

PETROLEUM REFINERIES SECTOR

Highlights

- The Petroleum Refineries Sector is the third largest greenhouse gas (GHG) emitting industrial sector among stationary sources behind Power Plants and Petroleum and Natural Gas Systems.
- The Petroleum Refineries Sector is the second highest ranked sector in terms of GHG emissions per facility, with an average of 1.22 million metric tons of carbon dioxide equivalent (MMT CO₂e), behind only the Power Plant Sector.
- The largest source of emissions in the Refineries Sector is stationary fuel combustion, representing about two-thirds of GHG emissions in 2013.
- Emissions from this sector increased by approximately 1.5 percent from 2012 to 2013. Two facilities had significantly higher emissions; one due to a recent expansion and the other due to re-starting after being idled during 2012.

All emissions presented here are as of 8/18/2014 and exclude biogenic CO₂. All GHG emissions data displayed in units of carbon dioxide equivalent (CO₂e) reflect the global warming potential (GWP) values from [IPCC AR4](#).

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 refining processes emit GHGs from venting, flares, and fugitive leaks from equipment (e.g., valves, flanges, and 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 carbon dioxide.

Who Reports?

In 2013, 145 facilities in the Petroleum Refineries Sector reported GHG emissions of 176.7 MMT CO₂e. The Refinery Sector reflects 1.8% of the facilities reporting direct emissions to the GHGRP. In 2013, the Petroleum Refineries sector represented 2.7% of total U.S. GHG emissions.¹

Table 1: Petroleum Refineries Sector – Reporting Schedule by Subpart

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

¹ The total U.S. GHG emissions are 6,525.6 MMT CO₂e as reported in the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012. U.S. Environmental Protection Agency. April 15, 2014. EPA 430-R-14-003..

Table 2: Petroleum Refineries Sector – Number of Reporters (2011–2013)

Petroleum Refineries Sector	Number of Reporters		
	2011	2012	2013
Petroleum Refineries	149	147	145

Table 3: Petroleum Refineries Sector – GHGRP Coverage (as of Reporting Year 2012)

Source Category	GHGRP Coverage of Industry	Estimated Percent of Industry Facilities Covered by GHGRP	Estimated Percent of Industry Emissions Covered by GHGRP
Petroleum Refineries	All facilities	100%	100%

Reported Emissions

Table 4: Petroleum Refineries Sector – Emissions (2011–2013)

Sector	Emissions (MMT CO ₂ e)		
	2011	2012	2013
Petroleum Refineries	178.3	174.0	176.7

Reported Process Emission Sources

The largest sources of GHG emissions at petroleum refineries are stationary fuel combustion units (e.g. steam boilers, process furnaces, and process heaters). The Petroleum Refineries Sector also reports process emissions from catalytic cracking units, fluid coking units, delayed coking units, catalytic reforming units, coke calcining units, asphalt blowing operations, blowdown systems, storage tanks, equipment leaks, loading operations, flares, and sulfur recovery plants. The chart below shows total reported emissions from these processes and fuel combustion.

Figure 1: Petroleum Refineries Sector – Emissions by Source (2013)^{a,b}

- ^a Emissions from Fuel Combustion are defined here as emissions reported under Subpart C. Emissions from other process are reported under Subpart Y.
- ^b “Other Sources” includes 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.

Table 5: Petroleum Refineries – Emissions from Fuel Combustion and Other Processes^{a,b,c}

Fuel Type	Total Reported Emissions (MMT CO ₂ e)		
	2011	2012	2013
Fuel Combustion	120.5	117.1	120.1
Process Emissions	57.2	56.9	56.6
Sorbent ^d	**	0	0

- ^a Emissions from Fuel Combustion are defined here as emissions reported under Subpart C. Emissions from other process are reported under Subpart Y.
- ^b Emission values presented may differ slightly from other publicly available GHGRP data due to minor differences in the calculation methodology.
- ^c Does not include sorbent emissions monitored by CEMS.
- ** Total reported emissions are less than 0.05 MMT CO₂e.

The predominant fuel used by refineries is fuel gas, which is a byproduct off-gas from refining processes that is captured and used as a fuel.

Table 6: Petroleum Refineries Sector – Combustion Emissions by Fuel Type^a

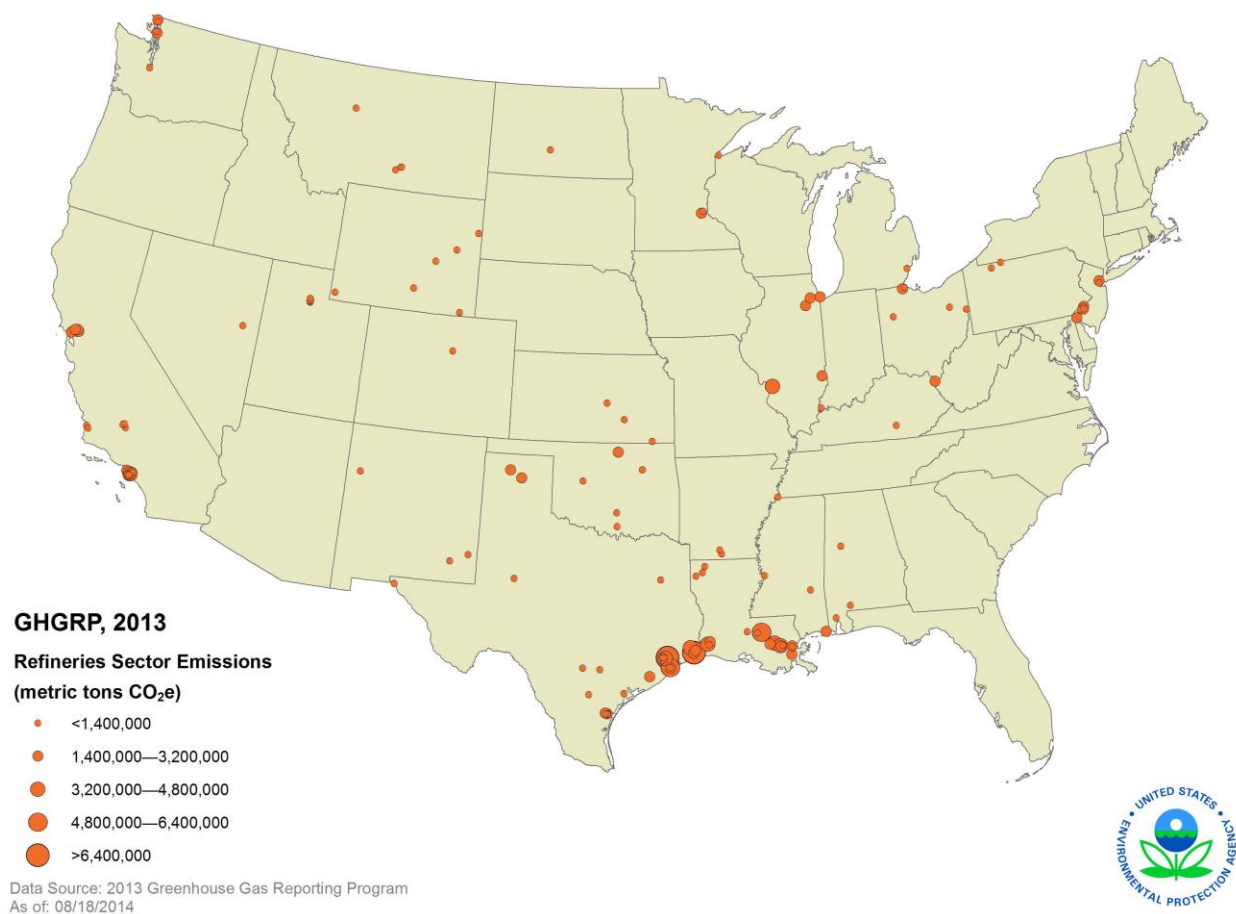
Fuel Type	Total Reported Emissions (MMT CO ₂ e) ^b		
	2011	2012	2013
Coal	0.1	0.1	0.1
Natural Gas	20.7	20.3	22.0
Petroleum Products	99.7	96.7	98.1
Other Fuels ^c	**	**	**

^a In cases where CO₂ emissions were reported at the unit level (i.e. CEMS-monitored sources), fuel level CO₂ emissions were calculated by EPA based on other data directly reported by facilities, as well as default emission factors.

^b The sum of the individual fuels might not match the total due to individual rounding.

^c Excludes biogenic CO₂.

** Total reported emissions are fewer than 0.05 MMT CO₂e.

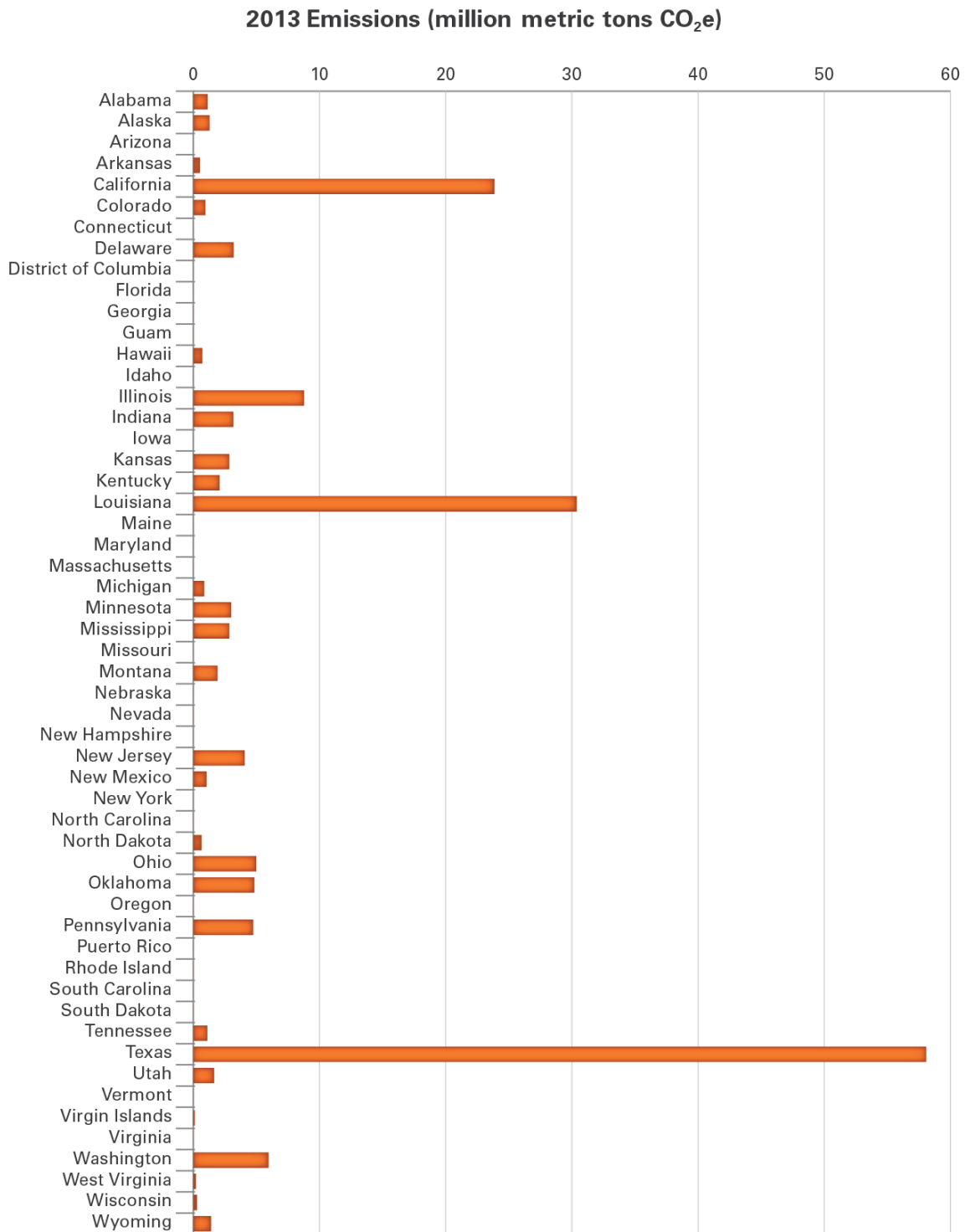
Figure 2: Location and Emissions Range for Each Reporting Facility in the Petroleum Refineries Sector (as of 8/18/14)

This map shows the locations of direct-emitting facilities. The size of a circle corresponds to the quantity of emissions reported by that facility. There are also petroleum refineries located in Alaska, Hawaii, and Puerto Rico 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 Greenhouse Gases (FLIGHT) website (<http://ghgdata.epa.gov>).

Figure 3: Petroleum Refineries Sector – Emissions by State (2013)

DIRECT EMISSIONS BY STATE FROM THE REFINERIES SECTOR



[Click here to view the most current information using FLIGHT.](#)

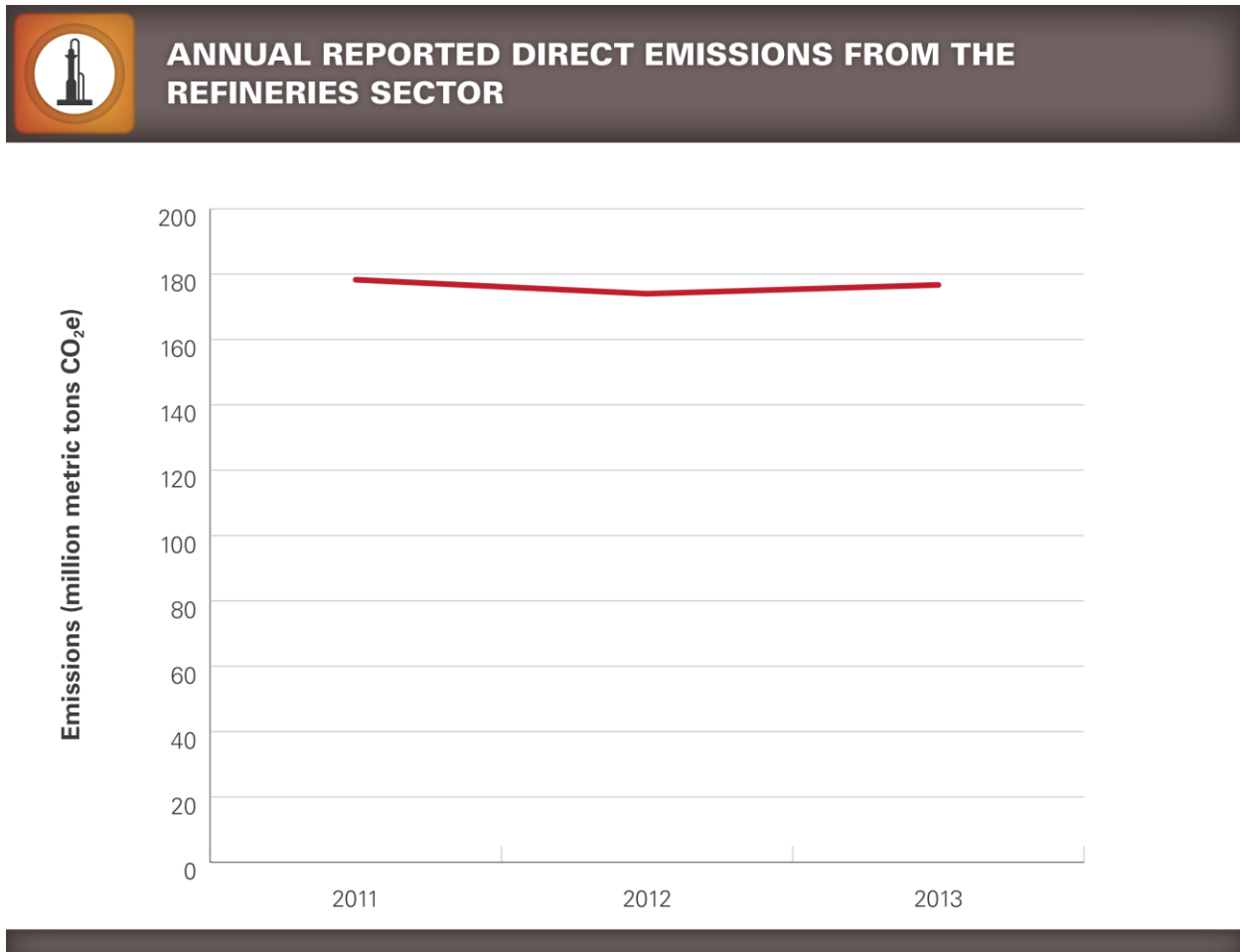
Petroleum Refineries Sector: Emissions Trends 2012 to 2013

Emissions in the Petroleum Refineries Sector increased by approximately 1.5% from 2012 to 2013, even though there were two fewer reporters. Two facilities had large emission increases that, combined, were greater than the total sector-wide increase from 2012 to 2013. One facility completed its first full year of operations after finishing a significant expansion. Another resumed operations in 2013 after being idled and experiencing a subsequent ownership change in 2012.

Petroleum Refineries Sector: Longer-Term Emissions Trends

Emissions in the Petroleum Refineries Sector have remained in a relatively narrow range from 2010 to 2013, as has the number of reporting facilities. The fewest number of reporters occurred in 2013, with 145, and the largest number occurred in 2011, with 149. Emissions have ranged from a low of 174.0 MMT CO₂e in 2012 to a high of 178.3 MMT CO₂e in 2011. A long-term trend in the petroleum refining industry is that the number of facilities has steadily declined while production and operating capacity have remained fairly constant. The declining number of facilities points to a steadily increasing average refinery capacity, as the result of expansions at existing refineries over time.

Figure 4: Petroleum Refineries Sector – Emissions Trend (2011–2013)



[Click here to view the most current information using FLIGHT.](#)

Table 7: Petroleum Refineries Sector – Emissions by GHG (MMT CO₂e)^a

Petroleum Refineries Sector	Reporting Year		
	2011	2012	2013
Number of facilities	149	147	145
Total emissions (MMT CO ₂ e)	178.3	174.0	176.7
Emissions by GHG			
Carbon dioxide (CO ₂)	177.0	173.0	175.0
Methane (CH ₄)	0.9	0.9	1.0
Nitrous oxide (N ₂ O)	0.5	0.5	0.5

^a Totals may not sum due to independent rounding.

Figure 5: Petroleum Refineries Sector – Average Emissions per Reporter (2013)



AVERAGE EMISSIONS PER REPORTER FROM THE REFINERIES SECTOR

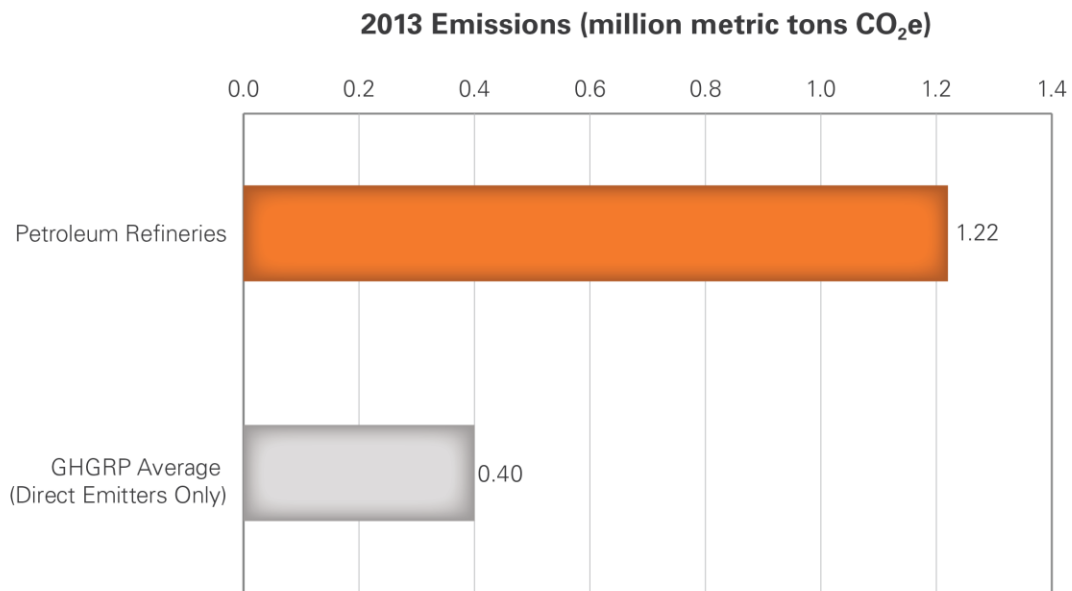


Figure 6: Petroleum Refineries Sector – Percentage of Reporters by Emissions Range (2013)

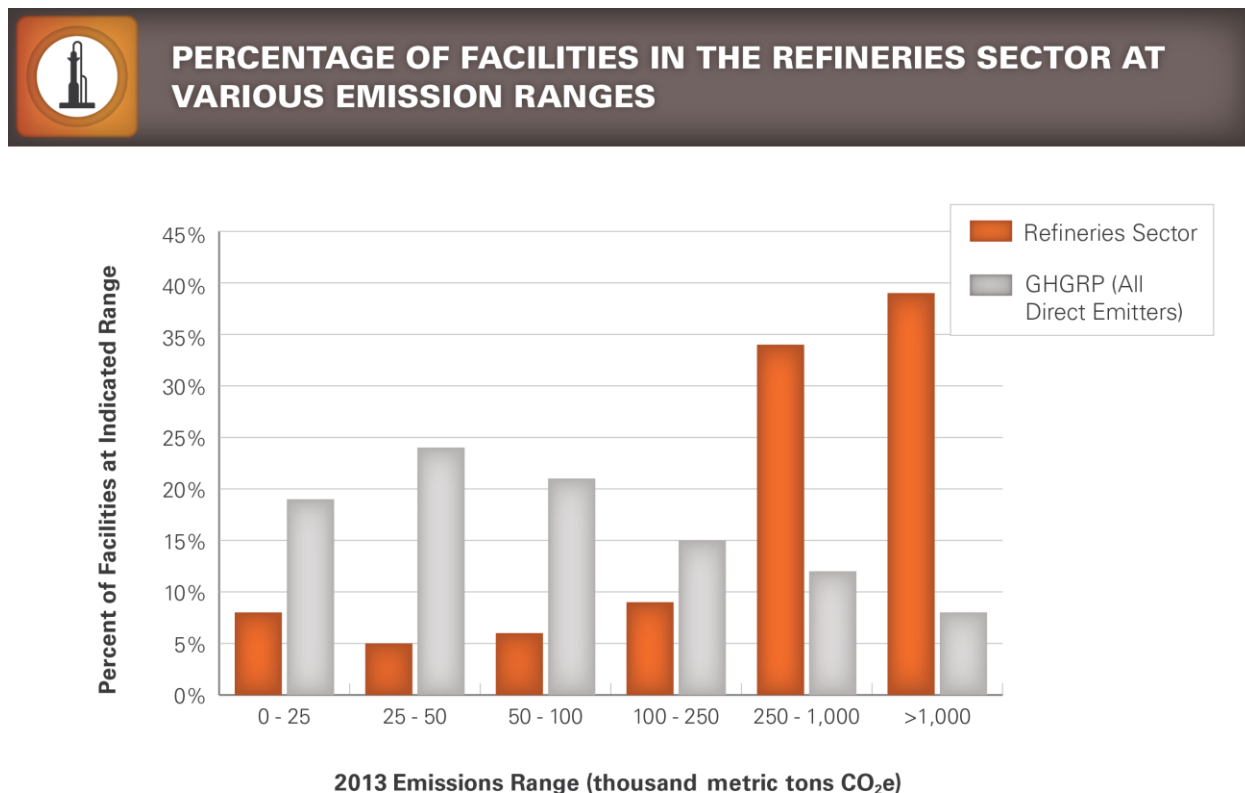


Table 8: Petroleum Refineries Sector – Number of Reporters by Emissions Range (2013)

Petroleum Refineries Sector	Emissions Range (MMT CO ₂ e)					
	0 - 0.025	0.025 - 0.05	0.05 - 0.1	0.1 - 0.25	0.25 - 1	> 1
Total Refineries Sector	11	7	8	13	49	57

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 CO₂, CH₄, and N₂O 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 Emissions 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 CO₂ emissions:

- **CEMS** – Operate a CEMS in the final exhaust stack.
- **Monitoring** – Large catalytic cracking units and fluid coking units must monitor exhaust gas O₂, CO₂, 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 (bbls/sd) 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 bbls/sd can calculate emissions using a coke burn-off factor and the carbon content of the coke (either 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.

Table 9: Petroleum Refineries Sector Emission Calculation Methodologies

Type of Emissions	Methodology	Percent of Emissions Monitored by Method (by Type)		
		2011	2012	2013
Process Emissions	CEMS	15.6%	17%	16.0%
	Measurement data	74.6%	72.5%	71.9%
	Engineering estimates or emission factors	9.8%	10.5%	12.1%
Combustion Emissions	CEMS (Tier 4) ^a	0.2%	0.2%	0.3%
	Measured carbon content, and, if applicable, molecular weight (Tier 3)	84.3%	84.1%	83.8%
	Measured high heating values (HHVs) and default emission factors (Tier 2)	12.4%	13.0%	13.1%
	Default HHVs and emission factors (Tier 1)	3.1%	2.7%	2.8%

^a CEMS emissions include CO₂ from fossil fuel combustion and, if applicable, CO₂ from sorbent.

Best Available Monitoring Methods (BAMM)

During the first year that the GHGRP applied, facilities were allowed for most source categories to optionally use a best available monitoring method (BAMM) to determine emissions inputs for specific emissions sources for a limited amount of time. The use of BAMM was allowed because it was not always feasible for a newly subjected facility to acquire, install, and operate all of the required monitoring equipment by the date required by the GHGRP. EPA's BAMM provision provided time for these facilities to replace their equipment in a way that could minimize impacts to normal business operations. Refineries were automatically eligible to use BAMM from January 1, 2010 through March 31, 2010. [Learn more about BAMM.](#)

Refineries were required to follow applicable monitoring and QA/QC requirements beginning on April 1, 2010, unless EPA approved a BAMM extension. Petroleum refineries are eligible to apply to use BAMM through December 31, 2015.

Table 10: Petroleum Refineries Sector – Percent of Facilities Using BAMM (2011–2013)

BAMM Use	2011	2012	2013
Petroleum Refineries Sector	12%	6%	1%

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](#).

The EPA also used an outside data set from the Department of Energy's Energy Information Administration (EIA) to evaluate emissions reported to the GHGRP. This dataset may be accessed [here](#). Specifically, the U.S. Gross Inputs to Refineries data observed a 2.2% increase in the daily average atmospheric crude input from 2012 to 2013. This compares favorably to the 1.5% emissions increase from this sector over the same time period.

GLOSSARY

BAMM means Best Available Monitoring Methods. Facilities approved for BAMM may use best available monitoring methods for any parameter (e.g., fuel use, feedstock rates) that cannot reasonably be measured according to the monitoring and QA/QC requirements of a relevant subpart.

CEMS means continuous emissions monitoring system.

CO₂e means carbon dioxide equivalent, which is a metric used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). The carbon dioxide equivalent 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 greenhouse gases 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 greenhouse gases 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 (Diesel Fuels No. 1, No. 2, and No. 4), and fuel oils (Fuel Oils No. 1, No. 2, and No. 4).

FLIGHT refers to EPA's GHG data publication tool, named 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 greenhouse gas 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 greenhouse gases to meet U.S. government commitments to the United Nations Framework Convention on Climate Change. The GHGRP and Inventory datasets are complementary and may inform each other over time. 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 Reisinger, A. (eds)]. IPCC, Geneva, Switzerland, 2007. The 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.

NAICS means the North American Industry Classification System, the standard used by federal statistical agencies to classify business establishments into industrial categories for collecting and publishing statistical data related to the U.S. economy.

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

Petroleum products means 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.