

# 2011-2023 Greenhouse Gas Reporting Program Industrial Profile: Petroleum Refineries Sector

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## INTRODUCTION

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*All emissions presented here are as of 8/16/2024 and exclude biogenic carbon dioxide (CO<sub>2</sub>). All greenhouse gas (GHG) emission data displayed in units of carbon dioxide equivalent (CO<sub>2</sub>e) reflect the global warming potential (GWP) values from Table A-1 of 40 CFR 98, which is generally based on the Intergovernmental Panel on Climate Change's Fourth Assessment Report (IPCC AR4).*

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### Highlights

- The Petroleum Refineries Sector is the fourth-largest greenhouse gas (GHG) emitting industrial sector among stationary sources behind Power Plants, Petroleum and Natural Gas Systems, and Chemicals, respectively.
- The Petroleum Refineries Sector is the highest ranked sector in terms of GHG emissions per facility, with an average of 1.22 million metric tons of carbon dioxide equivalent (MMT CO<sub>2</sub>e), just overtaking Power Plants.
- The largest source of emissions in the Petroleum Refineries Sector is stationary fuel combustion, representing almost three quarters of GHG emissions in 2023.
- Emissions from this sector decreased by 9% from 2011 to 2023, with a low of 160.6 MMT CO<sub>2</sub>e in 2020 and a high of 181.7 MMT CO<sub>2</sub>e in 2018.
- In 2023, 63.0% of the emissions from the Petroleum Refineries Sector came from facilities in Texas, Louisiana, and California.

### About this Sector

The Petroleum Refineries Sector consists of facilities that produce gasoline, gasoline blending stocks, naphtha, kerosene, distillate fuel oils, residual fuel oils, lubricants, or asphalt (bitumen) by the distillation of petroleum or the re-distillation, cracking, or reforming of unfinished petroleum derivatives. Petroleum refineries emit GHGs from various processes, including but not limited to, venting, flares, and fugitive leaks from equipment (e.g., valves, flanges, pumps).

In addition to emissions from petroleum refining processes, this sector includes combustion emissions from stationary combustion units, except for electricity generating units (Subpart D), the emissions of which are included in the Power Plant Sector. Emissions from hydrogen production plants located at refineries are included in the Non-Fluorinated Chemicals Sector. Emissions from industrial waste landfills and industrial wastewater treatment at these facilities are included in the Waste Sector. Most petroleum refineries also report as suppliers of petroleum products and a few petroleum refineries also report as suppliers of CO<sub>2</sub>.

### Who Reports?

As shown in Table 1, refineries began reporting to the Greenhouse Gas Reporting Program (GHGRP) in 2010. When the program began in 2010, all US refinery facilities reported to the GHGRP. Due to

the program's off-ramping provisions, some refineries qualified to discontinue reporting.<sup>1</sup> In 2023, as shown in Tables 2 and 3, 133 facilities in the Petroleum Refineries Sector reported GHG emissions of 162 MMT CO<sub>2</sub>e. The Petroleum Refineries Sector reflects 1.8% of the facilities reporting direct emissions to the GHGRP. In 2022, the Petroleum Refineries Sector represented 2.6% of total U.S. GHG emissions.<sup>2</sup>

**Table 1: Petroleum Refineries Sector – Reporting Schedule by Subpart**

Subpart	Source Category	Applicability	First Reporting Year
Y	Petroleum refineries	All facilities	2010

**Table 2: Petroleum Refineries Sector–Number of Reporters (2011–2023)**

Petroleum Refineries Sector	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Petroleum refineries	150	147	146	142	144	144	144	140	139	140	138	136	133

## Reported Emissions

**Table 3: Petroleum Refineries Sector– Emissions (MMT) (2011–2023)**

Sector	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Petroleum refineries	178.2	172.6	174.3	175.3	176.9	180.9	178.7	181.7	177.5	160.6	164.5	163.6	162.0

## Reported Emission Sources

Figure 1 shows the Petroleum Refineries Sector emissions by source for 2023. The largest sources of GHG emissions at petroleum refineries are stationary fuel combustion units (e.g., steam boilers, process furnaces, process heaters). The Petroleum Refineries Sector also reports process emissions from flares, catalytic cracking unit, fluid and delayed coking units, catalytic reforming units, sulfur recovery plants, coke calcining units, asphalt blowing operations, process vents, uncontrolled blowdown systems, equipment leaks, storage tanks and loading operations. Table 4 shows total reported emissions from process emissions, fuel combustion and sorbent emissions.

<sup>1</sup> Refer to FAQ: When is a Facility Eligible to Stop Reporting? Available at: <http://www.ccdsupport.com/confluence/pages/viewpage.action?pageId=243139271>.

<sup>2</sup> Total U.S. GHG emissions for 2022 were 6,343 MMT CO<sub>2</sub>e, as reported in the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2022. U.S. Environmental Protection Agency. April 11, 2024. EPA 430-R-24-004. Available at: <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.

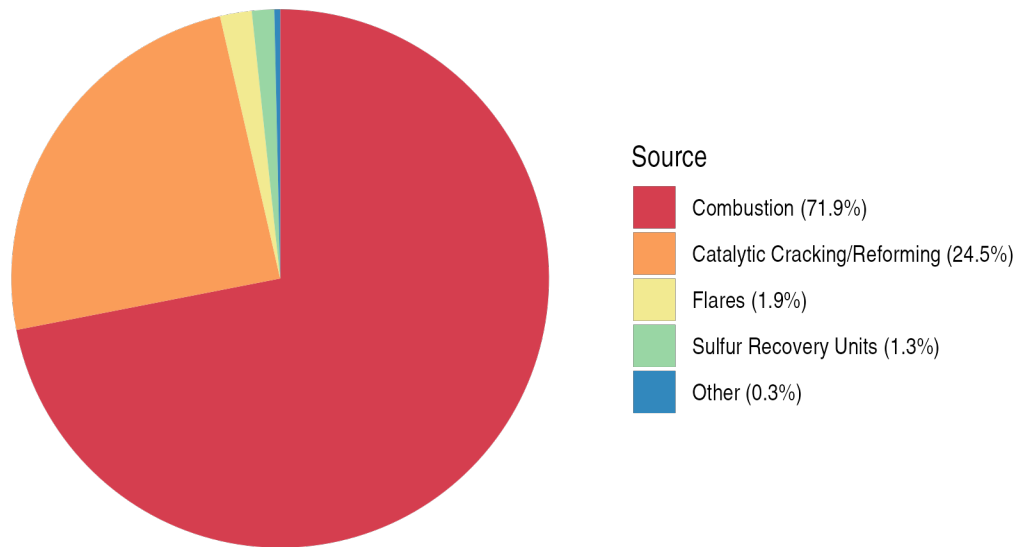
**Table 4: Petroleum Refineries - Emissions (MMT CO<sub>2</sub>e) from Fuel Combustion and Other Processes <sup>a, b</sup>**

Emissions Source Type	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Fuel Combustion	121.3	117.3	120.3	120.9	122.6	124.4	123.7	126.9	124.3	115.3	117.2	116.2	116.0
Process	56.9	55.3	53.9	54.3	54.3	56.5	55.0	54.9	53.2	45.3	47.4	47.5	46.0
Sorbent <sup>c</sup>	NA	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

<sup>a</sup> Emissions from fuel combustion are defined here as emissions reported under Subpart C. Emissions from other processes are reported under Subpart Y.

<sup>b</sup> Emission values presented may differ slightly from other publicly available GHGRP data due to minor differences in the calculation methodology. Sums of individual rows might not match totals sector emissions due to individual rounding.

<sup>c</sup> Does not include sorbent emissions monitored by a continuous emission monitoring system (CEMS).

**Figure 1: 2023 Petroleum Refineries Sector: Emissions by Source** <sup>a, b, c</sup>

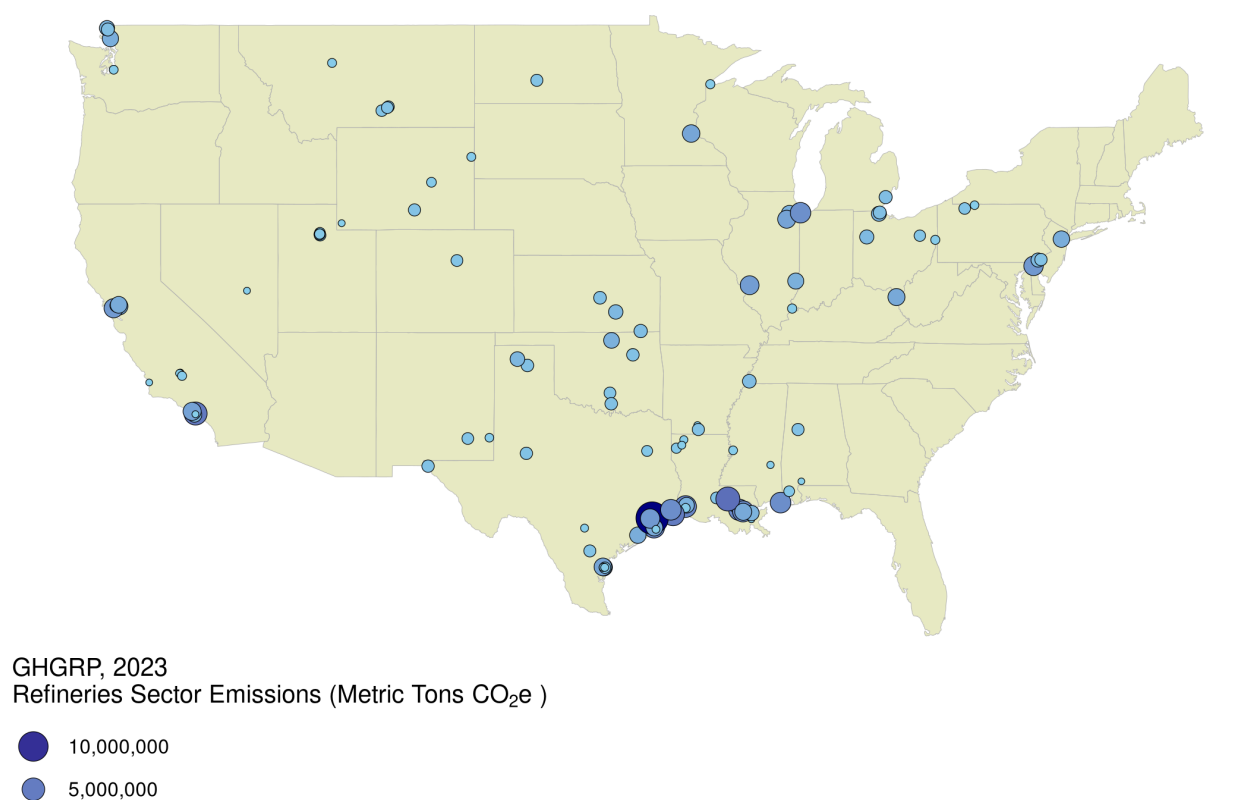
<sup>a</sup> Emissions from fuel combustion are defined here as emissions reported under Subpart C, and emissions from other processes are reported under Subpart Y.

<sup>b</sup> "Other Sources" include coke calcining units, process vents, uncontrolled blowdown systems, asphalt blowing operations, equipment leaks, delayed coking units, storage tanks, loading operations, and emissions from sorbent use (not including sorbent emissions monitored by a CEMS).

<sup>c</sup> Emission values presented may differ slightly from other publicly available GHGRP data due to minor differences in the calculation methodology. Sums of individual rows might not match totals sector emissions due to individual rounding.

Figure 2 shows the locations of direct-emitting facilities in the contiguous United States.

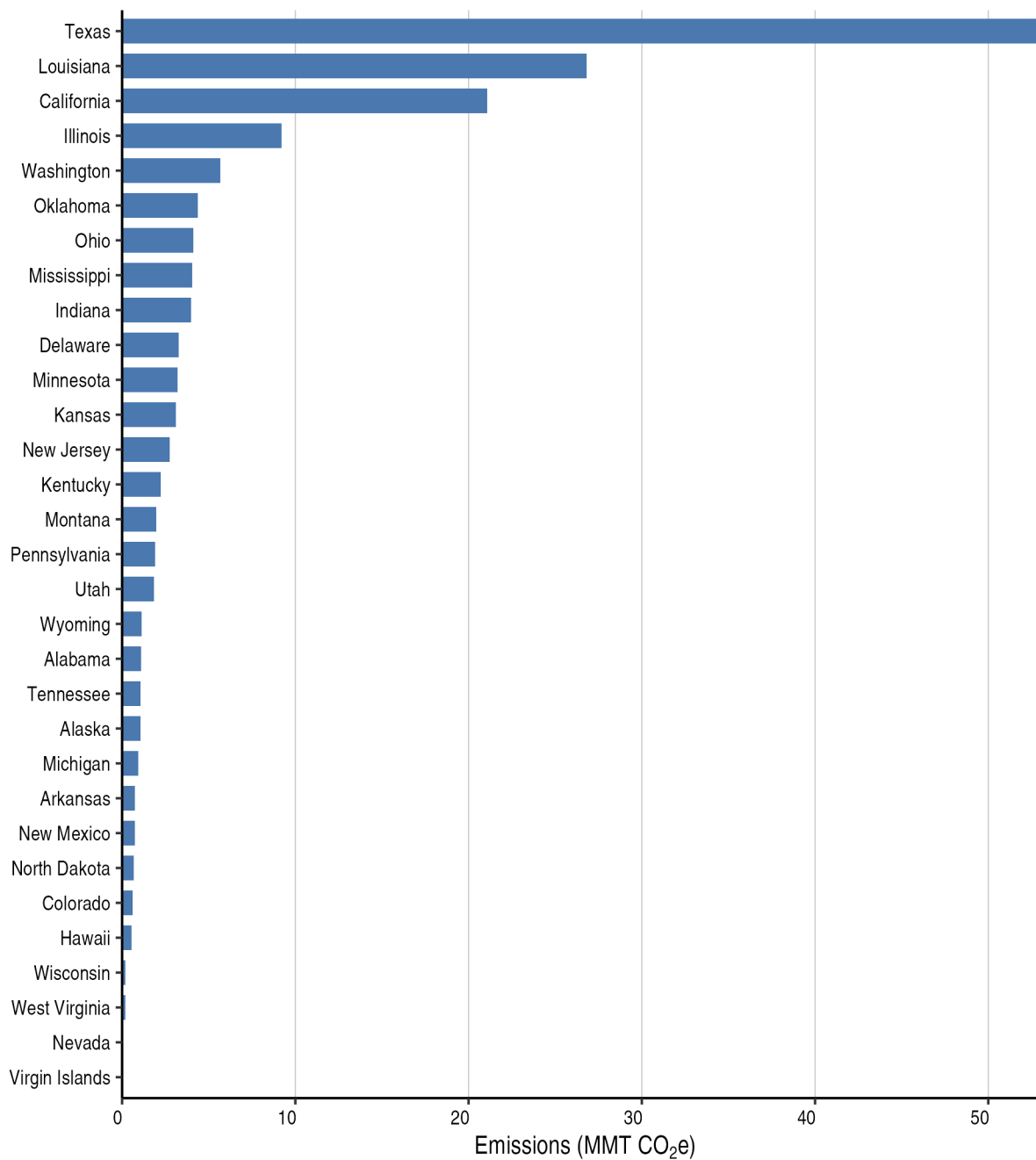
**Figure 2: Location and Relative Emissions for Facilities Reporting in the Petroleum Refineries Sector (2023)**



*Note: Each circle on the map corresponds to a facility reporting in the petroleum refineries sector. Both the size and color of each circle are continuous gradients corresponding to a facility's emissions.*

Circle sizes in Figure 2 correspond to the quantity of emissions reported by that facility. Petroleum refineries are also located in Alaska, Hawaii, and the U.S. Virgin Islands (<https://www.epa.gov/ghgreporting/ghgrp-refineries>). Readers can identify the largest-emitting facilities by visiting the Facility Level Information on the Greenhouse Gases Tool (FLIGHT) website (<https://ghgdata.epa.gov/ghgp/main.do>).

Figure 3 shows the GHGRP emissions from the Petroleum Refineries Sector by state for 2023. In 2023, 63.0% of the emissions from the Petroleum Refineries Sector came from facilities in Texas, Louisiana, and California.

**Figure 3: Petroleum Refineries Sector: Emissions by State (2023) <sup>a</sup>**

<sup>a</sup> Represents total emissions reported to the GHGRP from this sector. States not shown had no petroleum refining sector emissions reported to the GHGRP in 2023. [Access the most recent data using FLIGHT.](#)

## Petroleum Refineries Sector: Emission Trends 2022 - 2023

Emissions in the Petroleum Refineries Sector decreased by approximately 1% from 2022 to 2023, with the number of reporters decreasing 2.2% over the same timeframe.



## Petroleum Refineries Sector: Longer-Term Emission Trends

Refineries sector emissions that reported to GHGRP remained relatively constant from 2011 to 2019, followed by a significant drop of nearly 10% in reported emissions in 2020 due to reduced demand during the COVID-19 pandemic. A rebound in production and associated emissions began in 2021, with emissions increasing by roughly 2% to 164.5 MMT CO<sub>2</sub>e from the record low emissions reported to the GHGRP in 2020. In 2023, emissions from refineries decreased by 1.0% compared to 2022 levels, to a total of 162.0 MMT CO<sub>2</sub>e from 163.6 MMT CO<sub>2</sub>e.

Historically, refinery emissions trends are influenced by three key factors: the number of operating refineries, the operable capacity, and the production slate. With respect to the number of reporting facilities, the count has decreased from 150 to 133 over the last decade. This is the result of refinery closures and the fact that several small refineries are no longer required to report.<sup>3</sup> However, U.S. refining capacity increased in 2023 due to expansions at existing facilities.<sup>4</sup>

With respect to operable capacity (measured in thousand barrels per calendar day), overall levels have increased by 2% over the last decade.<sup>5</sup> From 2019 to 2023, however, there has been a decrease in operable capacity of more than 3%. While the decades-long trend demonstrates that the expanded production capacity at existing and new refineries more than offsets production declines from refinery closures, the trend may be turning toward a sustained nationwide decline in operating capacity due to factors driving refinery closures, such as the expected shift toward electric vehicles and the increasing use of renewable fuels. However, as noted above, the trend did reverse in 2023.

Finally, finished motor gasoline, distillate fuel oil, and jet fuel are the predominant fuels produced by refineries. In 2023, the production of finished motor gasoline (including motor gasoline blend components) and kerosene jet fuel decreased by 0.6% and increased by 5.9%, respectively, compared to 2022.<sup>6</sup> In addition, distillate oil production decreased by 2.3% over the period 2022-2023.<sup>7</sup> These overall changes in demand resulted in a net 0.1% increase in refinery throughput in 2023 compared to 2022 (measured as gross input to refineries in thousand barrels per day).<sup>8</sup>

Figure 4 shows the trend of normalized emissions per gross input from 2011 to 2023, and Table 5 shows that GHGRP emissions in the Petroleum Refineries Sector have remained in a relatively narrow range from 2011 to 2023.

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<sup>3</sup> 40 CFR §98.2(i)(1) and (2) describe provisions under which a facility may discontinue reporting.

<sup>4</sup> U.S. Energy Information Administration, *U.S. refining capacity increased in 2023 with expansions at existing facilities* (accessed September 27, 2024) at: <https://www.eia.gov/todayinenergy/detail.php?id=62624>.

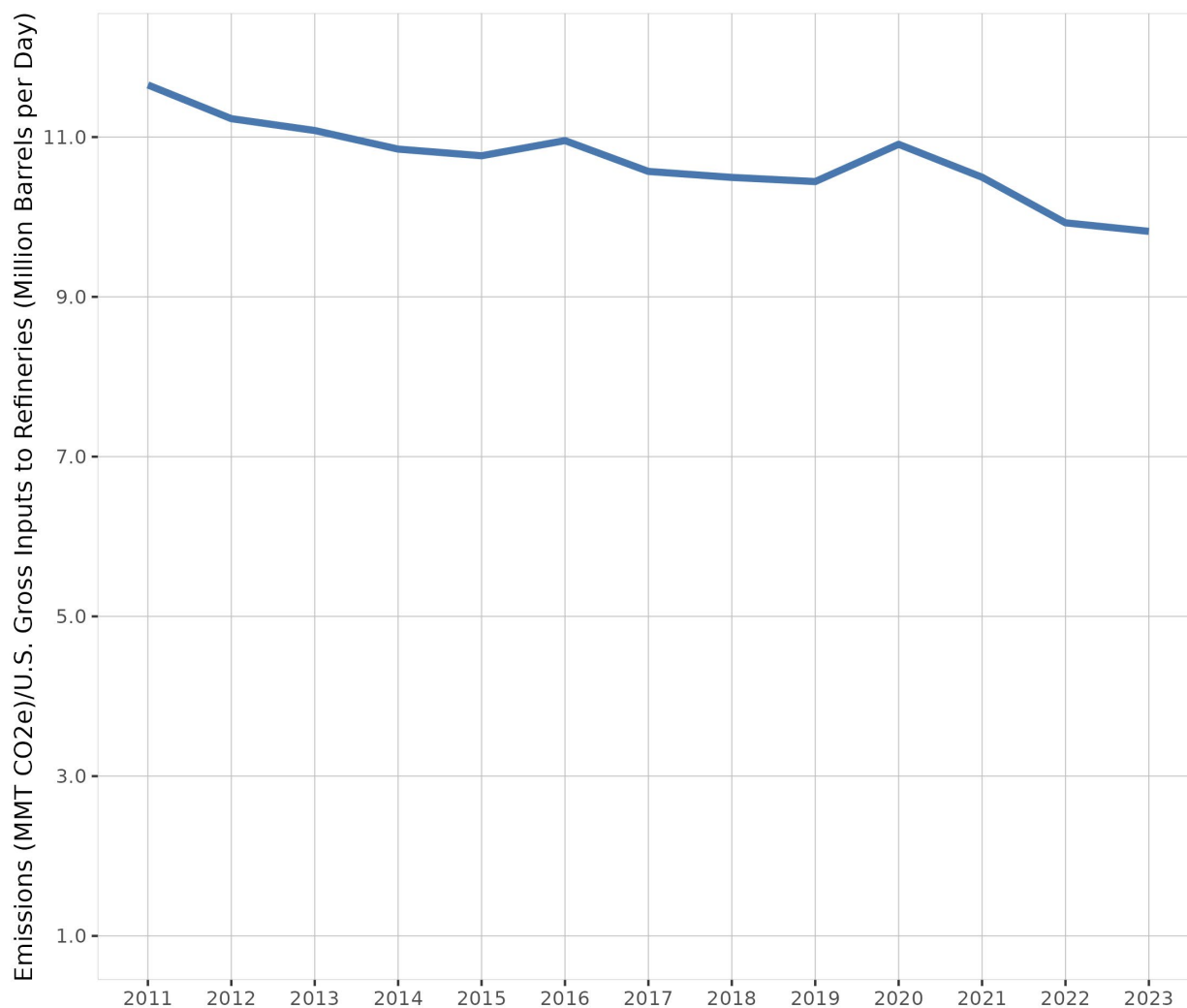
<sup>5</sup> U.S. Energy Information Administration, *Refinery Utilization and Capacity* (accessed September 27, 2024) at: [http://www.eia.gov/dnav/pet/pet\\_pnp\\_unc\\_dcu\\_nus\\_a.htm](http://www.eia.gov/dnav/pet/pet_pnp_unc_dcu_nus_a.htm).

<sup>6</sup> U.S. Energy Information Administration, *U.S. Refinery Net Production* (accessed September 27, 2024) at: [http://www.eia.gov/dnav/pet/pet\\_pnp\\_ref2\\_dc\\_nus\\_mbb1\\_a.htm](http://www.eia.gov/dnav/pet/pet_pnp_ref2_dc_nus_mbb1_a.htm).

<sup>7</sup> U.S. Energy Information Administration, *U.S. Refinery Net Production* (accessed September 27, 2024) at: [http://www.eia.gov/dnav/pet/pet\\_pnp\\_ref2\\_dc\\_nus\\_mbb1\\_a.htm](http://www.eia.gov/dnav/pet/pet_pnp_ref2_dc_nus_mbb1_a.htm).

<sup>8</sup> U.S. Energy Information Administration, *Refinery Utilization and Capacity* (accessed September 27, 2024) at: [http://www.eia.gov/dnav/pet/pet\\_pnp\\_unc\\_dcu\\_nus\\_a.htm](http://www.eia.gov/dnav/pet/pet_pnp_unc_dcu_nus_a.htm).

**Figure 4: Normalized Emissions Per Gross Input to Petroleum Refineries (2011 - 2023)<sup>a</sup>**



<sup>a</sup> EIA data source: <https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mgirius2&f=a>.

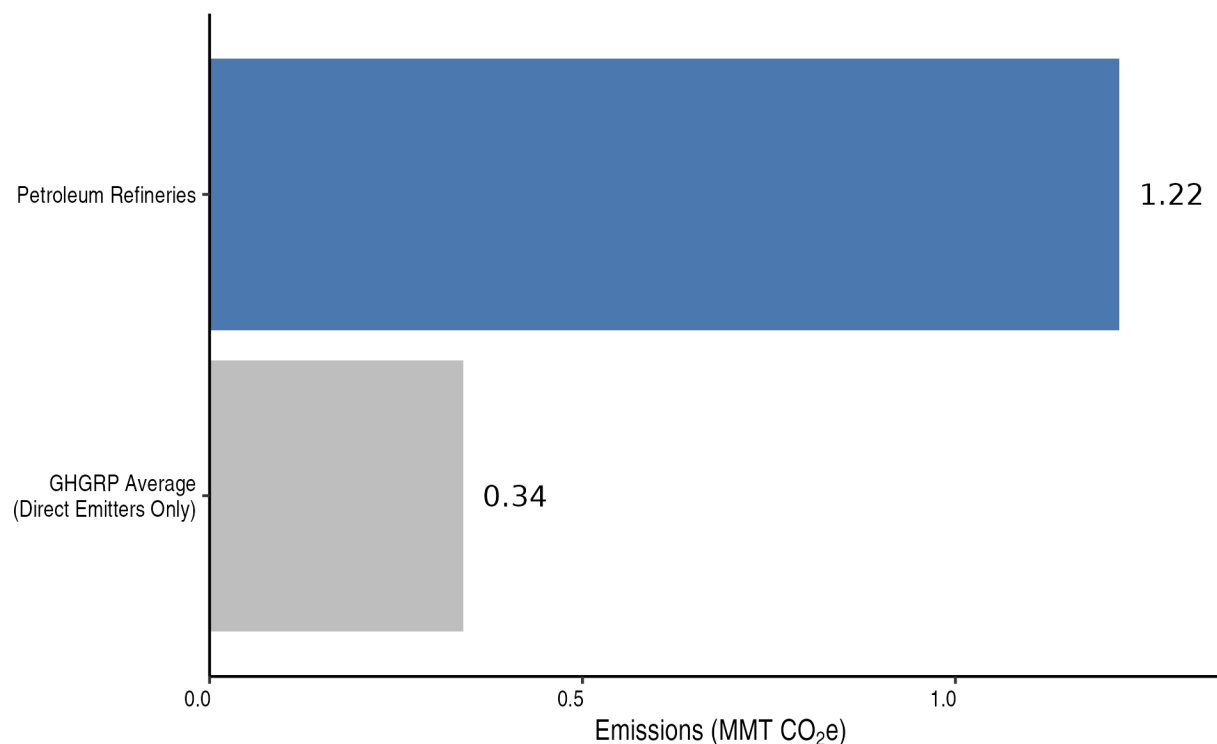
**Table 5: Petroleum Refineries Sector - Emissions by GHG (MMT CO<sub>2</sub>e)**

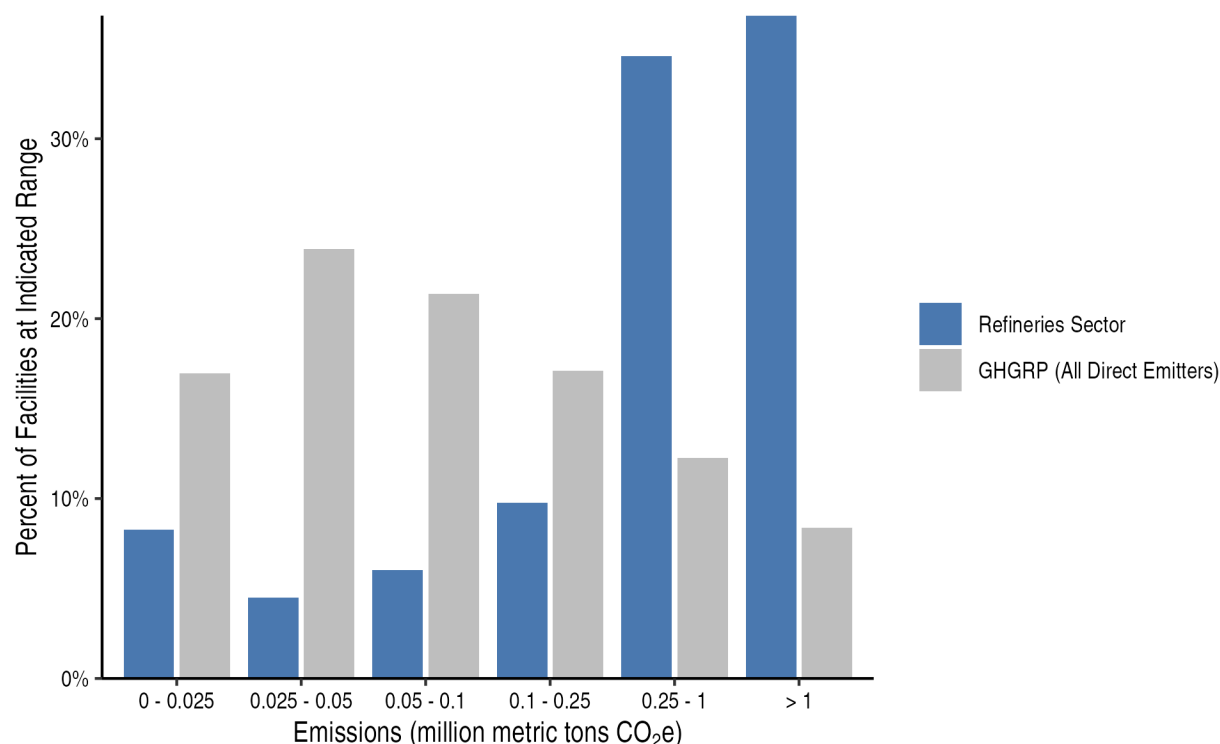
Petroleum Refineries Sector	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Carbon Dioxide	176.8	171.3	173.0	174.0	175.6	179.6	177.3	180.4	176.0	159.4	163.3	162.4	160.9
Methane	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.8	0.8	0.8	0.7
Nitrous Oxide	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.4

### Average and Range of Emissions per Reporter

Figure 5 shows the average emissions per reporter for the Petroleum Refineries Sector compared with the average emissions per reporter for all GHGRP direct emitters. The Petroleum Refineries Sector is the highest ranked sector in terms of GHG emissions per facility, with an average of 1.22 MMT CO<sub>2</sub>e, just overtaking the Power Plants Sector. Figure 6 and Table 6 display the percentage and numbers of facilities reporting at different emission ranges, respectively. Figure 6 additionally shows a comparison to the GHGRP overall. Figure 6 shows a larger percentage of refineries reporting emissions in higher emission ranges than those reported by all GHGRP direct emitters.

**Figure 5: Average Emissions per Reporter from the Petroleum Refineries Sector (2023)**



**Figure 6: Percentage of Facilities in the Petroleum Refineries Sector by Emission Ranges (2023)****Table 6: Petroleum Refineries Sector - Number of Reporters by Emission Ranges (MMT) (2023)**

Petroleum Refineries Sector	0 - 0.025	0.025 - 0.05	0.05 - 0.1	0.1 - 0.25	0.25 - 1	> 1
Total refineries sector	11	6	8	13	46	49

## Calculation Methods Used

### Emission Calculation Methodology from Stationary Fuel Combustion Units

For fuel combustion emissions, facilities must generally follow the applicable tier methodology prescribed in Subpart C (general stationary fuel combustion sources) to calculate CO<sub>2</sub>, methane, and nitrous oxide emissions. However, the Petroleum Refineries Sector has more stringent requirements for fuel gas, and thus the vast majority of fuel gas combustion emissions have to be calculated using Subpart C's Tier 3 calculation methodology. The calculation methodologies for Subpart C are explained [here](#).

### Emission Calculation Methodologies for Process Emission Sources

*Process vents.* The major source of process vent emissions at petroleum refineries – catalytic cracking, fluid coking, and catalytic reforming units – have the following options for calculating CO<sub>2</sub> emissions:

- **CEMS** - Operate a CEMS in the final exhaust stack.
- **Monitoring** – Large catalytic cracking units and fluid coking units must monitor exhaust gas oxygen, CO<sub>2</sub>, and, if necessary, CO concentrations continuously, or no less frequently than hourly, prior to the combustion of other fossil fuels. Catalytic reforming and smaller (i.e., less than 10,000 barrels per stream day) catalytic cracking and fluid coking units have the option to measure these parameters at least daily or use an emission factor (see below).
- **Emission factor** - Catalytic cracking units and fluid coking units with rated capacities less than 10,000 barrels per stream day can calculate emissions using a coke burn-off factor and the carbon content of the coke (either the measured or default value). Catalytic reforming units, regardless of size, can also use a coke burn-off factor.

*Other process emission sources.* The calculation methodologies include direct measurements, engineering calculations, process knowledge, and emission factors.

## Data Verification and Analysis

As a part of the reporting and verification process, EPA evaluates annual GHG reports with electronic checks. EPA contacts facilities regarding potential reporting issues and facilities resubmit reports as errors are identified. Additional information on EPA's verification process is available [here](#).

As discussed above, EPA also used an outside dataset from the Department of Energy's EIA to evaluate emissions reported to the GHGRP. This dataset may be accessed [here](#).

## Glossary

**CEMS** means continuous emissions monitoring system.

**CO<sub>2</sub>e** means carbon dioxide equivalent, which is a metric used to compare the emissions from various GHGs based upon their GWP. The CO<sub>2</sub> for a gas is calculated by multiplying the tons of the gas by the associated GWP.

**Direct emitters** are facilities that combust fuels or otherwise put GHGs into the atmosphere directly from their facility. Alternatively, suppliers are entities that supply certain fossil fuels or fluorinated gases into the economy that – when combusted, released, or oxidized – emit GHGs into the atmosphere.

**Distillate fuel oil** means a classification for one of the petroleum fractions produced in conventional distillation operations and from crackers and hydrotreating process units. The generic term “distillate fuel oil” includes kerosene, kerosene-type jet fuel, diesel fuels (No. 1, No. 2, and No. 4), and fuel oils (No. 1, No. 2, and No. 4).

**FLIGHT** refers to EPA's GHG data publication tool, named the Facility Level Information on Greenhouse Gases Tool (<http://ghgdata.epa.gov>).

**Fuel gas** means gas that is generated as a byproduct at a petroleum refinery or petrochemical plant and that is combusted separately or in combination with any type of gas.

**GHGRP** means EPA's Greenhouse Gas Reporting Program (40 CFR Part 98).

**GHGRP vs. GHG Inventory:** EPA's Greenhouse Gas Reporting Program (GHGRP) collects and disseminates annual GHG data from individual facilities and suppliers across the U.S. economy. EPA also develops the annual Inventory of U.S. Greenhouse Gas Emissions and Sinks (GHG Inventory) to track total national emissions of GHGs to meet U.S. government commitments to the United Nations Framework Convention on Climate Change. The GHGRP and Inventory datasets are complementary; however, there are also important differences in the data and approach. For more information, please see <https://www.epa.gov/ghgreporting/greenhouse-gas-reporting-program-and-us-inventory-greenhouse-gas-emissions-and-sinks>.

**IPCC AR4** refers to the Fourth Assessment Report by the Intergovernmental Panel on Climate Change. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K. and A. Reisinger (eds.)]. IPCC, Geneva, Switzerland, 2007. The IPCC AR4 values also can be found in the current version of Table A-1 in Subpart A of 40 CFR Part 98.

**MMT** means million metric tons.

**Naphtha** is a generic term applied to a petroleum fraction of crude oil that is the raw material for gasoline.

**Petroleum products** mean all refined and semi-refined products that are produced at a refinery by processing crude oil and other petroleum-based feedstocks, including petroleum products derived from co-processing biomass and petroleum feedstock together, but not including plastics or plastic products. Petroleum products may be combusted for energy use, or they may be used either for non-energy processes or as non-energy products. Fuel gas is included in the petroleum product fuel category for all sectors other than petrochemical production. For petrochemical production, fuel gas is classified separately.

**Residual fuel oil** refers to fuel oils No. 5 and No. 6.