Air Pollution from Oil Refineries with Outdated Boilers and Heaters

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The United States is home to 132 petroleum refineries that convert crude oil into various products, including gasoline, fuel oil, and chemicals used for industry.[1] Refineries depend on heat systems like heaters, boilers, and furnaces to power their operations, but unfortunately many of these systems in the refinery industry are badly outdated and inefficient. Outdated boilers and heaters are a threat to public health and the climate because they can release more greenhouse gases and health-damaging air pollution than newer and more efficient systems. Companies should invest in more modern and efficient heat systems – not just to improve their long-term financial health, but to improve the health of downwind communities and ensure a livable climate for future generations.

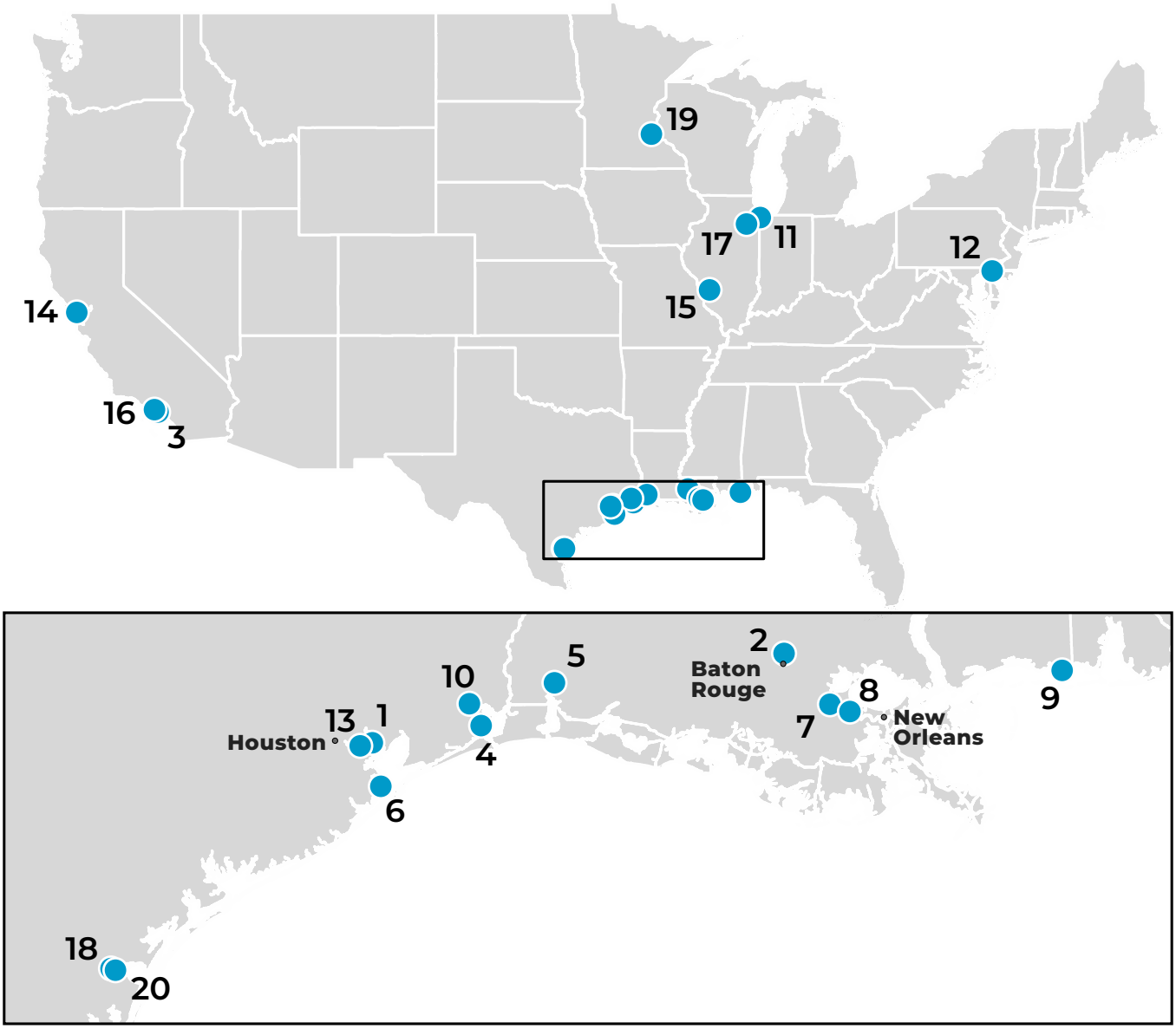
The Environmental Integrity Project (EIP) examined publicly available data and records for the 20 petroleum refineries in the U.S. that reported emitting the most greenhouse gases in 2023. We found that, out of the refinery boilers and heaters with age information, 87 percent of these units (739 of 845) are outdated. While experts have concluded that boilers and heaters work most efficiently when they are 15 years old or younger, the average age of the heating systems in the largest refineries is more than 40 years old, with some dating back to World War II.

About 87 percent of the heaters and boilers at America's largest oil refineries are outdated. This is a problem because outdated heating systems often produce more air pollution. Shown here is the ExxonMobil Baytown Refinery east of Houston. Photo by Garth Lenz/Flight SouthWings

Not surprisingly, antiquated industrial systems can cause major pollution problems and serious health threats. Almost a third of the largest refineries (six of 20) have been flagged by EPA as having an unresolved "high priority violation" of the Clean Air Act for at least the last three years, according to EPA's Enforcement and Compliance History Online database.[2] These violations often harm lower income neighborhoods and people of color living near the industry, with 70 percent of the refineries (14 of 20) located in what EPA considered disadvantaged communities, according to EPA's Environmental Justice screening tool.[3]

Overall, the 20 refineries we examined released more than 82 million metric tons of greenhouse gases in 2023, as much as 22 coal-fired power plants operating around the clock, or 19 million cars and trucks running for a year.[4] These refineries also reported emitting 80,981 tons of health-damaging "criteria" air pollutants (including microscopic soot particles that can trigger asthma and heart attacks) in 2020; and 6.9 million pounds of hazardous air pollutants (some of which, like benzene, are carcinogens). An estimated 43 percent of criteria pollutants, 16 percent of greenhouse gases, and five percent of hazardous air pollutants came from the heaters, boilers, or furnaces at the refineries, and this is likely an underestimate due to gaps in publicly available data. See Table 3 for a list of refineries and their emissions.

The 20 U.S. Refineries with the Largest Greenhouse Gas Emissions in 2023



Background

EIP created a unit-level inventory of heaters, boilers, and furnaces at the 20 refineries that reported the most greenhouse gas pollution to EPA in 2023. The following analysis is based on a review of Clean Air Act permit documents and EPA emission data.

We found that two-thirds of the refineries (13 of the 20) are located in areas with unsafe levels of smog or ground-level ozone. These are called ozone "nonattainment areas" under the Clean Air Act. Ozone forms when nitrogen oxides and volatile organic compounds react with sunlight, and exposure to unsafe levels has been linked to respiratory problems, such as shortness of breath, asthma attacks, and increased risk of respiratory infections.[5] Plants in nonattainment areas are required to take additional measures to reduce pollution.

Three refineries are also located in areas that fail to meet health standards for particulate matter, and two are in areas with unsafe levels of lead in the air. One of these refineries (Motiva's Port Arthur Refinery in East Texas) is exceeding EPA's "action level" for benzene, a carcinogen, as measured by air monitors placed along the fenceline of the facility.[6] When companies exceed the "action level" for benzene, they are required by federal regulations to conduct an analysis to find the source of the pollution and then take action to clean it up.

Refineries are complex facilities. They have many processes and emission sources, including heaters, boilers, furnaces, flares, vents, tanks, thermal oxidizers, wastewater treatment systems, and a multitude of valves and flanges that can leak gases into the air. They also produce waste gases, often called refinery gas, that consists of methane and ethane and is often used as an additional fuel source.

The Motiva Port Arthur refinery in East Texas had levels of benzene, a carcinogen, detected at its fence line that exceeded EPA's "action level." Photo by Garth Lenz/ Flight SouthWings

Our analysis focused on the heaters, boilers, and furnaces at refineries. We examined this equipment at the unit level within refineries to identify inefficiencies and opportunities for improvement. Upgrading these workhorse systems — including by adopting modern heat technologies where feasible or replacing old equipment — can significantly reduce climate and health harming emissions and improve overall efficiency.[7]

In total, EIP identified 1,182 heaters, boilers, and furnaces at the 20 refineries we studied. 739 of those units are considered outdated (meaning more than 15 years old). Five hundred and eighty-two of them—or 69 percent of the units with age information—have a maximum heat input capacity below 240 million British thermal units per hour (MMBtu/hr) and depending on the heat output needed, could be replaced with more modern and efficient equipment that reduces pollution. At 14 refineries, at least 50 percent of their units are outdated and fit into this category.

Most of the units across these refineries burn either natural gas and/or various types of refinery gasses labeled as waste gas, fuel gas, or process gas. A small number of units burn oil in addition to natural and refinery gasses. Should refineries begin to electrify more of their operations as a way of reducing their environmental footprint, they will need to consider options for managing excess waste gas. Since fuel gas is mostly ethane and methane, there are other industrial processes in which these gases can be used as ingredients, including ethane "cracking" to create petrochemicals.[8]

Health-Harming Air Pollution

Together, these 20 refineries released 80,981 tons of criteria air pollutants and precursors in 2020, according to EPA's National Emissions Inventory. Criteria air pollutants include six common pollutants—ozone, particulate matter, carbon monoxide, lead, sulfur dioxide, and nitrogen dioxide—for which the EPA has established National Ambient Air Quality Standards. Combined, furnaces, boilers, and heaters represent the largest sources of criteria air pollutants at refineries, followed by unclassified sources (28 percent) and fugitive emissions (5 percent). EIP was able to determine criteria air pollutant and hazardous air pollutant emissions for individual heaters and boilers at 18 of the top 20 refineries.[9] While we weren't able to collect emissions data for all units, we were able to identify emissions from 66 percent of boilers and heaters across the 20 facilities. Seven hundred and eighty-four of the 1,182 units EIP identified across these refineries released around 34,900 tons of criteria air pollutants—43 percent of the total from the top 20 refineries.

Table 1. Tons of Criteria Air Pollutants Emitted by Source at Refineries

Source of Pollution	Tons of Pollutants Emitted
Boilers, Heaters, and Furnaces	34,872 (43%)
Unclassified	22,675 (28%)
Fugitive Emissions	4,049 (5%)
Total	80,981

Source: 2020 National Emissions Inventory

Refineries also emit hazardous air pollutants, which pose serious health risks and include carcinogens like benzene, 1,3-butadiene, and formaldehyde. In 2020, the top 20 refineries reported emitting 6.9 million pounds of hazardous pollutants. The same universe of 782 heaters and boilers only attributed to seven percent—or 480,188 pounds—of refinery hazardous air pollutant emissions. Fugitive sources accounted for 20 percent, storage tanks for 21 percent, and unclassified sources for 38 percent of total hazardous air pollutant emissions. These emissions are often underreported.[10]

Climate-Warming Air Pollution

In 2023, petroleum refining was the fourth largest source of greenhouse gases among all the industrial categories in EPA's Greenhouse Gas Reporting Program. Refining accounting for six percent – 162 million metric tons – of all greenhouse gases reported that year, and the top 20 refineries were responsible for over half of the emissions from the entire refinery sector. Approximately 16 percent (13.2 million metric tons) of the greenhouse gas emissions from these refineries could be traced back to heaters or boilers, though this is an underestimate because unit level emissions data was not always available. At 11 refineries, EIP couldn't separate boiler and heater emissions from other GHGRP-reported sources. At five others, we could only isolate emissions for a third or fewer of the units. Only four refineries reported unit-level data for 65 percent or more of their boilers and heaters.

There are several ways refineries can reduce health-harming and greenhouse gas emissions from their heaters and boilers. These include the replacement of old equipment with newer and more fuel-efficient models, improved combustion systems, and the insulation of boilers.[11] Today, industrial heat pumps can also be installed as a cleaner and more energy-efficient alternative to traditional boilers and heaters powered by fossil fuels. According to a 2024 report from the American Council for an Energy-Efficient Economy, many low-capacity boilers—those with heat input ratings under 240 MMBtu per hour—could be substituted with heat pump systems that are commercially available.[12] For larger boilers and heaters, refineries could, at the very least, replace their older units with newer, more efficient models that release less air pollution and greenhouse gases. A challenge in the refinery sector is the energy density required for some processes, like crude oil distillation, which requires temperatures up to 1000 degrees Fahrenheit.[13] These types of processes remain challenging to electrify with the technology currently available.[14]

Table 2. Top 20 Refineries that Reported Releasing the Most Greenhouse Gases in 2023

Refinery (State)	State	2023 Greenhouse Gas Emissions (metric tons)	No. of Outdated Heaters and Boilers	Clean Air Act Compliance Status	Regional Air Quality Attainment Status
ExxonMobil – Baytown Refinery	TX	12,627,474	83 of 125	High Priority Violation	Non-Attainment: Ozone
ExxonMobil - Baton Rouge Refinery and Chemical Plant	TX	5,873,304	46 of 51	No Violation Identified	Non-Attainment: Ozone
Marathon - Los Angeles Refinery	CA	5,225,209	46*	High Priority Violation	Non-Attainment: Ozone; Lead; PM 2.5
Motiva Enterprises - Port Arthur Refinery	TX	5,015,249	65 of 95	Violation within 1 Year	Non-Attainment: Ozone
CITGO - Lake Charles Refinery	LA	4,476,976	51 of 61	No Violation Identified	In Attainment
Marathon - Galveston Bay Refinery	TX	4,242,743	14 of 118	High Priority Violation	Non-Attainment: Ozone
Marathon - Garyville Refinery	LA	4,207,065	39 of 48	No Violation Identified	In Attainment
Shell - Norco Manufacturing Complex	LA	4,091,456	18 of 23	No Violation Identified	In Attainment
Chevron - Pascagoula Refinery	MS	3,878,376	65 of 71	No Violation Identified	In Attainment
ExxonMobil - Beaumont Refinery	TX	3,878,315	50 of 64	No Violation Identified	Non-Attainment: Ozone
BP - Whiting Refinery	IN	3,788,135	55 of 59	High Priority Violation	Non-Attainment: Ozone
Premcor - Delaware City Refinery	DE	3,260,220	11 of 35	Violation within 1 Year	Non-Attainment: Ozone
Pemex - Deer Park Refinery	TX	3,230,829	33 of 56	Violation within 1 Year	Non-Attainment: Ozone
Chevron - Richmond Refinery	CA	3,141,245	42*	High Priority Violation	Non-Attainment: Ozone; PM 2.5
Phillips 66 - Wood River Refinery	IL	2,976,945	59 of 76	Violation within 1 Year	Non-Attainment: Ozone
Chevron - El Segundo Refinery	CA	2,632,447	43*	High Priority Violation	Non-Attainment: Ozone; Lead; PM 2.5

ExxonMobil - Joliet Refinery	IL	2,601,421	21 of 21	No Violation Identified	Non-Attainment: Ozone
Flint Hills Resources - Corpus Christi Refinery (West)	TX	2,486,742	42 of 55	Violation within 1 Year	In Attainment
Flint Hills Resources - Pine Bend Refinery	MN	2,405,885	50 of 57	Violation within 1 Year	In Attainment
Valero - Corpus Christi Refinery (West)	TX	2,342,349	34 of 38	Violation within 1 Year	In Attainment

***Note:** "Outdated" means more than 15 years old. The number of "outdated" units is a conservative estimate, given that the installation year is unknown for a number of units in this universe.
Source: EPA's Greenhouse Gas Reporting Program. Emissions are facility-wide, and measured in carbon dioxide equivalent tons (CO_2e). For refineries in California, EIP was unable to identify the installation date for the relevant units as that information is not collected by the state environmental agency.

Boilers, Heaters, and Furnaces

Boilers burn fuel to produce steam, which can then be used to generate energy or used as heat itself. Process heaters and furnaces directly create heat to vaporize petroleum fluids used in the refining process. Typical process heaters used in the refining process include crude oil heaters (which heat crude oil prior to distillation), cracking furnaces (which convert larger molecules into smaller molecules, usually with a catalyst), and a multitude of other process heaters. These units operate at high temperatures depending on their function—process heaters for vacuum distillation units typically reach 700 to 800 degrees Fahrenheit, while fluidized-bed catalytic cracking units require even higher temperatures, ranging from 880 to 980 degrees Fahrenheit.[15]

The largest boilers and heaters examined for this study were at the CITGO Lake Charles Refinery in Louisiana.

Using permit records and state and federal emission databases, EIP identified a total of 1,119 boilers, process heaters, and furnaces at the 20 refineries evaluated in this analysis. Since industrial heat is used in several components of crude oil refining, the number and size of units at a given facility varies greatly. The average number of units per refinery was 56, though the number of units at a single refinery ranged from 21 at the ExxonMobil Joliet refinery to 125 at the ExxonMobil Baytown refinery. At the refineries in our analysis, 980 of the units were furnaces, while 139 were boilers.

At individual refineries, the amount of pollution released by industrial boilers, heaters, and furnaces depends on several factors, including the size of the unit, the type of fuel used, and the unit's condition. Boiler and heater size is typically measured by maximum heat input capacity, measured in millions of British thermal units (MMBtu). Among the top-emitting refinery units, boiler sizes varied significantly from one facility to another. Of the 136 boilers with heat input capacity data available, the average heat input capacity was 367 MMBtu per hour,[16] and it ranged from 3 MMBtu per hour to 1,543 MMBtu per hour. The three largest boilers were all at the CITGO Lake Charles Refinery in Louisiana. More prevalent than boilers, the average heat input capacity for the 964 heaters and furnaces with data available was 145 MMBtu per hour, ranging

in size from 1 MMBtu per hour up to 2,530 MMBtu per hour.[17] Seventy-eight percent, or 864 out 1,100 heaters, boilers, and furnaces with heat input capacity data, were below 240 MMBtu/hr.

Boilers, heaters, and furnaces become less efficient as they age, releasing more pollution. Industry experts consider these units to be outdated after 15 to 20 years, though companies operate these units well past that timeline.[18] EIP was able to determine the age of 82 boilers and 750 heaters or furnaces. Six hundred and sixty-five heaters (89 percent) and 70 boilers (85 percent) at these 20 refineries could be considered outdated. The table below summarizes information about the age of boilers and heaters at the refineries evaluated in this analysis.

Table 3. Boiler, Heater, and Furnace Age

	Boilers	Heaters and Furnaces
Number with known ages	82	750
Percent older than 15 years old	85%	89%
Average Age	40	45
Earliest date installed	1948	1939

Conclusion

This analysis highlights an important opportunity for reducing air pollution and climate-warming emissions from the nation's most polluting refineries by modernizing outdated heaters, boilers, and furnaces. With over 700 units at the 20 refineries we examined past their expected operational lifespan—many operating at lower heat capacities—there is a technical basis for driving upgrades. These systems are responsible for a significant share of emissions, yet current data likely underestimates their full impact due to reporting gaps and limitations in available data.

Refineries cannot fully decarbonize overnight, especially for operations requiring extremely high temperatures. But targeted investments in cleaner, more efficient heat systems can deliver meaningful reductions in health-harming and climate-altering emissions. Prioritizing upgrades at the most outdated and polluting units, particularly in communities already burdened by unhealthy air, is a vital step towards a more responsible oil refining industry and protection of our climate and downwind communities.

Table 4. Detailed Emissions for the Top 20 Refinery Emitters

Map #	Location	Facility	Fuel Type(s)	Number of Outdated Heaters & Boilers	Facility Emissions		% From Heaters & Boilers (if known)	Air Compliance Status
1	Baytown, TX	ExxonMobil - Baytown Refinery [1]	Gaseous fuels, natural gas	83 out of 125 (42 unknown)	Greenhouse Gases (metric tons CO_2e):	12,627,474		High Priority Violation
					Criteria Air Pollution (tons):	8,221	42%	
					Hazardous Air Pollution (lbs):	946,695	2%	
2	Baton Rouge, LA	ExxonMobil - Baton Rouge Refinery and Chemical Plant [1]	Natural gas, refinery gas	46 out of 51 (4 unknown)	Greenhouse Gases (metric tons CO_2e):	5,873,304		No Violation Identified
					Criteria Air Pollution (tons):	5,270	76%	
					Hazardous Air Pollution (lbs):	425,784	20%	

Map #	Location	Facility	Fuel Type(s)	Number of Outdated Heaters & Boilers	Facility Emissions		% From Heaters & Boilers (if known)	Air Compliance Status
3	Carson, CA	Marathon - Los Angeles Refinery [1]	Refinery gas, natural gas, tail gas	46 [2] All unknown	Greenhouse Gases (metric tons CO_2e):	5,225,209	13%	High Priority Violation
					Criteria Air Pollution (tons):	2,475	13%	
					Hazardous Air Pollution (lbs):	105,490	1%	
4	Port Arthur, TX	Motiva Enterprises - Port Arthur Refinery [1]	Refinery gas, fuel gas	65 out of 95 (19 unknown)	Greenhouse Gases (metric tons CO_2e):	5,015,249	84%	Violation within 1 Year
					Criteria Air Pollution (tons):	3,173	46%	
					Hazardous Air Pollution (lbs):	333,510	0.1%	
5	Westlake, LA	CITGO - Lake Charles Refinery	Refinery fuel gas, natural gas	51 out of 61 (6 unknown)	Greenhouse Gases (metric tons CO_2e):	4,476,976	59%	No Violation Identified
					Criteria Air Pollution (tons):	5,967	69%	
					Hazardous Air Pollution (lbs):	310,416	< .01%	
6	Texas City, TX	Marathon - Galveston Bay Refinery [1]	Gaseous fuels, landfill gas, renewable non-fossil fuel gases, natural gas, refinery gas	14 out of 118 (48 unknown)	Greenhouse Gases (metric tons CO_2e):	4,242,743		High Priority Violation
					Criteria Air Pollution (tons):	5,385	39%	
					Hazardous Air Pollution (lbs):	370,380	1%	
7	Garyville, LA	Marathon - Garyville Refinery	Refinery gas, natural gas	39 out of 48 (2 unknown)	Greenhouse Gases (metric tons CO_2e):	4,207,065	3%	No Violation Identified
					Criteria Air Pollution (tons):	3,555	54%	
					Hazardous Air Pollution (lbs):	169,220	0.1%	
8	Norco, LA	Shell - Norco Manufacturing Complex	Fuel gas, natural gas	18 out of 23 (4 unknown)	Greenhouse Gases (metric tons CO_2e):	4,091,456		No Violation Identified
					Criteria Air Pollution (tons):	3,453	75%	
					Hazardous Air Pollution (lbs):	130,668	13%	
9	Pascagoula, MS	Chevron - Pascagoula Refinery	Natural gas, refinery gas	65 out of 71 (6 unknown)	Greenhouse Gases (metric tons CO_2e):	3,878,376		No Violation Identified
					Criteria Air Pollution (tons):	5,121	49%	
					Hazardous Air Pollution (lbs):	352,650	2%	
10	Beaumont, TX	ExxonMobil - Beaumont Refinery [1]	Gaseous fuels, landfill gas, natural gas	50 out of 64 (14 Unknown)	Greenhouse Gases (metric tons CO_2e):	3,878,315		No Violation Identified
					Criteria Air Pollution (tons):	7,393	25%	
					Hazardous Air Pollution (lbs):	1,253,557	2%	
11	Whiting, IN	BP - Whiting Refinery [1]	Natural gas, refinery gas, liquefied petroleum gas	55 out of 59 (3 unknown)	Greenhouse Gases (metric tons CO_2e):	3,788,135	60%	High Priority Violation
					Criteria Air Pollution (tons):	2,824		
					Hazardous Air Pollution (lbs):	174,136		

Map #	Location	Facility	Fuel Type(s)	Number of Outdated Heaters & Boilers	Facility Emissions		% From Heaters & Boilers (if known)	Air Compliance Status
12	Delaware City, DE	Premcor - Delaware City Refinery [1]	Natural gas, desulfurized refinery fuel gas, process vent gas	11 out of 35 (19 unknown)	Greenhouse Gases (metric tons CO_2e):	3,260,220		Violation within 1 Year
					Criteria Air Pollution (tons):	3,268	29%	
					Hazardous Air Pollution (lbs):	219,908	0.1%	
13	Deer Park, TX	Pemex - Deer Park Refinery [1]	Refinery gas, process gas	33 out of 54 (17 unknown)	Greenhouse Gases (metric tons CO_2e):	3,230,829	45%	Violation within 1 Year
					Criteria Air Pollution (tons):	3,535	53%	
					Hazardous Air Pollution (lbs):	293,372	10%	
14	Richmond, CA	Chevron - Richmond Refinery [1]	Fuel gas, natural gas	42 [2] All unknown	Greenhouse Gases (metric tons CO_2e):	3,141,245		High Priority Violation
					Criteria Air Pollution (tons):	2,472	19%	
					Hazardous Air Pollution (lbs):	190,809	18%	
15	Roxana, IL	Phillips 66 - Wood River Refinery [1]	Natural gas, refinery gas, SZU waste gas, process off-gas	59 out of 76 (3 unknown)	Greenhouse Gases (metric tons CO_2e):	2,976,945	7%	Violation within 1 Year
					Criteria Air Pollution (tons):	5,431	56%	
					Hazardous Air Pollution (lbs):	417,383	1%	
16	El Segundo, CA	Chevron - El Segundo Refinery [1]	Natural gas, process gas, refinery gas, vaporized LPG	43 [2] All unknown	Greenhouse Gases (metric tons CO_2e):	2,632,447	19%	High Priority Violation
					Criteria Air Pollution (tons):	2,079		
					Hazardous Air Pollution (lbs):	30,503		
17	Channahon, IL	ExxonMobil - Joliet Refinery [1]	Fuel gas, oil, refinery fuel gas, blended fuel gas, CO waste gas	21 out of 21	Greenhouse Gases (metric tons CO_2e):	2,601,421		No Violation Identified
					Criteria Air Pollution (tons):	3,069	50%	
					Hazardous Air Pollution (lbs):	17,668	1%	
18	Corpus Christi, TX	Flint Hills Resources - Corpus Christi Refinery (West)	Natural gas, byproduct, waste gas, fuel gas	42 out of 55 (13 unknown)	Greenhouse Gases (metric tons CO_2e):	2,486,742		Violation within 1 Year
					Criteria Air Pollution (tons):	1,924	61%	
					Hazardous Air Pollution (lbs):	224,875	20%	
19	Rosemount, MN	Flint Hills Resources - Pine Bend Refinery	Refinery gas, natural gas, fuel gas, purge gas	50 out of 57 (3 unknown)	Greenhouse Gases (metric tons CO_2e):	2,405,885		Violation within 1 Year
					Criteria Air Pollution (tons):	2,916	30%	
					Hazardous Air Pollution (lbs):	260,044	21%	
20	Corpus Christi, TX	Valero - Corpus Christi Refinery (West)	Fuel gas, natural gas	34 out of 38 (4 unknown)	Greenhouse Gases (metric tons CO_2e):	2,342,349	49%	Violation within 1 Year
					Criteria Air Pollution (tons):	3,449	20%	
					Hazardous Air Pollution (lbs):	681,195	1%	

***Note:** "Outdated" means more than 15 years old. The number of "outdated" units is a conservative estimate, given that the installation year is unknown for a number of units in this universe.

[1] Located in a nonattainment area for at least one pollutant.

[2] For refineries in California, EIP was unable to identify the installation date for the relevant units as that information is not collected by the state environmental agency.

Sources: 2023 Greenhouse Gas Reporting Program, 2020 National Emission Inventory, state emission inventories, Clean Air Act permits, 2008 Boiler MACT Database

Methodology

The refinery sector was defined using the North American Industry Classification System (NAICS) codes for petroleum refineries. The refineries were then ranked by total greenhouse gas emissions, using EPA's 2023 Greenhouse Gas Reporting Program (GHGRP). After ranking the facilities, EIP gathered information about the units of interest (heaters, boilers, and furnaces). EIP removed emissions from electric generation and any co-located chemical plants from the total GHG emissions at each refinery.

EIP reviewed permit documents, state and/or facility emission inventory submittals, and the most recent (2020) National Emissions Inventory (NEI), to identify heaters, boilers, and furnaces at these refineries. EIP used some of those same information sources as well as EPA's 2008 Boiler MACT database in order to gather information on the age and capacities of units. There are gaps in these information sources, and we were unable to collect installation dates and capacities for every unit. For example, the California Air Resource Boards don't collect unit-level installation date data in their permits or emission inventories, and there does not appear to be any publicly available age data for the California refineries. In many cases, information was outdated or inconsistent across the different datasets, and where applicable, we used our best judgement, deferring to permit records when possible.

After identifying the universe of units at these refineries, we then identified unit-level greenhouse gas emissions from the GHGRP and unit-level criteria and hazardous air pollutant emissions from the NEI. In some cases, unit-level emissions were difficult to discern due to aggregation in the reported data or differences in names for emitting units. Some of these refineries are co-located with chemical plants, and in those instances, the greenhouse gas emissions for both the refinery and the chemical plant are reported under the same reporting ID. In those cases, EIP excluded units from the chemical plant.

Criteria air pollution includes both conventional pollutants and precursors like nitrogen oxides, sulfur dioxide, carbon monoxide, particulate matter, ammonia, lead, and volatile organic compounds. Hazardous air pollutants include chemicals that are known or suspected to cause cancer or other serious health effects, like benzene, formaldehyde, and 1,3-butadiene.

Clean Air Act compliance and nonattainment status information is from the Environmental Protection Agency's Enforcement and Compliance History Online database, which is based on industry self-reported data. EIP obtained this information in March 2025. A facility's compliance status and a region's attainment status may change over time. It should be noted that while data from EPA's ECHO database offers a glimpse of the compliance and enforcement history of these plants, the data is not always complete. States — which have primary enforcement responsibilities under the Clean Air Act — do not always update or inform EPA's ECHO database about enforcement actions taken at the state level.

References and Endnotes

[1] Energy Information Administration, "Refinery Capacity Report", Accessed May 16, 2025. Link: https://www.eia.gov/petroleum/refinerycapacity/table1.pdf

[2] EPA Enforcement and Compliance History Online (ECHO) database, Link: https://echo.epa.gov/. It should be noted that while data from EPA's ECHO database offers a glimpse of the compliance and enforcement history of these plants, the data is not always complete. States — which have primary enforcement responsibilities under the Clean Air Act — do not always update or inform EPA's ECHO database about enforcement actions taken at the state level.

[3] EJScreen data was accessed using the Public Environmental Data Project's clone of EPA's EJAM Multisite Tool. We defined a disadvantaged community as a community within 3-miles of the refinery where the percent people of color and/or the percent low income was higher than the national averages, which are 40 and 30 percent respectively. Accessed May 12, 2025. Link: https://ejam.policyinnovation.info/

[4] Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator". Accessed May 12, 2025. Link: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[5] American Lung Association, "What Makes Outdoor Air Unhealthy – Ozone". Link: https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/ozone

[6] Environmental Integrity Project, "Benzene Pollution at Refinery and Chemical Plant Fencelines", Link: https://environmentalintegrity.shinyapps.io/fencelinemonitoring/

[7] Environmental Protection Agency, "Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from Industrial, Commercial, and Institutional Boilers", October 2010. Link: https://www.epa.gov/sites/default/files/2015-12/documents/iciboilers.pdf

[8] Oil and Gas Climate Initiative, "Powering Up: A roadmap to decarbonize refining", October 2023. Link: https://www.ogci.com/wp-content/uploads/2023/10/Roadmap-to-Decarbonize-Refining.pdf

[9] Unable to attribute any individual unit emissions at BP Whiting and Chevron El Segundo.

[10] Qi Li, et al., "A modeling framework to assess fenceline monitoring and self-reported upset emissions of benzene from multiple oil refineries in Texas," Atmospheric Environment: X, August 2024. Link: https://www.sciencedirect.com/science/article/pii/S2590162124000480

[11] Environmental Protection Agency, "Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from Industrial, Commercial, and Institutional Boilers", October 2010. Link: https://www.epa.gov/sites/default/files/2015-12/documents/iciboilers.pdf

[12] Chen, H. & Hoffmeister, A., "Net-zero industry by 2050: A scenario of analysis of boiler replacement with industrial heat pumps", American Council for an Energy-Efficient Economy (2024). Link: https://www.aceee.org/sites/default/files/pdfs/net-zero_industry_by_2050_-_a_scenario_analysis_of_boiler_replacement_with_industrial_heat_pumps.pdf

[13] Environmental Protection Agency, "Appendix A – Overview of Petroleum Refining", November 2005. Link: https://www.epa.gov/sites/default/files/documents/AppendixA_Overview_of_Petroleum_Ref.pdf

[14] Agora Industry, "Direct electrification of industrial heat processes", June 2024. Link: https://www.agora-industry.org/fileadmin/Projects/2023/2023-20_IND_Electrification_Industrial_Heat/A-IND_329_04_Electrification_Industrial_Heat_WEB.pdf

[15] Environmental Protection Agency, "Appendix A – Overview of Petroleum Refining", November 2005. Link: https://www.epa.gov/sites/default/files/documents/AppendixA_Overview_of_Petroleum_Ref.pdf

[16] Three boilers did not have heat input capacity data available.

[17] Twenty-six process heaters/furnaces did not have heat input capacity data available.

[18] Industrial Boilers America, "How long do industrial boilers last?". Link: https://www.industrialboilersamerica.com/how-long-do-industrial-boilers-last/?srsltid=AfmBOopHndHvQ-brOEB0we_lSkQ-nNOBVguJDlPtQO1csCAbvJE7CrUE