Benchmarking Air Emissions

Of the 100 Largest Electric Power Producers in the United States

November 2023

Data Downloads at: www.erm.com

Contributors:

BANK OF AMERICA

Ceres
Sustainability is the bottom line.

Constellation.

NRDC

Preface

The 2023 Benchmarking report is the 19th collaborative effort highlighting environmental performance and progress in the U.S. electric power sector. The Benchmarking series began in 1997 and uses publicly reported data to compare the emissions performance of the 100 largest power producers in the United States. Due to data availability, company-specific data and all associated company metrics are based on 2021 generation and emissions data (final 2022 data used for company-specific analyses were not available at time of publication). However, because national and sector-wide data are generally available through 2022, aggregate sector-wide trends are presented through 2022 (unless otherwise noted).

Data on U.S. power plant generation and air emissions are available to the public through several databases maintained by state and federal agencies. Publicly- and privately-owned electric generating companies are required to report fuel and generation data to the U.S. Energy Information Administration (EIA). Most power producers are also required to report air pollutant emissions data to the U.S. Environmental Protection Agency (EPA). These data are reported and recorded at the boiler, generator, or plant level, and must be combined and presented so that company-level comparisons can be made across the industry.

The Benchmarking report facilitates the comparison of emissions performance by combining generation and fuel consumption data compiled by EIA with emissions data on sulfur dioxide (SO_2), nitrogen oxides (NOx), carbon dioxide (CO_2), and mercury (Hg) compiled by EPA; error checking the data; and presenting emissions information for the nation's 100 largest power producers in a graphic format that aids in understanding and evaluating the data. The report is intended for a wide audience, including electric industry executives, environmental advocates, financial analysts, investors, journalists, power plant managers, and public policymakers.

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Select plant- and company-level data used in this report are available at www.erm.com.

Interactive Analytical Resources

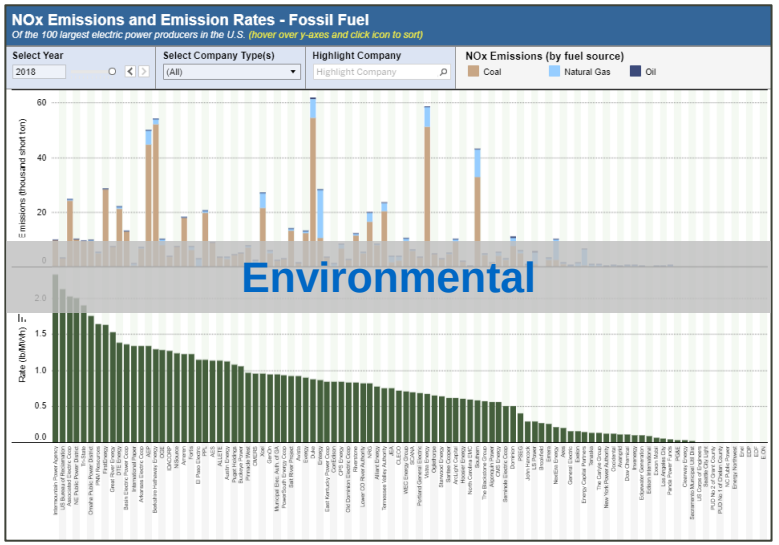
The Benchmarking Report includes a series of interactive, web-based dashboards to further visualize the emissions and electricity generation from power producers in the United States. These tools provide insight into how facility- and company-level emissions and generation are changing over time by utilizing historical Benchmarking data (2008-2021). Data include:

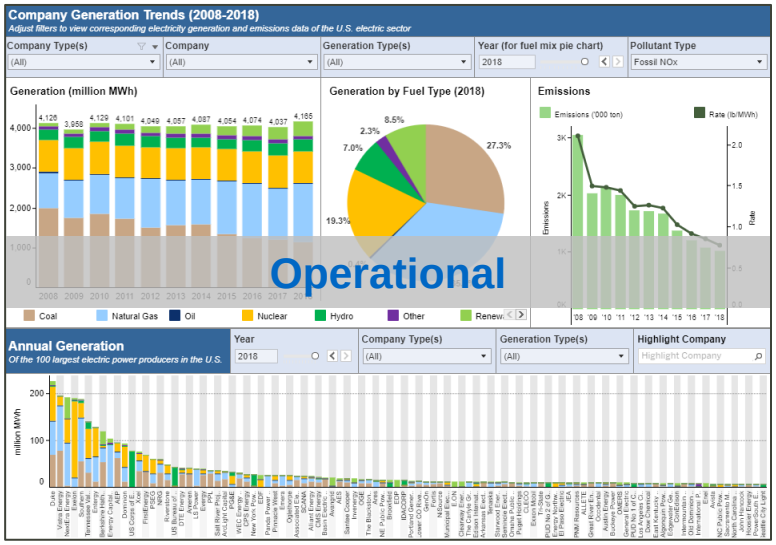
Environmental: Company-specific emissions and emission rates by company type and pollutant

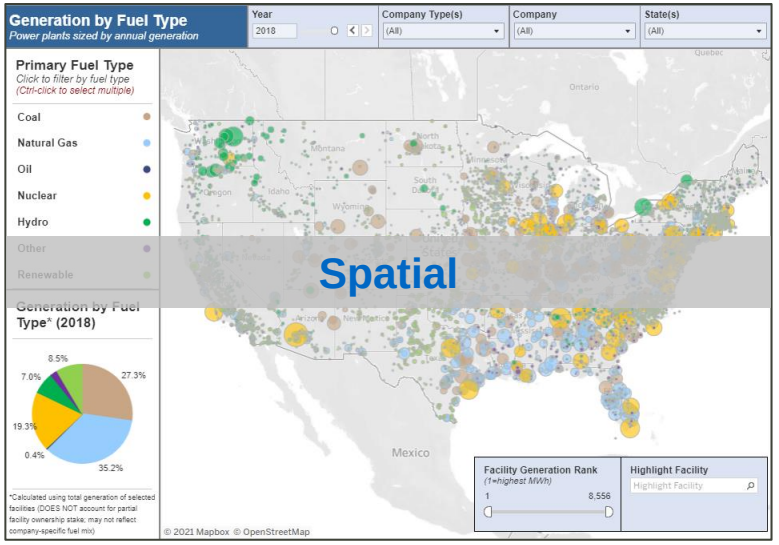
Operational: Electricity generation and relevant data aggregated by company type, company, and other metrics

Spatial: Facility-level emissions and generation visualized by fuel type, company ownership, and other metrics

These tools are available at www.erm.com.







Key Findings

- The 100 largest power producers in the United States own over 3,800 power plants and account for around 80 percent of the sector's electric generation and reported air emissions. Their fuel mix, emissions, and emission rates vary widely as summarized throughout this report (based on 2021 data).
- For the electric sector overall, in 2022, power plant SO_2 and NOx emissions were 94% and 87% lower, respectively, than in 1990 when Congress passed major amendments to the Clean Air Act. In 2022, power plant SO_2 and NOx emissions were 8% and 3% lower, respectively, than they were in 2021.
- Although power sector CO_2 emissions in 2022 were 16% lower than 1990 levels and about 34% lower than their peak in 2007, power sector CO_2 emissions decreased by less than 1% between 2021 and 2022, largely due to a significant increase in natural gas generation.
- Mercury air emissions from power plants (as reported to the TRI database) have decreased 93% since 2000. The first-ever federal limits on mercury and other hazardous air pollutants from coal-fired power plants went into effect in 2015.

BENCHMARKING AIR EMISSIONS

OF THE
100 LARGEST ELECTRIC POWER PRODUCERS
IN THE UNITED STATES

Download plant level data from the 2023 Benchmarking Air Emissions report at:
www.erm.com

Electricity in the United States

The electricity sector in the United States includes a wide array of companies that produce and distribute electricity to homes and offices, industrial facilities, and other customers. The services it provides are essential to the growth and functioning of the U.S. economy. Electricity is expected to serve a growing share of energy consumption in the U.S. with the electrification of transportation and other end-uses.

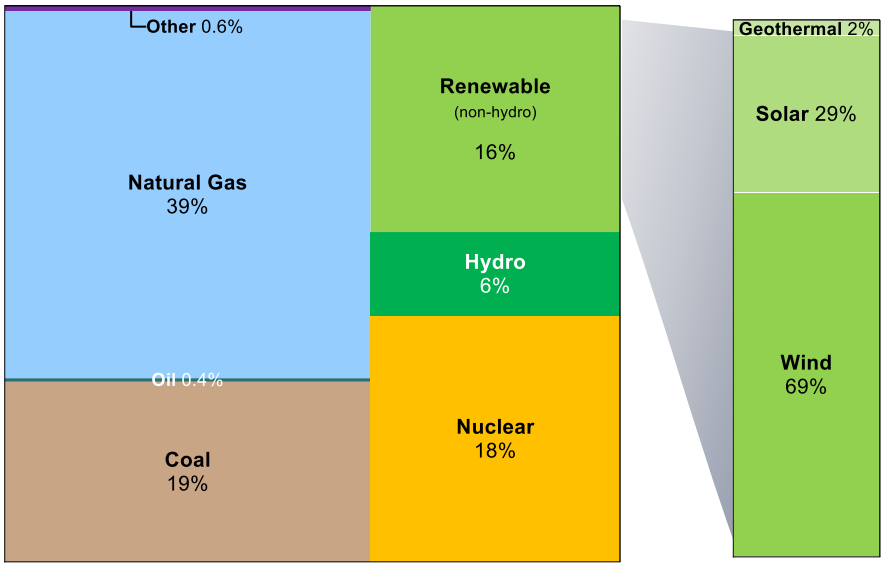
Section I

U.S. Electric Sector Highlights

U.S. Generation by Fuel Type

- In 2022, the U.S. electric system shifted toward pre-COVID trends associated with zero-emitting generation growth and coal decline. However, natural gas was responsible for more generation in 2022 than any preceding year and fossil sources were responsible for nearly 60% of electricity generation.
- After increasing significantly between 2020 and 2021, coal generation declined by 8% from 2021 but was still 7% higher than coal generation in 2020. Natural gas generation rebounded in 2022, increasing by 7% and 4% from 2021 and 2020, respectively.
- Despite the changes between 2021 and 2022, the current generation mix still represents a significant shift from a decade ago. In 2012, coal accounted for 37% of power production, while natural gas generated only 30%.
- Nuclear plants accounted for 18% of total U.S. generation, hydroelectric resources 6%, and oil-fired resources <1%. Non-hydroelectric renewables (wind, solar, and geothermal) accounted for 16% of total U.S. generation (increasing from 15% in 2021).

U.S. Electricity Generation by Fuel Type (2022)



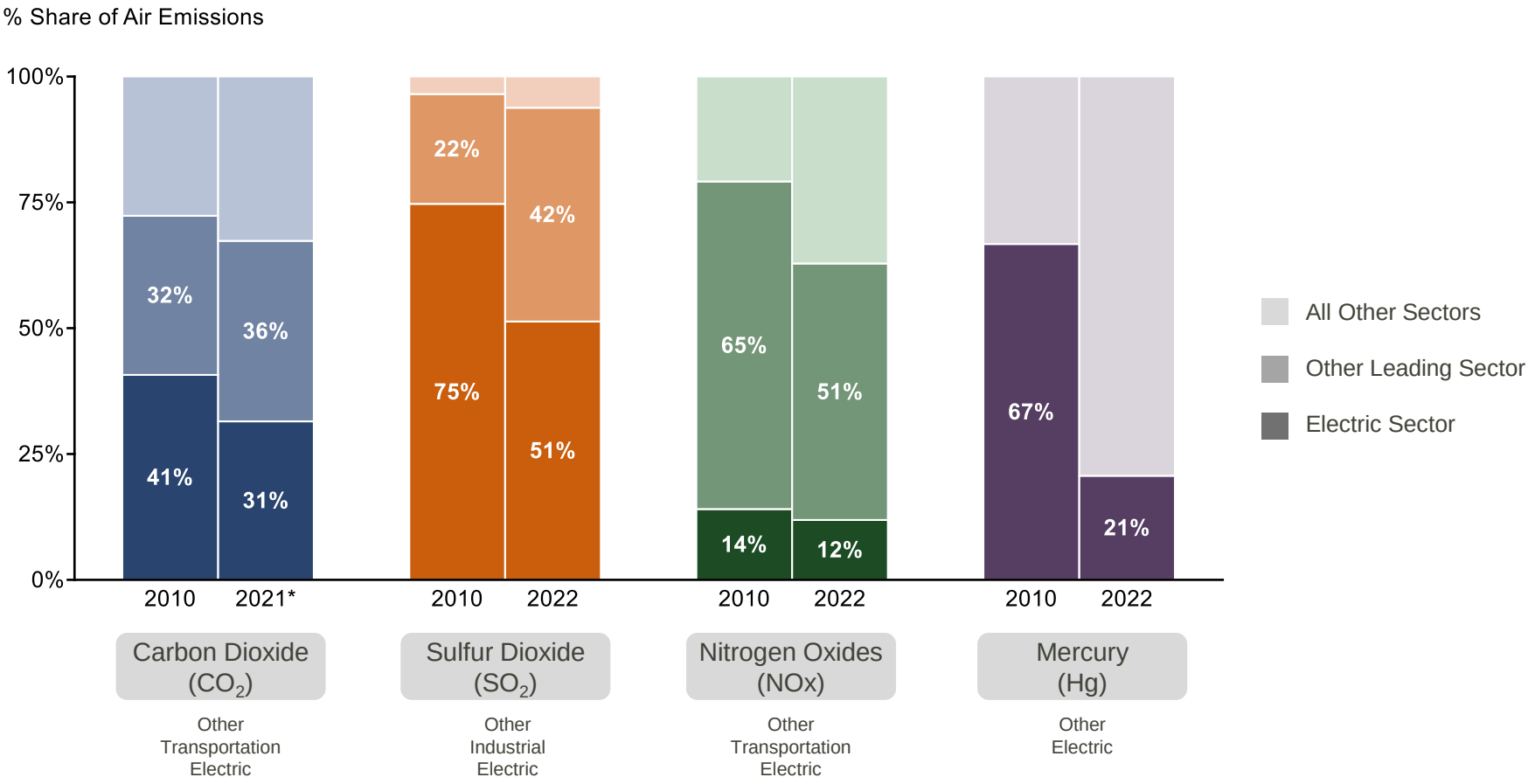
Zero-Carbon Generation in the United States

In 2022, renewables and other zero-carbon resources generated approximately 41% of U.S. electricity, making the combined category the leading source of power generation in the United States. Of the zero-carbon resources, nuclear made up 44%, renewables 41% (wind, solar, geothermal), and hydro 15%.

Note: See “Data Sources” (page 41) for more information.

Share of Emissions by Sector

Share of Emissions: U.S. Electric Sector and Other Sectors



* Most recent sector-wide data
Note: See “Data Sources” (page 41) for more information.

Section II

Emissions of the 100 Largest Electric Power Producers

The 100 Largest Electric Power Producers

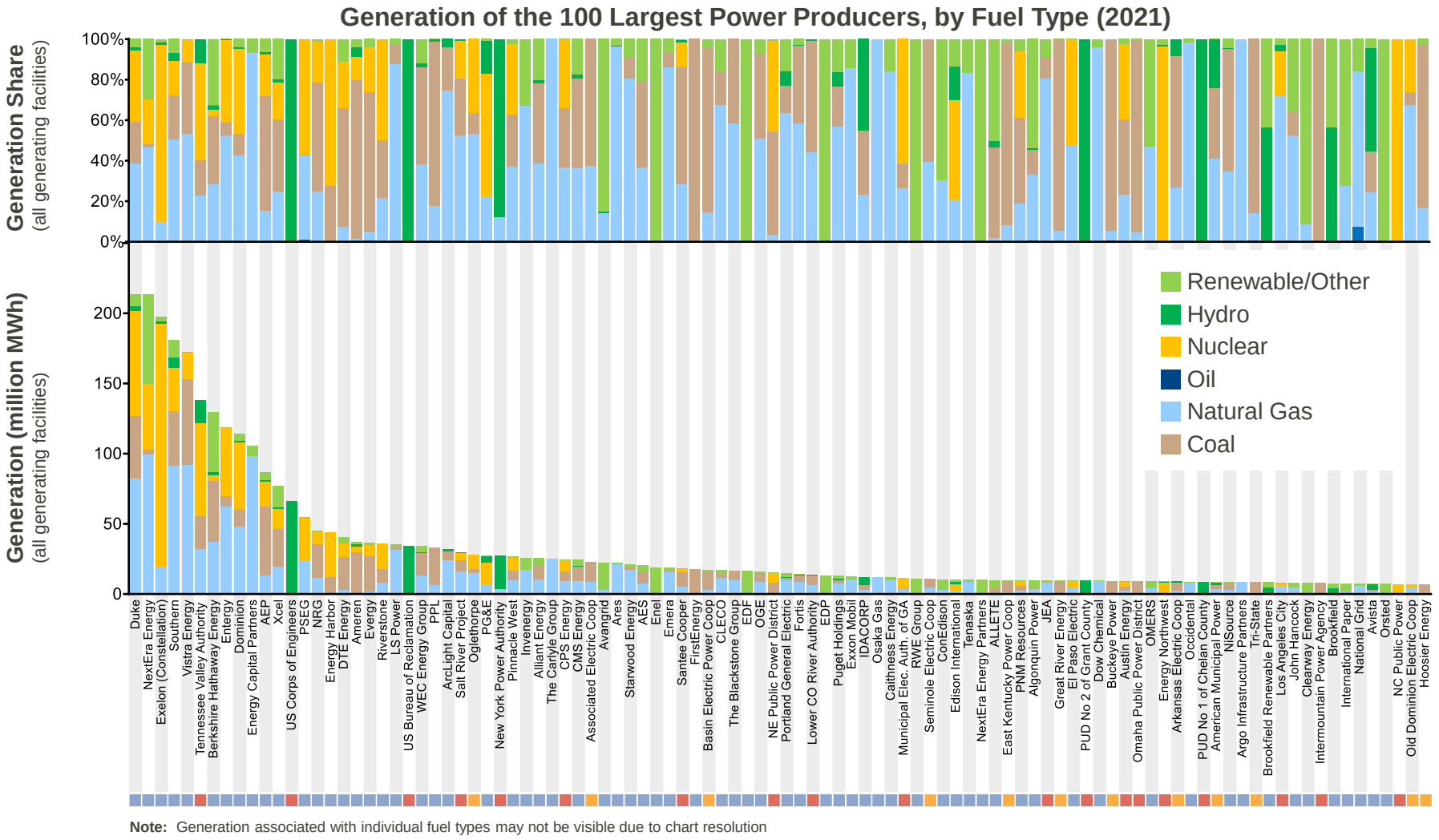
The report examines and compares the stack air pollutant emissions of the 100 largest power producers in the United States based on their 2021 generation, plant ownership, and emissions data. The table below lists the 100 largest power producers featured in this report ranked by their total electricity generation from fossil fuel, nuclear, and renewable energy facilities. These producers include public and private entities (collectively referred to as "companies" or "producers" in this report) that own nearly 3,800 power plants and account for around 80% of both reported electric generation and CO_2 emissions.

The report focuses on four power plant pollutants for which public emissions data are available: sulfur dioxide (SO_2), nitrogen oxides (NOx), mercury (Hg), and carbon dioxide (CO_2). At sufficient concentrations, these pollutants are associated with significant environmental and/or public health problems, including acid deposition, mercury deposition, nitrogen deposition, global warming, ground-level ozone, regional haze, and/or fine particle air pollution, which can lead to asthma and other respiratory illnesses. The report benchmarks, or ranks, each company's absolute emissions and its emission rate (determined by dividing emissions by electricity produced) for each pollutant. In 2021, the 100 largest power producers emitted, in aggregate, approximately 0.77 million short tons of SO_2, 0.64 million short tons of NOx, 2.66 short tons of mercury, and 1.40 billion short tons of CO_2.

Rank	Producer Name	TWh	Rank	Producer Name	TWh	Rank	Producer Name	TWh	Rank	Producer Name	TWh
1	Duke	213.4	26	Salt River Project	29.6	51	Portland General Electric	14.7	76	Buckeye Power	9.1
2	NextEra Energy	213.3	27	Oglethorpe	27.9	52	Fortis	14.0	77	Austin Energy	9.0
3	Exelon (Constellation)	197.7	28	PG&E	27.3	53	Lower CO River Authority	13.6	78	Omaha Public Power District	9.0
4	Southern	180.8	29	New York Power Authority	27.2	54	EDP	13.1	79	OMERS	9.0
5	Vistra Energy	172.7	30	Pinnacle West	26.4	55	Puget Holdings	12.8	80	Energy Northwest	8.8
6	Tennessee Valley Authority	138.1	31	Invenergy	25.9	56	Exxon Mobil	12.3	81	Arkansas Electric Coop	8.8
7	Berkshire Hathaway Energy	129.6	32	Alliant Energy	25.5	57	IDACORP	12.1	82	Occidental	8.5
8	Entergy	118.5	33	The Carlyle Group	25.0	58	Osaka Gas	11.6	83	PUD No 1 of Chelan County	8.5
9	Dominion	113.7	34	CPS Energy	24.6	59	Caithness Energy	11.5	84	American Municipal Power	8.5
10	Energy Capital Partners	105.6	35	CMS Energy	24.4	60	Municipal Elec. Auth. of GA	11.4	85	NiSource	8.5
11	AEP	86.6	36	Associated Electric Coop	22.7	61	RWE Group	10.8	86	Argo Infrastructure Partners	8.4
12	Xcel	76.8	37	Avangrid	22.3	62	Seminole Electric Coop	10.7	87	Tri-State	8.3
13	US Corps of Engineers	66.1	38	Ares	22.2	63	ConEdison	10.4	88	Brookfield Renewable Partners	8.2
14	PSEG	54.9	39	Starwood Energy	20.8	64	Edison International	10.3	89	Los Angeles City	8.1
15	NRG	45.3	40	AES	20.4	65	Tenaska	10.1	90	John Hancock	7.9
16	Energy Harbor	44.1	41	Enel	18.8	66	NextEra Energy Partners	9.9	91	Clearway Energy	7.8
17	DTE Energy	40.3	42	Emera	18.6	67	ALLETE	9.9	92	Intermountain Power Agency	7.6
18	Ameren	37.2	43	Santee Cooper	17.9	68	East Kentucky Power Coop	9.8	93	Brookfield	7.5
19	Evergy	36.7	44	FirstEnergy	17.5	69	PNM Resources	9.8	94	International Paper	7.5
20	Riverstone	36.1	45	Basin Electric Power Coop	17.2	70	Algonquin Power	9.7	95	National Grid	7.4
21	LS Power	35.6	46	CLECO	16.9	71	JEA	9.6	96	Avista	7.4
22	US Bureau of Reclamation	34.2	47	The Blackstone Group	16.6	72	Great River Energy	9.6	97	Orsted	7.2
23	WEC Energy Group	34.1	48	EDF	16.6	73	El Paso Electric	9.5	98	NC Public Power	7.0
24	PPL	33.1	49	OGE	16.3	74	PUD No 2 of Grant County	9.5	99	Old Dominion Electric Coop	6.8
25	ArcLight Capital	31.7	50	NE Public Power District	15.5	75	Dow Chemical	9.4	100	Hoosier Energy	6.5

*On February 2, 2022, Constellation Energy Corp, which includes the power generation and competitive energy division of Exelon, Constellation Generation, LLC, formally launched as a standalone, publicly traded company.

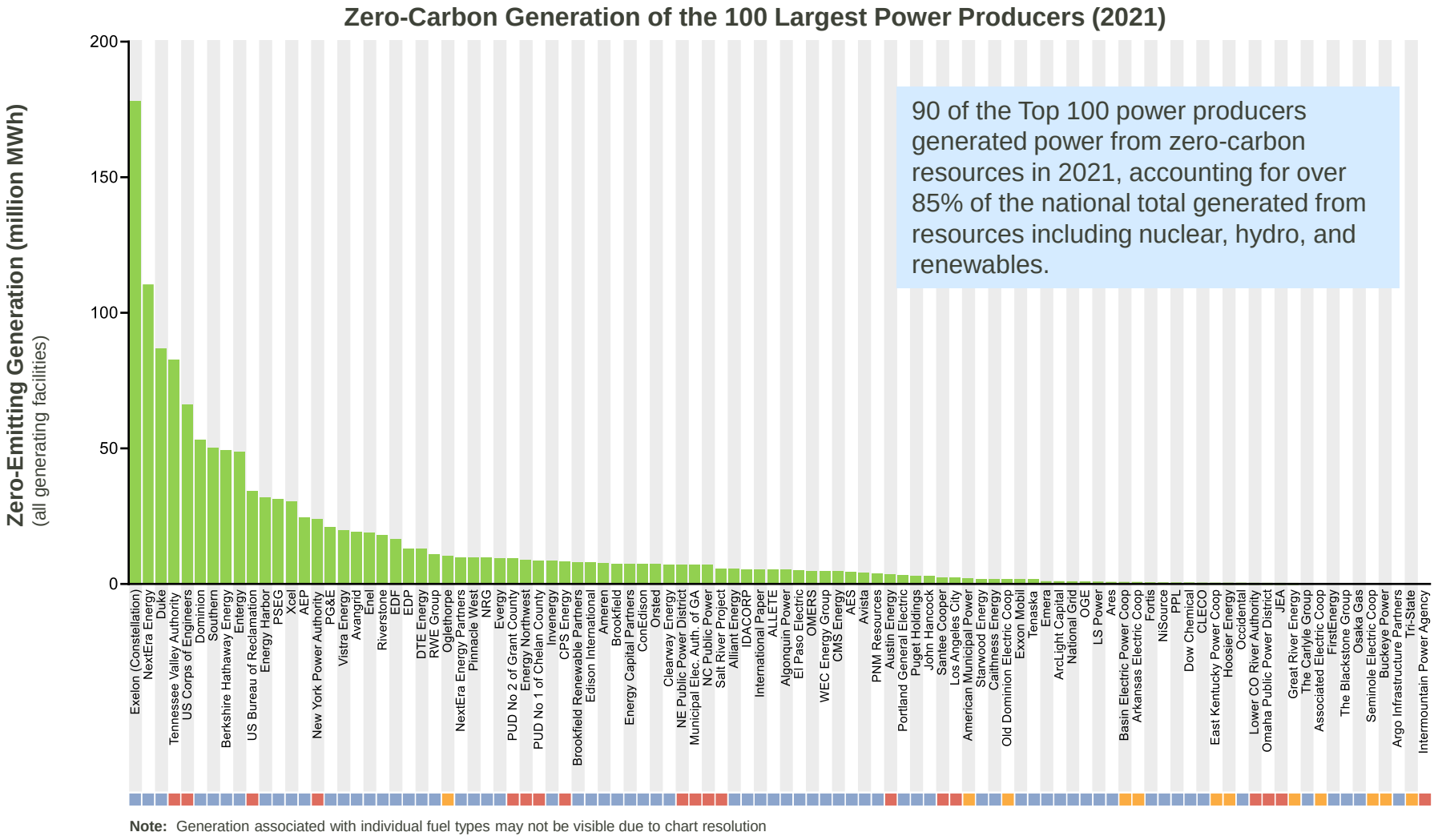
Rankings by Generation



Note: Generation associated with individual fuel types may not be visible due to chart resolution

Breakdown of ownership categories provided in “Methodology” (page 42): privately/investor owned | public power | cooperative

Rankings by Zero-Carbon Generation



Note: Generation associated with individual fuel types may not be visible due to chart resolution

Breakdown of ownership categories provided in “Methodology” (page 42): privately/investor owned | public power | cooperative

Emission Rankings

Important Note on Emission Rankings

The Benchmarking Report presents generation and emissions information of power producers, not distribution utilities that deliver electricity to customers. In order to apply a uniform methodology to all power producers, the Report assigns electricity generation and associated emissions to power producers according to their known generating asset ownership as of December 31, 2021. Assets retired or sold before this date are not allocated to power producers on a prorated basis. For example, a company which retires a generating unit before this date will not see its generation reflected in the rankings. Similarly, a company which purchases a generating unit from another will take on the unit's full output for the calendar year.

The above is true even when a producer's generating facilities are part of one or more contractual agreements (e.g., power purchase contracts, etc.) with other entities (often utilities). In other words, this Report attributes all generation and emissions to the owner of an asset, not to purchasers of the asset's output or to counterparties to the contracts. Publicly available data do not allow the accurate and exhaustive tracking of such agreements.

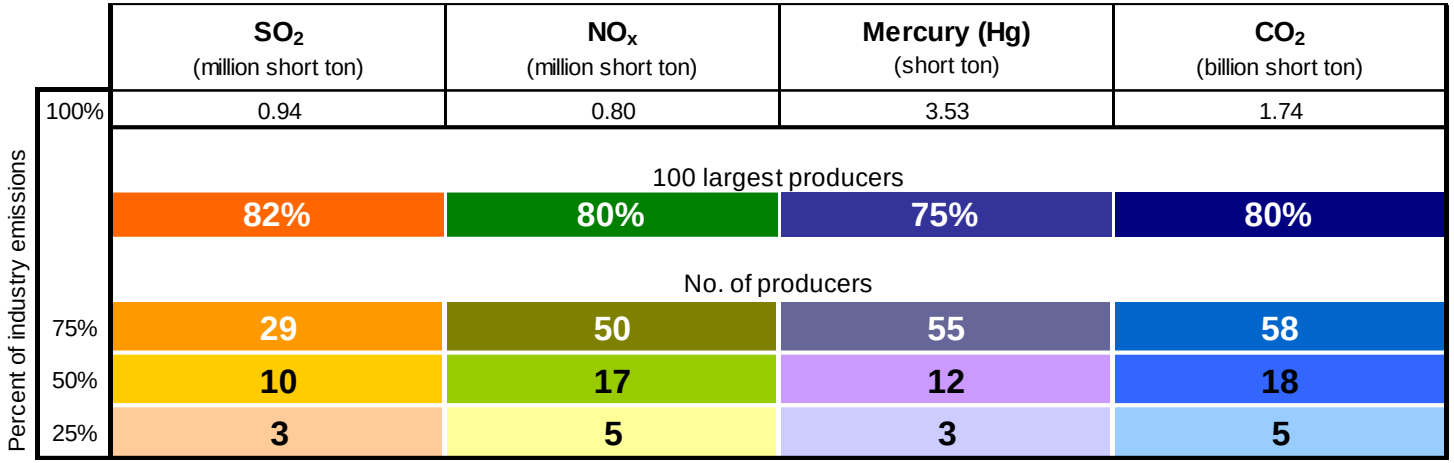
There are a host of reasons why a company's generation profile may differ from that of the electricity it delivers to customers. For example, rural cooperatives, which are non-profit entities and are thus generally unable to directly take advantage of renewable tax credits, tend to rely on power purchase agreements and other non-asset owning mechanisms to deliver renewable electricity to their customers.

A vertically integrated utility that owns a large fossil generating fleet, but also delivers purchased renewable electricity to its customers, might have lower average emission rates than the level attributed in this report to the power producer that owns the said fossil fleet, if the renewable energy purchases were factored into the utility's performance. By the same token, the utility's emissions or emission rate would increase if it contracted with a higher emitting facility or relied on market purchases with associated emissions.

The charts in the next few pages present both the total emissions by company as well as their average emission rates. The evaluation of emissions performance by both emission levels and emission rates provides a more complete picture of relative emissions performance than viewing these measures in isolation. Total emission levels are useful for understanding each producer's contribution to overall emissions loading, while emission rates are useful for assessing how electric power producers compare according to emissions per unit of energy produced when size is eliminated as a performance factor.

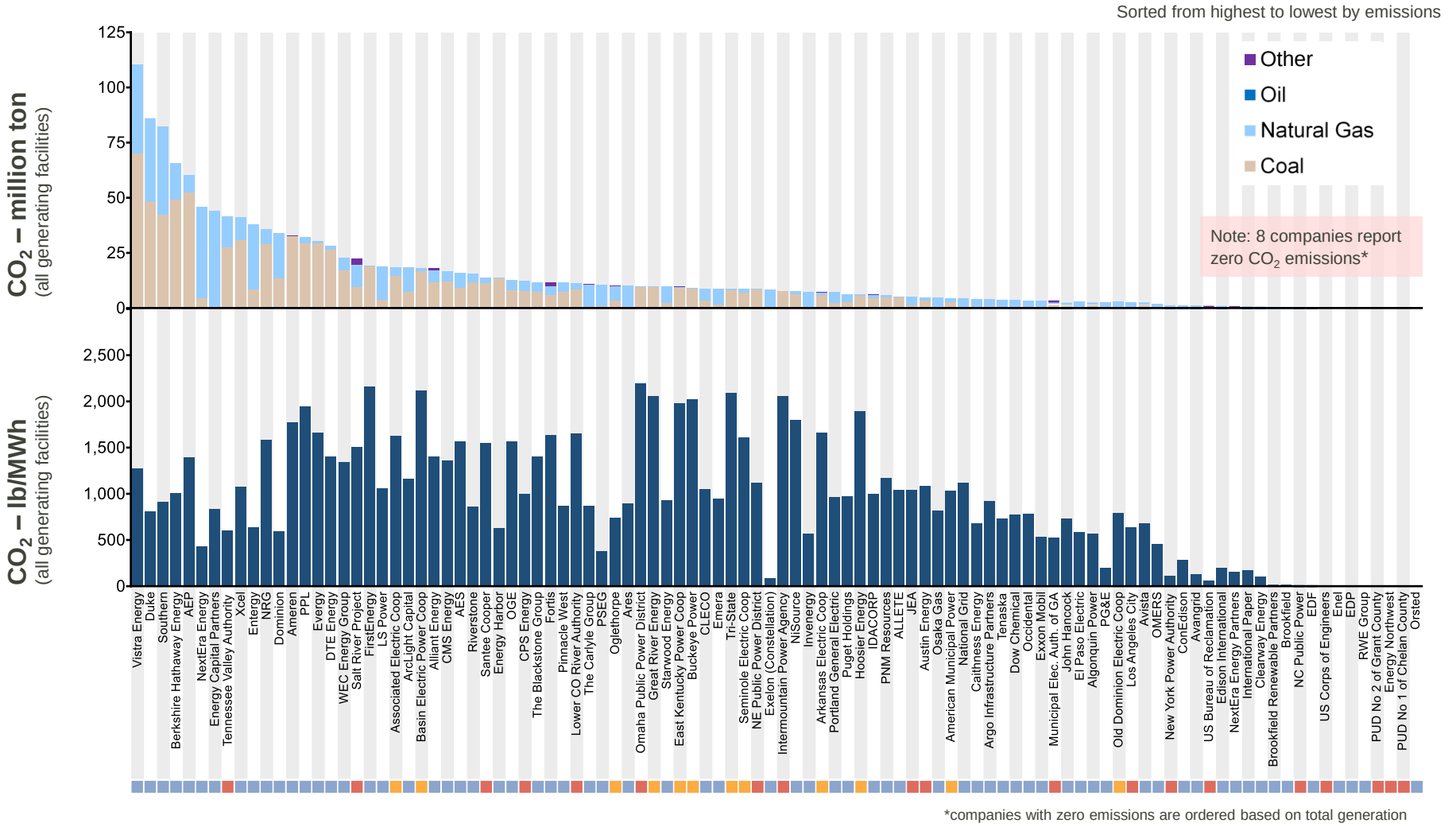
The charts illustrate significant differences in the total emission levels and emission rates of the 100 largest power producers. For example, CO_2 emissions range from zero to over 110 million short tons per year. The NOx emission rates range from zero to 2.8 pounds per megawatt-hour of generation. A power producer's total emissions are influenced by the amount of generation that the producer owns and by the fuels and technologies that it uses to generate electricity.

Emission Contributions



Air pollution emissions from power plants are highly concentrated among a small number of producers. For example, nearly a quarter of the electric power industry's SO_2 and CO_2 emissions are emitted by just three and five top 100 producers, respectively.

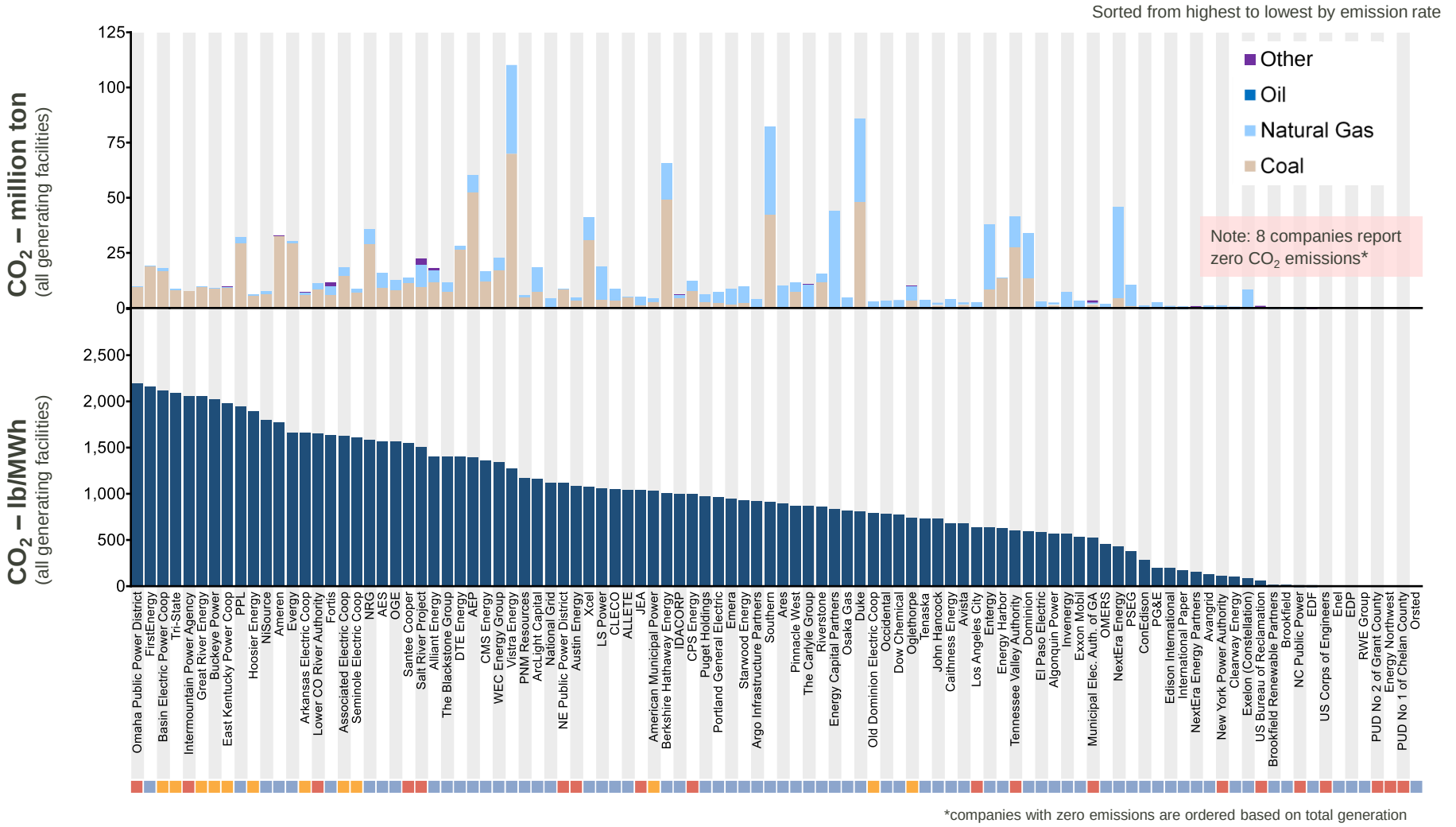
CO_2: Total Emissions and Emission Rates



*companies with zero emissions are ordered based on total generation

Breakdown of ownership categories provided in “Methodology” (page 42): privately/investor owned | public power | cooperative

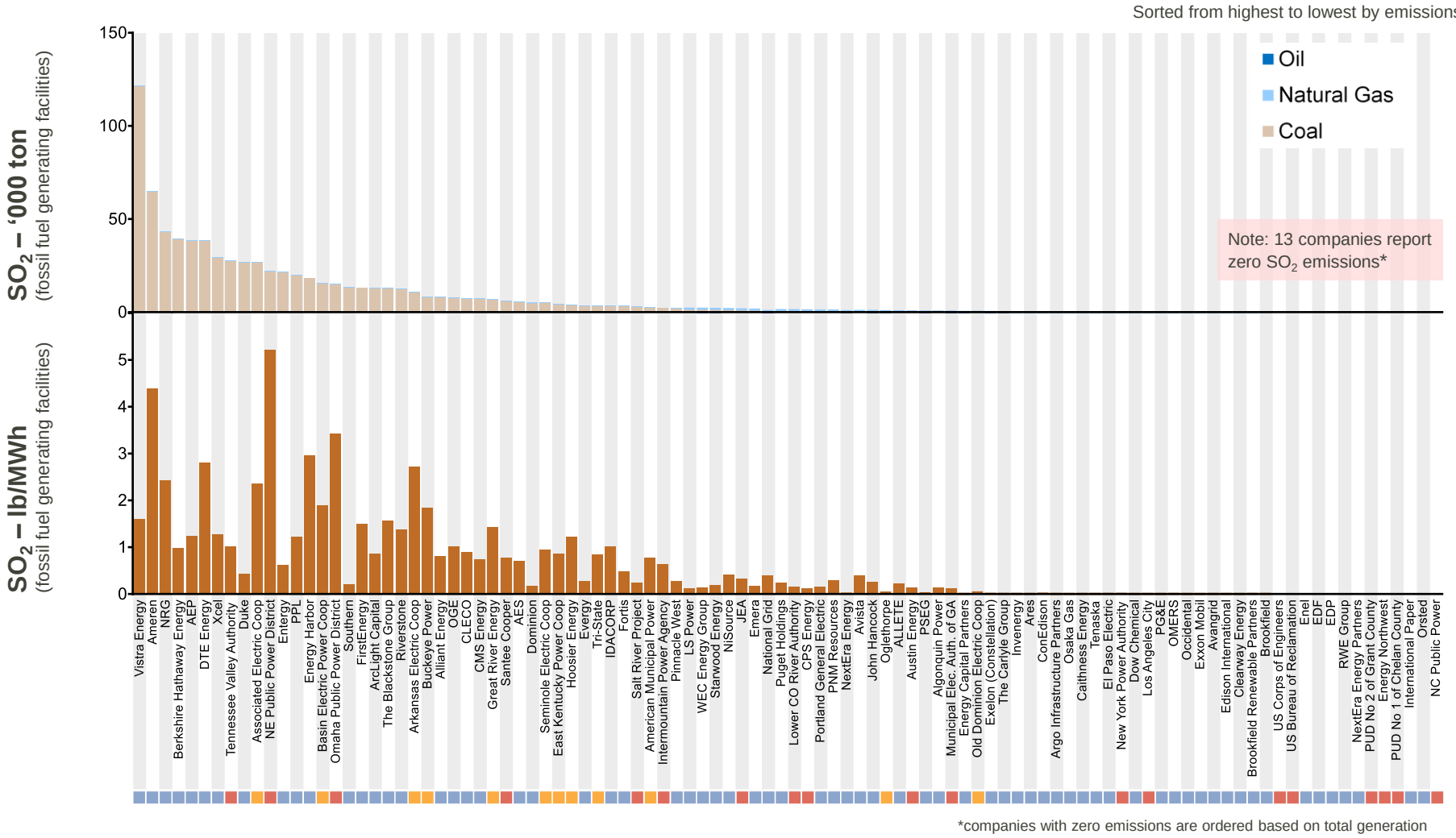
CO_2: Total Emissions and Emission Rates



*companies with zero emissions are ordered based on total generation

Breakdown of ownership categories provided in “Methodology” (page 42): privately/investor owned | public power | cooperative

SO_2: Total Emissions and Emission Rates



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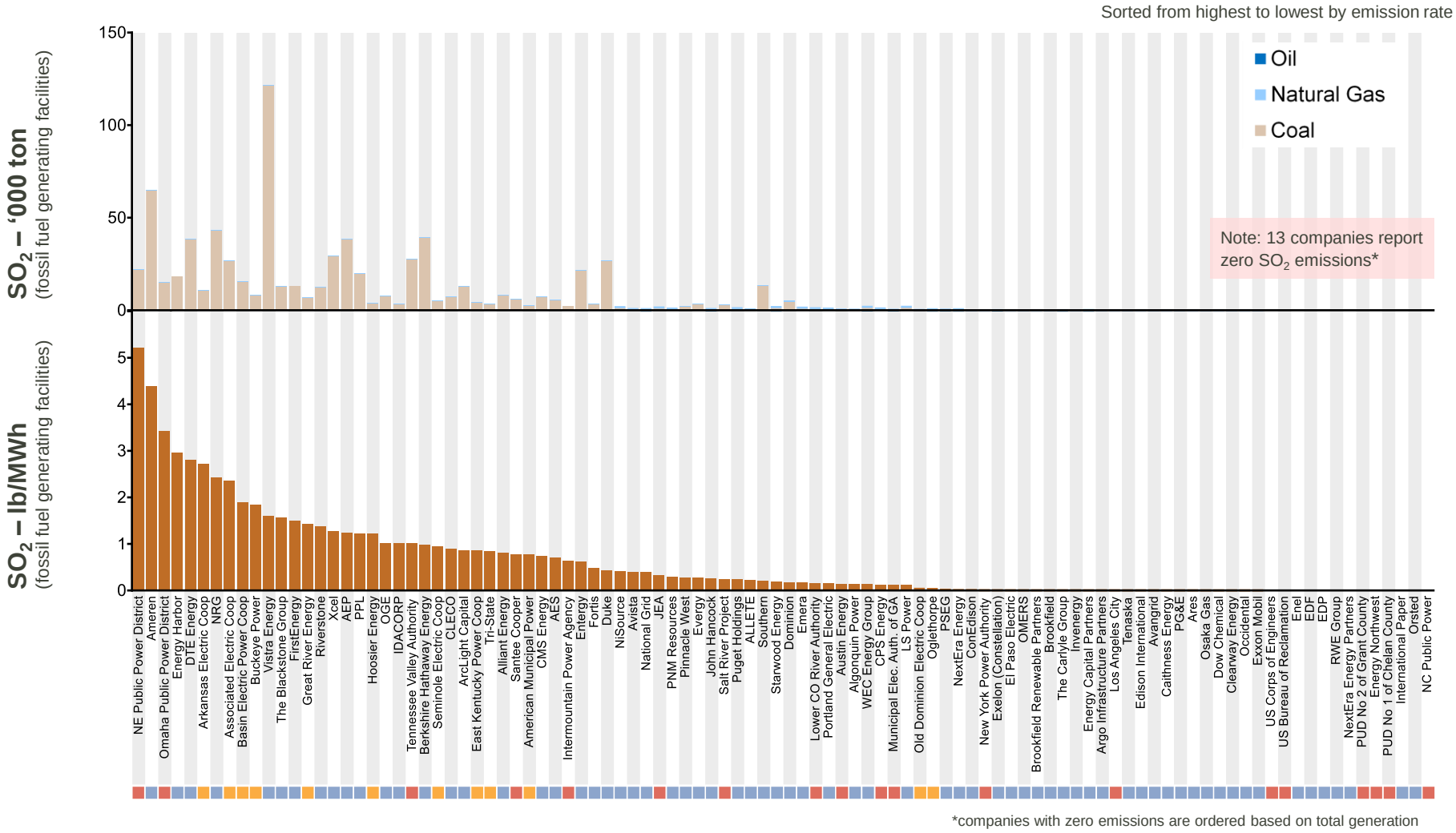
SO_2: Total Emissions and Emission Rates



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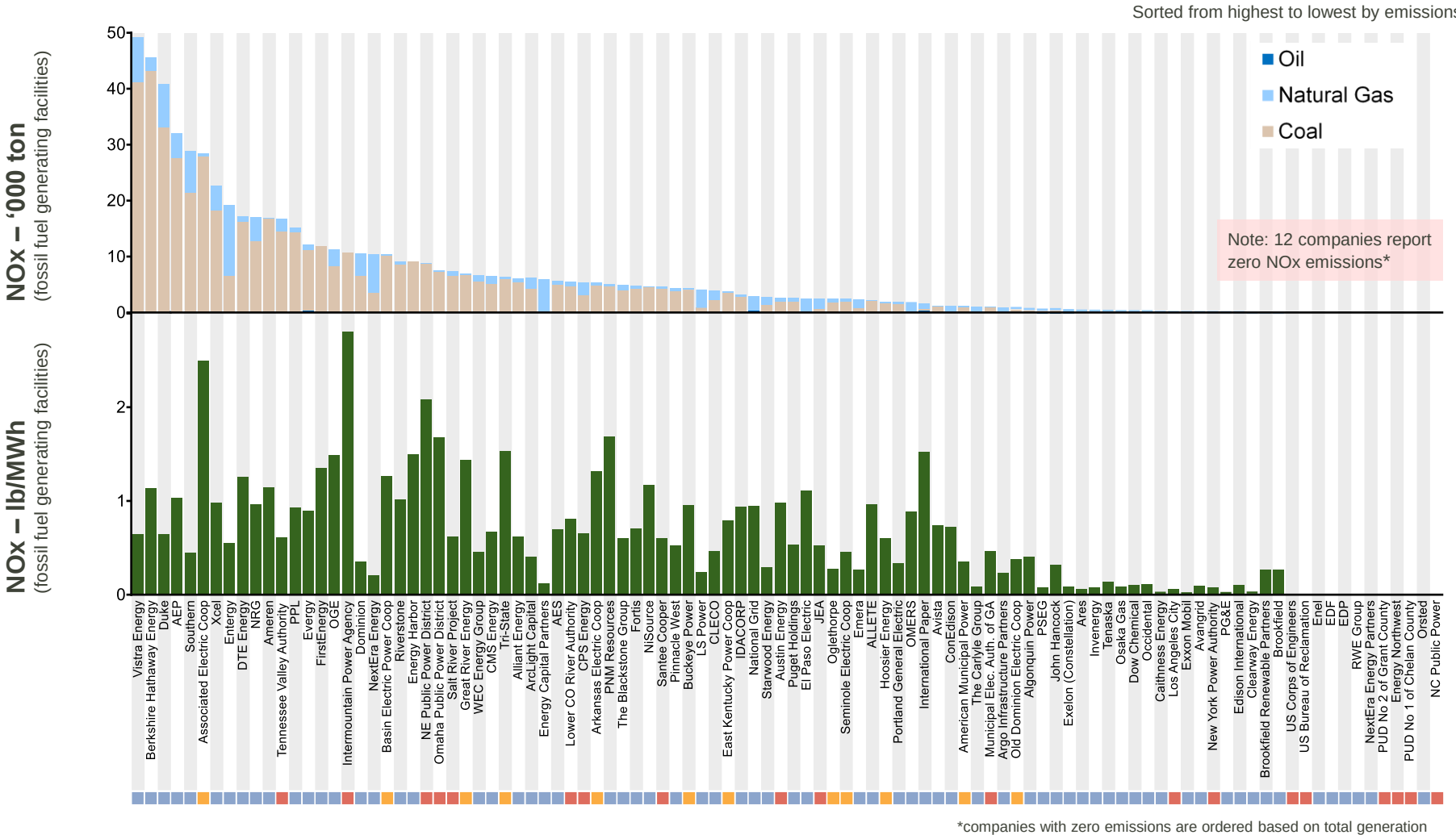
Breakdown of ownership categories provided in "Methodology" (page 42): privately/investor owned | public power | cooperative

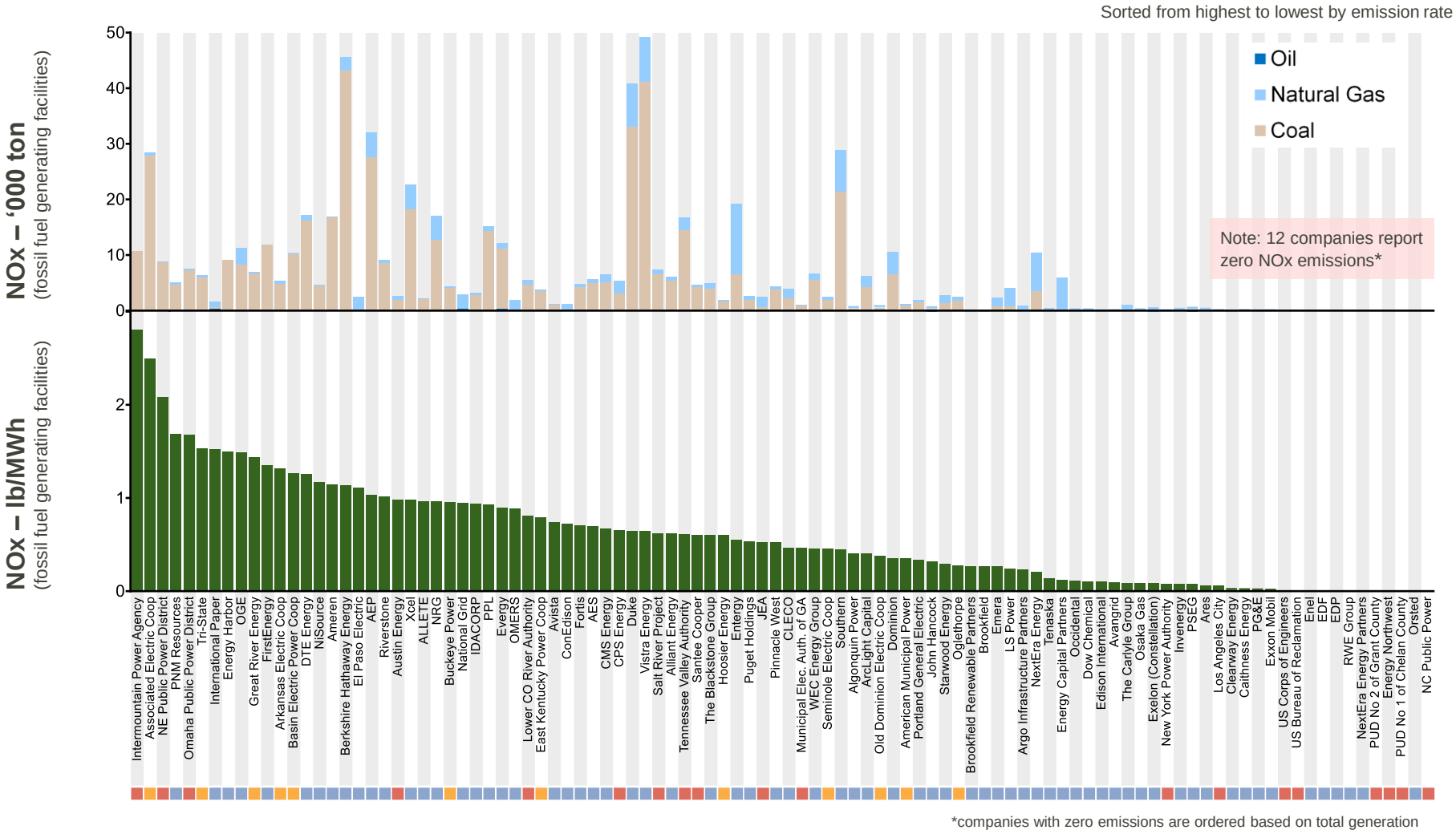
NOx: Total Emissions and Emission Rates



*companies with zero emissions are ordered based on total generation

Breakdown of ownership categories provided in "Methodology" (page 42): privately/investor owned | public power | cooperative

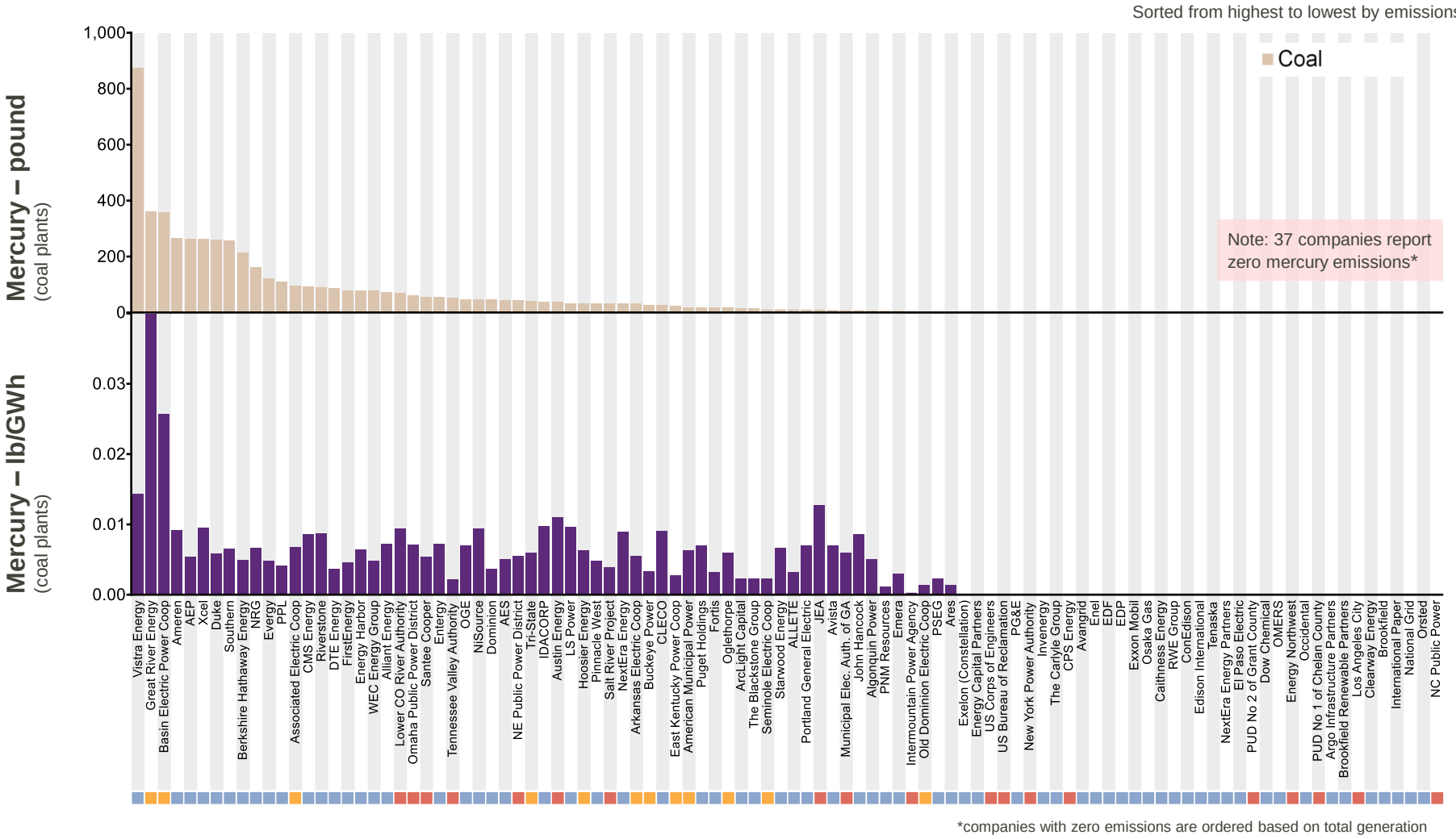
NOx: Total Emissions and Emission Rates



*companies with zero emissions are ordered based on total generation

Breakdown of ownership categories provided in "Methodology" (page 42): privately/investor owned | public power | cooperative

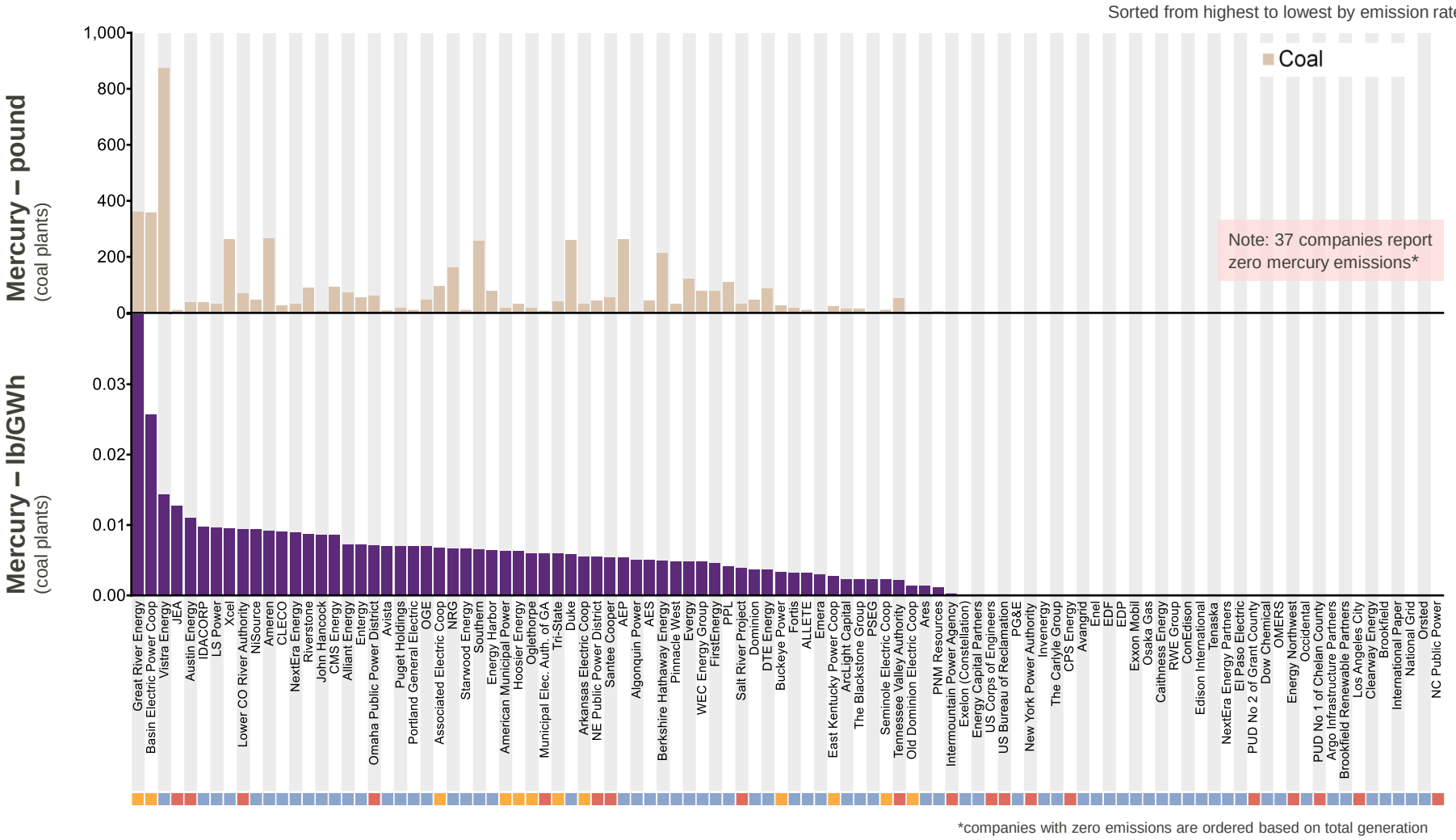
Mercury: Total Emissions and Emission Rates



*companies with zero emissions are ordered based on total generation

Breakdown of ownership categories provided in “Methodology” (page 42): privately/investor owned | public power | cooperative

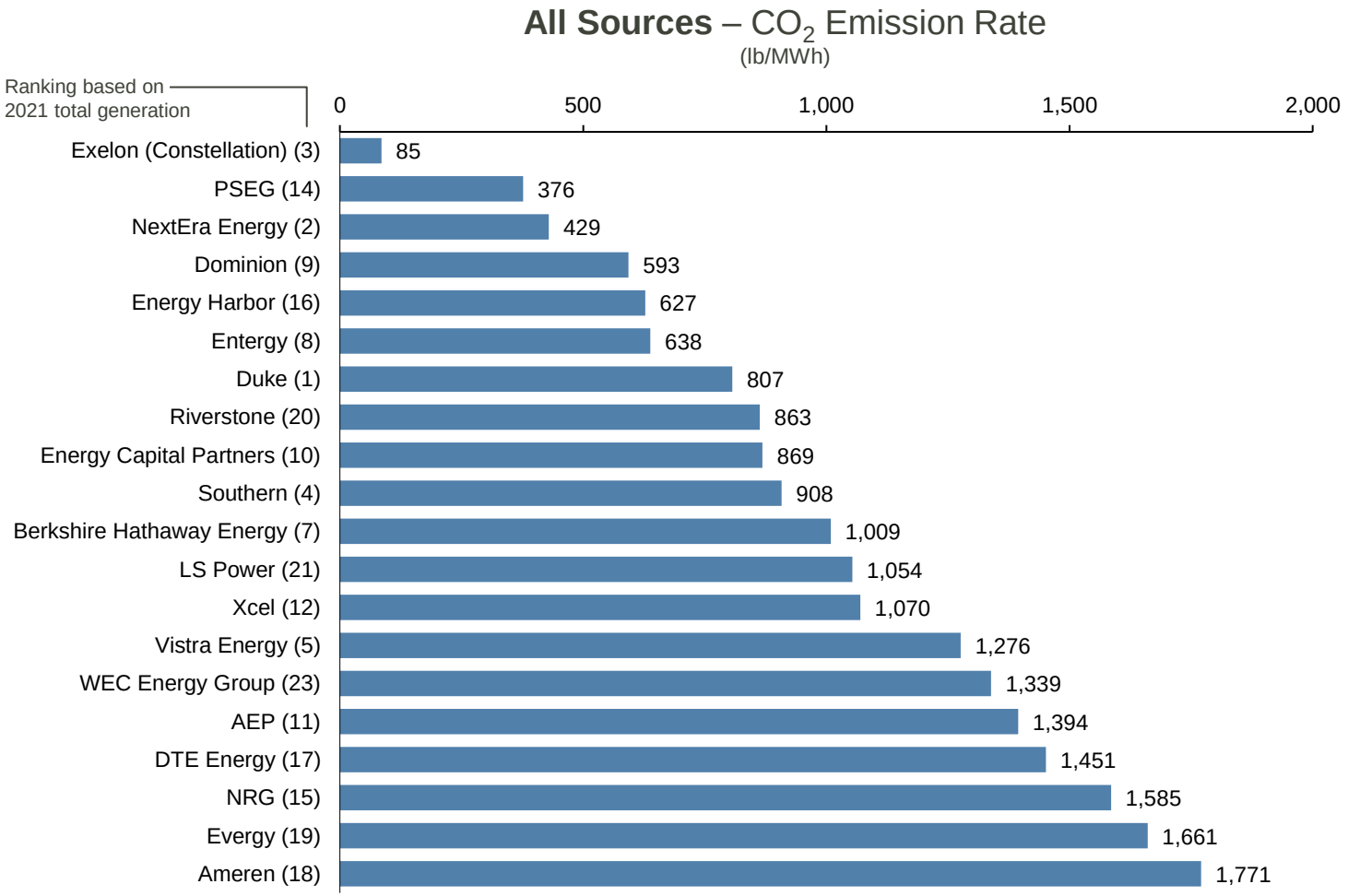
Mercury: Total Emissions and Emission Rates



*companies with zero emissions are ordered based on total generation

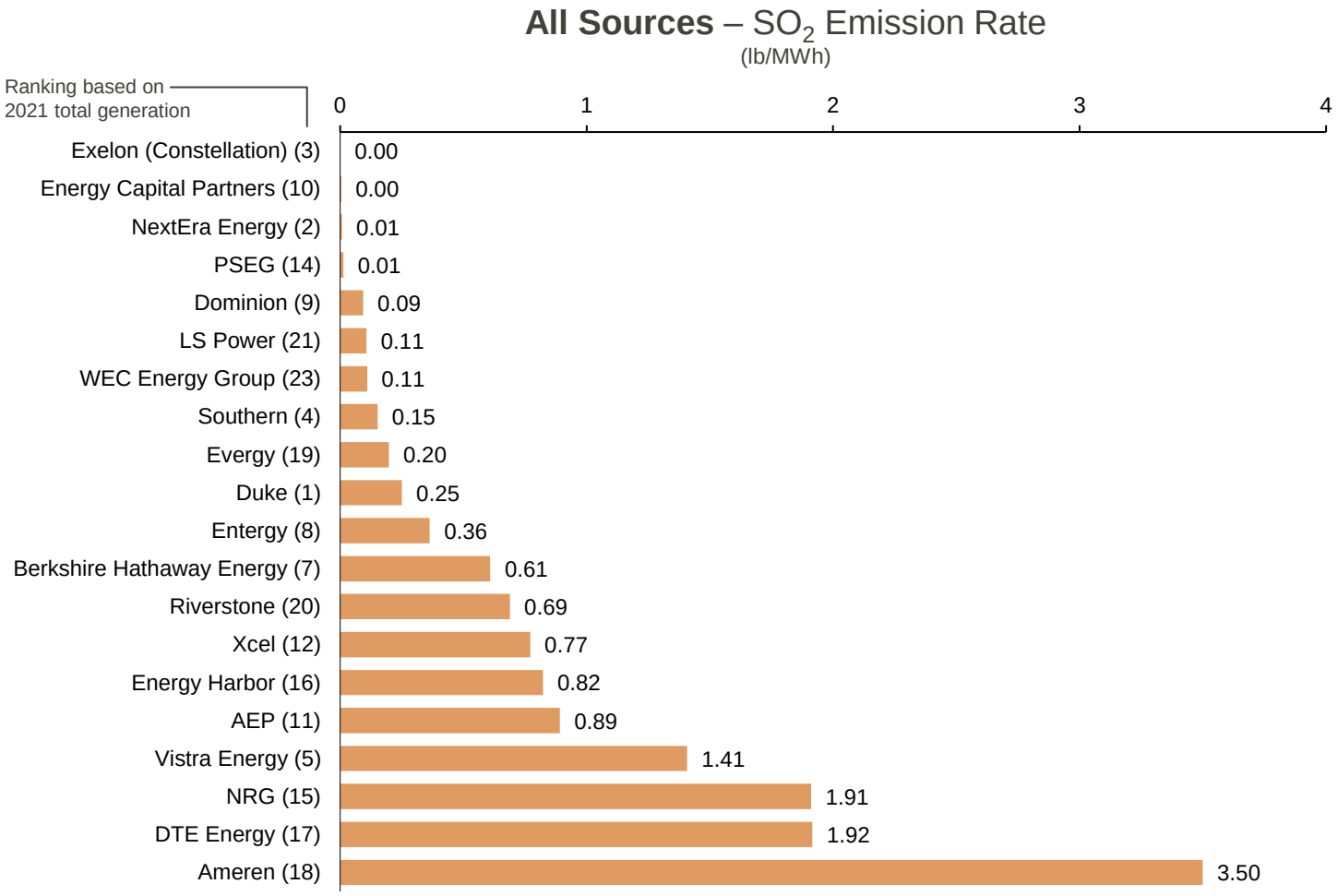
Breakdown of ownership categories provided in “Methodology” (page 42): privately/investor owned | public power | cooperative

Rankings by CO_2 Emission Rate
(Top 20 Privately-/Investor-Owned Power Producers)



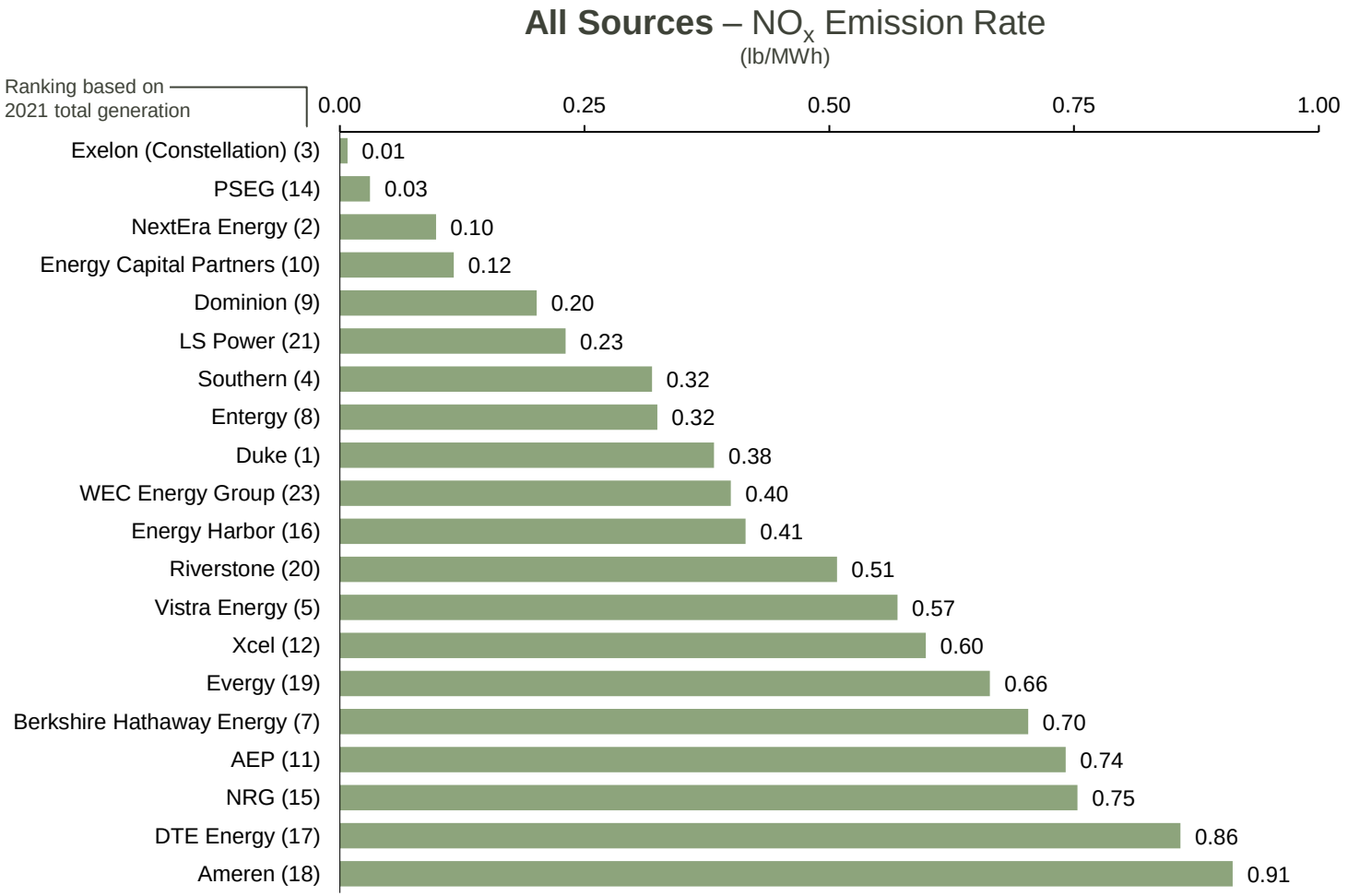
Note: "Privately/investor owned" power producers include investor owned, privately held, and foreign owned corporations. This chart does not show public power producers (federal power authorities, state power authorities, municipalities, power districts) or cooperatives.

Rankings by SO_2 Emission Rate
(Top 20 Privately-/Investor-Owned Power Producers)



Note: "Privately/investor owned" power producers include investor owned, privately held, and foreign owned corporations. This chart does not show public power producers (federal power authorities, state power authorities, municipalities, power districts) or cooperatives.

Rankings by NO_x Emission Rate
(Top 20 Privately-/Investor-Owned Power Producers)

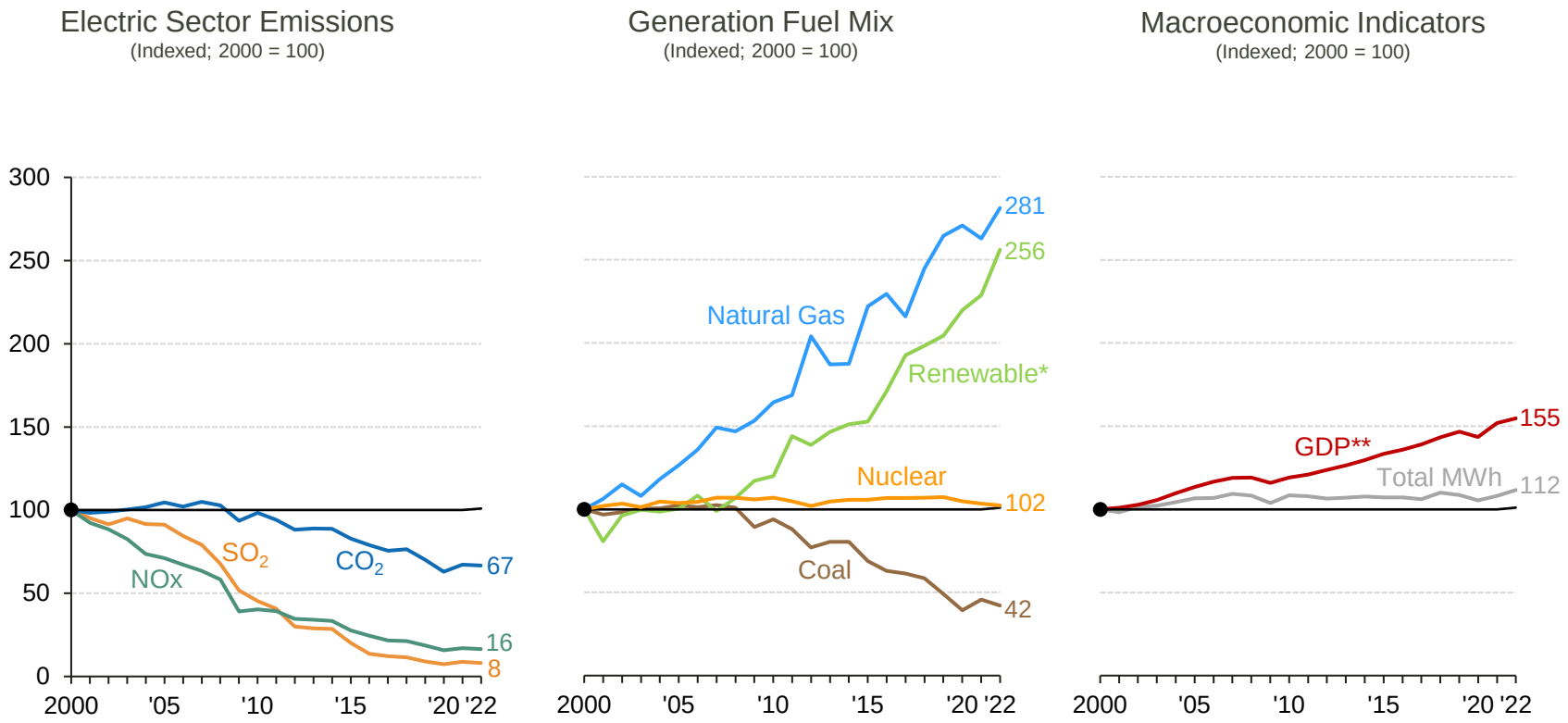


Note: "Privately/investor owned" power producers include investor owned, privately held, and foreign owned corporations. This chart does not show public power producers (federal power authorities, state power authorities, municipalities, power districts) or cooperatives.

Section III

Emissions Trends Analysis

Annual Trends: U.S. Electric Sector

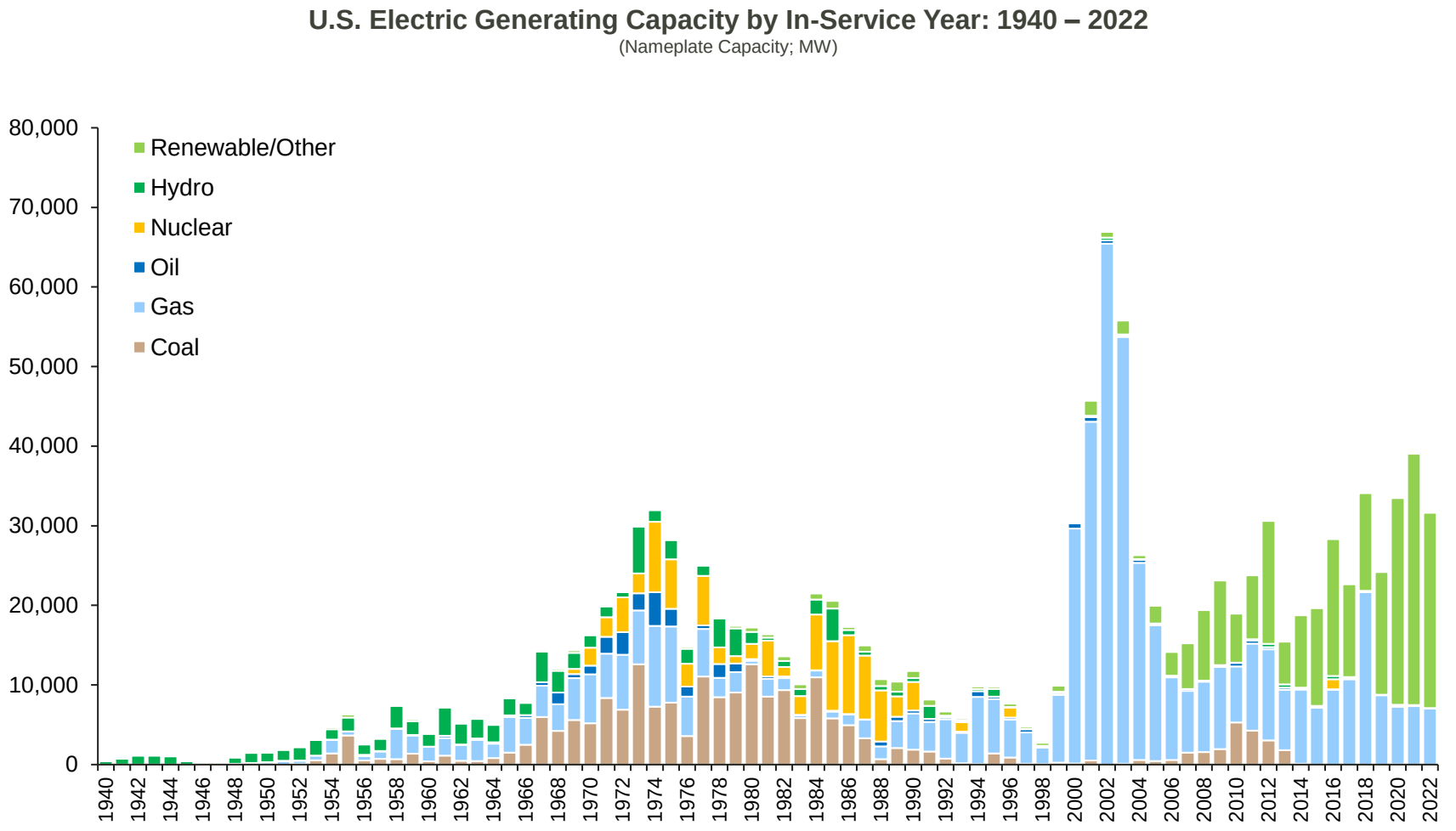


*Includes hydroelectric, wind, solar, biomass, geothermal, and other renewable sources.
**GDP in chained 2017 dollars.

The electric power sector has made significant progress in terms of reducing its NOx and SO_2 emissions. From 2000 through 2022, SO_2 and NOx emissions decreased 92% and 84%, respectively. From 2000 to 2022, CO_2 emissions decreased 33% while GDP grew 55%. Over the same period, generation from renewables increased by over 150%.

Note: See “Data Sources” (page 41) for more information.

Existing Capacity



Most existing coal and nuclear generating capacity came online in the 1970s and 1980s, while most natural gas capacity has been installed since 2000. Effectively all non-hydro renewable capacity came online in the last fifteen years.

Average Capacity Factors

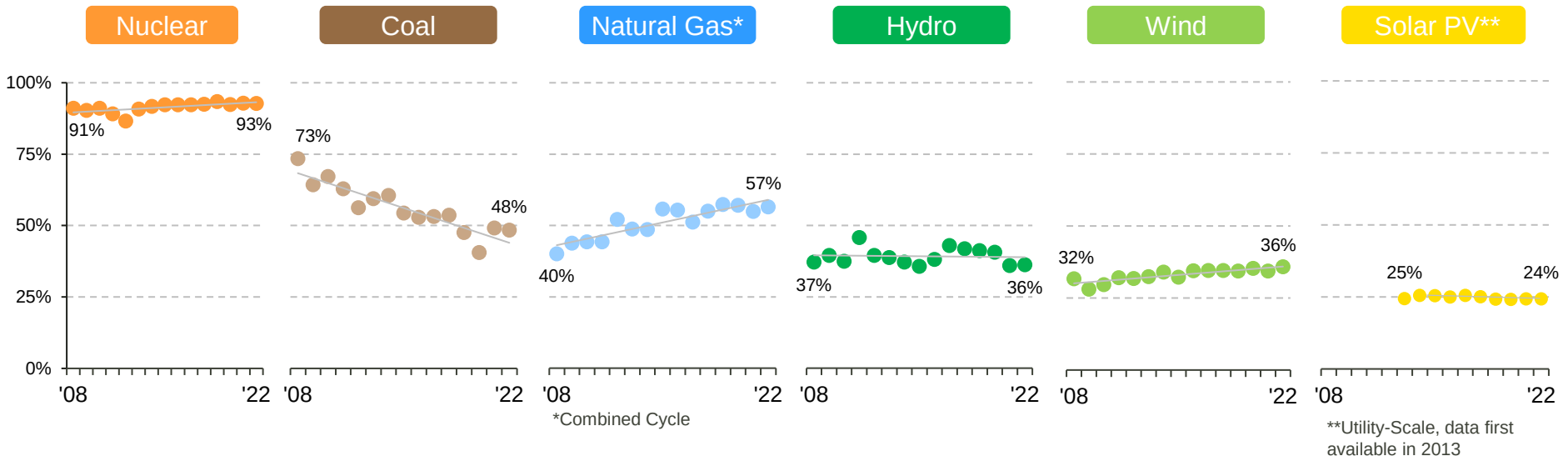
Annual Capacity Factors for Select Fuels and Technologies

Capacity factors measure the extent to which a power plant is utilized over the course of time. The technical definition is the ratio of the electrical energy produced by a generating unit to the electrical energy that could have been produced assuming continuous full power operation.

Coal plant utilization declined over the last decade, but capacity factors increased from a low of 41% in 2020 to 48% in 2022. Natural gas combined-cycle capacity factors rose from 40% to 56% from 2008-2015 and has largely plateaued through 2022.

Nuclear plants have high utilization rates, consistently running at above 90% average capacity factor. Hydropower capacity factors have remained relatively constant over the past decade.

Wind capacity factors have increased from 28% in 2009 to 35% in 2022, largely due to improvements in wind turbine technology. Since EIA began publishing data for utility-scale solar projects in 2014, annual capacity factors have remained steady at around 25%.



Note: See "Data Sources" (page 41) for more information.

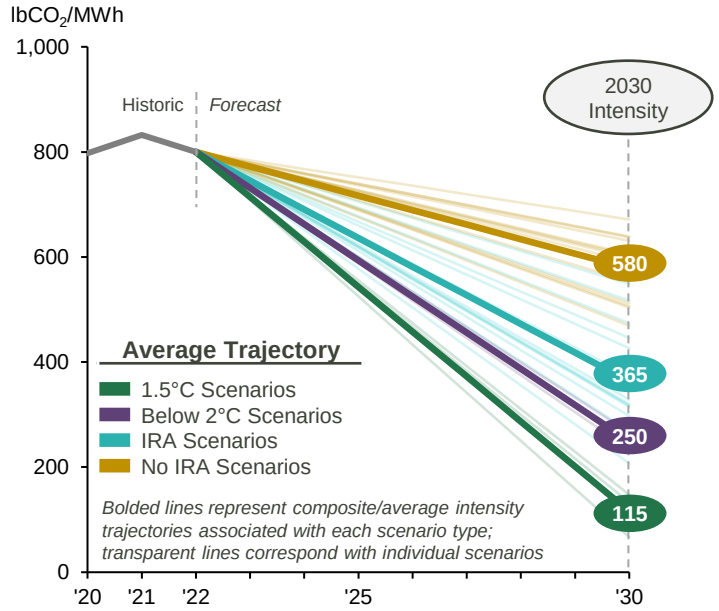
Power Sector in Low-Carbon Scenarios

Over the last few years, organizations have released detailed low-carbon scenario models that provide data on the emission and energy pathways different sectors could follow to limit global warming to specific levels. Scenarios are often categorized as those that limit warming to 1.5°C (aligned with net zero by 2050) or 2°C by 2100. Due to its significant contribution to total GHG emissions and potential opportunities for emission reductions, models show the power sector decarbonizing faster than other areas of the economy. The decline in emissions intensity in the U.S. is faster than in many other regions of the world, reflecting model assumptions that advanced economies have the technical and financial resources necessary to support rapid transition to lower-carbon resources.

1.5°C and 2°C scenarios show rapid decarbonization of the U.S. power sector, with CO_2 intensity declining by an average of around 90% and 70%, respectively, between 2020 and 2030. This decline is driven by substantial growth in renewable generation, a decline in fossil generation, and modest deployment of carbon capture on a growing percentage of remaining fossil assets. Under all scenarios, total generation grows through 2030 as demand from other sectors (e.g., transportation) increases, leveraging decarbonization of the electric grid to reduce emissions from other sectors of the economy. The recently passed Inflation Reduction Act (IRA) will help drive deployment of low- and zero-carbon generation that will facilitate U.S. progress toward future intensities derived from low-carbon scenarios, but additional decarbonization may be required to fully align with 1.5°C and below 2°C scenarios.

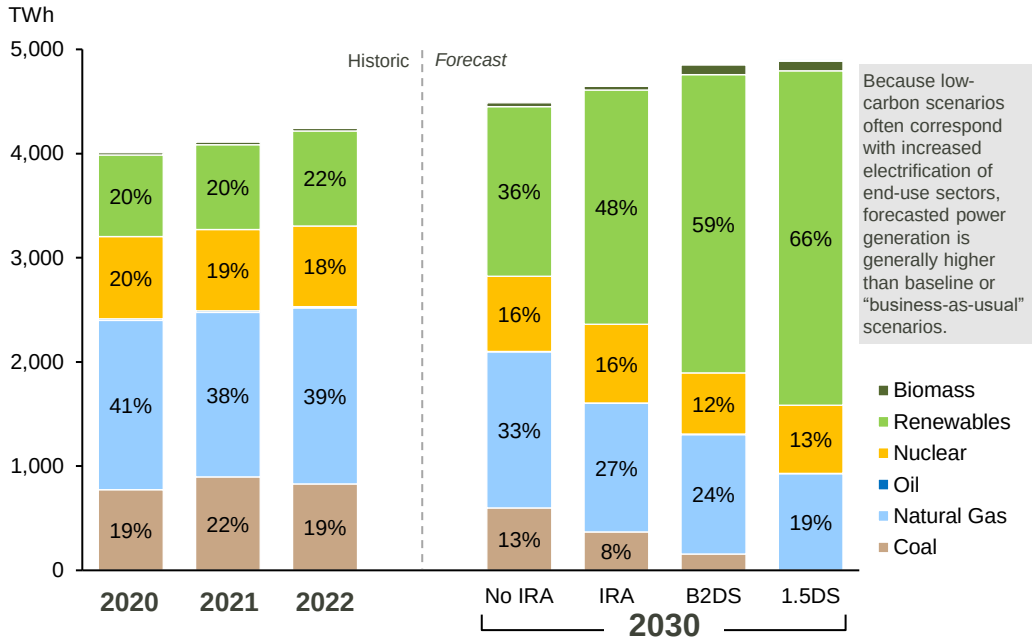
Electricity CO_2 Intensity: United States

pound CO_2 per megawatt-hour ($lbCO_2/MWh$)



Electricity Generation: United States

terawatt-hour (TWh)



Note: See "Data Sources" (page 41) for more information.

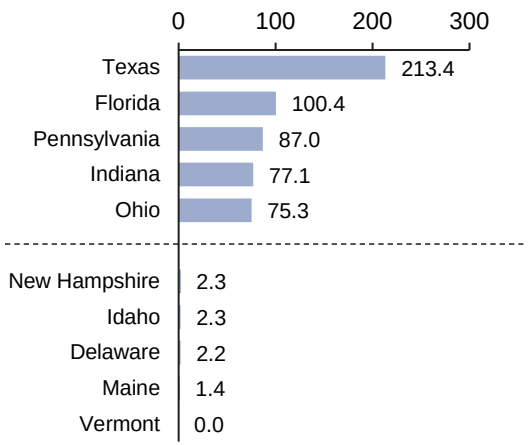
Section IV

State-by-State Emissions Summary

State-by-State CO_2 Emissions: U.S. Electric Sector, 2021*

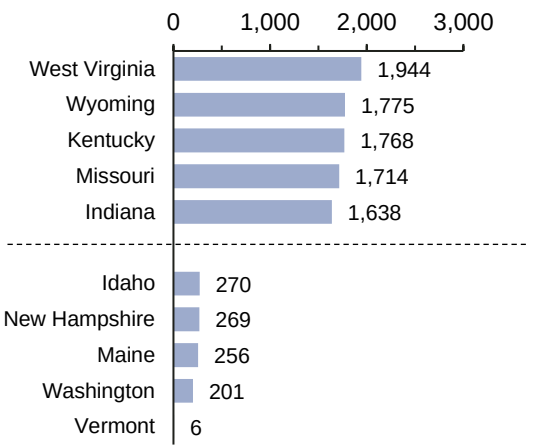
Total CO_2 Emissions by State

(million ton; top 5 and bottom 5 are shown)



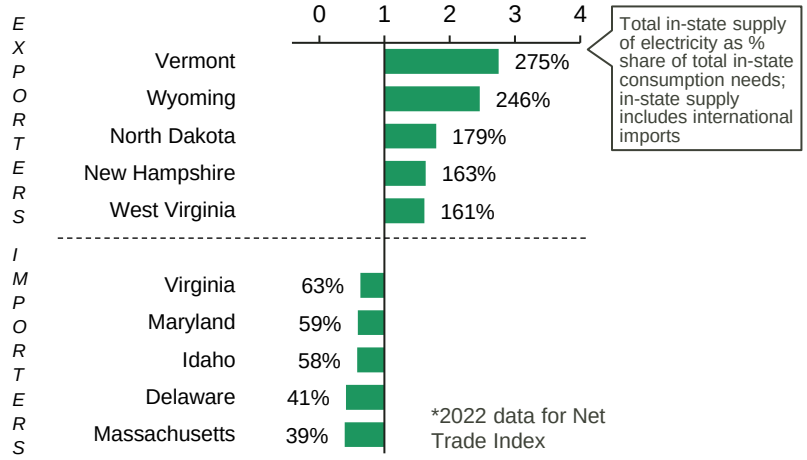
All Generating Sources – CO_2 Emission Rate

(lb/MWh; top 5 and bottom 5 are shown)



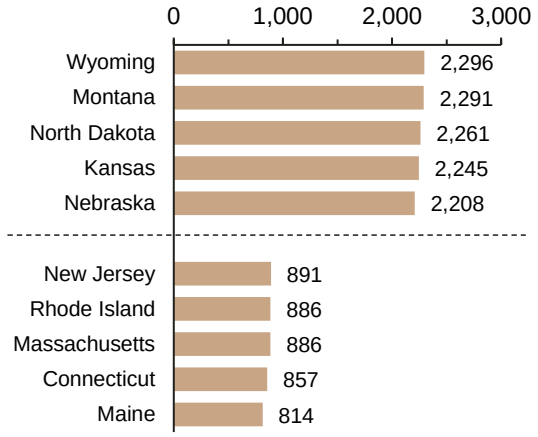
Electricity Exporters/Importers

(2022* Net Trade Index; top 5 exporters and importers are shown)



Fossil Generators – CO_2 Emission Rate

(lb/MWh; top 5 and bottom 5 are shown)



Section V

Fuel Mix of 100 Largest Power Producers in 2021

Fuel Mix of 100 Largest Power Producers, 2021

Rank	Holding Company	Total (million MWh)	Share of Total					
			Coal	Gas	Oil	Nuclear	Hydro	Renew able / Other
1	Duke	213.4	20.7%	38.5%	0.1%	35.3%	1.4%	4.0%
2	NextEra Energy	213.3	1.6%	46.5%	0.1%	22.0%	0.0%	29.7%
3	Exelon (Constellation)	197.7	0.0%	9.8%	0.0%	87.5%	1.1%	1.6%
4	Southern	180.8	21.8%	50.4%	0.0%	17.2%	3.8%	6.8%
5	Vistra Energy	172.7	35.4%	53.0%	0.1%	11.2%	0.0%	0.3%
6	Tennessee Valley Authority	138.1	17.2%	22.8%	0.1%	48.1%	11.9%	0.0%
7	Berkshire Hathaw ay Energy	129.6	33.7%	28.3%	0.1%	3.0%	2.2%	32.7%
8	Entergy	118.5	6.4%	52.5%	0.0%	40.9%	0.2%	0.0%
9	Dominion	113.7	10.9%	42.1%	0.2%	42.0%	0.8%	4.1%
10	Energy Capital Partners	105.6	0.0%	93.0%	0.0%	0.0%	0.0%	6.9%
11	AEP	86.6	56.6%	15.0%	0.2%	20.7%	1.1%	6.3%
12	Xcel	76.8	35.8%	24.5%	0.1%	18.4%	1.2%	19.9%
13	US Corps of Engineers	66.1	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%
14	PSEG	54.9	0.4%	41.3%	1.1%	56.8%	0.0%	0.4%
15	NRG	45.3	53.8%	24.7%	0.1%	20.3%	0.0%	1.2%
16	Energy Harbor	44.1	27.7%	0.1%	0.0%	72.2%	0.0%	0.0%
17	DTE Energy	40.3	58.7%	7.0%	0.2%	23.2%	0.0%	10.9%
18	Ameren	37.2	78.5%	1.2%	0.1%	11.5%	4.8%	3.9%
19	Evergy	36.7	68.9%	4.6%	0.5%	21.9%	0.0%	4.1%
20	Riverstone	36.1	28.7%	21.3%	0.2%	49.8%	0.0%	0.0%
21	LS Pow er	35.6	9.7%	87.4%	0.1%	0.0%	0.0%	2.8%
22	US Bureau of Reclamation	34.2	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%
23	WEC Energy Group	34.1	47.9%	37.9%	0.3%	0.0%	2.2%	11.8%
24	PPL	33.1	81.2%	17.6%	0.0%	0.0%	1.1%	0.0%
25	ArcLight Capital	31.7	21.7%	74.1%	0.2%	0.0%	4.0%	0.0%
26	Salt River Project	29.6	28.1%	52.5%	0.1%	18.7%	0.7%	0.0%
27	Oglethorpe	27.9	10.2%	53.3%	0.0%	36.5%	0.0%	0.0%
28	PG&E	27.3	0.0%	22.6%	0.0%	60.4%	16.1%	0.9%
29	New York Pow er Authority	27.2	0.0%	12.2%	0.0%	0.0%	87.8%	0.0%
30	Pinnacle West	26.4	25.9%	37.0%	0.0%	34.8%	0.0%	2.2%

Fuel Mix of 100 Largest Power Producers, 2021

Rank	Holding Company	Total (million MWh)	Share of Total					
			Coal	Gas	Oil	Nuclear	Hydro	Renew able / Other
31	Invenergy	25.9	0.0%	67.3%	0.0%	0.0%	0.0%	32.7%
32	Alliant Energy	25.5	39.9%	38.5%	0.1%	0.0%	1.2%	20.3%
33	The Carlyle Group	25.0	0.0%	99.8%	0.2%	0.0%	0.0%	0.0%
34	CPS Energy	24.6	29.4%	36.6%	0.0%	33.9%	0.0%	0.0%
35	CMS Energy	24.4	44.7%	35.9%	0.2%	0.0%	1.6%	17.6%
36	Associated Electric Coop	22.7	62.6%	37.3%	0.1%	0.0%	0.0%	0.0%
37	Avangrid	22.3	0.0%	14.2%	0.0%	0.0%	0.6%	85.2%
38	Ares	22.2	0.2%	96.4%	0.0%	0.0%	0.0%	3.3%
39	Starw ood Energy	20.8	10.6%	80.1%	0.1%	0.0%	0.0%	9.1%
40	AES	20.4	42.2%	36.5%	0.2%	0.0%	0.0%	21.1%
41	Enel	18.8	0.0%	0.0%	0.0%	0.0%	0.2%	99.8%
42	Emera	18.6	7.1%	86.0%	0.0%	0.0%	0.1%	6.7%
43	Santee Cooper	17.9	57.9%	28.0%	0.2%	12.2%	1.4%	0.2%
44	FirstEnergy	17.5	99.8%	0.1%	0.1%	0.0%	0.0%	0.0%
45	Basin Electric Pow er Coop	17.2	81.7%	13.9%	0.2%	0.0%	0.0%	4.2%
46	CLECO	16.9	16.9%	67.4%	0.0%	0.0%	0.0%	15.7%
47	The Blackstone Group	16.6	41.6%	58.3%	0.1%	0.0%	0.0%	0.0%
48	EDF	16.6	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
49	OGE	16.3	42.4%	50.5%	0.2%	0.0%	0.0%	6.9%
50	NE Public Pow er District	15.5	51.0%	3.5%	0.1%	44.5%	0.3%	0.6%
51	Portland General Electric	14.7	13.6%	63.5%	0.0%	0.0%	7.1%	15.8%
52	Fortis	14.0	38.5%	58.0%	0.1%	0.0%	0.6%	2.8%
53	Low er CO River Authority	13.6	55.2%	44.2%	0.1%	0.0%	0.6%	0.0%
54	EDP	13.1	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
55	Puget Holdings	12.8	19.5%	56.9%	0.0%	0.0%	7.5%	16.1%
56	Exxon Mobil	12.3	0.0%	85.9%	0.0%	0.0%	0.0%	14.1%
57	IDACORP	12.1	31.9%	22.9%	0.0%	0.0%	45.1%	0.0%
58	Osaka Gas	11.6	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
59	Caithness Energy	11.5	0.0%	84.3%	0.0%	0.0%	0.0%	15.7%
60	Municipal Elec. Auth. of GA	11.4	12.5%	26.1%	0.0%	61.3%	0.0%	0.0%

Fuel Mix of 100 Largest Power Producers, 2021

Rank	Holding Company	Total (million MWh)	Share of Total					
			Coal	Gas	Oil	Nuclear	Hydro	Renew able / Other
61	RWE Group	10.8	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
62	Seminole Electric Coop	10.7	60.8%	39.0%	0.2%	0.0%	0.0%	0.0%
63	ConEdison	10.4	0.0%	30.5%	0.0%	0.0%	0.0%	69.5%
64	Edison International	10.3	0.0%	20.9%	0.3%	48.7%	16.8%	13.3%
65	Tenaska	10.1	0.0%	83.5%	0.0%	0.0%	0.0%	16.5%
66	NextEra Energy Partners	9.9	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
67	ALLETE	9.9	44.7%	1.7%	0.0%	0.0%	3.6%	50.1%
68	East Kentucky Pow er Coop	9.8	90.1%	7.8%	0.2%	0.0%	0.0%	1.9%
69	PNM Resources	9.8	42.5%	18.6%	0.2%	33.0%	0.0%	5.7%
70	Algonquin Pow er	9.7	12.8%	32.2%	0.6%	0.0%	0.5%	53.9%
71	JEA	9.6	11.1%	80.1%	0.2%	0.0%	0.0%	8.5%
72	Great River Energy	9.6	94.9%	4.8%	0.3%	0.0%	0.0%	0.0%
73	El Paso Electric	9.5	0.0%	47.3%	0.1%	52.4%	0.0%	0.2%
74	PUD No 2 of Grant County	9.5	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%
75	Dow Chemical	9.4	0.0%	96.2%	0.0%	0.0%	0.0%	3.8%
76	Buckeye Pow er	9.1	94.5%	5.1%	0.4%	0.0%	0.0%	0.0%
77	Austin Energy	9.0	37.4%	23.0%	0.1%	37.1%	0.0%	2.4%
78	Omaha Public Pow er District	9.0	95.1%	4.2%	0.2%	0.0%	0.0%	0.6%
79	OMERS	9.0	0.0%	47.1%	0.0%	0.0%	0.0%	52.9%
80	Energy Northw est	8.8	0.0%	0.0%	0.0%	96.2%	1.0%	2.8%
81	Arkansas Electric Coop	8.8	65.1%	26.6%	0.2%	0.0%	8.2%	0.0%
82	Occidental	8.5	0.0%	98.3%	0.0%	0.0%	0.0%	1.7%
83	PUD No 1 of Chelan County	8.5	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%
84	American Municipal Pow er	8.5	34.8%	41.0%	0.0%	0.0%	24.1%	0.1%
85	NiSource	8.5	60.4%	34.7%	0.0%	0.0%	0.5%	4.4%
86	Argo Infrastructure Partners	8.4	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
87	Tri-State	8.3	85.9%	13.6%	0.4%	0.0%	0.0%	0.0%
88	Brookfield Renew able Partners	8.2	0.0%	0.9%	0.0%	0.0%	55.5%	43.6%
89	Los Angeles City	8.1	0.0%	71.9%	0.0%	22.4%	2.8%	2.9%
90	John Hancock	7.9	11.7%	52.0%	0.2%	0.0%	0.0%	36.1%

Fuel Mix of 100 Largest Power Producers, 2021

Rank	Holding Company	Total (million MWh)	Share of Total					
			Coal	Gas	Oil	Nuclear	Hydro	Renewable / Other
91	Clearway Energy	7.8	0.0%	8.6%	0.0%	0.0%	0.0%	91.4%
92	Intermountain Power Agency	7.6	99.7%	0.0%	0.3%	0.0%	0.0%	0.0%
93	Brookfield	7.5	0.0%	0.9%	0.0%	0.0%	55.5%	43.6%
94	International Paper	7.5	0.0%	27.4%	0.3%	0.0%	0.0%	72.3%
95	National Grid	7.4	0.0%	76.9%	7.2%	0.0%	0.0%	15.8%
96	Avista	7.4	20.4%	24.3%	0.0%	0.0%	50.9%	4.4%
97	Orsted	7.2	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
98	NC Public Power	7.0	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
99	Old Dominion Electric Coop	6.8	6.5%	67.2%	0.3%	26.0%	0.0%	0.0%
100	Hoosier Energy	6.5	80.6%	16.9%	0.1%	0.0%	0.0%	2.4%
	Total (top-100 producers)	3,297.7	22.6%	36.9%	0.1%	23.0%	6.4%	11.0%
	Total (all U.S. producers)	4,106.2	21.8%	38.4%	0.3%	18.9%	6.1%	14.4%

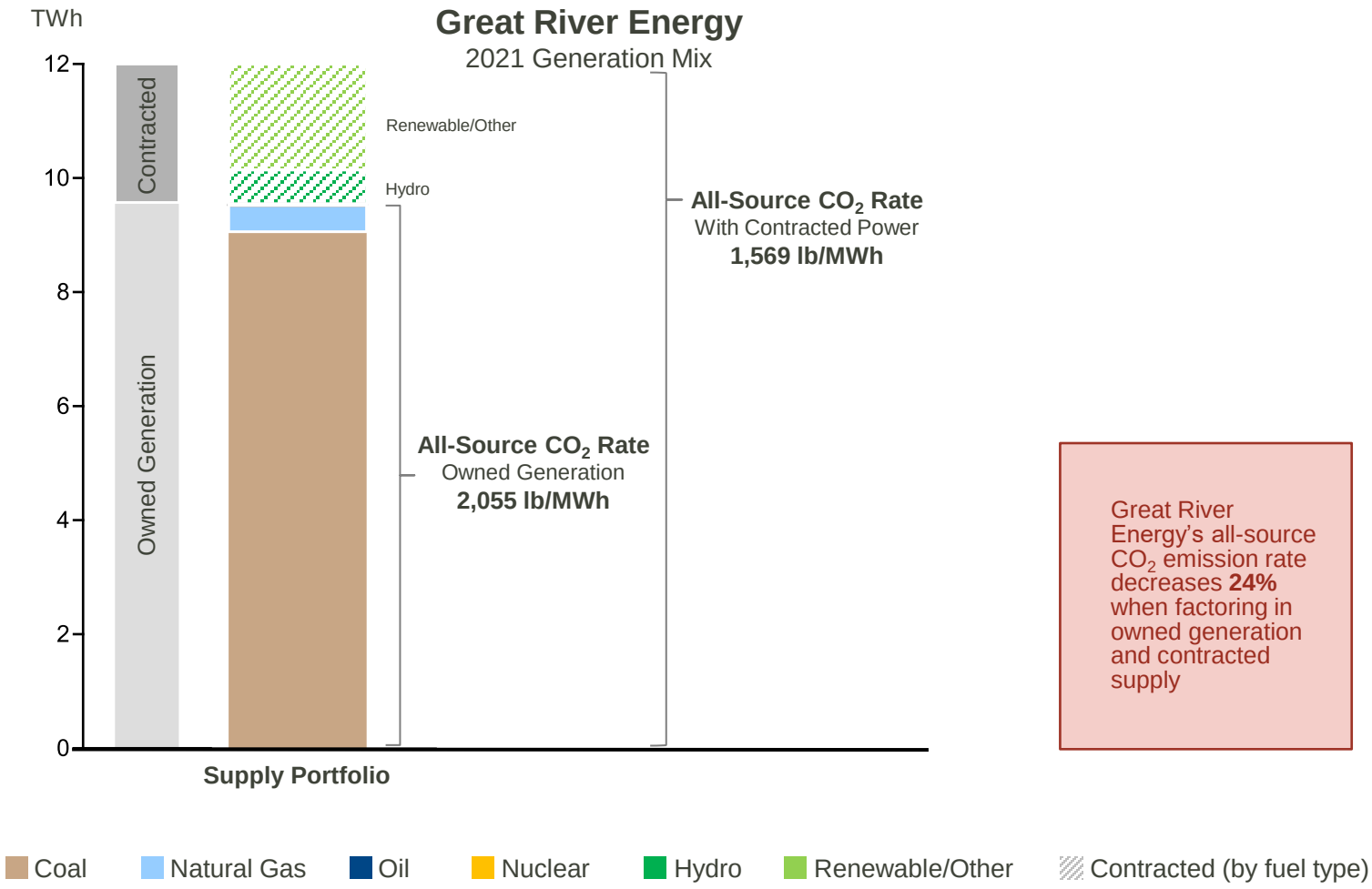
Section VI

Appendix

Ranking Utility Portfolios

- As described above, the Benchmarking Report presents generation and emissions information of power producers, not utility companies with obligations to deliver electricity to customers. In order to apply a uniform methodology to all power producers, the Report assigns electricity generation and associated emissions to power producers according to their known generating asset ownership as of December 31, 2021.
- If a power producer is also a distribution utility, the fuel mix and emissions associated with the utility's total supply portfolio may differ substantially from its owned generation, depending on the nature and extent of any power purchase agreements and other contractual agreements to which the utility may be party. The distribution utility might also rely on market purchases to supply its customers (e.g., purchases from the PJM or MISO markets). A power producer might also sell excess supply to the market or to other utilities.
- To highlight the potential implications of these two different approaches, the following pages present the generation mix and all-source CO_2 emission rate for a rural electric cooperative (Great River Energy) and investor-owned utility (Xcel). The graph also reports the CO_2 emission rate associated with part of the company's supply portfolio (owned generation and long-term contracts); the supply portfolio emission rate does not reflect the emissions associated with market purchases, which may be fossil-fired, renewables, or other sources.
- In the examples shown, the CO_2 emission rate associated with supply is lower because both companies contract for non-emitting, renewable resources in addition to owned wind or solar projects (Great River Energy only owns fossil assets). Rural cooperatives are non-profit entities that are generally unable to take advantage of renewable tax credits, so they will tend to purchase renewable energy under long-term contracts rather than owning the facilities.
- Both approaches—generation and supply—can be helpful in evaluating a company's performance. Unfortunately, there is no publicly available source for the data that would be required to benchmark utility resource portfolios in the same way that we can benchmark owned-generation assets.
- The following pages illustrate the all-source CO_2 emissions rates for Great River Energy and Xcel. The companies voluntarily supplied the information displayed. The charts include the emission rate for owned generation only (consistent with the focus and methodology of the Benchmarking report) as well as the all-source emission rate associated with the combination of owned generation and long-term contract purchases.

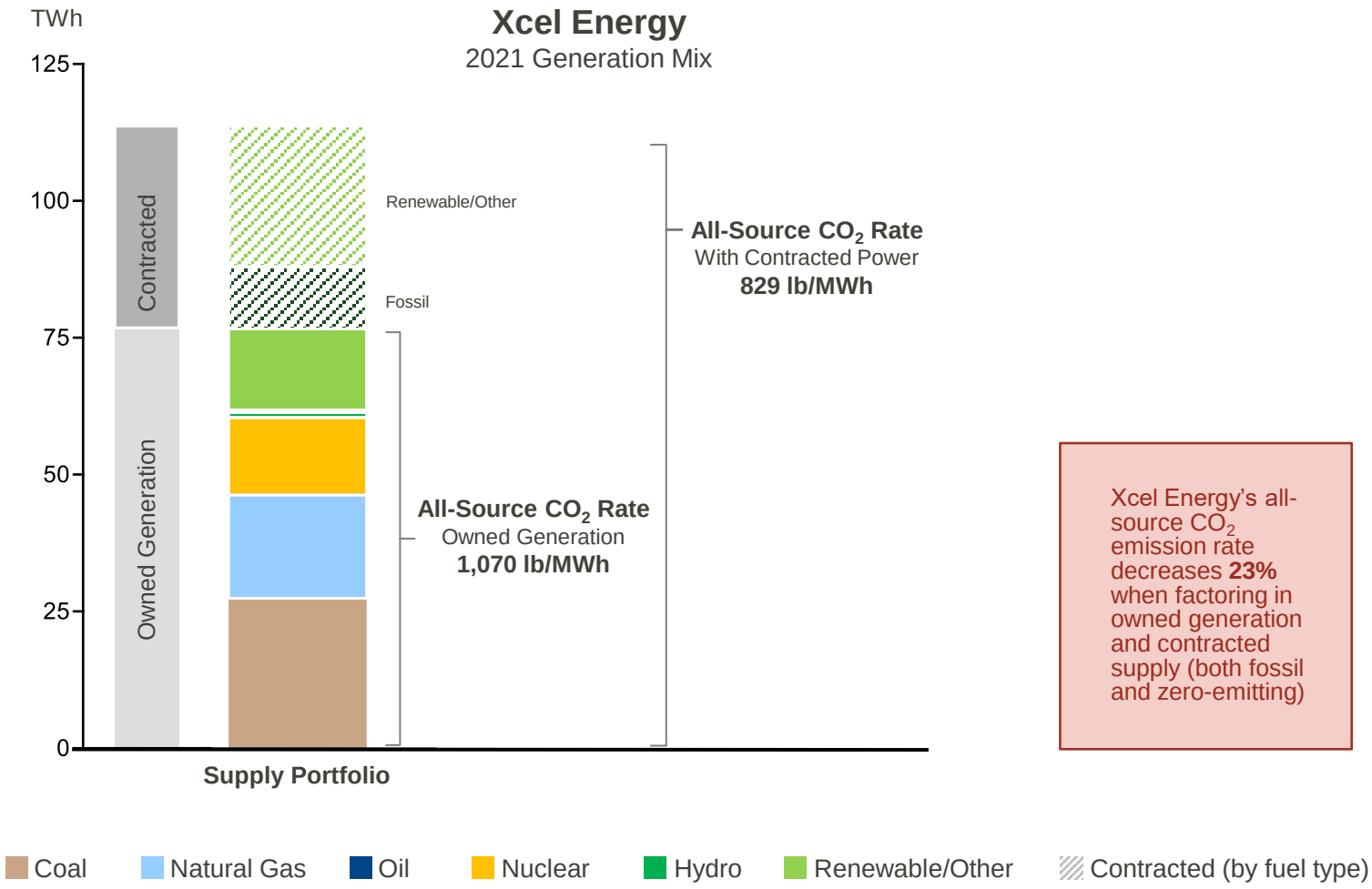
Case Study: Owned Generation and Contracted Supply



Great River Energy's all-source CO_2 emission rate decreases **24%** when factoring in owned generation and contracted supply

Note: Additional supply obtained from market purchases not included in contracted power

Case Study: Owned Generation and Contracted Supply



Xcel Energy's all-source CO_2 emission rate decreases **23%** when factoring in owned generation and contracted supply (both fossil and zero-emitting)

Note: Contracted power includes long-term PPAs and market purchases

Data Sources

The following public data sources were used to develop company-specific 2021 data for this report:

EPA Air Markets Program Data (AMP): EPA's Air Markets Program Data account for effectively all SO_2 and NOx emissions, and about 30 percent of the CO_2 emissions analyzed in this report.

EPA Toxic Release Inventory (TRI): 2021 mercury emissions used in this report are based on TRI reports submitted by facility managers.

EIA Form 923 (2021): EIA Form 923 provides data on the electric generation and heat input by fuel type for utility and non-utility power plants. Heat input data are used to calculate approximately 80 percent of the CO_2 emissions analyzed in this report.

EIA Form 860 (2021): EIA Form 860 is a generating unit level data source that includes information about generators at electric power plants, including information about generator ownership.

EPA U.S. Inventory of Greenhouse Gas Emissions and Sinks (2021): EPA's U.S. Inventory of Greenhouse Gas Emissions and Sinks report provides in Annex 2 heat contents and carbon content coefficients of various fuel types. These data are used in conjunction with EIA Form 923 to calculate approximately 30 percent of the CO_2 emissions analyzed in this report.

The following public data sources were used to develop sector-wide 2022 data for this report:

EIA Electric Power Monthly: Sector-wide 2022 data (page 6) and "Average Capacity Factors" (page 28)

EPA Air Pollutant Emissions Trends Data: Sector-wide 2022 data (page 7)

EPA Air Markets Program Data: "Electric Sector Emissions" (page 26)

EIA Monthly Energy Review: "Generation Fuel Mix" (page 26)

U.S. Bureau of Economic Analysis (GDP): "Macroeconomic Indicators" (page 26)

The following data sources were used to develop composite low-carbon scenario pathways:

EPA (Electricity Sector Emissions Impact of the Inflation Reduction Act report)

International Energy Agency (IEA) World Energy Outlook (WEO)

Network for Greening the Financial System (NGFS)

Principles for Responsible Investment (PRI) Inevitable Policy Response (IPR)

Princeton Net-Zero America

Methodology

Plant Ownership

This report aims to reflect power plant ownership as of December 31, 2021. Plant ownership data used in this report are primarily based on the EIA-860 database from the year 2021. EIA-860 includes ownership information on generators at electric power plants owned or operated by electric utilities and non-utilities, which include independent power producers, combined heat and power producers, and other industrial organizations. It is published annually by EIA.

For the largest 100 power producers, plant ownership is further checked against self-reported data from the producer's 10-K form filed with the SEC, listings on their website, and other media sources. Ownership of plants is updated based on the most recent data available. Consequently, in a number of instances, ultimate assignment of plant ownership in this report differs from EIA-860's reported ownership. This primarily happens when the plant in question falls in one or more of the categories listed below:

1. It is owned by a limited liability partnership of shareholders of which are among the 100 largest power producers.
2. The owner of the plant as listed in EIA-860 is a subsidiary of a company that is among the 100 largest power producers.
3. It was sold or bought during the year 2021. Because form 10-K for a particular year is usually filed by the producer in the first quarter of the following year, this report assumes that ownership as reported in form 10-K is more accurate.

Publicly available data do not provide a straightforward means to accurately track lease arrangements and power purchase agreements. Therefore, to apply a standardized methodology to all companies, this report allocates generation and emissions according to reported asset ownership as of December 31, 2021.

Identifying "who owns what" in the dynamic electricity generation industry is probably the single most difficult and complex part of this report. In addition to the categories listed above, shares of power plants are regularly traded and producers merge, reorganize, or cease operations altogether. While considerable effort was expended in ensuring the accuracy of ownership information reflected in this report, there may be inadvertent errors in the assignment of ownership for some plants where public information was either not current or could not be verified.

Power producers are ultimately divided into three categories, or company types: 1) privately-/investor-owned (privately-, investor-, and/or foreign-owned corporations), 2) public power (federal power authorities, state power authorities, municipalities, power districts), and 3) cooperative. Private entities include privately-held utilities and non-utility power producers (e.g., independent power producers). Publicly-owned electric utilities are nonprofit government entities that are organized at either the local or state level. There are also several federal electric utilities in the United States, such as the Tennessee Valley Authority. Cooperative electric utilities are owned by their members (i.e., the consumers they serve).

Generation Data and Cogeneration Facilities

Plant generation data used in this report come from EIA Form 923.

Cogeneration facilities produce both electricity and steam or some other form of useful energy. Because electricity is only a partial output of these plants, their reported emissions data generally overstate the emissions associated with electricity generation. Generation and emissions data included in this report for cogeneration facilities have been adjusted to reflect only their electricity generation. For all such cogeneration facilities emissions data were calculated on the basis of heat input of fuel associated with electricity generation only. Consequently, for all such facilities EIA Form 923, which report a plant's total heat input as well as that which is associated with electricity production only, was used to calculate their emissions.

Methodology (continued)

NOx and SO_2 Emissions

The EPA AMP database collects and reports SO_2 and NOx emissions data for nearly all major power plants in the U.S. Emissions information reported in the AMP database is collected from continuous emission monitoring (CEM) systems. SO_2 and NOx emissions data reported to the AMP account for all of the SO_2 and NOx emissions assigned to the 100 largest power producers in this report.

The AMP database collects and reports SO_2 and NOx emissions data by fuel type at the boiler level. This report consolidates this data at the generating unit and plant levels. In the case of jointly owned plants, because joint ownership is determined by producer's share of installed capacity, assignment of SO_2 and NOx emissions to the producers on this basis implicitly assumes that emission rates are uniform across the different units. This may cause producers to be assigned emission figures that are slightly higher or lower than their actual shares.

The appointment of NOx emissions between coal and natural gas at boilers that can burn both fuels may in certain instances slightly overstate coal's share of the emissions. This situation is likely to arise when a dual-fuel boiler that is classified as "coal-fired" within AMP burns natural gas to produce electricity in substantial amounts. Because AMP datasets do not make this distinction, apportioning emissions based on the fuel-type of the boiler would increase coal's share of emissions.

SO_2 and CO_2 emissions are mostly not affected by this issue. Natural gas emits virtually no SO_2. CO_2 emissions can be calculated from the heat input data reported in EIA Form 923, which allows for the correct apportionment of emissions between coal and natural gas.

CO_2 Emissions

A majority of CO_2 emissions used in this report were calculated using heat input data from EIA form 923 and carbon content coefficients of various fuel types provided by EPA. The table on the following page shows the carbon coefficients used in this procedure. Non-emitting fuel types, whose carbon coefficients are zero, are not shown in the table. CO_2 emissions reported through the EPA AMP account for a small share of the CO_2 emissions used in this report.

The datasets report heat input and emissions data by fuel type at either the prime mover or boiler level. This report consolidates that data at the generating unit and plant levels. In the case of jointly owned plants, because joint ownership is determined by producer's share of installed capacity, assignment of CO_2 emissions to the producers on this basis implicitly assumes that emission rates are uniform across the different units. This may cause producers to be assigned emission figures that are slightly higher or lower than their actual shares.

Mercury Emissions

Mercury emissions data for coal power plants presented in this report were obtained from EPA's Toxic Release Inventory (TRI). Mercury emissions reported to the TRI are based on emission factors, mass balance calculations, or data monitoring. The TRI contains facility-level information on the use and environmental release of chemicals classified as toxic under the Clean Air Act. The TRI contains information on all toxic releases from a facility; mercury emissions in this report are based on air releases only. Because coal plants are the primary source of mercury emissions within the electric industry, the mercury emissions and emission rates presented in this report reflect the emissions associated with each producer's fleet of coal plants only.

Carbon Content Coefficients by Fuel Type

From Annex 2 of EPA GHG Inventory 2023 (2021 data)

Fuel Type	Carbon Content Coefficients (Tg Carbon/Qbtu)
Coal	
Anthracite Coal	28.28
Bituminous Coal	25.43
Sub-bituminous Coal	26.49
Lignite Coal	26.80
Waste/Other Coal (includes anthracite culm, bituminous gob, fine coal, lignite waste, waste coal)	26.09
Coal-based Synfuel, including briquettes, pellets, or extrusions, which are formed by binding materials or processes that recycle materials	25.34
Coal-based Synthetic Gas	18.55
Oil	
Distillate Fuel Oil (Diesel, No. 1, No. 2, and No. 4 Fuel Oils)	20.22
Jet Fuel	19.70
Kerosene	19.96
Residual Fuel Oil (No. 5, No. 6 Fuel Oils, and Bunker C Fuel Oil)	20.48
Waste/Other Oil (including Crude Oil, Liquid Butane, Liquid Propane, Oil Waste, Re-Refined Motor Oil, Sludge Oil, Tar Oil, or other petroleum-based liquid wastes)	20.55
Petroleum Coke	27.85
Gas	
Natural Gas	14.43
Blast Furnace Gas	74.81
Other Gas	18.55
Gaseous Propane	16.76

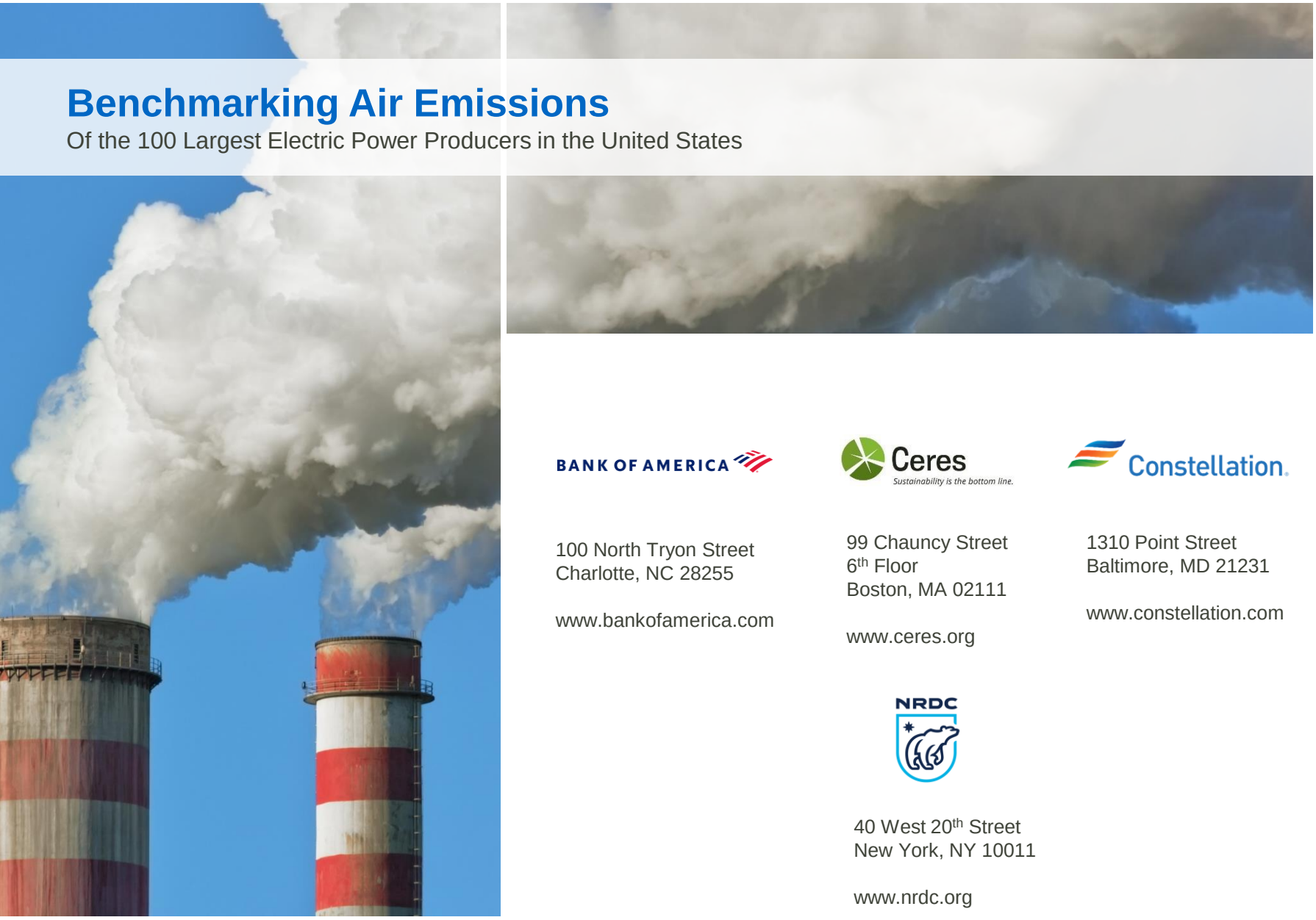
Quality Assurance

This report examines the air pollutant emissions of the 100 largest electricity generating companies in the United States based on 2021 electricity generation, emissions, and ownership data. The report relies on publicly-available information reported by the U.S. Energy Information Administration (EIA), U.S. Environmental Protection Agency (EPA), Securities and Exchange Commission (SEC), state environmental agencies, company websites, and media articles. Emission data may include revisions to 2021 data that companies were in the process of submitting or have already submitted to EPA at the time of publication of this report.

This report relies almost entirely on publicly available information. Data sets published by EIA and EPA are the primary source of the generation and emissions data used in this report. The organizations that fund this report believe maintaining public access to this information is essential to tracking the industry's performance and making accurate and informed analyses and policy decisions.

Benchmarking Air Emissions

Of the 100 Largest Electric Power Producers in the United States



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