,392	3.7	Coal mining
Enterprise products partners	173,206,677	3.4	Natural gas extraction
Chevron	142,085,079	2.8	Petroleum refineries
BP	133,113,765	2.6	Petroleum refineries
Arch resources	109,913,336	2.2	Coal mining
Shell PLC	108,564,959	2.1	Petroleum refineries and wholesale
Top 10 total	2,136,648,400	42.2	
All suppliers total	5,065,438,885	100.0	
US GHG emissions	5,973,000,000		

Table 2. Top 10 GHG-supplying companies ranked by CO_2-e emissions, by fuel.

Parent corporation	CO_2-e emissions (mt)	Share of supply (%)
Coal mining		
Peabody energy	187,589,392	17.1
Arch resources	109,913,336	10.0
Invesco	75,745,101	6.9
Navajo Transitional Energy Company LLC	74,018,280	6.8
Trafigura Group	66,917,138	6.1
Alliance Resource Partners LP	60,151,098	5.5
CONSOL energy	42,016,232	3.8
Mike Jamison; Petri E Koivula; John McNab	39,908,541	3.6
NACCO industries	33,600,464	3.1
Foresight Energy Labor LLC	31,662,329	2.9
Top 10 total	721,521,911	65.8
Coal mining sector total	1,096,345,305	100.0
Petroleum companies (including petroleum companies with natural-gas operations)		
Marathon Petroleum	401,574,105	14.9
Phillips 66	300,637,006	11.2
Valero energy	298,505,939	11.1
Exxon Mobil	281,458,143	10.5
Chevron	142,085,079	5.3
BP	133,113,765	4.9
Shell PLC	108,564,959	4.0
Saudi Arabian Oil Company (Saudi Aramco)	102,916,368	3.8
PDVSA (Petroleos de Venezuela S.A.)	99,698,714	3.7
PBF energy	94,524,465	3.5
Top 10 total	1,963,078,543	73.0
Petroleum sector total	2,690,604,620	100.0
Natural gas (companies without petroleum operations)		
Enterprise products partners	173,206,677	13.7
Targa resources	75,988,228	6.0
Energy transfer	72,435,027	5.7
Oneok	59,530,874	4.7
NiSource	49,010,028	3.9
Sempra energy	45,705,202	3.6
Southern Company	43,524,349	3.4
PG&E Corp.	40,301,528	3.2
Dominion energy	40,071,370	3.2
National grid	37,550,095	3.0
Top 10 total	637,323,378	50.2
Gas sector total	1,268,600,642	100.0

Notes: Each panel reports the top ten suppliers of GHG precursors by the main supply source, coal, petroleum, and natural gas. Some petroleum companies also have natural gas operations. The natural gas companies here are limited to companies without petroleum operations.

concentrated; the top ten companies introducing petroleum into the U.S. economy are responsible for almost three-quarters (73.0 percent) of all CO_2-e from petroleum supplied to the U.S. economy. Coal mining is also highly concentrated with the top ten companies supplying roughly two-thirds (65.8 percent) of all coal supplied to the U.S. economy. In the case of gas, the top ten companies are responsible for 50 percent of all gas supplied. In summary, all of the GHG supply sectors are highly concentrated industries.

The detailed Greenhouse Suppliers 100 application includes links to a company's Toxic 100 Air, Toxic 100 Water, and Greenhouse 100 pages if the company also appears in those databases.[6] Greenhouse Supplier 100 companies also are linked to data on dollar penalties for each company from Good Jobs

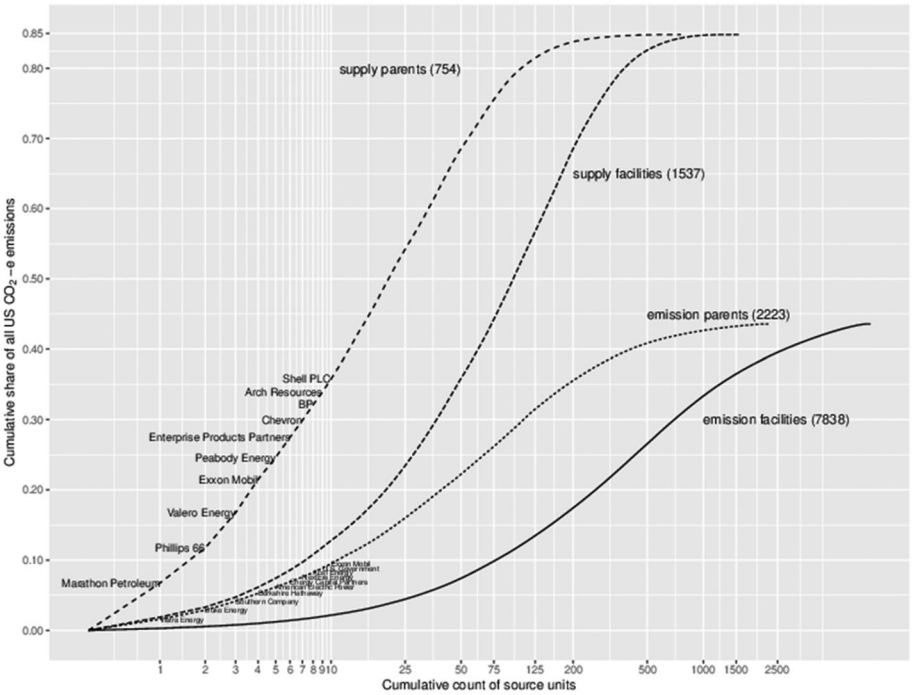

Figure 3. Concentration of GHG emissions for supplier and emitter facilities and parents. Source: Authors' calculations from the CTIP Greenhouse 100 Suppliers database.

First's Violation Tracker and to data on local, state, and federal subsidies for each company from Good Jobs First's Subsidy Tracker.

Figure 3 plots concentration curves, showing the rank of each firm on the horizontal axis against the share of all US emissions accumulated from all the entities up to that rank on the vertical axis. Note that the horizontal axis is nonlinear to focus attention on the large share of the top-ranked entities. Reading the parents curve for suppliers, the top four final parent companies, Marathon Petroleum, Phillips 66, Valero Energy, and ExxonMobil, together account for the supply of fossil fuels that yield around 22 percent of all US GHG emissions. The top 25 final parent companies account for 55 percent of all US GHG emissions. The top 200 companies account for almost 85 percent of all US GHG emissions, and essentially all of the GHG emissions are sourced from GHG suppliers. (The remainder of US GHG emissions are from other pathways such as agriculture that are not associated with supply companies.)

The curve for supplier facilities reports the equivalent relationship between rank and the share of all US emissions for individual facilities rather than for final-parent companies. The supply parents curve strictly dominates the supply facility curve because the ownership of fossil-fuel supplying facilities is concentrated in a relatively smaller number of companies.

The curve for emission parents again reports the relationship between rank and the share of all US emissions accumulated from all final parents up to that rank. The top three emitting companies, Vistra Energy, Duke Energy, and Southern Company are all electrical generation companies; together they accounted for slightly <5 percent of all US GHG emissions. Responsibility for direct emissions is less concentrated than responsibility for fossil-fuel supply. The top 10 emitting companies account for around 10 percent of all US GHG emissions, and the top 25 accounts for slightly <25 percent; these cumulative shares are less than half the cumulative shares for the equivalently ranked supplier companies.

For emitting facilities, the concentration at the top of the distribution is substantially lower than for emitting parent companies, again reflecting the concentration of ownership. Direct emissions from large facilities, such as electrical generation units and industrial activity, account in total for slightly <45 percent of all US GHG emissions, with the remainder coming from transportation, residential and commercial activity, agriculture, and other non-point source activity. The 500 largest emitting companies emit slightly over 40 percent of all US GHG emissions, and the next 1000, i.e., from the 500th to the 1500th position, account for <5 percent of emissions. The concentration of activity among the almost 8000 facilities that report to the GHGRP is substantially more concentrated, however, than the emissions of the more than 100 million households with emissions from individual transportation and residential heating.

The profiles of the top GHG emitters and suppliers are quite different. The top of the GHG emitters list is dominated by electrical energy producers. In contrast, the top of the GHG suppliers list is dominated by petroleum firms. Some of these companies are also natural gas (methane) extractors, such as Enterprise Products Partners (at number 6). The top ten also includes two coal mining companies, Peabody Energy (at number 5) and Arch Resources at (number 9). The companies topping this list thus represent a broad swath of fuel provision activities.

In summary, a high degree of disproportionality is evident in both emissions and supply of GHGs, but the supply side is exceptionally concentrated. The concentration bears on selecting effective sites for regulation in reducing GHG emissions.

Concluding remarks

Equity challenges of the energy transition have been documented widely, especially the challenges in coal-dependent communities. Pollin and Callaci (2019) articulate a just-transition framework for the coal industry, noting the relatively low number of coal-industry employees in relation to the national economy but

their high concentration in particular areas. Pollin (2023) articulates principles for just transition across the fossil-fuel sector. It also critically reviews the policies that are in place but inadequate in Germany and the UK, that are under development in Canada and the European Union, and that need substantial attention in Japan and the United States, and it provides a detailed accounting of what a just-transition program would require in West Virginia, a coal-intensive region in the US. Cha (2020) describes some of these issues in the Powder Basin of Wyoming and the challenge of undertaking the transition in the absence of an effective regional planning apparatus. Wishart and Pierce (2023) elaborate on the full chain of harms and inequalities in coal-based energy activity from extraction through processing and consumption. Data on corporate suppliers of GHG in the CTIP Greenhouse 100 database provide an additional window into the distributional challenges associated with the clean energy transition.

The open-source availability of the CTIP databases, with their interface of corporate and facility-level information on toxic releases, GHG emissions and supplies, environmental justice performance (Ash and Boyce 2011), and linkages to data on subsidies and penalties, provide powerful tools for further analysis by researchers and advocates concerned with pollution, climate change, and corporate responsibility.

One of the underlying strengths of the project is the availability of the mandated right-to-know reporting from the US EPA GHGRP. The United States pioneered facility-level and chemical-level pollutant release and transfer registers (PRTRs) with the initiation of the US EPA Toxics Release Inventory in 1987, which then provided a model for public databases such as the European PRTR, the Japanese PRTR, the Canadian NPRI, the Mexican RETC, and others.[7] Some of these national pollutant release and transfer registers have included greenhouse gas emissions among the tracked releases which, in turn, provided a model for the US EPA GHGRP emitters database (as greenhouse gases are not among the pollutants included in the US EPA TRI). The US EPA GHGRP supplier database, which mandates facility reports of the amount of CO_2-equivalent that would be released if the products produced, imported, or exported were released, combusted, or oxidized, is an early instance of uniform, required, right-to-know reporting that can provide a model for tracking GHG supply within countries and globally.

Despite their pioneering importance, The US EPA GHGRP supplier data are not without deficiencies. As we outlined in the case of the coal-mining exclusion from the US EPA's GHGRP, the data collection effort by public agencies often contains important exemptions. As another example, natural gas, coal, and petroleum extraction activities are exempt from reporting to the US EPA Toxics Release Inventory, as are electrical generation facilities that burn exclusively natural gas. Data intermediation such as that undertaken by PERI's CTIP can play an important role in consolidating publicly

available information and enabling cross-linkages so that this information can be brought to bear on scholarship and informed public participation in environmental decision-making.

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Notes

1. These analyses cite Kopp et al. (1999) and Hargrave (1998), which predate the Greenhouse Gas Reporting Program.
2. See http://greenhouse100.org/ and http://toxic100.org/.
3. See https://climateaccountability.org/carbon-majors/ and https://globalenergymonitor.org/.
4. https://peri.umass.edu/u-s-coal-producers-and-greenhouse-gas-emissions-2020
5. Kilograms of CO_2 per short ton of coal:
   Coal (all types): 1827.04
   Anthracite: 2592.33
   Bituminous: 2236.08
   Subbituminous: 1699.78
   Lignite: 1275.08
   Coke: 3254.16
   Source: U.S. Energy Information Administration https://www.eia.gov/environment/emissions/co2_vol_mass.php, last revised February 9, 2022.
6. https://grconnect.com/greensup100/ry2020/
7. See https://www.oecd.org/env/ehs/pollutant-release-transfer-register/ and https://www.oecd.org/env_prtr_data/ for consolidated and partially harmonized access to individual national PRTR.

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