CENTER FOR
GLOBAL SUSTAINABILITY

3

Energy

Authors

Vincent Camobreco, Melissa Weitz

Suggested Citation

V. Camobreco & M. Weitz (2026). Chapter 3. Energy. In Desai et al., *Greenhouse Gas Inventory and Analysis for the United States: 1990-2024* (pp. 3-1 to 3-83). Center for Global Sustainability, University of Maryland, College Park.

Chapter 3. Energy

Emissions from the energy sector include greenhouse gases (GHGs) from fuel combustion and fugitive emissions associated with energy production, transmission, and use. The vast majority of energy-related emissions come from fossil fuel combustion, with carbon dioxide (CO_2) being the primary gas emitted, along with smaller amounts of methane (CH_4) and nitrous oxide (N_2O). Other energy-related activities, such as the production, transmission, storage, and distribution of coal, oil, and natural gas, also emit GHGs. These emissions are primarily fugitive CH_4 emissions from natural gas systems, coal mining, and petroleum systems. Additional non-combustion emissions from industrial production and product use sources are reported in Chapter 4. Industrial Process and Product Use. These energy-related activities are the primary sources of U.S. anthropogenic GHG emissions.

In 2024, emissions from this sector were 5,050.6 million metric tons (MMT) CO_2 equivalent (CO_2 Eq.), accounting for approximately 81.4 percent of total gross U.S. GHG emissions on a CO_2 Eq. basis. This included 96, 40, and 9 percent of the nation's CO_2, CH_4, and N_2O gross emissions, respectively. Figure 3-1 shows the energy sector emissions trends by category from 1990 to 2024.

Figure 3-1: Trends in Energy Sector Greenhouse Gas Sources

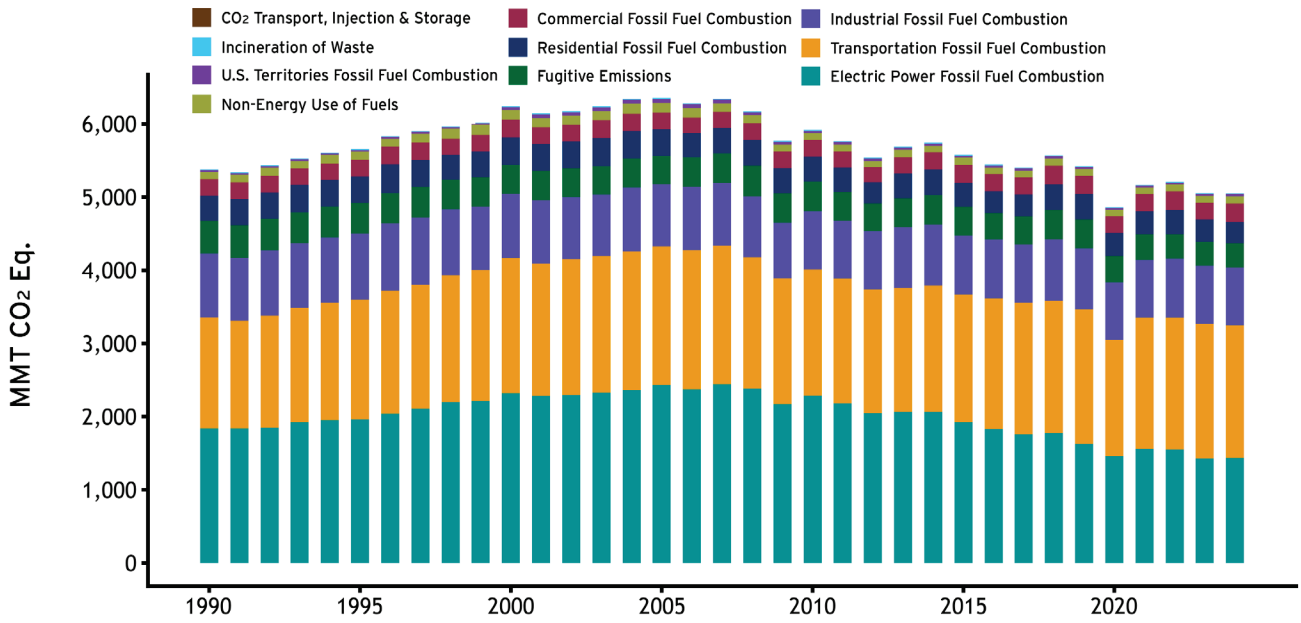


Table 3-1 has the energy sector emissions by category and gas for select years.

Table 3-1: CO_2, CH_4, and N_2O Emissions from Energy (MMT CO_2 Eq.)

Gas/Source	1990	2005	2020	2021	2022	2023	2024
CO_2	**4,909.0**	**5,921.3**	**4,524.5**	**4,838.4**	**4,888.0**	**4,747.3**	**4,738.0**
Fossil Fuel Combustion	4,748.8	5,735.0	4,360.0	4,673.7	4,725.0	4,581.7	4,568.1
Transportation	1,473.1	1,852.8	1,575.7	1,772.0	1,776.9	1,817.7	1,788.6
Electricity Generation	1,820.0	2,400.1	1,439.6	1,540.9	1,531.7	1,414.9	1,420.8
Industrial	870.4	843.3	778.3	786.8	807.5	791.7	789.7
Residential	338.6	359.1	314.0	313.4	329.4	300.7	290.6
Commercial	226.7	227.8	229.1	234.8	255.7	229.5	250.5
U.S. Territories	20.0	51.8	23.2	25.7	23.8	27.2	27.9
Non-Energy Use of Fuels	100.6	132.4	83.7	89.9	89.5	89.6	96.0
Natural Gas Systems	32.5	26.3	36.8	35.7	36.4	37.7	37.4
Petroleum Systems	9.6	10.2	28.9	24.1	22.1	23.3	22.3
Incineration of Waste	12.9	13.3	12.9	12.5	12.5	12.4	11.9
Coal Mining	4.6	4.2	2.2	2.5	2.5	2.4	2.3
CO_2 Transport, Injection, and Geological and Storage	0.0	0.0	+	0.1	0.1	0.1	0.1
Abandoned Oil and Gas Wells	+	+	+	+	+	+	+
Biomass-Wood[a]	215.2	206.9	189.5	192.8	207.1	190.6	185.7
International Bunker Fuels[b]	103.6	113.3	69.6	80.2	98.2	96.2	97.8
Biofuels-Ethanol[a]	4.2	22.9	71.8	79.1	79.6	80.7	80.9
Biofuels-Biodiesel[a]	0.0	0.9	17.7	16.1	15.6	18.2	18.2
Biomass-MSW[a]	18.5	14.7	15.6	15.3	14.9	13.9	13.9
CH_4	**410.4**	**360.1**	**302.3**	**290.9**	**279.0**	**271.4**	**276.2**
Natural Gas Systems	219.6	210.7	180.1	174.6	172.8	162.4	169.8
Coal Mining	108.0	71.4	46.1	45.7	43.6	45.4	44.3
Petroleum Systems	50.0	48.4	50.6	45.1	36.3	38.0	36.5
Abandoned Oil and Gas Wells	7.8	8.2	8.5	8.6	8.5	8.5	8.4
Stationary Combustion	9.6	8.8	7.9	8.0	9.0	8.2	8.1

(continued)

Table 3-1: CO_2, CH_4, and N_2O Emissions from Energy (MMT CO_2 Eq.) *(continued)*

Gas/Source	1990	2005	2020	2021	2022	2023	2024
Abandoned Underground Coal Mines	8.1	7.4	6.5	6.2	6.1	6.1	6.4
Mobile Combustion	7.2	5.2	2.6	2.7	2.7	2.7	2.7
Incineration of Waste	+	+	+	+	+	+	+
International Bunker Fuels[b]	0.2	0.1	0.1	0.1	0.1	0.1	0.1
N_2O	**60.50**	**72.85**	**37.03**	**39.40**	**39.88**	**36.4**	**36.3**
Stationary Combustion	22.3	30.5	20.5	22.0	22.7	19.5	19.0
Mobile Combustion	37.8	42.0	16.1	17.0	16.9	16.5	17.0
Incineration of Waste	0.4	0.3	0.3	0.4	0.3	0.3	0.3
Petroleum Systems	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas Systems	0.0	0.0	0.0	0.0	0.0	0.0	0.0
International Bunker Fuels[b]	0.8	0.9	0.5	0.6	0.8	0.8	0.8
Total	**5,379.8**	**6,354.3**	**4,863.8**	**5,168.7**	**5,206.9**	**5,055.0**	**5,050.6**

+ Does not exceed 0.05 MMT CO_2 Eq.

[a] Emissions from biomass and biofuel consumption are not included specifically in summing energy sector totals. Net carbon fluxes from changes in biogenic carbon reservoirs are accounted for in the estimates for Land Use, Land-Use Change and Forestry (LULUCF).

[b] Emissions from international bunker fuels are not included in totals. These values are presented for informational purposes only, in line with the 2006 Intergovernmental Panel on Climate Change Guidelines.

Note: Totals may not sum due to independent rounding.

Unless otherwise noted, all estimates in this chapter are provided in MMT CO_2 Eq. Consistent with GHG inventories from other countries, this report uses 100-year Global Warming Potential values from Table 8.A.1 in Appendix 8.A of the *IPCC Fifth Assessment Report* for calculating CO_2 Eq. emissions. Supplemental data tables published with this *Greenhouse Gas Inventory and Analysis for the United States (GHGIA)* for download include all the tables presented in this chapter as well as tables with unweighted units reported as kilotons (kt).

Methodological Framework

Emissions are estimated based on Volume 2 (Energy) of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Intergovernmental Panel on Climate Change [IPCC], 2006) and the *2019 Refinement to the 2006 IPCC Guidelines for National Inventories* (IPCC, 2019), using country-specific data where available. Unless otherwise noted (see Table 3-2), methods are consistent with those used in *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2023* (Environmental Protection Agency [EPA], 2025). Consistent with IPCC good practices, the *GHGIA* applies higher tier methods for more significant sources (e.g., Tier 2 and Tier 3 methods that

include use of country-specific methods and models, emission factors and site-specific information) and where feasible for smaller sources.

Table 3-2: Energy Sector Methods Summary

Category (CRT Code)[a]	Gas(s)	IPCC Methodological Tier	Methodological Refinements Compared to 1990-2023 (EPA, 2025)
Source Category: Fossil Fuel Combustion (1A)			
Electricity Sector	CO_2	Tier 2	No change
Electricity Sector	CH_4	Tier 2	No change
Electricity Sector	N_2O	Tier 2	No change
Transportation Sector	CO_2	Tier 2, Tier 3	No change
Transportation Sector	CH_4	Tier 2, Tier 3	No change
Transportation Sector	N_2O	Tier 2, Tier 3	No change
Industrial Sector	CO_2	Tier 2	No change
Industrial Sector	CH_4	Tier 1	No change
Industrial Sector	N_2O	Tier 1	No change
Residential Sector	CO_2	Tier 2	No change
Residential Sector	CH_4	Tier 1	No change
Residential Sector	N_2O	Tier 1	No change
Commercial Sector	CO_2	Tier 2	No change
Commercial Sector	CH_4	Tier 1	No change
Commercial Sector	N_2O	Tier 1	No change
Territories	CO_2	Country Specific, Tier 2	No change
Territories	CH_4	Tier 1	No change
Territories	N_2O	Tier 1	No change
Source Category: Carbon Emitted from Non-Energy Use (1A)			
Non-Energy Use of Fossil Fuels	CO_2	Country Specific, Tier 2	No change

(continued)

Table 3-2: Energy Sector Methods Summary (continued)

Category (CRT Code)[a]	Gas(s)	IPCC Methodological Tier	Methodological Refinements Compared to 1990-2023 (EPA, 2025)
Source Category: Waste Incineration (1A)			
Biogenic Municipal Solid Waste (MSW)	CO_2	Country Specific, Tier 2	Yes, use of U.S. Energy Information Administration (EIA) data for MSW amount combusted
Biogenic Municipal Solid Waste	CH_4	Country Specific, Tier 2	Yes, use of EIA data for MSW amount combusted
Biogenic Municipal Solid Waste	N_2O	Country Specific, Tier 2	Yes, use of EIA data for MSW amount combusted
Non-biogenic Municipal Solid Waste	CO_2	Country Specific, Tier 2	Yes, use of EIA data for MSW amount combusted
Non-biogenic Municipal Solid Waste	CH_4	Country Specific, Tier 2	Yes, use of EIA data for MSW amount combusted
Non-biogenic Municipal Solid Waste	N_2O	Country Specific, Tier 2	Yes, use of EIA data for MSW amount combusted
Source Category: Coal Mining (1B1a)			
Underground Mines	CH_4	Tier 2, Tier 3	Yes, proxy based on 2023 for Greenhouse Gas Reporting Program (GHGRP) mine data
Surface Mines	CH_4	Tier 2, Tier 3	No change
Underground Mines	CO_2	Tier 1	Yes, proxy based on 2023 for GHGRP mine data
Surface Mines	CO_2	Tier 1	No change
Source Category: Abandoned Underground Coal Mines (1B1a)			
Abandoned Underground Mines	CH_4	Tier 2, Tier 3	No change
Source Category: Petroleum Systems (1B2a)			
Petroleum Systems	CH_4	Tier 2, Tier 3	No change
Petroleum Systems	CO_2	Tier 2, Tier 3	No change
Petroleum Systems	N_2O	Tier 2, Tier 3	No change
Source Category: Natural Gas Systems (1B2b)			
Natural Gas Systems	CH_4	Tier 2	No change
Natural Gas Systems	CO_2	Tier 2	No change
Natural Gas Systems	N_2O	Tier 2	No change

(continued)

Table 3-2: Energy Sector Methods Summary (continued)

Category (CRT Code)[a]	Gas(s)	IPCC Methodological Tier	Methodological Refinements Compared to 1990-2023 (EPA, 2025)
Source Category: Abandoned Oil and Gas Wells (1B2a and 1B2b)			
Abandoned wells	CH_4	Tier 2	No change
Abandoned wells	CO_2	Tier 2	No change
Source Category: CO_2 Transportation, Injection, and Geologic Storage (TIGS) (1C)			
Transport of CO_2	CO_2	Tier 1	No change
Injection and Storage	CO_2	Tier 3	Yes, proxy based on 2023 for GHGRP data
Other	CO_2	Tier 3	Yes, proxy based on 2023 for GHGRP data
Source Category: International Bunker Fuels (Memo Item)			
Memo Items: International Bunkers	CO_2	Tier 2	Yes, proxy missing military and commercial aviation data
Memo Items: International Bunkers	CH_4	Tier 1	Yes, proxy missing military and commercial aviation data
Memo Items: International Bunkers	N_2O	Tier 1	Yes, proxy missing military and commercial aviation data
Source Category: Biomass (1A)			
Memo Items: Biomass Combustion	CO_2	Tier 2	No change
Electricity Sector	CH_4	Tier 2	No change
Electricity Sector	N_2O	Tier 2	No change
Transportation Sector	CH_4	Tier 2	No change
Transportation Sector	N_2O	Tier 2	No change
Industrial Sector	CH_4	Tier 1	No change
Industrial Sector	N_2O	Tier 1	No change
Residential Sector	CH_4	Tier 1	No change
Residential Sector	N_2O	Tier 1	No change
Commercial Sector	CH_4	Tier 1	No change
Commercial Sector	N_2O	Tier 1	No change

[a] Codes in parentheses represent common reporting table (CRT) codes. The CRT codes are a classification system to organize quantitative reporting of detailed emission and removal data in standardized data tables (i.e., CRTs) to facilitate comparison of national inventory data and trends. The code reflects classification levels, e.g., sector, subsector, category, subcategory. Translating 1A: 1 = energy sector, A = subsector Fossil Fuel Combustion

This chapter presents the methodologies and estimates of emissions for the following sources, each presented in its own section:

- fossil fuel combustion (CO_2, CH_4, N_2O)
  - broken out by end-use sector
- carbon emitted from non-energy use (NEU) of fossil fuels (CO_2)
- incineration of waste (CO_2, CH_4, N_2O)
- coal mining (CO_2, CH_4)
- abandoned underground coal mines (CH_4)
- petroleum systems (CO_2, CH_4, N_2O)
- natural gas systems (CO_2, CH_4, N_2O)
- abandoned oil and gas wells (CO_2, CH_4)
- CO_2 transport injection and geologic storage (TIGS) (CO_2)
- memo item: International bunker fuels (CO_2, CH_4, N_2O)
- memo item: Wood biomass and biofuels consumption (CO_2)

Quality Assurance/Quality Control

To ensure the quality of the energy sector GHG emission estimates, general and category-specific quality assurance/quality control (QA/QC) procedures were implemented. The category-specific procedures that were implemented involved checks specifically focusing on the activity data and methodology used for estimating each source of emissions from the energy sector. Emission totals for the different sectors and fuels were compared, and trends were investigated to determine whether any corrective actions were needed. Minor corrective actions were taken as necessary.

Along with the QA/QC checks for fossil fuel combustion, a "top-down" reference approach for estimating CO_2 emissions from fossil fuel combustion was implemented in addition to the primary "bottom-up" sectoral methodology presented in this chapter, in line with IPCC guidelines. The reference approach (detailed in Annex 3) uses alternative methodologies and different data sources than those used for the sectoral approach. The reference approach estimates fossil fuel consumption by adjusting national aggregate fuel production data by imports, exports, and stock changes rather than relying on the end-user consumption surveys that are used for the sectoral approach. The reference approach assumes that once carbon-based fuels are brought into a national economy, they are either saved (e.g., stored in products, kept in fuel stocks, or left unoxidized in ash) or combusted, and therefore the carbon in them is oxidized and, if not captured and stored, released into the atmosphere. In the reference approach, accounting for actual consumption of fuels at the sectoral or sub-national level is not required. One difference between the two approaches is that emissions from carbon that is emitted during non-energy use (NEU) of fuels are subtracted from the sectoral approach and reported separately (see Section 3.2). These emissions, however, are included directly in the reference approach and not reported separately.

Future Areas for Improvement

Continuous improvement efforts are important for reflecting the latest science and reducing uncertainties to the extent practicable in estimating emissions from energy sector activities, especially for significant categories and those with higher uncertainty in results. For categories where the methodology has not changed in this *GHGIA* and remains consistent with previous analyses, any improvements identified in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025) will be reviewed. Any improvements that have been incorporated into this *GHGIA* are discussed in the Methods and Recalculations sections of those respective categories.

There are several categories where potentially more significant methodological changes and/or refinements are anticipated, primarily due to challenges with data availability or changes compared with previous analysis. These include the following categories:

- Transportation fossil fuel combustion: Data for on-road gasoline and diesel fuel use is based on information from the U.S. Department of Transportation, Federal Highway Administration (FHWA). For the 2024 data release, FHWA changed their off-road model, which results in a discontinuity with older data for gasoline and diesel fuel use. A planned improvement is to examine ways to ensure the time series consistency of the data. There were some data sources, as discussed in the methodology section for transportation fossil fuel combustion emissions, that were proxied for this analysis. A planned improvement is to investigate gathering alternative data for those sources going forward.
- Electric power fossil fuel combustion: A longer-term planned improvement is to investigate differences between electricity sector characterization across different sources, including how biomass use and non-CO_2 emissions are counted under different sources.
- Industry fossil fuel combustion: Previously, data from the U.S. Greenhouse Gas Reporting Program (GHGRP) was used to help better characterize the industrial sector's energy consumption in the United States and further classify total industrial sector fossil fuel combustion emissions by business establishments according to industrial economic activity type. Future planned improvements include considering other data sources and methods that could be used to disaggregate industrial sector energy use by subsectors.
- U.S. Territories fossil fuel combustion: For the most part, the same physical characteristics are assumed for fuels used in U.S. Territories as for those used in the continental United States. There may be differences in heating contents of fuels used in U.S. Territories that would impact the calculations of total energy use. A planned improvement is to investigate other data sources for heating content of fuels used in U.S. Territories.
- NEU: A longer-term improvement is to review the links between NEU, fossil fuel combustion, and Industrial Processes and Product Use (IPPU) approaches to ensure there is no double counting but also to streamline reporting to make it more in line with IPCC methods for reporting NEU emissions under IPPU.
- CO_2 TIGS and waste incineration: A near-term improvement is to investigate alternative data sources due to lack of GHGRP data.

- International bunker fuels: There were some data sources, as discussed in the methodology section for International Bunker Fuels emissions, that were proxied for this analysis. A planned improvement is to investigate gathering alternative data for those sources going forward. This includes looking into Federal Energy Management Program (FEMP) data for military emissions and Department of Transportation data on commercial flights.
- Petroleum and natural gas systems: The 2026 *GHGIA* will be updated with the latest activity data, including revised well and well completion counts, and production data. The estimates will be updated to use the latest Bureau of Ocean Energy Management Inventory for offshore sources. Any available 2024 GHGRP data will be reviewed for potential updates and recalculations. In 2024, EPA had considered but did not implement updates to make the inventory more consistent with GHGRP emission factor updates. Implementing those updates would result in increased emissions estimates, closer to estimates derived by atmospheric observations. We will engage with researchers and will review available data that could improve our emission factors and/or methods for quantifying emissions from petroleum and natural gas systems.
- Abandoned oil and gas wells: The 2026 *GHGIA* will be updated with revised abandoned oil and gas well counts and the latest information on well plugging. Available data that could improve our emission factors and/or methods for quantifying emissions from abandoned oil and gas wells will be reviewed.

Future versions of this *GHGIA* will specify more on scope, timing, and plans for phasing in improvements.

3.1 Fossil Fuel Combustion (Source Category 1A)

The combustion of fossil fuels produces energy for useful heat and work. The combustion process oxidizes the carbon stored in the fuels, which is emitted as carbon dioxide (CO_2) and smaller amounts of other gases, including CH_4, carbon monoxide (CO), and non-methane volatile organic compounds (NMVOCs). In the context of estimating GHGs associated with fossil fuel combustion, it is assumed that all the carbon from fossil fuel combustion is eventually converted to atmospheric CO_2 (IPCC, 2006b).

The combustion of biomass and biofuels generates CO_2 as well as non-CO_2 emissions (CH_4 and N_2O). In accordance with IPCC inventory guidelines, CO_2 emissions from biomass and biofuel combustion are estimated separately from fossil fuel CO_2 emissions and are excluded from energy sector totals to avoid double counting. These emissions are instead accounted for within the land use, land-use change, and forestry (LULUCF) sector through estimates of net carbon stock changes in biogenic carbon pools associated with forest and cropland systems (see Chapter 6). Section 3.11 below has more detail on biomass and biofuel CO_2 emissions. Non-CO_2 emissions from biomass and biofuel combustion are included in energy sector totals and are reported in this section as part of stationary and mobile combustion source categories.

The GHGs CH_4 and N_2O are also produced during fossil fuel combustion. These emissions depend upon fuel and combustion device characteristics, along with pollution control equipment, ambient environmental conditions, and operation and maintenance practices. Nitrous oxide (N_2O) emissions are closely related to air-fuel mixes and combustion temperatures, as well as the characteristics of any pollution control equipment that is employed. N_2O from mobile sources, in particular, can be formed by the catalytic processes used to control NO_x, CO, and hydrocarbon emissions. Methane (CH_4) emissions are a function of the CH_4 content of the fuel and combustion efficiency. CH_4 emissions from motor vehicles are also impacted by any post-combustion control of hydrocarbon emissions (such as catalytic converters).

The approach for determining fossil fuel combustion emissions is based on multiplying emissions factors by activity data on fuel consumption. The activity data on fuel consumption is from energy balances prepared for EIA's Monthly Energy Review estimates (2026a). Fuel use is determined by fuel type because different types of fuels have different carbon contents and therefore different emissions factors. The amount of carbon in fuels varies significantly by fuel type. For example, coal contains the highest amount of carbon per unit of useful energy. Petroleum has roughly 75 percent of the carbon per unit of energy as coal, and natural gas has only about 55 percent.[1]

The fossil fuel combustion amounts are broken out by energy-consuming sectors of U.S. society to provide more detail and information on trends; the sectors included are transportation, electric power, industrial, residential, and commercial. Data from U.S. Territories are also included in the analysis and reported separately. Data obtained from *EIA's International Energy Statistics* (2026b) for U.S. Territories (including American Samoa, Guam, Puerto Rico, U.S. Virgin Islands, Wake Island, and other outlying U.S. Pacific Islands) are only available at the aggregate level and cannot be broken out by end-use sector so are just reported as a total.

Several adjustments are made to the data to account for fuel use and emissions that are either excluded or reported (or implicitly included) in other parts of the national inventory, as shown in Figure 3-2 (EPA, 2024).

[1] Based on national aggregate carbon content of all coal, natural gas, and petroleum fuels combusted in the United States.

Figure 3-2: Adjustments to Energy Consumption for Emissions Estimates

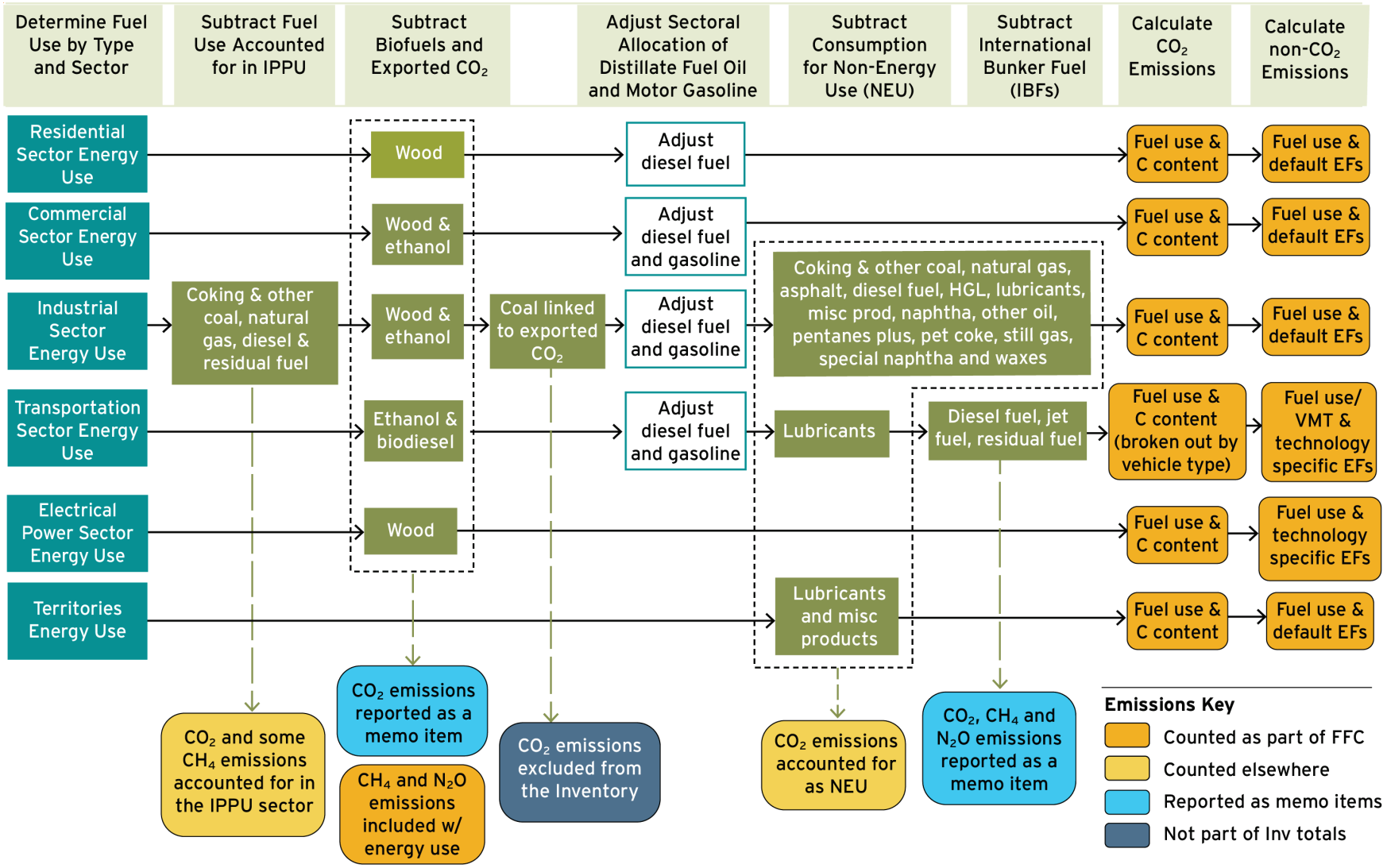


Table 3-3 provides an overview of the CO_2, CH_4, and N_2O emissions from fossil fuel combustion by sector and U.S. Territories.

Table 3-3: CO_2, CH_4, and N_2O Emissions from Fossil Fuel Combustion by Sector (MMT CO_2 Eq.)

End-Use Sector	1990	2005	2020	2021	2022	2023	2024
Electric Power	**1,838.7**	**2,427.8**	**1,458.5**	**1,561.3**	**1,552.6**	**1,433.0**	**1,438.4**
CO_2	1,820.0	2,400.1	1,439.6	1,540.9	1,531.7	1,414.9	1,420.8
CH_4	0.5	1.0	1.4	1.4	1.5	1.5	1.5
N_2O	18.2	26.7	17.5	19.0	19.4	16.6	16.0
Transportation	**1,518.1**	**1,900.0**	**1,594.4**	**1,791.7**	**1,796.6**	**1,836.9**	**1,808.3**
CO_2	1,473.1	1,852.8	1,575.7	1,772.0	1,776.9	1,817.7	1,788.6
CH_4	7.2	5.2	2.6	2.7	2.7	2.7	2.7
N_2O	37.8	42.0	16.1	17.0	16.9	16.5	17.0
Industrial	**875.2**	**847.9**	**782.0**	**790.5**	**811.3**	**795.3**	**793.2**
CO_2	870.4	843.3	778.3	786.8	807.5	791.7	789.7
CH_4	2.1	1.9	1.6	1.6	1.7	1.6	1.6
N_2O	2.8	2.6	2.1	2.1	2.1	2.0	2.0
Residential	**345.4**	**364.5**	**318.2**	**317.8**	**334.6**	**305.2**	**294.9**
CO_2	338.6	359.1	314.0	313.4	329.4	300.7	290.6
CH_4	5.9	4.5	3.6	3.7	4.5	3.9	3.7
N_2O	0.9	0.8	0.6	0.6	0.7	0.6	0.6
Commercial	**228.2**	**229.3**	**230.7**	**236.4**	**257.3**	**231.0**	**252.1**
CO_2	226.7	227.8	229.1	234.8	255.7	229.5	250.5
CH_4	1.2	1.2	1.2	1.3	1.3	1.2	1.3
N_2O	0.3	0.3	0.3	0.3	0.3	0.3	0.3
U.S. Territories[a]	**20.1**	**52.1**	**23.3**	**25.8**	**23.8**	**27.3**	**28.0**
CO_2	20.0	51.8	23.2	25.7	23.8	27.2	27.9
CH_4	0.0	0.1	0.0	0.0	0.0	0.0	0.0
N_2O	0.0	0.1	0.1	0.1	0.1	0.1	0.1

(continued)

Table 3-3: CO_2, CH_4, and N_2O Emissions from Fossil Fuel Combustion by Sector (MMT CO_2 Eq.)

End-Use Sector	1990	2005	2020	2021	2022	2023	2024
Total	**4,825.8**	**5,821.5**	**4,407.1**	**4,723.5**	**4,776.3**	**4,628.7**	**4,614.9**
CO_2	4,748.8	5,735.0	4,360.0	4,673.7	4,725.0	4,581.7	4,568.1
CH_4	16.9	14.0	10.5	10.7	11.7	10.9	10.9
N_2O	60.1	72.5	36.7	39.0	39.5	36.1	36.0

[a] U.S. Territories are not apportioned by sector, and emissions shown in the table are total greenhouse gas emissions from all fuel combustion sources.

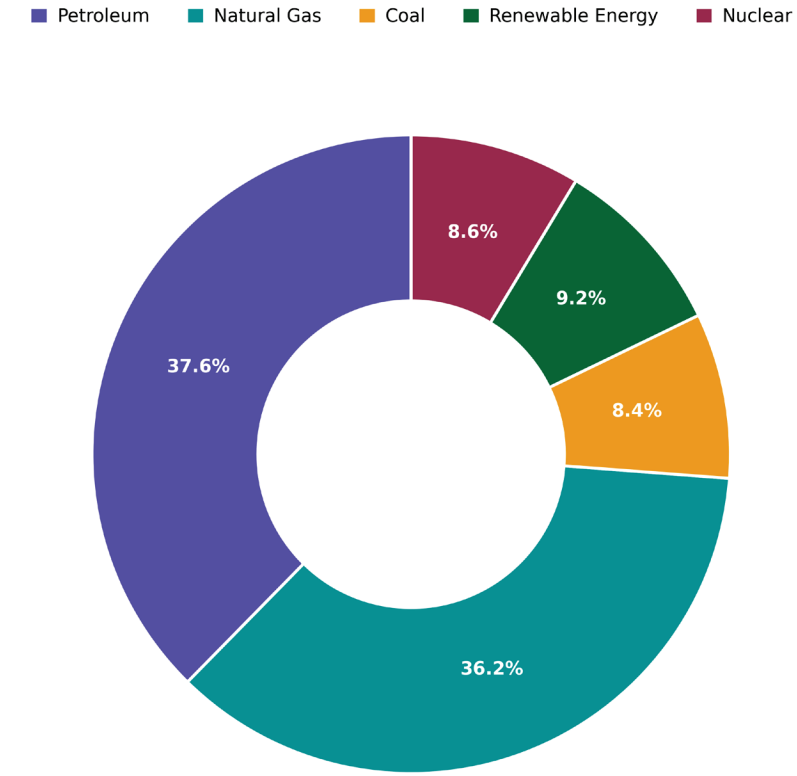
Note: Totals may not sum due to independent rounding.

CO_2 is the primary gas emitted from fossil fuel combustion and represents the largest share of U.S. total GHG emissions. In 2024, CO_2 emissions from fossil fuel combustion decreased by 0.3 percent relative to 2023 and were 3.8 percent below emissions in 1990. The change in CO_2 emissions from fossil fuel combustion is largely driven by changes in the total amount and type of fossil fuel energy used.

In the United States, 77.6 percent of the energy used in 2024 was produced through the combustion of fossil fuels such as petroleum, natural gas, and coal (see Figure 3-3 and Figure 3-4). Petroleum supplied the largest share of domestic energy demands, accounting for 37.7 percent of total U.S. energy used in 2024. Natural gas and coal followed in order of fossil fuel energy demand significance, accounting for approximately 36.2 percent and 8.4 percent of total U.S. energy used, respectively. Petroleum was consumed primarily in the transportation end-use sector, while the majority of coal was used in the electric power sector, and natural gas was broadly consumed in all end-use sectors except transportation (see Figure 3-5). The remaining portion of energy used in 2024 was supplied by nuclear electric power (8.7 percent) and by a variety of renewable energy sources (9.2 percent), primarily wind energy, hydroelectric power, solar, geothermal, and biomass (EIA, 2026a).[2]

[2] Renewable energy, as defined in EIA's energy statistics, includes the following energy sources: hydroelectric power, geothermal energy, biomass, solar energy, and wind energy.

Figure 3-3: 2024 U.S. Energy Use by Energy Source



Note: Totals may not sum due to independent rounding.

Figure 3-4: Annual U.S. Energy Use

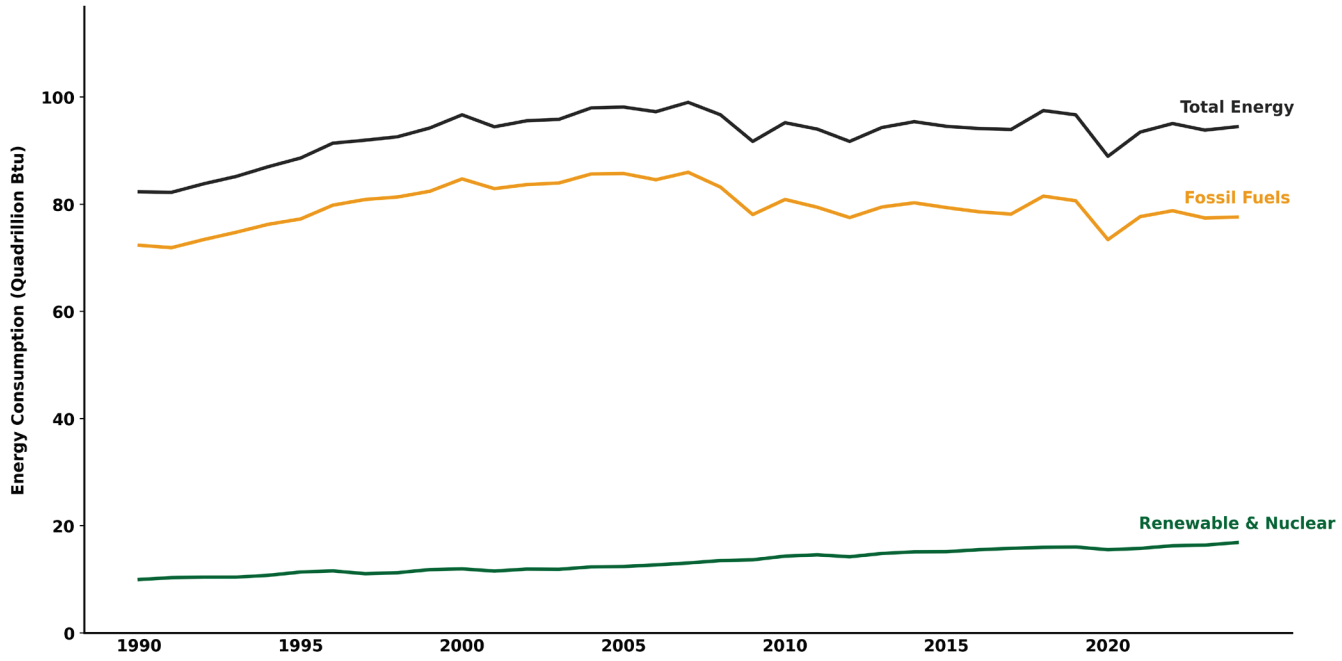
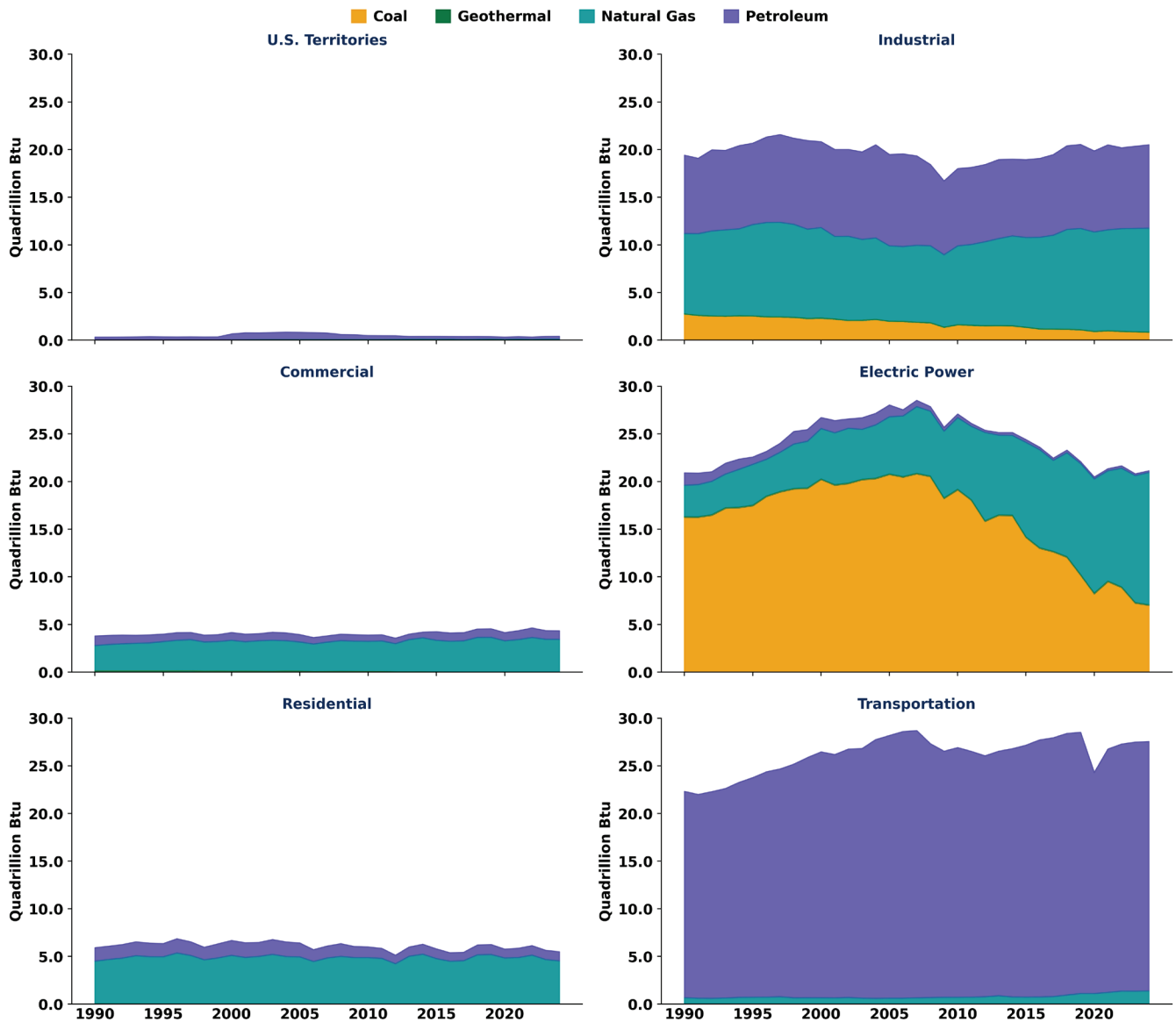


Figure 3-5: Fuel Use by End-Use Sector



CO_2 emissions from fossil fuel combustion are presented in Table 3-4 by sector and fuel type. The decrease in CO_2 emissions from fossil fuel combustion was a result of a change in types of fossil fuel energy use. See Annex 5 for data on energy use. CO_2 emissions from coal consumption decreased by 3.3 percent (24.1 MMT CO_2 Eq.) from 2023 to 2024, whereas CO_2 emissions from natural gas use increased by 1.4 percent (24.0 MMT CO_2 Eq.), and emissions from petroleum use decreased by 0.6 percent (13.6 MMT CO_2 Eq.) from 2023 to 2024. The increase in natural gas consumption and associated emissions in 2024 is observed mostly in the electric power sector; the decrease in petroleum use is mainly in the transportation sector offset by an increase in the commercial sector; and the coal decrease is mainly due to reduced use in the electric power sector. In 2024, CO_2 emissions from fossil fuel combustion were 4,568.1 MMT CO_2 Eq.

Table 3-4: CO_2 Emissions from Fossil Fuel Combustion by Fuel Type and Sector (MMT CO_2 Eq.)

Fuel/Sector	1990	2005	2020	2021	2022	2023	2024
Coal	**1,719.8**	**2,113.7**	**835.6**	**957.4**	**898.8**	**734.6**	**710.5**
Residential	3.0	0.8	0.0	0.0	0.0	0.0	0.0
Commercial	12.0	9.3	1.4	1.4	1.4	1.1	1.1
Industrial	157.8	117.8	43.0	43.0	43.0	36.4	34.9
Transportation	NO	NO	NO	NO	NO	NO	NO
Electric Power	1,546.5	1,982.8	788.2	910.1	851.5	694.6	672.0
U.S. Territories	0.5	3.0	3.1	2.9	2.9	2.5	2.5
Natural Gas	**998.6**	**1,166.6**	**1,630.1**	**1,636.3**	**1,724.0**	**1,741.1**	**1,765.1**
Residential	237.8	262.2	256.4	258.6	272.0	247.8	240.5
Commercial	142.0	162.9	173.5	180.4	192.3	182.4	181.8
Industrial	407.4	388.3	504.0	515.4	525.3	529.2	529.8
Transportation	36.0	33.1	58.8	65.2	72.3	71.9	73.7
Electric Power	175.4	318.9	634.8	612.8	659.3	705.3	734.8
U.S. Territories	NO	1.3	2.6	3.9	2.7	4.5	4.5
Petroleum	**2,029.9**	**2,454.2**	**1,893.9**	**2,079.6**	**2,101.8**	**2,105.6**	**2,092.1**
Residential	97.8	96.1	57.6	54.8	57.4	52.9	50.1
Commercial	72.7	55.6	54.3	53.0	62.0	46.0	67.6
Industrial	305.1	337.2	231.4	228.4	239.2	226.1	225.0
Transportation	1,437.1	1,819.7	1,516.9	1,706.8	1,704.6	1,745.8	1,714.8
Electric Power	97.5	98.0	16.2	17.7	20.5	14.7	13.7
U.S. Territories	19.5	47.5	17.5	18.9	18.1	20.1	20.9
Geothermal[a]	**0.5**	**0.5**	**0.4**	**0.4**	**0.4**	**0.4**	**0.3**
Electric Power	0.5	0.5	0.4	0.4	0.4	0.4	0.3
Total	**4,748.8**	**5,735.0**	**4,360.0**	**4,673.7**	**4,725.0**	**4,581.7**	**4,568.1**

NO (Not Occurring)

[a] Although not technically a fossil fuel, geothermal energy-related CO_2 emissions are included for reporting purposes. The source of CO_2 is non-condensable gases in subterranean heated water.

Note: Totals may not sum due to independent rounding.

An alternative method of presenting combustion emissions is to allocate emissions associated with electric power to the sectors in which it is used. Four end-use sectors are defined: transportation, industrial, residential, and commercial. In Table 3-5 below, electric power emissions have been distributed to each end-use sector based upon the sector's share of national electricity use, with the exception of CH_4 and N_2O from transportation electricity use.[3] This method assumes that emissions from combustion sources are distributed across the four end-use sectors based on the ratio of electricity use in that sector.

Table 3-5: CO_2, CH_4, and N_2O Emissions from Fossil Fuel Combustion by End-Use Sector with Electricity Emissions Distributed (MMT CO_2 Eq.)

End-Use Sector	1990	2005	2020	2021	2022	2023	2024
Transportation	**1,521.3**	**1,904.9**	**1,598.1**	**1,795.8**	**1,801.3**	**1,842.2**	**1,815.1**
CO_2	1,476.3	1,857.7	1,579.4	1,776.1	1,781.6	1,823.0	1,795.3
CH_4	7.2	5.2	2.6	2.7	2.7	2.7	2.7
N_2O	37.8	42.0	16.1	17.0	16.9	16.5	17.0
Industrial	**1,516.2**	**1,523.8**	**1,158.3**	**1,201.0**	**1,214.8**	**1,168.7**	**1,167.8**
CO_2	1,504.8	1,511.5	1,149.7	1,191.9	1,205.6	1,160.4	1,159.6
CH_4	2.2	2.2	2.0	2.0	2.0	2.0	2.0
N_2O	9.1	10.1	6.6	7.1	7.2	6.3	6.2
Residential	**971.8**	**1,265.8**	**891.9**	**919.9**	**929.5**	**839.1**	**827.7**
CO_2	958.6	1,250.2	880.2	907.6	916.3	827.8	816.9
CH_4	6.0	4.9	4.2	4.3	5.1	4.5	4.2
N_2O	7.2	10.7	7.5	8.0	8.2	6.8	6.6
Commercial	**796.5**	**1,074.9**	**735.5**	**781.1**	**806.8**	**751.4**	**776.3**
CO_2	789.1	1,063.7	727.4	772.4	797.8	743.3	768.3
CH_4	1.3	1.6	1.7	1.7	1.8	1.8	1.9
N_2O	6.0	9.6	6.4	6.9	7.2	6.3	6.2
Total	**4,805.7**	**5,769.4**	**4,383.8**	**4,697.7**	**4,752.4**	**4,601.4**	**4,586.9**

Notes: Totals may not sum due to independent rounding. Emissions from fossil fuel combustion by electric power are allocated based on aggregate national electricity use by each end-use sector.

[3] Separate calculations are performed for transportation and mobile source related CH_4 and N_2O emissions; see that section for more details.

The following sections include a discussion of fossil fuel combustion emissions by energy—consuming sectors. A discussion of emissions in the electricity production sector is first, followed by discussions of the other electricity end-use sectors including transportation, industrial, and combined residential and commercial. Finally, there is a discussion of U.S. Territories combustion emissions.

3.1.1 Electric Power Sector

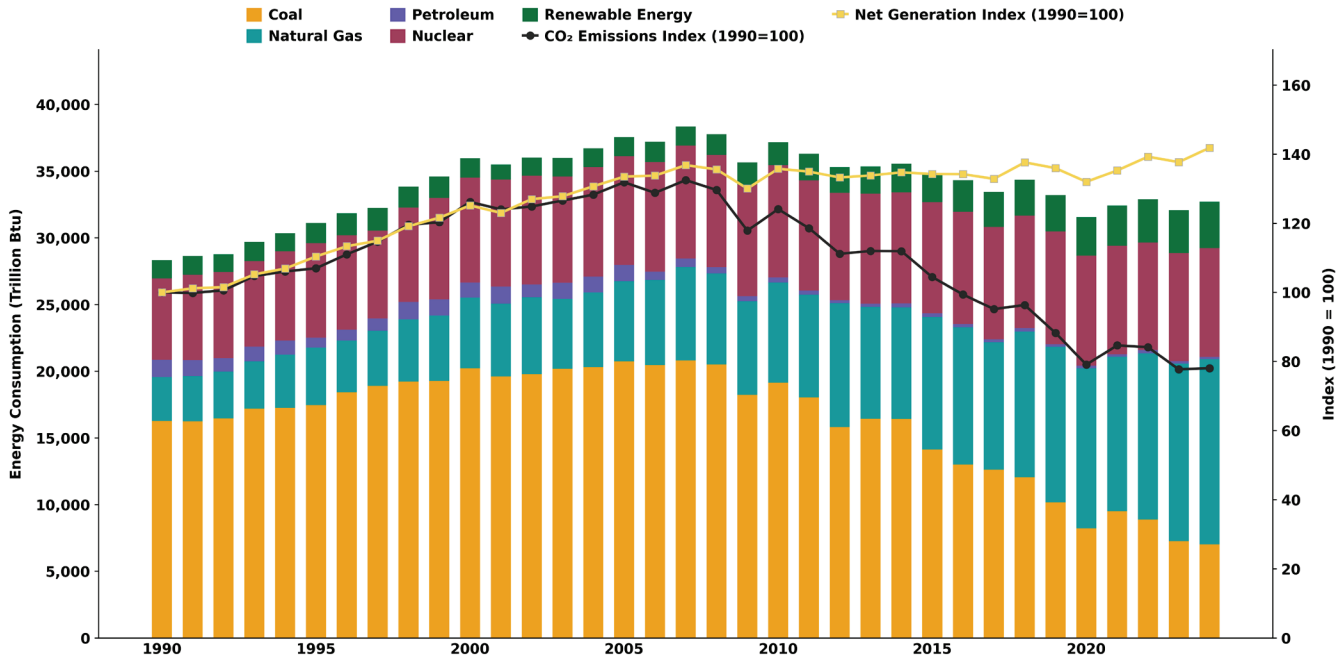
EIA places electric power generation into three functional categories: the electric power sector, the commercial sector, and the industrial sector. Energy use and emissions associated with electric generation in the commercial and industrial sectors (i.e., on-site generation of electricity at commercial facilities) are reported in those other sectors.[4]

The energy use and emissions associated with the electric power sector are included here. As defined by EIA, the electric power sector consists of electric utilities and independent power producers whose primary business is the production of electricity. This includes both regulated utilities and non-utilities (e.g., independent power producers, qualifying co-generators, and other small power producers) (EIA, 2026a).

Total GHG emissions from the electric power sector have decreased by 21.9 percent since 1990. Historical trends in electric power sector emissions are driven by electricity demand and the carbon intensity of electricity generated. The carbon intensity of electricity generated, in terms of CO_2 Eq. per kilowatt-hour (kWh), depends on the types of fuels and method used to generate electricity. Trends over time are shown in Figure 3-6. Generally, there has been a recent decoupling of emissions and electricity production indicating a decrease in the carbon intensity of electricity generation. This recent decarbonization of the electric power sector is a result of several key drivers.

[4] Where electricity generation occurs outside the EIA-defined electric power sector, it is typically for the entity's own use.

Figure 3-6: Fuels Used in Electric Power Generation and Total Electric Power Sector CO_2 Emissions



Coal-fired electric generation (in kWh) decreased from 54.1 percent of total generation in 1990 to 15.6 percent in 2024.[5] This corresponded with an increase in natural gas generation and renewable energy generation, largely from wind and solar energy. Natural gas generation (in kWh) represented 10.7 percent of electric power generation in 1990 and increased over the 35-year period to represent 42.4 percent of electric power sector generation in 2024 (see Table 3-6). Natural gas has a much lower carbon content than coal and is generated in power plants that are generally more efficient in terms of kWh produced per Btu of fuel combusted, which has led to lower emissions as natural gas replaces coal-powered electricity generation.

[5] Values represent electricity *net* generation from the electric power sector (EIA, 2026a).

Table 3-6: Electric Power Generation by Fuel Type (Percent)

Fuel Type	1990	2005	2020	2021	2022	2023	2024
Coal	54.1%	51.1%	19.9%	22.6%	20.3%	16.6%	15.6%
Natural Gas	10.7%	17.5%	39.5%	37.3%	38.8%	42.2%	42.4%
Nuclear	19.9%	20.0%	20.5%	19.7%	18.9%	19.2%	18.8%
Renewables	11.3%	8.3%	19.5%	19.8%	21.4%	21.5%	22.8%
Petroleum	4.1%	3.0%	0.4%	0.5%	0.5%	0.4%	0.3%
Other Gases[a]	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Net Electricity Generation (Billion kWh)[b]	2,905	3,902	3,852	3,955	4,076	4,031	4,161

[a] Other gases include blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuels.

[b] Represents net electricity generation from the electric power sector. Excludes net electricity generation from commercial and industrial combined-heat-and-power and electricity-only plants. Does not include electricity generation from purchased steam as the fuel used to generate the steam cannot be determined.

In 2024, CO_2 emissions from the electric power sector increased by 0.4 percent relative to 2023. This increase in CO_2 emissions was primarily driven by an increase in natural gas consumed to produce electricity in the electric power sector, offset by a decrease in coal consumption. Consumption of natural gas for electric power increased by 4.2 percent, whereas consumption of coal decreased 3.2 percent from 2023 to 2024, leading to a slight overall increase in emissions. Electricity generation from renewable sources increased by 5.9 percent from 2023 to 2024.

Emissions also include a small amount of CO_2 capture and sequestration, which have been netted out of the results for electric power sector coal CO_2 emissions. More information on CO_2 transport, injection, and geologic sequestration can be found in Section 3.9. Table 3-7 presents the GHG emissions from fossil fuel combustion in the electric power sector.

Table 3-7: GHG Emissions from Fossil Fuel Combustion in the Electric Power Sector (MMT CO_2 Eq.)

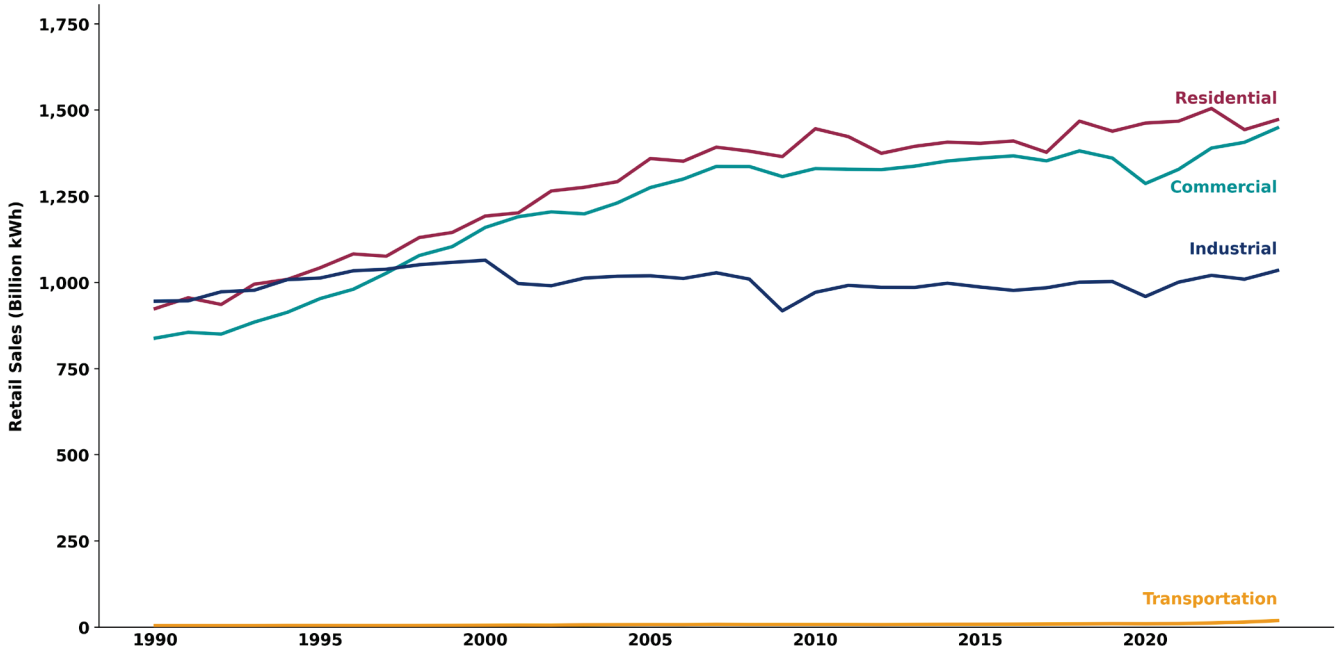
Fuel Type	1990	2005	2020	2021	2022	2023	2024
CO_2	**1,820.0**	**2,400.1**	**1,439.6**	**1,540.9**	**1,531.7**	**1,414.9**	**1,420.8**
Coal	1,546.5	1,982.8	788.2	910.1	851.5	694.6	672.0
Natural gas	175.4	318.9	634.8	612.8	659.3	705.3	734.8
Petroleum	97.5	98.0	16.2	17.7	20.5	14.7	13.7
Geothermal	0.5	0.5	0.4	0.4	0.4	0.4	0.3
CH_4	**0.5**	**1.0**	**1.4**	**1.4**	**1.5**	**1.5**	**1.5**
Coal	0.4	0.4	0.2	0.2	0.2	0.2	0.2
Petroleum	+	+	+	+	+	+	+
Natural gas	0.1	0.5	1.2	1.2	1.3	1.3	1.4
Wood	+	+	+	+	+	+	+
N_2O	**18.2**	**26.7**	**17.5**	**19.0**	**19.4**	**16.6**	**16.0**
Coal	17.9	24.9	13.5	15.1	15.2	12.1	11.4
Petroleum	0.1	0.1	+	+	+	+	+
Natural gas	0.3	1.7	4.0	3.9	4.2	4.4	4.6
Wood	+	+	+	+	+	+	+
Total	1,838.7	2,427.8	1,458.5	1,561.3	1,552.6	1,433.0	1,438.4

+ Does not exceed 0.05 MMT CO_2 Eq.

Note: Totals may not sum due to independent rounding.

Electricity was used primarily in the residential, commercial, and industrial end-use sectors for lighting, heating, electric motors, appliances, electronics, and air conditioning (see Figure 3-7). Use of electricity in the transportation sector has historically been used in rail but has grown recently due to use of electric vehicles. Section 3.1.2 Transportation Sector and Mobile Combustion provides a break-out of CO_2 emissions from electricity use in the transportation end-use sector.

Figure 3-7: Electric Power Retail Sales by End-Use Sector



In 2024, electricity sales to the residential and commercial end-use sectors increased by 2.0 percent and 3.0 percent relative to 2023, respectively. Electricity sales to the industrial sector in 2024 increased by 2.5 percent relative to 2023. The sections below describe end-use sector energy use in more detail. Overall, in 2024, the amount of electricity retail sales (in kWh) increased by 2.6 percent relative to 2023.

Methods

CO_2 emissions from fossil fuel combustion are largely dependent on fuel type and carbon content, whereas CH_4 and N_2O emissions also depend on combustion technologies and other factors. Therefore, methodologies for estimating CO_2 emissions from fossil fuel combustion differ from the estimation of non-CO_2 (CH_4 and N_2O) emissions from stationary fossil fuel combustion.

For this *GHGIA*, the methods used to estimate CO_2 emissions and non-CO_2 emissions from the electric power sector are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* report (EPA, 2025).

Recalculations

Recalculations were implemented on historic estimates to incorporate updated data from EIA. EIA often updates historical data when new data becomes available, impacting the most recent years of data. Updates to historical data based on the latest EIA data used (2026a) resulted in a 0.1 percent increase in emissions from natural gas used in the electric power sector in 2023.

3.1.2 Transportation Sector and Mobile Combustion

The transportation sector includes all vehicles whose primary purpose is transporting people and/or goods from one physical location to another. Included are automobiles; trucks; buses; motorcycles; trains, subways, and other rail vehicles; aircraft; and ships, barges, and other waterborne vehicles (EIA, 2026a). CO_2 emissions from other mobile source vehicles whose primary purpose is not transportation (e.g., construction cranes and bulldozers, farming vehicles, and warehouse tractors and forklifts) are generally reported in the end-use sector where they occur, e.g., in the industrial and commercial sectors. However, some non-CO_2 emissions from these non-transportation mobile sources are included in this section. This is because CO_2 emissions are estimated based on fuel use (allocated across end use sectors) while the methodology involved in estimating non-CO_2 emissions is based on the combustion source which is similar for all these vehicles.

Annex 5 presents the total emissions from all transportation and mobile sources, including CO_2, N_2O, CH_4, and hydrofluorocarbons (HFCs).

Petroleum-based products provide most of the energy consumed for transportation, with the majority being gasoline consumption in highway vehicles. Diesel fuel for freight trucks and jet fuel for aircraft accounted for most of the remaining consumption. CO_2 from fossil fuel combustion is the largest source of emissions from the transportation sector, with other non-CO_2 gases contributing a smaller amount.

The primary energy statistics used to calculate emissions from the transportation sector include consumption of fossil fuels that are ultimately used for international bunkers. Bunker fuel consumption is not included in nationally reported emissions and is instead reported separately as a memo item.[6] Therefore, the amount of each fuel type used for international bunkers was subtracted from fuel consumption data when determining fuel combustion emissions. Official estimates exclude emissions from the combustion of both aviation and marine international bunker fuels; however, estimates of international bunker fuel-related emissions are presented in the tables below for informational purposes. Section 3.10 has a further discussion of international bunker fuel related emissions.

In 2024 light-duty vehicles (including passenger cars and light-duty trucks) represented 54.9 percent of CO_2 emissions; medium- and heavy-duty trucks and buses represented 24.0 percent; aircraft represented 10.4 percent; and other sources represented 10.7 percent. In 2024, domestic transportation CO_2 emissions decreased by 1.5 percent (27.7 MMT CO_2 Eq.) compared to 2023 but still increased overall by 21.6 percent (318.9 MMT CO_2 Eq.) compared to 1990. See Table 3-8 for a detailed breakdown of transportation CO_2 emissions by mode and fuel type.

[6] As per IPCC and United Nations Framework Convention on Climate Change inventory reporting guidelines. There are other international organizations, including the International Civil Aviation Organization and the International Maritime Organization, that consider global action from these sectors.

Table 3-8: CO_2 Emissions from Fossil Fuel Combustion in Transportation End-Use Sector (MMT CO_2 Eq.)

Fuel/Vehicle Type	1990	2005	2020	2021	2022	2023	2024
Gasoline	**963.2**	**1,145.0**	**936.1**	**1,027.9**	**1,013.7**	**1,049.3**	**1,015.0**
Passenger Cars	625.5	522.7	297.5	313.8	296.4	297.5	278.2
Light-Duty Trucks	272.9	573.5	590.1	658.4	658.7	691.4	677.2
Medium- and Heavy-Duty Trucks[a]	42.0	28.7	29.5	34.7	35.8	36.7	36.0
Buses	5.2	1.8	3.1	3.5	3.9	4.2	4.2
Motorcycles	3.3	4.7	6.1	6.9	8.2	8.7	8.6
Recreational Boats	14.3	13.7	9.9	10.6	10.8	10.8	10.8
Diesel Fuel	**274.5**	**471.4**	**458.7**	**507.3**	**508.1**	**505.7**	**501.0**
Passenger Cars	9.9	4.1	2.0	2.1	2.0	1.9	1.7
Light-Duty Trucks	8.2	30.1	26.6	28.8	29.1	28.9	28.0
Medium- and Heavy-Duty Trucks[a]	191.9	355.7	363.6	402.9	401.1	400.1	395.9
Buses	7.8	14.9	16.4	18.5	20.3	20.2	20.1
Rail	35.6	46.0	32.0	34.0	34.3	33.9	34.9
Recreational Boats	2.7	2.8	2.6	2.9	3.1	3.1	3.3
Ships and Non-Recreational Boats	6.7	8.4	7.7	10.7	11.0	10.6	10.2
International Bunker Fuels	11.7	9.5	7.8	7.4	7.2	7.0	6.9
Jet Fuel	**222.3**	**249.5**	**160.4**	**203.5**	**231.5**	**245.5**	**251.7**
Commercial Aircraft[b]	109.9	132.7	91.3	119.0	129.7	129.7	129.7
Military Aircraft	35.7	19.8	11.7	12.5	12.4	11.5	10.5
General Aviation Aircraft	38.5	36.8	17.6	21.1	22.7	37.7	45.2
International Bunker Fuels	38.2	60.2	39.8	50.8	66.6	66.5	66.3
Aviation Gasoline	**3.1**	**2.4**	**1.4**	**1.5**	**1.5**	**1.5**	**1.6**
General Aviation Aircraft	3.1	2.4	1.4	1.5	1.5	1.5	1.6
Residual Fuel Oil	**76.3**	**62.9**	**29.4**	**46.2**	**47.3**	**39.3**	**42.5**
Ships and Non-Recreational Boats	22.6	19.3	7.3	24.2	22.9	16.6	18.0
International Bunker Fuels	53.7	43.6	22.1	21.9	24.4	22.7	24.5

(continued)

Table 3-8: CO_2 Emissions from Fossil Fuel Combustion in Transportation End-Use Sector (MMT CO_2 Eq.)

Fuel/Vehicle Type	1990	2005	2020	2021	2022	2023	2024
Natural Gas	**36.0**	**33.1**	**58.8**	**65.2**	**72.3**	**71.9**	**73.7**
Passenger Cars	+	+	+	+	+	+	+
Light-Duty Trucks	+	+	+	+	+	+	+
Medium- and Heavy-Duty Trucks[a]	+	+	0.1	0.1	0.1	0.1	0.1
Buses	+	0.2	0.2	0.2	0.2	0.3	0.3
Pipeline[c]	36.0	32.8	58.5	64.9	72.0	71.5	73.3
Liquified Petroleum Gas (LPG)	**1.4**	**1.8**	**0.5**	**0.6**	**0.7**	**0.7**	**0.8**
Passenger Cars	+	+	+	+	+	+	+
Light-Duty Trucks	0.1	0.1	+	+	0.1	0.1	0.1
Medium- and Heavy-Duty Trucks[a]	1.3	0.9	0.5	0.5	0.5	0.5	0.6
Buses	+	0.7	0.1	0.1	0.1	0.1	0.1
Electricity	**3.0**	**4.7**	**3.6**	**3.9**	**4.5**	**5.2**	**6.6**
Passenger Cars	+	+	0.9	1.0	1.2	1.5	2.0
Light-Duty Trucks	+	+	0.2	0.4	0.8	1.2	2.0
Buses	+	+	+	0.1	0.1	0.1	0.1
Rail	3.0	4.7	2.4	2.5	2.5	2.4	2.4
Total (excludes bunkers)	**1,476.2**	**1,857.5**	**1,579.3**	**1,775.9**	**1,781.5**	**1,822.8**	**1,795.1**
International Bunker Fuels	**103.6**	**113.3**	**69.6**	**80.2**	**98.2**	**96.2**	**97.8**

+ Does not exceed 0.05 MMT CO_2 Eq.

[a] Includes medium- and heavy-duty trucks over 8,500 lb.

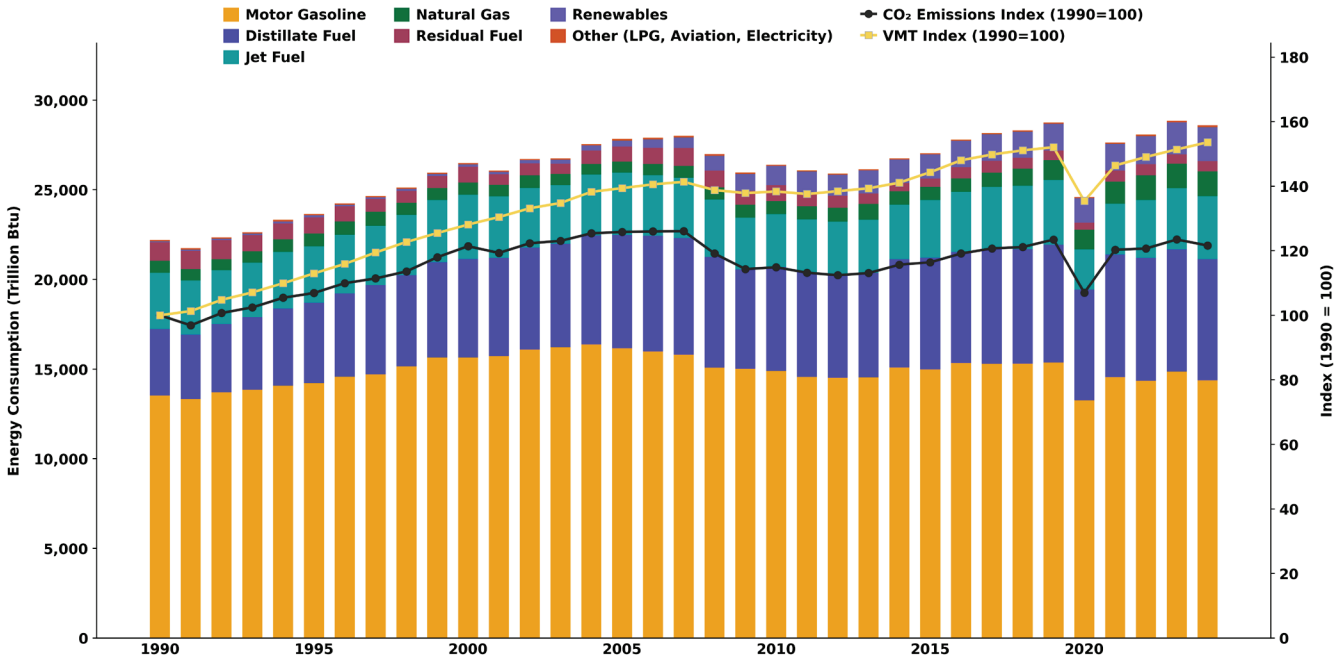
[b] Commercial aircraft, as modeled in Federal Aviation Administration's Aviation Environmental Design Tool, consists of passenger aircraft, cargo, and other chartered flights.

[c] Pipelines reflect CO_2 emissions from natural gas-powered pipelines transporting natural gas.

Notes: This table does not include emissions from non-transportation mobile sources, such as agricultural equipment and construction/mining equipment. It also does not include emissions associated with electricity consumption by pipelines or lubricants used in transportation. In addition, this table does not include CO_2 emissions from U.S. Territories, since these are covered in a separate chapter of the *GHGIA*. Totals may not sum due to independent rounding.

The increase in transportation emissions from fossil fuel combustion from 1990 to 2024 was, in large part, due to increased demand for travel (see Figure 3-8) along with changes in fuel efficiency as discussed below. The number of on-road vehicle miles traveled increased 53.6 percent, while on-road fleet fuel efficiency increased by 14.8 percent from 1990 to 2024.

Figure 3-8: Fuels Used in Transportation Sector, On-road VMT, and Total Sector CO_2 Emissions



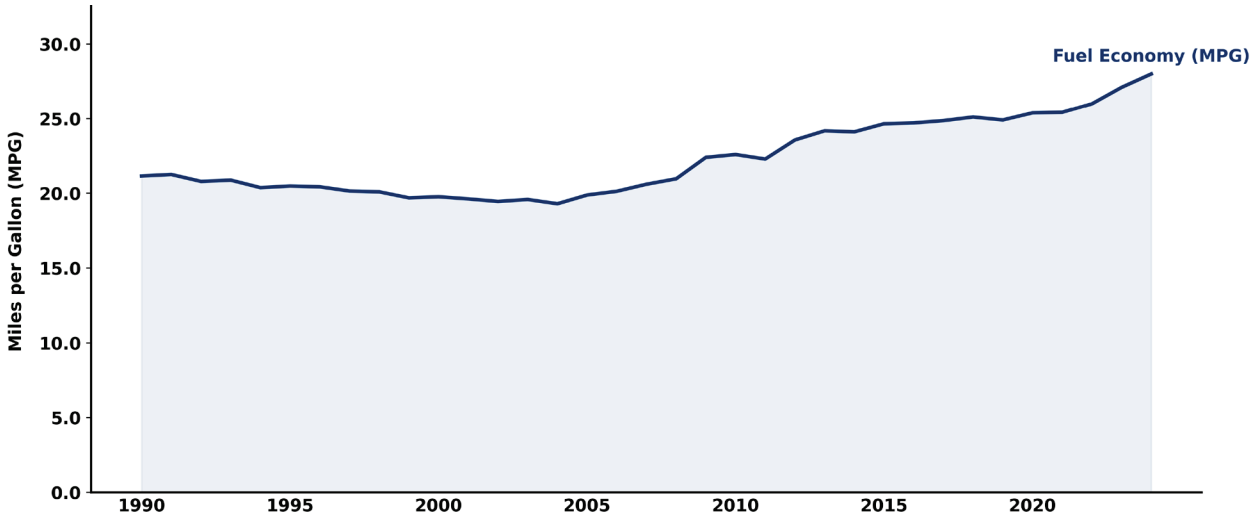
Notes: Distillate fuel, residual fuel, and jet fuel include adjustments for international bunker fuels. Distillate fuel and motor gasoline include adjustments for the sectoral allocation of these fuels. Other Fuels includes aviation gasoline and propane.

Source: Information on fuel consumption was obtained from EIA (2026a).

CO_2 emissions from passenger cars and light-duty trucks totaled 989.2 MMT CO_2 in 2024, an increase of 7.9 percent from 1990. In particular, the change in CO_2 emissions from passenger cars and light-duty trucks is, in large part, due to a change in demand for travel (as shown in Figure 3-8) and fleet-wide light-duty vehicle fuel economy. The change in new light-duty vehicle fuel economy (see Figure 3-9) reflects improved fuel economy and changes in market share of light-duty trucks versus light-duty cars (see Figure 3-10).

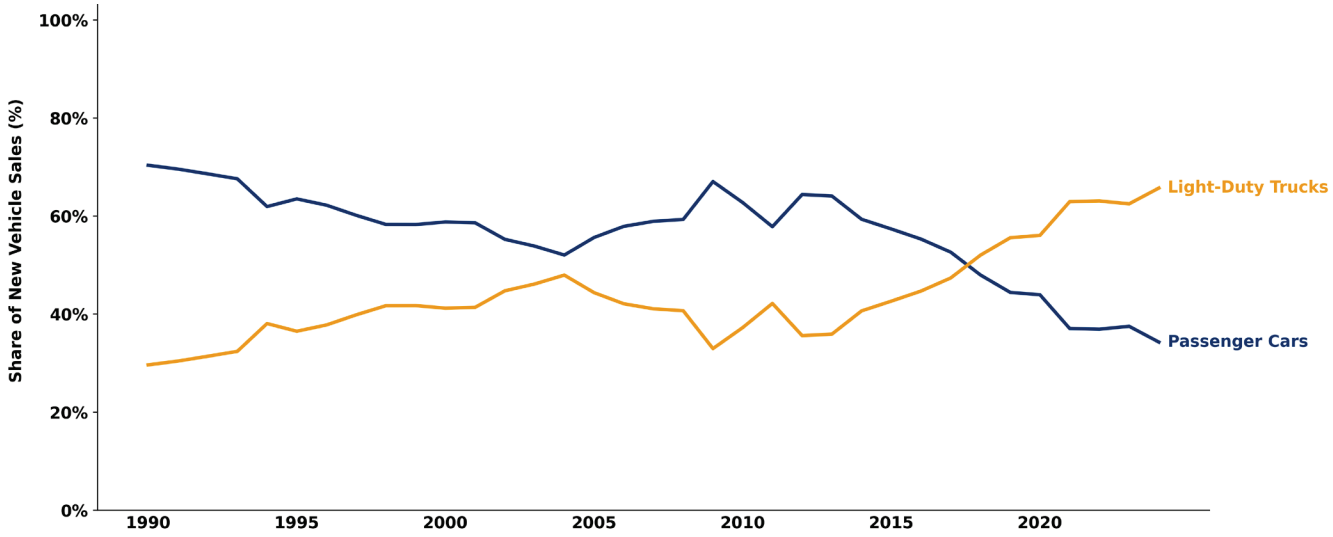
Average new vehicle fuel economy has improved almost every year since 2005, whereas the light-duty truck share of new vehicle sales has varied overtime. Since 2014, the light-duty truck share has steadily increased, reaching 66 percent of new vehicle sales in model year 2024.

Figure 3-9: Sales-Weighted Fuel Economy of New Passenger Cars and Light-Duty Trucks, 1990-2024



Source: EPA (2026).

Figure 3-10: Sales of New Passenger Cars and Light-Duty Trucks, 1990-2024



Source: EPA (2026).

Medium- and heavy-duty truck CO_2 emissions increased by 83.9 percent from 1990 to 2024. This increase was largely due to a substantial growth in medium- and heavy-duty truck vehicle miles traveled (VMT), which increased by 86.1 percent between 1990 and 2024.

Across all categories of aviation, excluding international bunkers, CO_2 emissions decreased by 0.1 percent between 1990 and 2024. Decreases in jet fuel emissions (excluding bunkers) started in 2007, in part due to improved operational efficiency that results in more direct flight routing, improvements in aircraft and engine technologies to reduce fuel burn and emissions, and the accelerated retirement of older, less fuel-efficient aircraft. However, the sharp decline in commercial aircraft emissions from 2019 to 2020 and their gradual recovery since is due to COVID-19 impacts on scheduled passenger air travel.

Table 3-9 and Table 3-10 provide fossil fuel CH_4 and N_2O emission estimates from mobile sources in MMT CO_2 Eq. Mobile combustion sources include emissions of CH_4 and N_2O from all transportation sources with the exception of pipelines and electric locomotives;[7] mobile sources also include non-transportation sources such as construction/mining equipment, agricultural equipment, vehicles used off-road, and other sources (e.g., snowmobiles, lawnmowers).

As described above, N_2O and CH_4 emissions are reported using different categories than CO_2. CO_2 emissions are reported by end-use sector (transportation, industrial, commercial, residential, U.S. Territories) and generally adhere to a fuel use and fuel emission factor approach to estimating emissions. CO_2 emissions from non-transportation mobile sources (e.g., lawn and garden equipment, farm equipment, construction equipment) are allocated to their respective end-use sector (i.e., construction equipment CO_2 emissions are included in the industrial end-use sector instead of the transportation end-use sector). CH_4 and N_2O emissions are reported using the "mobile combustion" category, which includes non-transportation mobile sources. CH_4 and N_2O emission estimates are technology-based estimates, based on total activity (fuel use, VMT) and emissions factors by source and technology type. These reporting schemes are in accordance with IPCC guidance. For informational purposes only, CO_2 emissions from non-transportation mobile sources are presented separately from their overall end-use sector in Annex 5, which also presents total emissions from all transportation and mobile sources, including CO_2, CH_4, N_2O, and HFCs.

From 1990 to 2024, mobile source CH_4 emissions declined, largely due to emissions control technologies employed in on-road vehicles since the mid-1990s to reduce CO, NOx, NMVOC, and CH_4 emissions. Earlier-generation control technologies initially resulted in elevated N_2O emissions. Improvements in later-generation emission control technologies have reduced N_2O output, resulting in an overall decrease in mobile source N_2O emissions from 1990 to 2024. Overall, CH_4 and N_2O emissions were predominantly from gasoline-fueled passenger cars, light-duty trucks, and non-highway sources.

[7] Emissions of CH_4 from natural gas systems are reported separately.

Table 3-9: CH_4 Emissions from Mobile Combustion (MMT CO_2 Eq.)

Fuel Type/Vehicle Type	1990	2005	2020[a]	2021	2022	2023	2024
Gasoline On-Road	**5.8**	**3.3**	**0.8**	**0.9**	**0.9**	**0.8**	**0.8**
Passenger Cars	3.8	1.8	0.2	0.2	0.2	0.2	0.2
Light-Duty Trucks	1.4	1.3	0.5	0.6	0.5	0.5	0.6
Medium- and Heavy-Duty Trucks and Buses	0.5	0.2	+	+	+	+	+
Motorcycles	+	+	+	+	+	+	+
Diesel On-Road	**+**	**+**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Passenger Cars	+	+	+	+	+	+	+
Light-Duty Trucks	+	+	+	+	+	+	+
Medium- and Heavy-Duty Trucks	+	+	0.1	0.1	0.1	0.1	0.1
Medium- and Heavy-Duty Buses	+	+	+	+	+	+	+
Alternative Fuel On-Road	+	+	+	+	+	+	+
Non-Road[a]	**1.4**	**1.8**	**1.6**	**1.7**	**1.8**	**1.7**	**1.7**
Ships and Boats	0.4	0.5	0.4	0.5	0.5	0.5	0.5
Rail[b]	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Aircraft	0.1	0.1	+	+	+	+	+
Agricultural Equipment[c]	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Construction/Mining Equipment[d]	0.2	0.3	0.2	0.2	0.2	0.2	0.2
Other[e]	0.5	0.7	0.8	0.7	0.8	0.8	0.8
Total	**7.2**	**5.2**	**2.6**	**2.7**	**2.7**	**2.7**	**2.7**

+ Does not exceed 0.05 MMT CO_2 Eq.

[a] Non-road fuel consumption estimates for 2020 are adjusted to account for the COVID-19 pandemic and associated restrictions. For agricultural equipment and airport equipment, sector-specific adjustment factors were applied to the 2019 data. For all other sectors, a 7.7 percent reduction factor is used, based on transportation diesel use trends in 2020 (EIA 2026a).

[b] Rail emissions do not include emissions from electric-powered locomotives. Class II and Class III diesel consumption data for 2014 to 2024 is estimated by applying the historical average fuel usage per carload factor to the annual number of carloads.

[c] Includes equipment, such as tractors and combines, and fuel consumption from trucks that are used off-road in agriculture.

[d] Includes equipment, such as cranes, dumpers, and excavators, and fuel consumption from trucks that are used off-road in construction.

[e] "Other" includes snowmobiles and other recreational equipment, logging equipment, lawn and garden equipment, railroad equipment, airport equipment, commercial equipment, and industrial equipment, as well as fuel consumption from trucks that are used off-road for commercial/industrial purposes.

Note: Totals may not sum due to independent rounding.

Table 3-10: N_2O Emissions from Mobile Combustion (MMT CO_2 Eq.)

Fuel Type/Vehicle Type	1990	2005	2020[a]	2021	2022	2023	2024
Gasoline On-Road	**31.4**	**33.4**	**6.4**	**6.2**	**5.6**	**5.0**	**5.2**
Passenger Cars	22.3	16.4	2.0	1.9	1.7	1.5	1.3
Light-Duty Trucks	8.2	15.8	4.2	4.1	3.7	3.3	3.6
Medium- and Heavy-Duty Trucks and Buses	0.9	1.2	0.2	0.2	0.2	0.2	0.2
Motorcycles	+	+	0.1	0.1	0.1	0.1	0.1
Diesel On-Road	**0.2**	**0.4**	**2.9**	**3.3**	**3.4**	**3.5**	**3.7**
Passenger Cars	+	+	+	+	+	+	+
Light-Duty Trucks	+	+	0.2	0.2	0.2	0.2	0.3
Medium- and Heavy-Duty Trucks	0.2	0.3	2.5	2.9	2.9	3.0	3.2
Medium- and Heavy-Duty Buses	+	+	0.2	0.2	0.2	0.2	0.3
Alternative Fuel On-Road	**+**	**+**	**+**	**0.1**	**0.1**	**0.1**	**0.1**
Non-Road[a]	**6.2**	**8.1**	**6.7**	**7.4**	**7.8**	**7.9**	**8.0**
Ships and Boats	0.2	0.2	0.1	0.3	0.3	0.2	0.2
Rail[b]	0.2	0.3	0.2	0.2	0.2	0.2	0.2
Aircraft	1.5	1.6	1.0	1.3	1.4	1.5	1.5
Agricultural Equipment[c]	1.2	1.4	1.1	1.1	1.1	1.1	1.1
Construction/Mining Equipment[d]	1.2	1.9	1.6	1.7	1.7	1.8	1.8
Other[e]	1.8	2.8	2.7	2.9	3.1	3.2	3.2
Total	**37.8**	**42.0**	**16.1**	**17.0**	**16.9**	**16.5**	**17.0**

+ Does not exceed 0.05 MMT CO_2 Eq.

[a] Non-road fuel consumption estimates for 2020 are adjusted to account for the COVID-19 pandemic and associated restrictions. For agricultural equipment and airport equipment, sector-specific adjustment factors were applied to the 2019 data. For all other sectors, a 7.7 percent reduction factor is used, based on transportation diesel use (EIA 2026a).

[b] Rail emissions do not include emissions from electric-powered locomotives. Class II and Class III diesel consumption data for 2014 through 2024 is estimated by applying the historical average fuel usage per carload factor to the annual number of carloads.

[c] Includes equipment, such as tractors and combines, and fuel consumption from trucks that are used off-road in agriculture.

[d] Includes equipment, such as cranes, dumpers, and excavators, and fuel consumption from trucks that are used off-road in construction.

[e] "Other" includes snowmobiles and other recreational equipment, logging equipment, lawn and garden equipment, railroad equipment, airport equipment, commercial equipment, and industrial equipment, as well as fuel consumption from trucks that are used off-road for commercial/industrial purposes.

Note: Totals may not sum due to independent rounding.

Methods

As discussed, CO_2 emissions from fossil fuel combustion are mainly based on fuel type and carbon content, whereas CH_4 and N_2O emissions also depend on combustion technologies and other factors. Therefore, methodologies for estimating CO_2 emissions from fossil fuel combustion differ from the estimation of non-CO_2 (CH_4 and N_2O) emissions from mobile fossil fuel combustion.

For CO_2 emission estimates, on-road fuel consumption data from FHWA were used to determine total on-road use of motor gasoline and diesel fuel (FHWA, 1996 through 2026). Ratios developed from the MOtor Vehicle Emission Simulator version 5 (MOVES5) output are used to apportion FHWA fuel consumption data to vehicle type and fuel type (see the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* [EPA, 2025] for more information about the MOVES5 model and how it was used).

For non-CO_2 emission estimates, gasoline and diesel fuel highway vehicle mileage estimates are based on data from FHWA Highway Statistics Table VM-1 (FHWA, 1996 through 2026). VMT estimates from FHWA are allocated to vehicle type using ratios of VMT per vehicle type to total VMT, derived from EPA's MOVES5 model.

For this *GHGIA,* the methods used to estimate CO_2 and non-CO_2 emissions from the transportation sector are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* report (EPA, 2025). However, there were a few areas where data was unavailable for 2024 and was proxied:

- Data for alternative fuel vehicles fuel use and emissions was proxied to 2023
- Data was proxied for vehicle control technologies; the same mix of technologies was assumed as for 2023
- Data on bunker fuel use was also largely proxied, as the data from multiple sources was not available (see Section 3.10 on International Bunker Fuels for more detail)

One change in data source used was that electricity use from light-duty battery electric vehicles and plug-in hybrid electric vehicles was taken directly from EIA data (2026c) for the years 2018 forward. This differed from a previous analysis that was based on research as outlined in Browning (2024).

Recalculations

There were some adjustments made to the historical data to reflect changes in data sources and updates to the existing data. The gasoline and diesel fuel allocation across sectors was updated to reflect totals from top-down estimates from EIA. This included updating the amounts of biofuels excluded from the analysis. Gasoline and diesel fuel use was also updated for 2023 based on updated FHWA data for 2023. The EIA Fuel Oil and Kerosine Sales (FOKS) data (EIA, 1991 through 2022) was discontinued in 2020. The FOKS data is used to allocate diesel fuel use to specific end-use categories, including maritime use. For this *GHGIA*, recent years of diesel fuel used in ships were extrapolated based on the historical percentages of total transportation sector diesel used in shipping. This was a change from using the 2020 data as a proxy for recent years. As a result of these updates, petroleum use emissions in the transportation sector increased by 2.4 percent in

2023 compared with previous estimates. The overall average annual change in emissions was 0.02 percent over the time series.

There was also a slight change in natural gas estimates in 2023 based on the latest data from EIA (EIA, 2025), resulting in less than a 0.2 percent change in 2023 natural gas estimates compared with the previous estimates.

3.1.3 Industrial Sector

The industrial end-use sector, per the underlying energy use data from EIA (2026a), includes activities such as manufacturing, construction, mining, and agriculture. The largest of these activities in terms of energy use is manufacturing, which represents the majority of energy use. This sector also includes generators that produce electricity and/or useful thermal output primarily to support the above-mentioned industrial activities.

Table 3-11 presents GHG emissions from fossil fuel combustion in the industrial sector including emissions from the electric power sector that are distributed to the industrial sector based on the amount of electricity used in the sector.

Table 3-11: GHG Emissions from Fossil Fuel Combustion in the Industrial Sector (MMT CO_2 Eq.)

GHG/Fuel Type	1990	2005	2020	2021	2022	2023	2024
CO_2	**1,504.8**	**1,511.5**	**1,149.7**	**1,191.9**	**1,205.6**	**1,160.4**	**1,159.6**
Coal	157.8	117.8	43.0	43.0	43.0	36.4	34.9
Natural gas	407.4	388.3	504.0	515.4	525.3	529.2	529.8
Petroleum	305.1	337.2	231.4	228.4	239.2	226.1	225.0
Electricity Distributed	634.4	668.1	371.4	405.1	398.1	368.7	369.9
CH_4	**2.2**	**2.2**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**
Coal	0.5	0.3	0.1	0.1	0.1	0.1	0.1
Petroleum	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Natural gas	0.2	0.2	0.3	0.3	0.3	0.3	0.3
Wood	1.2	1.2	1.1	1.1	1.1	1.1	1.1
Electricity Distributed	0.2	0.3	0.4	0.4	0.4	0.4	0.4
N_2O	**9.1**	**10.1**	**6.6**	**7.1**	**7.2**	**6.3**	**6.2**
Coal	0.7	0.5	0.2	0.2	0.2	0.2	0.1
Petroleum	0.5	0.5	0.3	0.3	0.3	0.2	0.2
Natural gas	0.2	0.2	0.2	0.2	0.2	0.2	0.3
Wood	1.5	1.5	1.4	1.4	1.4	1.3	1.3
Electricity Distributed	6.4	7.5	4.5	5.0	5.1	4.3	4.2
Total Direct Emissions	**875.2**	**847.9**	**782.0**	**790.5**	**811.3**	**795.3**	**793.2**
Total w/ Electricity Distributed	**1,516.2**	**1,523.8**	**1,158.3**	**1,201.0**	**1,214.8**	**1,168.7**	**1,167.8**

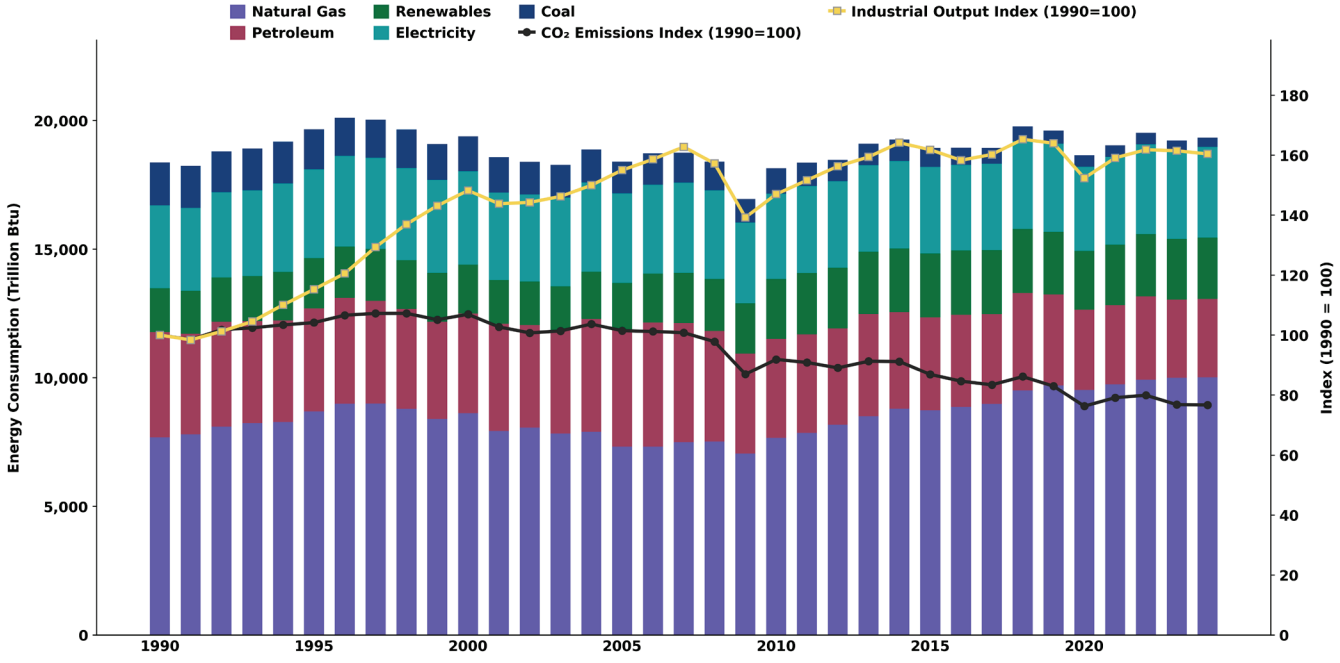
Note: Totals may not sum due to independent rounding.

In 2024, CO_2, CH_4, and N_2O emissions from fossil fuel combustion and electricity use within the industrial end-use sector totaled 1,167.8 MMT CO_2 Eq., a 0.1 percent decrease from 2023 emissions.

There are many dynamics that impact emissions from the industrial sector, including economic activity, changes in the make-up of the industrial sector, changes in the emissions intensity of industrial processes, and weather-related impacts on heating and cooling of industrial buildings.[8]

Despite the growth in industrial output (60.4 percent) from 1990 to 2024, direct emissions from fossil fuel combustion in the industrial sector decreased by 9.4 percent over the same time series (see Figure 3-11). Structural changes within the U.S. economy are to some extent responsible for the decoupling of industrial output growth from industrial GHG emissions, for example: (1) more rapid growth in output from less energy-intensive industries relative to traditional manufacturing industries (e.g., from steel to computer equipment), and (2) energy efficiency methods employed in energy-intensive industries such as increased use of electric arc furnaces.

Figure 3-11: Fuels and Electricity Used in Industrial Sector, Industrial Output, and Total Sector CO_2 Emissions (Including Electricity)



[8] Some large commercial customers pay an industrial price for natural gas and/or electricity and are grouped with the industrial end-use sector in U.S. energy statistics. This may cause the industrial end-use sector to appear to be sensitive to weather conditions due to the heating and cooling demands of the large commercial facilities.

Methods

As discussed, CO_2 emissions from fossil fuel combustion are mainly based on fuel type and carbon content, whereas CH_4 and N_2O emissions also depend on combustion technologies and other factors. Therefore, methodologies for estimating CO_2 emissions from fossil fuel combustion differ from the estimation of non-CO_2 (CH_4 and N_2O) emissions from stationary fuel combustion.

For this *GHGIA*, the methods used to estimate CO_2 emissions and non-CO_2 emissions from the industrial sector are consistent with the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* report (EPA, 2025). However, there were some areas where data had to be proxied due to lack of 2024 data. As noted previously, adjustments were made to the industrial sector energy use data before calculating emissions. These mainly include adjusting for energy use that is transferred to the IPPU and NEU calculations. Many of the IPPU adjustments relied in part on data from the U.S. EPA Greenhouse Gas Reporting Program (GHGRP) including, for example, energy use for iron and steel and ammonia (see the IPPU Chapter 4 for more details). Due to lack of 2024 GHGRP data, these adjustments were, for the most part, proxied to 2023 values. The amount of energy use that was proxied represented 2.5 percent of unadjusted industrial sector energy use. So, while the proxy approach may lead to an under or over allocation of energy use between fossil fuel combustion and IPPU, the overall effect will be minor. More details on activity data are provided in Annex 5.

One other update to the prior approach was to revise the IPPU sector adjustment for carbon black. Previous estimates adjusted residual and other oil used in the industrial sector fossil fuel combustion emission calculations to account for the energy use and emissions that are included under IPPU. The previous estimates had more residual oil used in carbon black production than was reported to be used in the industrial sector, which resulted in undercounting some of the energy used in IPPU. The approach used in this *GHGIA* relies on the total industrial sector residual fuel oil use with the remaining amount needed assuming to come from other oils (which are adjusted under NEU).

Recalculations

Recalculations were implemented on historical estimates based on updates in the underlying data from EIA (2026a). EIA often updates historical data when new data becomes available, mostly impacting the most recent years of data. Updates to historical data based on the EIA data used resulted in a 0.3 percent decrease in coal use in 2023.

The biggest change in historical data resulted from an update to the amount of fuel used in NEU. This impacts the industrial sector fossil fuel combustion emissions, as energy used in NEU is subtracted from the industrial sector fossil fuel emission calculations and accounted for as part of NEU emissions. There was a decrease in the amount of natural gas used in NEU increasing the amount of natural gas use and emissions in the industrial sector fossil fuel combustion emissions. The change resulted in a 2.8 percent increase in natural gas emissions in 2023 compared with previous estimates and an average annual increase of 0.6 percent over the time series. The emissions from hydrocarbon gas liquids (HGLs) were also impacted due to updates in the amounts of HGLs used for NEU and the emission factors for HGLs, which were updated to reflect the mix of HGLs used for energy and NEU. The change resulted in a 6.3 percent decrease in industrial sector

fossil fuel combustion emissions in 2023 compared with previous estimates. The adjustment for gasoline and diesel used in the transportation sector also impacted other sectors, as they were adjusted to keep the totals the same. That resulted in an average annual decrease of 0.8 percent over the time series.

3.1.4 Residential and Commercial Sectors

According to EIA, the residential sector is an energy-consuming sector that consists of living quarters for private households. Common uses of energy associated with this sector include space heating, water heating, air conditioning, and lighting, refrigeration, cooking, and running a variety of other appliances. The residential sector excludes institutional living quarters (EIA, 2026a).

The commercial sector is an energy-consuming sector that consists of service-providing facilities and equipment of businesses; federal, state, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The commercial sector includes institutional living quarters. It also includes sewage treatment facilities. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a wide variety of other equipment. This sector includes generators that produce electricity and/or useful thermal output primarily to support the activities of the above-mentioned commercial establishments (EIA, 2026a).

Table 3-12 presents GHG emissions from fossil fuel combustion in the residential and commercial sectors, including emissions from the electric power sector that are distributed to the residential and commercial sectors based on the amount of electricity used in those sectors.

Table 3-12: GHG Emissions from Fossil Fuel Combustion in the Residential and Commercial Sectors (MMT CO_2 Eq.)

GHG/Fuel Type	1990	2005	2020	2021	2022	2023	2024
CO_2	**1,747.7**	**2,314.0**	**1,607.6**	**1,680.0**	**1,714.0**	**1,571.1**	**1,585.2**
Coal	14.9	10.1	1.4	1.4	1.4	1.1	1.1
Natural gas	379.8	425.2	429.8	439.0	464.3	430.2	422.3
Petroleum	170.6	151.7	111.9	107.8	119.4	98.9	117.7
Electricity Distributed	1,182.4	1,727.0	1,064.5	1,131.8	1,128.9	1,040.9	1,044.1
CH_4	**7.4**	**6.5**	**5.9**	**6.0**	**6.9**	**6.2**	**6.1**
Coal	0.3	0.1	+	+	+	+	+
Petroleum	0.7	0.6	0.5	0.4	0.5	0.4	0.5
Natural gas	1.0	1.1	1.1	1.1	1.2	1.1	1.1
Wood	5.2	4.0	3.3	3.4	4.2	3.6	3.4
Electricity Distributed	0.3	0.7	1.0	1.0	1.1	1.1	1.1
N_2O	**13.1**	**20.4**	**13.9**	**14.9**	**15.4**	**13.2**	**12.8**
Coal	0.1	+	+	+	+	+	+
Petroleum	0.4	0.3	0.3	0.3	0.3	0.2	0.3
Natural gas	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Wood	0.6	0.5	0.4	0.4	0.5	0.5	0.4
Electricity Distributed	11.9	19.3	13.0	14.0	14.4	12.3	11.8
Total Direct Emissions	**573.7**	**593.8**	**548.9**	**554.1**	**592.0**	**536.2**	**547.0**
Total w/ Electricity Distributed	**1,768.2**	**2,340.8**	**1,627.4**	**1,700.9**	**1,736.3**	**1,590.5**	**1,604.1**

+ Does not exceed 0.05 MMT CO2 Eq.

Note: Totals may not sum due to independent rounding.

GHG emissions from the residential and commercial sectors increase substantially when emissions from electricity end-use are included, because the residential and commercial sectors use over 70 percent of the electricity generated in the United States (e.g., for building heating, ventilation, and air conditioning; lighting; and appliances) (National Renewable Energy Lab [NREL], 2023).

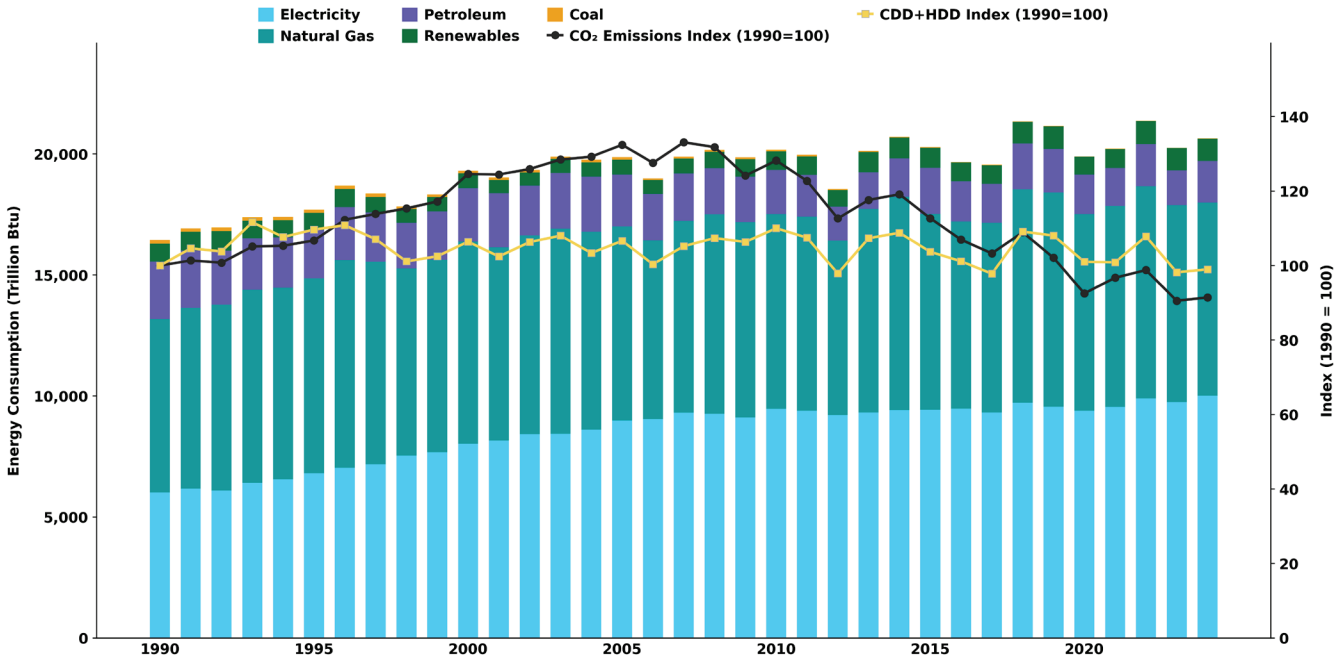
Short-term trends in the residential and commercial sectors are often correlated with seasonal weather conditions, which lead to fluctuations in energy use, rather than long-term economic conditions. Changes over time that tend to increase energy use include population growth and a trend toward larger houses. Other longer-term trends that tend to reduce energy use include population migration to warmer areas and improved energy efficiency and building insulation. The shift toward energy-efficient products and more stringent energy efficiency standards for

household equipment has also contributed to a decrease in energy demand in households (EIA, 2023; Nadel et al., 2015).

In 2024, total emissions (CO_2, CH_4, and N_2O) from fossil fuel combustion and electricity use within the residential and commercial sectors 1,604.1 MMT CO_2 Eq. The trends in the residential and commercial sectors when electricity power sector distributed emissions are included are, in large part, dependent on the carbon intensity of the electric power sector. For example, starting around 2014, total energy use and emissions in the residential and commercial sectors began to decouple due to the decarbonization of the electric power sector (see Figure 3-12).

Direct CO_2, CH_4, and N_2O emissions from fossil fuel combustion within the residential and commercial end-use sectors increased by 2.0 percent from 2023 to 2024. This is partly due to a decrease in heating degree days (2.9 percent), combined with a larger increase in cooling degree days (10.3 percent) from 2023 to 2024. See Box 3.1 for more details on weather-related data. From 2023 to 2024, direct energy use of coal and natural gas in the residential and commercial sectors decreased by 6.1 percent and 1.8 percent, respectively. Petroleum use in the residential and commercial sectors increased by 18.8 percent from 2023 to 2024; however, this could largely be due to a discontinuity in the FHWA data used to allocate gasoline and diesel fuel across sectors.

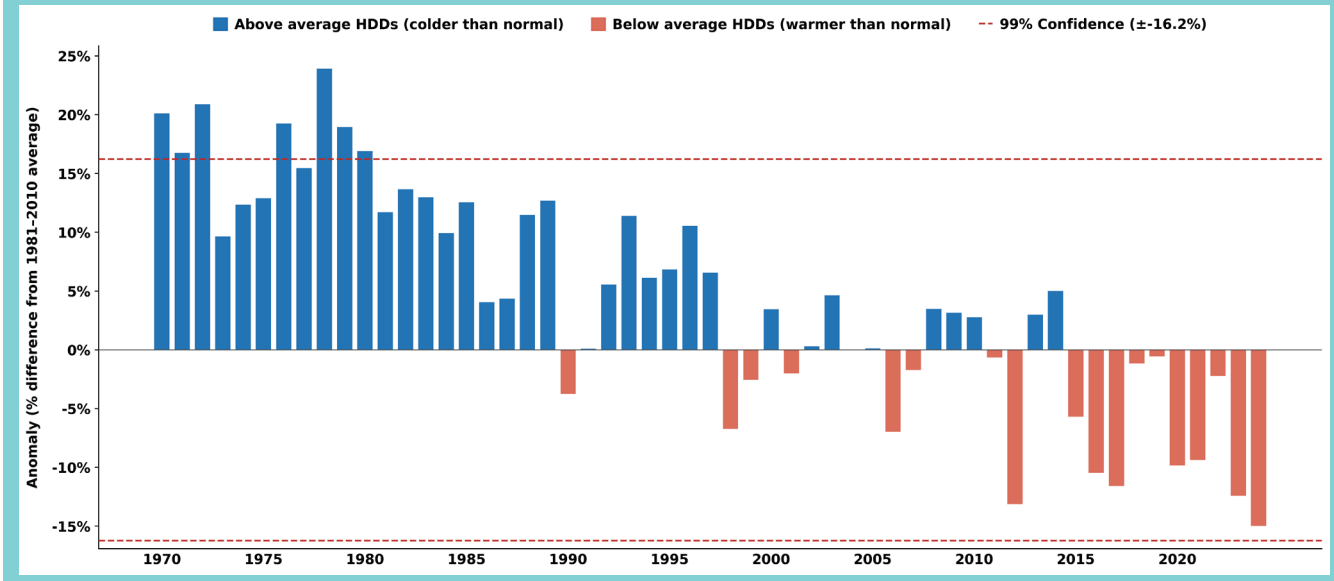
Figure 3-12: Fuels and Electricity Used in Residential and Commercial Sectors, Heating and Cooling Degree Days, and Total Sector CO_2 Emissions (Including Electricity)



Box 3-1: Weather and Non-Fossil Energy Effects on CO_2 Emissions from Fossil Fuel Combustion Trends

The United States in 2024 experienced a warmer winter overall compared to 2023, with a 2.9 percent decrease in heating degree days, and 2024 was warmer than normal with heating degree days 15.0 percent below normal[9] (see Figure 3-13). Along with a warmer winter, 2024 experienced a warmer summer than 2023, with cooling degree days 10.3 percent above 2023. Cooling degree days were 22.6 percent above normal (see Figure 3-14) (EIA, 2026a).[10] Warmer summers can lead to increased energy use, and associated emissions, to cool building spaces in the residential and commercial sectors, mostly from electricity use. Warmer winter conditions can lead to an overall decrease in direct energy use, and emissions from fossil fuel combustion, used for heating in the residential and commercial sectors.

Figure 3-13: Annual Deviations from Normal Heating Degree Days (HDDs) for the United States (1970–2023, Index Normal = 100)

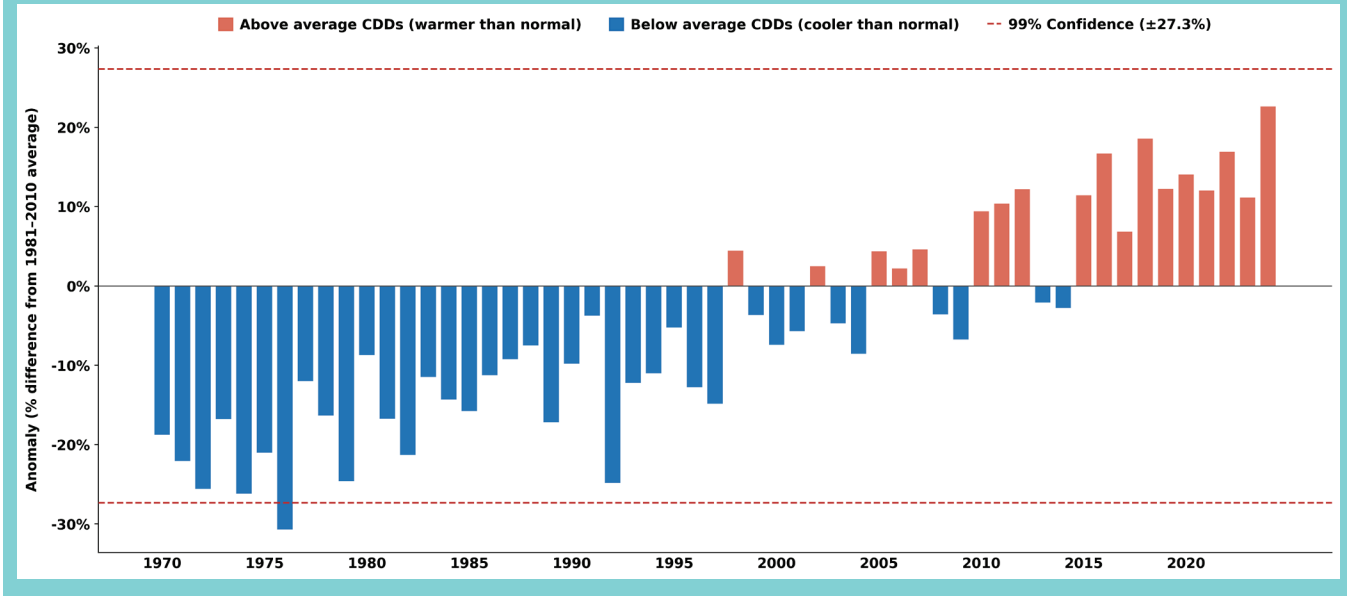


[9] The National Centers for Environmental Information of NOAA generates official U.S. climate normals every 10 years in keeping with the needs of the user community and the requirements of the World Meteorological Organization and National Weather Service. The 1991–2020 U.S. Climate Normals are the latest in a series of decadal normals first produced in the 1950s. See https://www.ncei.noaa.gov/products/land-based-station/us-climate-normals. The variation in these normals during this time period was ±16 percent and ±27 percent for heating and cooling degree days, respectively (99 percent confidence interval).

[10] Degree days are relative measurements of outdoor air temperature. Heating degree days are deviations of the mean daily temperature below 65 degrees Fahrenheit, whereas cooling degree days are deviations of the mean daily temperature above 65 degrees Fahrenheit. Heating degree days have a considerably greater effect on direct energy demand and related emissions than do cooling degree days. Excludes Alaska and Hawaii.

Box 3-1: Weather and Non-Fossil Energy Effects on CO_2 Emissions from Fossil Fuel Combustion Trends *(continued)*

Figure 3-14: Annual Deviations from Normal Cooling Degree Days (CDDs) for the United States (1970–2023, Index Normal = 100)



Methods

As discussed, CO_2 emissions from fossil fuel combustion are mainly based on fuel type and carbon content, whereas CH_4 and N_2O emissions also depend on combustion technologies and other factors. Therefore, methodologies for estimating CO_2 emissions from fossil fuel combustion differ from the estimation of non-CO_2 (CH_4 and N_2O) emissions from stationary fossil fuel combustion.

For this *GHGIA*, the methods used to estimate CO_2 emissions and non-CO_2 emissions from the residential and commercial sectors are consistent with prior estimates (EPA, 2025).

Recalculations

Recalculations were implemented on historical estimates based on updates in the underlying data from EIA (EIA 2026a). EIA often updates historical data when new data becomes available, mostly impacting the most recent years of data. Updates based on revised EIA data resulted in a slight increase (0.1 percent) in natural gas use in the residential sector and a slight decrease (0.2 percent) in natural gas use in the commercial sector in 2023 compared with previous estimates.

The adjustment to gasoline and diesel fuel used in the transportation sector also impacted the residential and commercial sectors. The updates resulted in a decrease in residential sector emissions of 11.2 percent and a 23.6 percent reduction in the commercial sector in 2023. The annual average change was a 0.2 percent decrease in residential sector and a 0.3 percent increase in the commercial sector over the time series compared with previous estimates.

3.1.5 Territories

U.S. Territories included in this analysis are American Samoa, Guam, Puerto Rico, U.S. Virgin Islands, Wake Island, and other outlying U.S. Pacific Islands. As described previously, this data is collected separately and is not available at the sector level. Therefore, U.S. Territories fossil fuel combustion emissions are presented in total but not broken out at the end-use sector level. The emissions will occur across all end-use sectors including stationary and mobile sources.

Table 3-13 presents GHG emissions from fossil fuel combustion in U.S. Territories.

Table 3-13: GHG Emissions from Fossil Fuel Combustion in U.S. Territories (MMT CO_2 Eq.)

GHG/Fuel Type	1990	2005	2020	2021	2022	2023	2024
CO_2	**20.0**	**51.8**	**23.2**	**25.7**	**23.8**	**27.2**	**27.9**
Coal	0.5	3.0	3.1	2.9	2.9	2.5	2.5
Natural gas	NO	1.3	2.6	3.9	2.7	4.5	4.5
Petroleum	19.5	47.5	17.5	18.9	18.1	20.1	20.9
CH_4	**+**	**0.1**	**+**	**+**	**+**	**+**	**+**
Coal	+	+	+	+	+	+	+
Petroleum	+	0.1	+	+	+	+	+
Natural gas	NO	+	+	+	+	+	+
Wood	NE	NE	NE	NE	NE	NE	NE
N_2O	**+**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Coal	+	+	+	+	+	+	+
Petroleum	+	0.1	+	+	+	+	+
Natural gas	NO	+	+	+	+	+	+
Wood	NE	NE	NE	NE	NE	NE	NE
Total	**20.1**	**52.1**	**23.3**	**25.8**	**23.8**	**27.3**	**28.0**

+ Does not exceed 0.05 MMT CO_2 Eq.
NO (Not Occurring)
NE (Not Estimated)
Note: Totals may not sum due to independent rounding.

The emissions from fossil fuel combustion in U.S. Territories have generally increased over time due to increased fuel use across all fuel types. The emissions peaked around 2004 and then have declined generally due to an increase and then decrease in petroleum fuel used over time. In 2024, CO_2 emissions from fossil fuel combustion were 28.0 MMT CO_2 Eq., a 2.7 percent increase from 2023 and a 39.5 percent increase from 1990. The CO_2 emissions from fossil fuel combustion

in U.S. Territories in 2024 represented only 0.6 percent of the total U.S. fossil fuel combustion CO_2 emissions.

Methods

As discussed, CO_2 emissions from fossil fuel combustion are mainly based on fuel type and carbon content, whereas CH_4 and N_2O emissions also depend on combustion technologies and other factors. Therefore, methodologies for estimating CO_2 emissions from fossil fuel combustion differ from the estimation of non-CO_2 (CH_4 and N_2O) emissions from stationary and mobile fossil fuel combustion.

For this *GHGIA*, the methods used to estimate CO_2 emissions and non-CO_2 emissions from U.S. Territories are consistent with previous reports (EPA, 2025). Some of the energy use data for 2024 was not available at the time of this *GHGIA* so was proxied to 2023 values.

Recalculations

Recalculations were implemented on historical estimates based on updates in the underlying data from EIA. EIA often updates historical data when new data becomes available, this mostly impacts the most recent years of data. The recalculations mostly impacted recent years of petroleum consumption. The 2023 data increased by 12.8 percent based on the revised data. The values over time were also impacted with an annual average change of 0.7 percent over the 1990 to 2023 time period.

Fossil Fuel Combustion Uncertainty

Uncertainty in emission estimates for fossil fuel combustion is associated with a few factors. As noted above, estimates of CO_2 from fossil fuel combustion are directly related to the amount of fuel combusted, the fraction of the fuel that is oxidized, and the carbon content of the fuel.

National statistics on the total amount of fossil fuel energy consumption are relatively accurate. However, the allocation to individual end-use sectors (i.e., residential, commercial, industrial, and transportation) is less certain. Uncertainties also result from the data and assumptions used to allocate emissions from the transportation end-use sector to individual vehicle types and transport modes.

There are also uncertainties associated with the adjustments made to energy use before calculating emissions. The adjustments include the amount of fuel used in non-energy production processes, the amount of fuel used in industrial processes, and fuel used in international bunker fuels. These factors all contribute to the uncertainty in the CO_2 estimates.

Another source of uncertainty is fuel consumption by U.S. Territories. The United States does not collect energy statistics for its territories at the same level of detail as for the fifty states and the District of Columbia. Therefore, estimating both emissions and bunker fuel consumption by these territories is difficult.

Uncertainties around carbon content of fuels and carbon oxidation efficiencies also occur. Given the same primary fuel type (e.g., coal, petroleum, or natural gas), the amount of carbon contained in the fuel per unit of useful energy can vary. For the United States, however, the impact of these uncertainties on overall CO_2 emission estimates is believed to be relatively small.

Uncertainties also occur around non-CO_2 fossil fuel combustion emission estimates from both stationary and mobile sources. CH_4 emission estimates from stationary sources exhibit high uncertainty, primarily due to uncertainties in emission estimates from wood combustion. There is also uncertainty associated with the use of broad indicators of emissions (i.e., fuel use multiplied by an aggregate emission factor for different sectors), rather than specific emission processes (i.e., by combustion technology and type of emission control). Uncertainty in mobile source non-CO_2 emission estimates are impacted by uncertainties in vehicle and fuel type VMT data, emission factor data, control technology type, fuel consumption, and emission factor data.

For this current *GHGIA*, the overall uncertainty associated with national estimates of CO_2 and non-CO_2 emissions from fossil fuel combustion is assumed to be similar to prior estimates (EPA, 2025) given the use of the same basic methodology and data sources for most years, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). This confidence level indicates a range of approximately 2 percent below and 4 percent above the CO_2 emission estimate, a range of approximately 34 percent below and 125 percent above the stationary CH_4 emission estimate, a range of approximately 23 percent below and 51 percent above the stationary N_2O emission estimate, a range of approximately 4 percent below and 30 percent above the mobile CH_4 emission estimate, and a range of approximately 7 percent below and 22 percent above the mobile N_2O emission estimate in 2024. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 3-43. Some differences in reporting methodologies, coverage, and data gaps may introduce additional uncertainty for the 2024 estimate and may affect consistency with previous years.

3.2 Carbon Emitted from Non-Energy Uses of Fossil Fuels (Source Category 1A)

In addition to being combusted for energy use, fossil fuels are also used for non-energy uses (NEUs). These uses are diverse and include feedstocks for manufacturing plastics, rubber, synthetic fibers, and other materials; reducing agents in the production of metals and inorganic products; and the creation of products such as lubricants, waxes, and asphalt. Fuels used for non-energy purposes are subtracted from total fuel consumption data to avoid double-counting with fossil fuel combustion emissions.

Carbon dioxide (CO_2) emissions from NEUs can occur through several pathways. Emissions may be released during manufacturing, as in the production of plastics or rubber from fuel-derived feedstocks. Emissions may also occur during a product's use phase, such as through solvent use.

Under IPCC Inventory guidelines, emissions from NEUs should be reported under IPPU (IPCC, 2006). However, due to national circumstances and the inability to fully separate these uses within the national energy balance, these emissions are reported within the energy sector.

Table 3-14 shows CO_2 emissions and the amount of carbon stored from NEU. In 2024, emissions from NEU of fossil fuels were 96.0 million metric tons (MMT) CO_2 Eq., which constituted approximately 2.1 percent of overall fossil fuel combustion emissions. NEU emissions in 2024 increased by 7.1 percent from 2023 and decreased by 4.5 percent from 1990.

Table 3-14: CO_2 Emissions from NEU Fossil Fuel Consumption (MMT CO_2 Eq. and Percent Carbon)

Year	1990	2005	2020	2021	2022	2023	2024
Potential Emissions	293.8	374.0	308.9	324.6	315.5	327.7	346.0
Carbon Stored	193.3	241.6	225.3	234.7	226.0	238.1	250.0
Emissions as a % of Potential	34%	35%	27%	28%	28%	27%	28%
Carbon Emitted	**100.6**	**132.4**	**83.7**	**89.9**	**89.5**	**89.6**	**96.0**

Totals may not sum due to independent rounding.

The changes in NEU emissions over time are driven by the amount of fuel used in various types of NEU and by the assumed storage factors applied to each fuel. The overall amount of carbon emitted as a percentage of total potential emissions is shown in Table 3-14 above. Table 3-15 shows the amount of fossil fuels assumed to be used in NEU. In 2024, the consumption of fuels for NEUs was 5,521.6 Trillion Btus (TBtu), a 5.8 percent increase over 2023.

Table 3-15: Adjusted Consumption of Fossil Fuels for NEUs (TBtu)

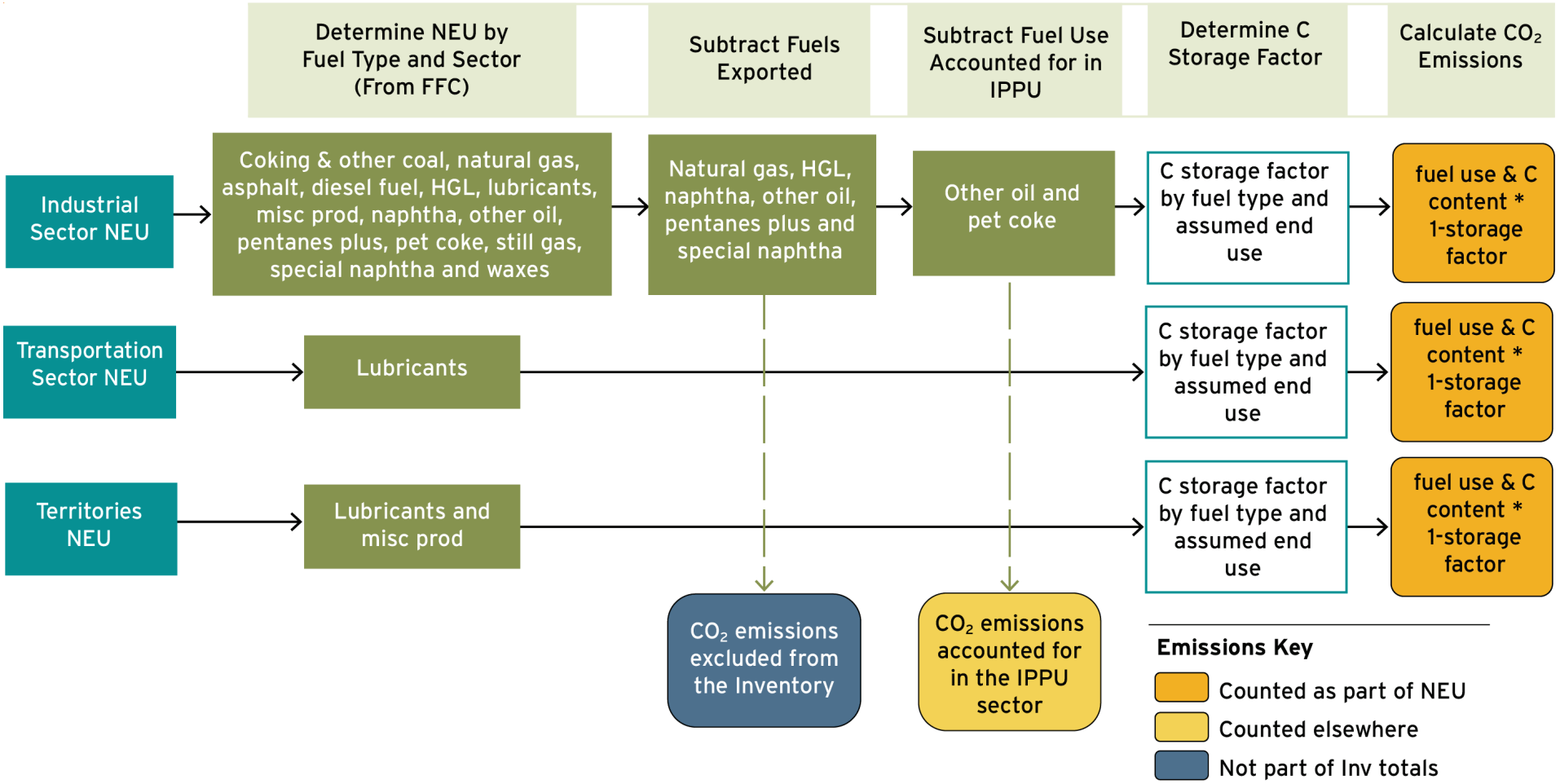
Year	1990	2005	2020	2021	2022	2023	2024
Industry	**4,138.8**	**5,172.6**	**4,763.2**	**4,987.5**	**4,890.3**	**5,121.6**	**5,426.2**
Industrial Coking Coal	0.0	80.4	79.4	77.5	46.4	65.4	57.9
Industrial Other Coal	7.6	11.0	9.5	9.5	9.5	9.5	9.4
Natural Gas to Chemical Plants	280.6	251.9	438.6	416.7	387.3	395.1	400.6
Asphalt & Road Oil	1,170.2	1,323.2	832.3	898.1	916.1	891.8	888.3
HGL	1,134.0	1,554.0	2,454.6	2,622.5	2,716.2	2,965.3	3,261.0
Lubricants	186.3	160.2	111.1	109.2	115.0	88.8	84.4
Naphtha (<401 °F)	325.4	679.1	326.2	327.5	242.5	251.7	238.5
Other Oil (>401 °F)	709.3	689.8	149.1	151.0	65.8	66.4	102.6
Still Gas	21.3	67.7	97.8	112.1	107.7	114.0	121.3
Petroleum Coke	25.2	138.0	0.0	0.0	0.0	0.0	0.0
Special Naphtha	100.6	60.9	80.0	75.3	81.9	83.0	73.2
Distillate Fuel Oil	7.1	12.2	4.9	5.5	5.5	5.4	5.2
Waxes	33.3	31.4	9.2	11.8	13.0	9.0	11.1
Miscellaneous Products	137.8	112.8	170.7	170.8	183.4	176.2	172.6
Transportation	**176.0**	**151.3**	**115.6**	**123.3**	**129.9**	**95.0**	**90.3**
Lubricants	176.0	151.3	115.6	123.3	129.9	95.0	90.3
U.S. Territories	**50.8**	**114.9**	**3.5**	**3.5**	**1.0**	**3.6**	**5.1**
Lubricants	0.7	4.6	1.0	1.0	1.0	1.0	1.0
Other Petroleum (Misc. Prod.)	50.1	110.3	2.5	2.5	0.0	2.5	4.0
Total	**4,365.7**	**5,438.8**	**4,882.4**	**5,114.3**	**5,021.3**	**5,220.2**	**5,521.6**

Note: Totals may not sum due to independent rounding.

Methods

Figure 3-15 outlines the method used to calculate NEU emissions (EPA, 2024). For this *GHGIA*, the methods used to estimate CO_2 emissions from NEU are consistent with prior estimates (EPA, 2025). Some of the data for 2024 were not available at the time of this *GHGIA*, so they were proxied to 2023 values—specifically, some of the data on product exports and some of the IPPU adjustments.

Figure 3-15: Approach for Calculating NEU Emission Estimates



Recalculations

Revisions were made across the time series based on several updates. The 2022 MECS (EIA, 2025b) data was available, which caused some adjustments in recent years regarding storage factors and assumptions about fuels used for NEU. The time series was also adjusted to better align with NEU fuel used listed by EIA (EIA, 2026a). In 2023, total NEU fuel use decreased by 5.9 percent compared with the value in prior analyses. The average annual change was a decrease of 1.1 percent over the 1990 to 2023 time period.

Uncertainty

The uncertainty in the NEU emission estimates is a function of uncertainty in both the quantity of fuel used for non-energy purposes and the storage factor associated with each fuel type. Several storage factors were based on U.S.-specific data, whereas others were based on IPCC defaults. There is uncertainty associated with the U.S.-specific data, as well as the applicability of the IPCC defaults to the U.S.-specific situation.

For this current *GHGIA*, the overall uncertainty associated with national estimates of CO_2 emissions from NEU is assumed to be similar to prior estimates (EPA, 2025), given the use of the same basic methodology and data sources for most years, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006b). This confidence level indicates a range of approximately 36 percent below and 62 percent above the CO_2 emission estimate in 2024. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 3.43. Some differences in reporting methodologies, coverage, and data gaps may introduce additional uncertainty for the 2024 estimate and may affect consistency with prior years.

3.3 Incineration of Waste (Source Category 1A)

Waste combustion in the United States includes all municipal solid waste (MSW), as well as scrap tires. Combustion of MSW generally occurs at waste-to-energy facilities or industrial facilities where useful energy is recovered. Similarly, scrap tires are mostly combusted for energy recovery at industrial sites. Therefore, emissions from waste combustion are accounted for in the Energy chapter.

Greenhouse gas (GHG) emissions from waste combustion result from conversion of the organic carbon containing inputs in the waste to carbon dioxide (CO_2) and from non-CO_2 (CH_4 and N_2O) emissions, which are dependent on waste combustion technologies used (De Soete, 1993; IPCC, 2006).

Organic materials in the waste stream come from biogenic and fossil origin. The emissions from waste combustion are calculated by estimating the quantity of waste combusted and the fraction of the waste that is carbon-derived from fossil sources and from biogenic sources. The CO_2 from biogenic origin is accounted for as a memo item in the *GHGIA*; see Section 3.11 for more details. The emissions from fossil-derived sources are accounted for here.

CO_2 emissions from combustion of waste in 2024 were 11.9 million metric tons (MMT) CO_2 Eq.—a decrease of 4.1 percent compared to 2023 and a 7.7 percent decrease since 1990. Emissions across the time series are shown in Table 3-16.

Waste combustion CH_4 and N_2O emissions are a relatively small amount of overall waste combustion emissions and have remained relatively constant over the time series. They are impacted by the total amount of waste combusted.

Table 3-16: CO_2, CH_4, and N_2O Emissions from the Combustion of Waste (MMT CO_2 Eq.)

Gas	1990	2005	2020	2021	2022	2023	2024
CO_2	12.9	13.3	12.9	12.5	12.5	12.4	11.9
CH_4	+	+	+	+	+	+	+
N_2O	0.4	0.3	0.3	0.4	0.3	0.3	0.3
Total	**13.3**	**13.6**	**13.3**	**12.8**	**12.8**	**12.8**	**12.2**

+ Does not exceed 0.05 MMT CO_2 Eq.

Note: Totals may not sum due to independent rounding.

Data for the total amount of MSW combusted was derived from several sources including *BioCycle*, EPA Facts and Figures Report, Energy Recovery Council, EPA's Greenhouse Gas Reporting Program (GHGRP), and the U.S. Energy Information Administration (EIA). Multiple sources were used to ensure a complete, quality dataset, as each source encompasses a different timeframe (EPA, 2025). Tire combustion data comes from the U.S. Tire Manufacturers Association.

Table 3-17 provides the estimated tons of MSW combusted including and excluding tires.

Table 3-17: Municipal Solid Waste Combusted (Short Tons)

	1990	2005	2020	2021	2022	2023	2024
Waste Combusted (excluding tires)	33,344,839	26,486,414	27,586,271	27,867,445	26,338,130	25,676,432	24,995,666
Waste Combusted (including tires)	33,766,239	28,631,054	29,106,686	29,261,445	27,808,130	27,222,432	26,541,666

Source: EPA (2025) for historical data

Methods

As with fossil fuel combustion estimates, different methods are used for estimating CO_2 and non-CO_2 emissions from waste combustion. Estimates of CO_2 emissions are based on the amount of waste combusted and carbon contents of the different components of the waste stream. For MSW, the amount of waste combusted comes from different sources over time (see Table 3.17). Most recently, MSW data was based on data from GHGRP. The carbon content of MSW is also based on data from the GHGRP and an implied emission factor is used for years where GHGRP data is not available. For tires, the amount combusted and composition is based on industry data. The carbon content of tires is based on carbon content of the different components. Non-CO_2 emissions are based on the total amount of waste and default emission factors (EPA, 2025).

The methods used here for CO_2 are consistent with those used in prior estimates (EPA, 2025). For 2024, GHGRP data is not available, so EIA data is used for the MSW combustion amount (EIA, 2025). Over time, the EIA MSW combustion data is fairly consistent with the data from GHGRP. Over the past 5 years of GHGRP data, the EIA MSW combustion data is within 2 percent of the GHGRP data. For 2024, an implied emission factor was applied for CO_2 estimates based on the last 5 years of GHGRP data. Data for 2024 on tires was not available so data was proxied to 2023. The CO_2 emission factors used in the analysis are shown in Table 3-18 and Table 3-19. The biogenic CO_2 factors shown in Table 3-19 are used to calculate biomass CO_2 emissions which are listed in Section 3.11.

Table 3-18: Calculated Fossil CO_2 Content per Ton Waste Combusted (kg CO_2/Short Ton Combusted)

	1990	2005	2020	2021	2022	2023	2024
CO_2 Emission Factors	366	366	377	365	382	384	374

Table 3-19: Calculated Biogenic CO_2 Content per Ton Waste Combusted (kg CO_2/Short Ton Combusted)

	1990	2005	2020	2021	2022	2023	2024
CO_2 Emission Factors	556	556	566	550	564	543	556

The non-CO_2 methods are consistent with those used in prior analysis (EPA, 2025). As described for CO_2 estimates, GHGRP data was not available for 2024, so EIA MSW amount was used instead.

Recalculations

Methods and activity data are consistent with prior analysis (EPA, 2025), and there were no updates to the underlying data sources used. Therefore, no recalculations were implemented for 1990–2023 for this source category.

Uncertainty

Uncertainties in waste combustion emission estimates are due to both the assumptions applied to the data and from the quality of the data. Key factors include reported MSW CO_2 emissions; N_2O and CH_4 emissions factors; and tire composition data. The highest levels of uncertainty surround the reported tonnage and emission estimates used in the analysis. Lower levels of uncertainty surround variables that were determined by quantitative measurements (e.g., combustion efficiency, carbon content of tire components).

For this *GHGIA*, the overall uncertainty associated with national estimates of CO_2 and non-CO_2 emissions from waste combustion are assumed to be similar to prior estimates (EPA, 2025), given the use of the same basic methodology and data sources for most years, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). This confidence level indicates a range of approximately 17 percent below and 20 percent above the CO_2 emission estimate, 102 percent below and 103 percent above the CH_4 emission estimate, and 53 percent below and 161 percent above the N_2O emission estimate in 2024. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 3-43. Some differences in reporting methodologies, coverage, and data gaps may introduce additional uncertainty for the 2024 estimate and may affect consistency with prior years.

3.4 Coal Mining (Source Category 1B1a)

Coal mining-related activities release both CH_4 and CO_2 to the atmosphere. Emissions can come from underground mining, surface mining, and post-mining (i.e., coal-handling) activities. Methane (CH_4) and CO_2 occur naturally in coal seams and can be released as the coal seam is exposed and mined. Underground mines can liberate gases from ventilation and degasification systems. The CH_4 generated can be recovered and used, reducing emissions to the atmosphere. Surface mines can generate emissions as the coal is exposed to the atmosphere during overburden removal. Post-mining activities can release trapped gases as the coal is processed, transported, and stored for use.

In 2024, 177 underground coal mines and 339 surface mines were operating in the United States (EIA, 2025). The amount of coal mined has generally declined since 1990 but does fluctuate from year to year (see Table 3-20). Total CH_4 emissions in 2024 were estimated to be 44.3 MMT CO_2 Eq., a decline of 2.5 percent relative to 2023 and a decline of 59.0 percent since 1990 (see Table 3-21).

Table 3-20: Coal Production (kt)

Year	1990	2005	2020	2021	2022	2023	2024
Underground							
Number of Mines	1,683	586	196	174	185	190	177
Production	384,244	334,399	177,380	200,122	201,525	217,929	206,167
Surface							
Number of Mines	1,656	789	350	332	354	362	339
Production	546,808	691,447	307,944	323,142	336,990	359,729	305,790
Total							
Number of Mines	3,339	1,398	546	506	539	552	516
Production	931,052	1,025,846	485,324	523,264	538,515	577,658	511,957

Note: Totals may not sum due to independent rounding.

Table 3-21: CH_4 Emissions from Coal Mining (MMT CO_2 Eq.)

Activity	1990	2005	2020	2021	2022	2023	2024
Underground (UG) Mining	**83.1**	**46.7**	**35.2**	**34.0**	**31.4**	**33.4**	**33.5**
Liberated	92.1	69.1	47.2	49.6	54.0	57.2	**57.3**
Recovered & Used	(9.1)	(22.4)	(12.1)	(15.6)	(22.6)	(23.8)	**(23.8)**
Surface Mining	**12.0**	**13.3**	**5.4**	**5.7**	**6.0**	**5.9**	**5.0**
Post-Mining (UG)	**10.3**	**8.6**	**4.3**	**4.8**	**4.8**	**4.8**	**4.7**
Post-Mining (Surface)	**2.6**	**2.9**	**1.2**	**1.2**	**1.3**	**1.3**	**1.1**
Total	**108.0**	**71.4**	**46.1**	**45.7**	**43.6**	**45.4**	**44.3**

Notes: Parentheses in above emissions tables indicate negative values. Totals may not sum due to independent rounding.

In 2024, total fugitive CO_2 emissions were estimated to be 2.3 MMT CO_2 Eq., a decline of 51.1 percent since 1990 and a decline of 6.5 percent since 2023 (see Table 3-22). Changes in emissions are due in part to changes in annual coal production but also depend on the number of underground mines and operating changes.

Table 3-22: CO_2 Emissions from Coal Mining (MMT CO_2 Eq.)

Activity	1990	2005	2020	2021	2022	2023	2024
Underground (UG) Mining	**4.2**	**3.6**	**2.0**	**2.2**	**2.2**	**2.1**	**2.0**
Liberated	4.2	3.6	1.9	2.2	2.2	2.1	2.0
Recovered & Used	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Flaring	NO	NO	+	+	+	+	+
Surface Mining	**0.4**	**0.6**	**0.2**	**0.3**	**0.3**	**0.3**	**0.2**
Total	**4.6**	**4.2**	**2.2**	**2.5**	**2.5**	**2.4**	**2.3**

+ Does not exceed 0.05 MMT CO_2 Eq.

NO (Not Occurring)

Notes: Parentheses indicate negative values. Totals may not sum due to independent rounding.

Methods

The methods used here are consistent with those used in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2023* (EPA, 2025). The approach for estimating emissions from underground coal mines relies heavily on net CH_4 emissions data reported by facilities under EPA's GHGRP. Data for 2024, as well as any updates to previously reported data, were not available at the time this *GHGIA* was prepared. The estimates also rely on data from the Mine Safety and Health Administration (MSHA), and state sales databases (EPA, 2025). Therefore, 2023 data was

used as a proxy to estimate portions of underground coal mine GHG emissions for 2024 including for GHGRP and state sales data. MSHA data was available and updated for 2024 (MSHA, 2025).

Recalculations

Recalculations were implemented to account for the degasification volumes for four mines that include pre-mining wells. It was changed to attribute annual degasification volumes to the year in which they occur (i.e., reporting year) per IPCC guidance (IPCC, 2019). As a result of recalculations, CH_4 emissions decreased by an average of less than 0.1 percent across the time series, compared with previous estimates.

Uncertainty

Uncertainty associated with the estimates of CH_4 from underground coal mines are due to uncertainties in the measurement of ventilation systems data. There is also uncertainty associated with estimates of CH_4 liberated and recovered by degasification systems. There is considerably more uncertainty associated with surface mining and post-mining emissions than are associated with underground mines. This is because of the difficulty in developing accurate emission factors from field measurements. However, since underground coal mining constitutes the majority of estimated total coal mining emissions, the uncertainty associated with underground emissions is the primary factor that determines overall uncertainty.

For this current *GHGIA*, the overall uncertainty associated with national estimates of CO_2 and CH_4 emissions from coal mining are assumed to be similar to prior estimates (EPA, 2025) given the use of the same basic methodology and data sources for most years, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). This confidence level indicates a range of approximately 10 percent below and 21 percent above the CH_4 emission estimate and 68 percent below and 76 percent above the CO_2 emission estimate in 2024. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 3.43. Some differences in reporting methodologies, coverage, and data gaps may introduce additional uncertainty for the 2024 estimate and may affect consistency with prior years.

3.5 Abandoned Underground Coal Mines (Source Category 1B1a)

Coal mines can continue to release CH_4 after being closed and abandoned. Flooded mines might only produce CH_4 emissions for a short period of time, whereas other abandoned mines might produce CH_4 at a near-steady rate over a longer period of time. The CH_4 can migrate to the surface through vents used to prevent buildup or through overburden fractures, particularly if the mine was not sealed adequately. In addition, CH_4 can migrate to the surface through natural cracks and fissures in the strata overlying the coal mine. The following factors influence abandoned coal mine emissions:

- Time since abandonment
- Gas content and adsorption characteristics of coal
- CH_4 flow capacity of the mine
- Mine flooding
- Presence of vent holes
- Mine seals

In 2024, gross abandoned mine emissions were 9.4 million metric tons (MMT) CO_2 Eq. (see Table 3-23). The gross emissions are reduced by CH_4 recovered and used, resulting in net emissions of 6.4 MMT CO_2 Eq. in 2024.

Table 3-23: CH_4 Emissions from Abandoned Coal Mines (MMT CO_2 Eq.)

Activity	1990	2005	2020	2021	2022	2023	2024
Abandoned Underground Mines	8.1	9.3	9.4	9.2	9.1	9.0	9.4
Recovered & Used	NO	(2.0)	(2.9)	(3.0)	(3.0)	(2.9)	(3.0)
Total	**8.1**	**7.4**	**6.5**	**6.2**	**6.1**	**6.1**	**6.4**

NO (Not Occurring)

Notes: Parentheses indicate negative values. Totals may not sum due to independent rounding.

Changes in CH_4 emissions over time are mainly due to the number of mines closed and to the magnitude of the emissions from those mines when active. A mine is considered a "gassy" mine if it emits more than 100 thousand cubic feet of CH_4 per day (100 Mcfd).

Table 3-24 presents the count of mines by post-abandonment state in 2024.

Table 3-24: Number of Gassy Abandoned Mines Present in U.S. Basins in 2024, Grouped by Class According to Post-Abandonment State

Basin	Sealed	Vented	Flooded	Total Known	Unknown	Total Mines
Central Appl.	44	26	50	120	146	266
Illinois	35	3	14	52	31	83
Northern Appl.	50	23	15	88	38	126
Warrior Basin	0	0	16	16	0	16
Western Basins	30	4	2	36	10	46
Total	**159**	**56**	**97**	**312**	**225**	**537**

Methods

Methods are consistent with those used in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2023* (EPA, 2025).

Recalculations

Methods and activity data are consistent with prior analysis (EPA, 2025), and there were no updates to the underlying data used. Therefore, no recalculations were implemented for 1990–2023 for this source category.

Uncertainty

Uncertainty in emission estimates for abandoned mines is associated with a number of factors. There are uncertainties in the values of parameters that are estimated for each mine to predict its emissions. Because these parameters are not available for each mine, a methodological approach to estimating emissions was used that generates a probability distribution of potential outcomes based on the most likely value and the probable range of values for each parameter. This approach results in uncertainties in the parameters used to estimate emissions.

For this current *GHGIA*, the overall uncertainty associated with national estimates of CH_4 emissions from abandoned underground coal mines are assumed to be similar to prior estimates (EPA, 2025) given the use of the same basic methodology and data sources for most years, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). This confidence level indicates a range of approximately 20 percent below and 24 percent above the CH_4 emission in 2024. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 3-43. Some differences in reporting methodologies, coverage, and data gaps may introduce additional uncertainty for the 2024 estimate and may affect consistency with prior years.

3.6 Petroleum Systems (Source Category 1B2a)

Methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O), emissions from leaks, venting, and flaring in petroleum systems are included in this category. The category covers petroleum exploration, production, transport, and refining segments. CH_4 emissions from petroleum systems are primarily associated with onshore and offshore crude oil exploration, production, transportation, and refining operations. CO_2 emissions from petroleum systems are primarily associated with onshore and offshore crude oil production and refining operations. CO_2 emissions in petroleum systems exclude all combustion emissions (e.g., engine combustion) except for flaring CO_2 emissions. All combustion CO_2 emissions (except for flaring) are accounted for in the fossil fuel combustion section above. Emissions of N_2O from petroleum systems are primarily associated with flaring.

Table 3-25: CH_4 Emissions from Petroleum Systems (MMT CO_2 Eq.)

	1990	2005	2020	2021	2022	2023	2024
Exploration	3.0	5.3	0.3	0.2	0.1	0.1	0.1
Production	46.1	42.2	49.3	44.0	35.2	37.0	35.4
Transportation	0.2	0.1	0.2	0.2	0.2	0.3	0.2
Refineries	0.7	0.9	0.7	0.7	0.7	0.7	0.7
Total	**50.0**	**48.4**	**50.6**	**45.1**	**36.3**	**38.0**	**36.5**

Table 3-26: CO_2 Emissions from Petroleum Systems (MMT)

	1990	2005	2020	2021	2022	2023	2024
Exploration	0.4	0.5	0.8	0.6	0.3	0.5	0.4
Production	6.0	6.2	25.2	20.5	18.9	19.9	19.1
Transportation	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Refineries	3.2	3.6	2.9	3.0	2.8	2.9	2.9
Total	**9.6**	**10.2**	**28.9**	**24.1**	**22.1**	**23.3**	**22.3**

Table 3-27: N_2O Emissions from Petroleum Systems (MMT CO_2 Eq.)

	1990	2005	2020	2021	2022	2023	2024
Exploration	+	+	+	+	+	+	+
Production	+	+	+	+	+	+	+
Transportation	+	+	+	+	+	+	+
Refineries	+	+	+	+	+	+	+
Total	+	+	+	+	+	+	+

+Less than 0.05 MMT CO_2 Eq.

In 2024, CH_4 emissions were estimated to be 36.5 MMT CO_2 Eq. (see Table 3-25), 4 percent lower than in 2023, and CO_2 emissions were estimated to be 22.3 MMT (see Table 3-26), 4 percent lower than in 2023. N_2O emissions were estimated to be less than 0.05 MMT CO_2 Eq (see Table 3-27), 57 percent higher than in 2023. This results from the approach of averaging 2022 (which had a higher value of N_2O emissions from production in 2022 than 2023) and 2023 and applying it to 2024. See discussion in Methods below.

Methods

The methodological approach for estimating petroleum system emissions is generally consistent with the approach described in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025). Emissions are estimated for activities in each segment (exploration, production, transport, and refining), summed for each segment and then summed for the total. Generally, emissions are estimated for each activity by multiplying emission factors (e.g., emission rate per equipment or per activity) by corresponding activity data (e.g., equipment count or frequency of activity). Certain sources within petroleum refineries are developed using an IPCC Tier 3 approach (i.e., all refineries in the nation report facility-level emissions data to the GHGRP, which are included directly in the national emissions estimates here). Other estimates are developed with a Tier 2 approach. Tier 1 approaches are not used.

Calculations for petroleum systems emissions rely heavily on data reported by facilities to the GHGRP. Data for year 2024 were unavailable to support the preparation of this *GHGIA*. It was not possible to develop updated estimates for individual activities (or to recalculate the time series with any corrected data) for this *GHGIA*.

Instead, emissions calculated in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025) were used for 1990–2023 without update, and emissions for 2024 were quantified for each segment by calculating the average emissions rates for CH_4, CO_2, and N_2O using emissions data for 2022 and 2023 for each segment and an activity dataset for which 2022, 2023, and 2024 data were available. The rates for 2022 and 2023 (EPA 2025 emissions divided by activity data for that year) were calculated and then averaged together and applied to the relevant activity data for 2024. Exploration and production segment emissions were

calculated using total oil wells as the activity data.[11] Transport and refining emissions were calculated using refinery input as the activity data.[12]

Recalculations

Methods and activity data are consistent with the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025); therefore, no recalculations were implemented for 1990–2023 for this source category.

Uncertainty

Uncertainty in emission estimates for petroleum systems is associated with a number of factors. The basic activity data that is used to scale up emissions estimates to the national level (e.g., oil well counts, petroleum production, petroleum refinery input) has very low uncertainty. Detailed refinery activity data (e.g., equipment counts) in general has low uncertainty as almost all refineries have reported data to GHGRP. For petroleum exploration and production, there is uncertainty associated with applying activity and emission factors developed from GHGRP to the non-GHGRP population. In all segments, there is uncertainty associated with emission factors.

In addition, using other methods (e.g., calculating emissions based on atmospheric methods), emissions have been estimated to be higher than those presented here.

For this *GHGIA*, the overall uncertainty associated with national estimates of emissions from petroleum systems is assumed to be similar to prior estimates (EPA, 2025) given the use of the same basic methodology and data sources for most years, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). For the CH_4 emission estimate in 2024, this confidence level indicates a range of approximately 13 percent below and 24 percent above. For both the CO_2 and N_2O emission estimates in 2024, this confidence level indicates a range of approximately 18 percent below for and 22 percent above.

However, given the methods to quantify 2024 emissions, additional uncertainty arises from the use of 2022 and 2023 emissions rates to quantify 2024 emissions, which can lead to over- or underestimates as changes in practices and data are not captured. For the exploration and production segments, 2024 GHGRP data would include some optional use of new methods that would improve emissions and activity data. In addition, for these segments, 2024 was the first year for which emissions reductions were expected from EPA's 2023 New Source Performance Standards (NSPS) for the oil and natural gas sector. EPA calculated that the NSPS would reduce emissions across natural gas and petroleum systems by 6.4 MMT CO_2 Eq. in 2024.[13] Further, 2024 was the first year for which certain facilities in these segments would have been subject to a Waste Emissions Charge (delayed in July 2025 by Congress until 2034), which may have led to

[11] https://www.eia.gov/petroleum/wells/xls/WDR2025_Appendix%20C.xlsx. EIA definitions for oil and gas wells differ from definitions used in EPA 2025.

[12] https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mttro_nus_1&f=a

[13] https://www.epa.gov/system/files/documents/2023-12/eo12866_oil-and-gas-nsps-eg-climate-review-2060-av16-ria-20231130.pdf

emissions reductions in 2024 in preparation for the charge.[14] EPA calculated that in 2024, the Waste Emissions Charge would lead to emissions reductions across natural gas and petroleum systems of 3.1 MMT CO2e.[15] Uncertainty assessments for 1990 and 2024 are summarized at the end of this chapter in Table 3-43.

[14] https://www.congress.gov/bill/119th-congress/house-bill/1/text

[15] https://www.epa.gov/system/files/documents/2024-11/wec-ria-final_11-2024.pdf

3.7 Natural Gas Systems (Source Category 1B2b)

Methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O), emissions from leaks, venting, and flaring in natural gas systems are included in this category. The category covers natural gas exploration, production (including gathering), processing, transmission and storage, distribution, and post-meter activities. CH_4 emissions from natural gas systems are primarily associated with production and transmission and storage. CO_2 emissions from natural gas systems are primarily associated with processing and production. CO_2 emissions in natural gas systems exclude all combustion emissions (e.g., engine combustion) except for flaring CO_2 emissions. All combustion CO_2 emissions (except for flaring) are accounted for in the fossil fuel combustion section above. Emissions of N_2O from natural gas systems are primarily associated with flaring.

Table 3-28: CH_4 Emissions from Natural Gas Systems (MMT CO_2 Eq.)

	1990	2005	2020	2021	2022	2023	2024
Exploration	6.7	19.7	0.2	0.1	0.2	0.1	0.1
Production	65.9	93.7	96.3	92.1	89.7	80.8	86.2
Processing	23.9	13.0	14.0	14.2	14.8	15.2	15.2
Transmission and Storage	64.0	46.1	41.1	39.8	39.6	37.3	38.8
Distribution	50.9	28.5	15.5	15.3	15.2	15.2	15.5
Post-Meter	8.1	9.6	13.0	13.1	13.4	13.8	13.8
Total	**219.6**	**210.7**	**180.1**	**174.6**	**172.8**	**162.4**	**169.8**

Table 3-29: CO_2 Emissions from Natural Gas Systems (MMT)

	1990	2005	2020	2021	2022	2023	2024
Exploration	0.6	2.7	0.1	0.0	0.0	0.0	0.0
Production	3.3	4.6	9.2	9.3	8.6	9.7	9.3
Processing	28.3	18.8	25.5	25.5	26.6	26.8	27.0
Transmission and Storage	0.2	0.2	2.0	0.9	1.1	1.2	1.2
Distribution	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Post-Meter	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**32.5**	**26.3**	**36.8**	**35.7**	**36.4**	**37.7**	**37.4**

Table 3-30: N_2O Emissions from Natural Gas Systems (MMT CO_2 Eq.)

	1990	2005	2020	2021	2022	2023	2024
Exploration	+	+	+	+	+	+	+
Production	+	+	+	+	+	+	+
Processing	+	+	+	+	+	+	+
Transmission and Storage	+	+	+	+	+	+	+
Distribution	+	+	+	+	+	+	+
Total	+	+	+	+	+	+	+

+Less than 0.05 MMT CO_2 Eq.

In 2024, CH_4 emissions were estimated to be 169.8 MMT CO_2 Eq. (see Table 3-28), 5 percent higher than in 2023, and CO_2 emissions were estimated to be 37.4 MMT (see Table 3-29), 1 percent lower than in 2023. N_2O emissions were estimated to be less than 0.05 MMT CO_2 Eq. (see Table 3-30) and 65 percent higher than in 2023. This results from the approach of averaging 2022 (which had a higher value of N_2O emissions from production and processing in 2022 than 2023) and 2023 and applying it to 2024. See discussion in Methods below.

Methods

The methodological approach for estimating natural gas system emissions is generally consistent with the approach described in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025). Emissions are estimated for activities in each segment (exploration, production, processing, transmission and storage, distribution and post-meter), summed for each segment, and then summed for the total. Generally, emissions are estimated for each activity by multiplying emission factors (e.g., emission rate per equipment or per activity) by corresponding activity data (e.g., equipment count or frequency of activity). The estimates are developed with an IPCC Tier 2 approach; Tier 1 approaches are not used.

Calculations for natural gas systems emissions rely heavily on data reported by facilities to the GHGRP. Data for year 2024 were unavailable to support the preparation of this *GHGIA*. It was not possible to develop updated estimates for individual activities (or to recalculate the time series with any corrected data) for this *GHGIA*.

Instead, emissions calculated in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025) were used for 1990–2023 without update, and emissions for 2024 were quantified for each segment by calculating the average emissions rates for CH_4, CO_2, and N_2O using emissions data for 2022 and 2023 for each segment and an activity dataset for which 2022, 2023, and 2024 data were available. The rates for 2022 and 2023 (GHGI emissions divided by activity data for that year) were calculated and then averaged together and applied to the relevant activity data for 2024. Exploration segment emissions were calculated using total gas

wells as the activity data.[16] Production, processing, and transmission and storage emissions were calculated using total natural gas production as the activity data.[17] Distribution and post-meter emissions were calculated using total natural gas consumption as the activity data.[18]

Recalculations

Methods and activity data are consistent with the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025); therefore, no recalculations were implemented for 1990–2023 for this source category.

Uncertainty

Uncertainty in emission estimates for natural gas systems is associated with a number of factors. The basic activity data that is used to scale up emissions estimates to the national level (e.g., gas well counts, gas production, gas consumption, pipeline miles) has very low uncertainty. For natural gas exploration through distribution, there is uncertainty associated with applying activity and emission factors developed from GHGRP to the non-GHGRP population. In all segments, there is uncertainty associated with emission factors.

In addition, using other methods (e.g., calculating emissions based on atmospheric methods), emissions have been estimated to be higher than those presented here.

For this *GHGIA*, the overall uncertainty associated with national estimates of emissions from natural gas systems is assumed to be similar to prior estimates (EPA, 2025) given the use of the same basic methodology and data sources for most years, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). For the CH_4 emission estimate in 2024, this confidence level indicates a range of approximately 10 percent below and 11 percent above. For both the CO_2 and N_2O emission estimates in 2024, this confidence level indicates a range of approximately 14 percent below and 17 percent above.

However, given the methods to quantify 2024 emissions, additional uncertainty arises from the use of 2022 and 2023 emissions rates to quantify 2024 emissions, which can lead to over or underestimates as changes in practices and data are not captured. For the exploration through distribution segments, 2024 GHGRP data would include some optional use of methods that would improve emissions and activity data. In addition, 2024 was the first year for which emissions reductions were expected from EPA's 2023 New Source Performance Standards (NSPS) for the oil and natural gas sector (impacting exploration through transmission and storage). EPA calculated that the NSPS would reduce emissions across natural gas and petroleum systems by 6.4 MMT CO_2 Eq. in 2024.[19] In addition, 2024 was the first year for which certain facilities in segments other than distribution and post-meter would have been subject to a Waste Emissions

[16] https://www.eia.gov/petroleum/wells/xls/WDR2025_Appendix%20C.xlsx

[17] https://www.eia.gov/petroleum/wells/xls/WDR2025_Appendix%20C.xlsx

[18] https://www.eia.gov/dnav/ng/hist/n9140us2a.htm

[19] https://www.epa.gov/system/files/documents/2023-12/eo12866_oil-and-gas-nsps-eg-climate-review-2060-av16-ria-20231130.pdf

Charge (delayed in July 2025 by Congress until 2034), which may have led to emissions reductions in 2024 in preparation for the charge, [20] EPA calculated that in 2024, the Waste Emissions Charge would lead to emissions reductions across natural gas and petroleum systems of 3.1 MMT CO2e.[21] Uncertainty assessments for 1990 and 2024 are summarized at the end of this chapter in Table 3-43.

[20] https://www.congress.gov/bill/119th-congress/house-bill/1/text

[21] https://www.epa.gov/system/files/documents/2024-11/wec-ria-final_11-2024.pdf

3.8 Abandoned Oil and Gas Wells (Source Categories 1B2a and 1B2b)

Methane (CH_4) and carbon dioxide (CO_2) emissions from wells with no recent production are included in this category. This includes wells with no owner (orphaned wells) and wells with owners with no recent production. It includes the emissions from wells that have not been plugged and wells that have been plugged, which have significantly lower emissions.

Although some wells that have been taken out of service are later brought back online, the total population of abandoned wells increases over time. Due to various efforts at national, state, and local levels the fraction of abandoned wells that is plugged increases over time.

Based on estimates developed for 2023 in *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025), the U.S. population of abandoned oil and gas wells is around 3.9 million (with around 3.0 million abandoned oil wells and 0.9 million abandoned gas wells), and around 43 percent of the abandoned well population in the United States is plugged.

Table 3-31: CH_4 Emissions from Abandoned Oil and Gas Wells (MMT CO_2 Eq.)

	1990	2005	2020	2021	2022	2023	2024
Abandoned oil wells	6.4	6.6	6.6	6.6	6.6	6.6	6.5
Abandoned gas wells	1.4	1.6	1.9	1.9	1.9	1.9	1.9
Total	**7.8**	**8.2**	**8.5**	**8.6**	**8.5**	**8.5**	**8.4**

Table 3-32: CO_2 Emissions from Abandoned Oil and Gas Wells (MMT)

	1990	2005	2020	2021	2022	2023	2024
Abandoned oil wells	+	+	+	+	+	+	+
Abandoned gas wells	+	+	+	+	+	+	+
Total	**+**	**+**	**+**	**+**	**+**	**+**	**+**

+ Less than 0.05

In 2024, CH_4 emissions were estimated to be 8.4 MMT CO_2 Eq. (see Table 3-31), 2 percent lower than in 2023, and CO_2 emissions were estimated to be less than 0.05 MMT (see Table 3-32) and 1 percent lower than in 2023.

Methods

The methodological approach for estimating abandoned oil and gas well emissions is generally consistent with the approach described in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023*. Emissions are estimated based on abandoned oil and gas well populations in Appalachia and outside of Appalachia. Within these populations, the percentage of wells plugged versus unplugged is determined and an emission factor for each group (region and plugging status) is applied.

It was not possible to develop updated estimates for abandoned oil and gas well populations or well plugging for 2024 (or to recalculate the time series with any corrected data) for this *GHGIA*. Instead, estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025) were used for 1990–2023 emissions. For 2024, emissions were quantified by calculating for abandoned oil wells and abandoned gas wells the average emissions rates for CH_4 and CO_2 using emissions calculated for 2022 and 2023 and total well oil well and total gas well populations using EIA data.[22] The rates for those 2 years were then averaged together and applied to the total populations for oil wells and of gas wells for year 2024.

Recalculations

Methods and activity data are consistent with the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025); therefore, no recalculations were implemented for 1990–2023 for this source category.

Uncertainty

Uncertainty in CH_4 and CO_2 emission estimates for abandoned wells is associated with activity data estimates of total abandoned wells, the population of abandoned wells that is plugged, and the emission factors applied.

For this *GHGIA*, the overall uncertainty associated with national estimates of emissions from abandoned oil and gas wells is assumed to be similar to prior estimates (EPA, 2025) given the use of the same basic methodology and data sources for most years, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). For the CH_4 and CO_2 emission estimates in 2024, this confidence level indicates a range of approximately 83 percent below for all well types and 223 percent above for oil wells and 255 percent above for gas wells.

However, given the methods to quantify 2024 emissions, additional uncertainty arises from lack of updated estimates for total abandoned wells and well plugging in 2024. Generally, the population of total abandoned wells rises over time as does the percentage of wells that are plugged. It is likely that the percentage of wells plugged has increased faster in 2024 compared with previous years due to impacts of well plugging programs under the 2021 Infrastructure

[22] https://www.eia.gov/petroleum/wells/xls/WDR2025_Appendix%20C.xlsx. Note that EIA definitions for oil and gas wells differ from definitions used in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025).

Investment and Jobs Act (under which over 10,000 wells have been plugged as of June 2025).[23] Future *GHGIA* years will likely show further increases in plugging due to the Methane Emissions Reduction Program of the 2022 Inflation Reduction Act.[24] Uncertainty assessments for 1990 and 2024 are summarized at the end of this chapter in Table 3-43.

[23] https://www.doi.gov/sites/default/files/documents/2025-11/fy-2025-orphaned-wells-congressional-report.pdf

[24] https://www.epa.gov/inflation-reduction-act/financial-assistance-methane-emissions-reduction-program

3.9 CO_2 Transport, Injection, and Geological Storage (Source Category 1C)

Carbon dioxide (CO_2) capture and geological storage includes the capture and compression of CO_2, its transport to a storage location, and its long-term isolation from the atmosphere. Geological storage can take place in natural underground reservoirs such as oil and gas fields, coal seams, and saline water-bearing formations utilizing natural geological barriers to isolate the CO_2 from the atmosphere. Geological CO_2 storage may take place either at sites where the sole purpose is CO_2 storage, or in tandem with enhanced oil recovery, enhanced gas recovery or enhanced coalbed methane (CH_4) recovery operations (IPCC, 2005).

As per the IPCC Guidelines (IPCC, 2006), emissions and reductions from CO_2 capture and sequestration are reported under the sector in which the capture takes place. Any fugitive emissions from the systems used to transport captured CO_2, from activities and equipment at the injection site and those from the end containment of CO_2 storage are represented as part of CO_2 transport, injection, and geological storage (TIGS) reporting. Emissions from TIGS are shown in Table 3-33.

Table 3-33: Emission from TIGS (kt CO_2)

	1990	2005	2020	2021	2022	2023	2024
Transport	NO	NO	2	2	2	2	2
Injection	NO	NO	13	37	28	31	31
Geological Storage	NO	NO	23	26	23	64	64
Total	**NO**	**NO**	**39**	**65**	**53**	**98**	**98**

NO (Not Occurring)

Note: Totals may not sum due to independent rounding.

The amount of CO_2 sequestered is allocated back to the different possible capture source categories as shown in Table 3-34. The allocation is based on information from the EPA Greenhouse Gas Reporting Program (GHGRP), 40 CFR Part 98, Subpart PP, also referred to as "Subpart PP" (EPA, 2024).

Table 3-34: Allocation of Sequestered CO_2 for Sector Adjustment (kt CO_2)

	1990	2005	2020	2021	2022	2023	2024
Adjustments Made							
Power Plants	NO	NO	-	-	-	360	360
Industrial Gas Plants	NO	NO	-	-	-	-	-
Chemical Plants	NO	NO	-	-	-	-	-
Synthetic Gas Production	NO	NO	-	-	-	-	-
Ammonia Plants	NO	NO	660	714	652	665	665
Ethanol Plants	NO	NO	522	444	603	903	903
Breweries	NO	NO	-	-	-	-	-
Distilleries	NO	NO	-	-	-	-	-
Paper Mills	NO	NO	-	-	-	-	-
Total Adjustments	**NO**	**NO**	**1,182**	**1,158**	**1,255**	**1,928**	**1,928**
Adjustments Not Made							
CO_2 Domes	NO	NO	4,156	3,960	4,624	10,420	10,420
Petroleum Refineries	NO	NO	-	-	-	-	-
Natural Gas Processing	NO	NO	1,465	1,835	2,174	3,951	3,951
Total (No Adjustments)	**NO**	**NO**	**5,621**	**5,794**	**6,798**	**14,370**	**14,370**

NO (Not Occurring)

Note: Totals may not sum due to independent rounding.

There is no adjustment needed for the CO_2 sequestered sourced from natural domes since it is considered a transfer from one sink to another. For the CO_2 from natural gas processing and petroleum refining, the captured and sequestered CO_2 emissions are already netted out in those emission source calculations.

Methods

Methods are consistent with those described in the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025).

All CO_2 transport is assumed to be through pipelines. To calculate emissions, a default factor was applied to pipeline miles, which are sourced from the Pipeline and Hazardous Materials Safety Administration (PHMSA, 2026). In 2024, 5,345 miles of CO_2 pipeline were in operation in the United States (see Table 3-35).

Table 3-35: Pipeline Mileage (Miles)

	1990	2005	2020	2021	2022	2023	2024
Miles	NO	NO	5,150	5,339	5,354	5,331	5,345

NO (Not Occurring)

Fugitive emissions from injection and storage and total amount of CO_2 sequestered are based on information from the GHGRP. Those values were assumed to be equal to 2023 levels because 2024 GHGRP data were not available at the time of analysis.

Recalculations

Methods and activity data are consistent with the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025), and there were no changes to underlying data sources. Therefore, no recalculations were implemented for 1990–2023 for this source category.

Uncertainty

The uncertainties in pipeline emissions arise from the data used on length of pipelines and from accuracy of the default emissions factor used to determine pipeline fugitive emissions. There are also uncertainties associated with equipment leakage and surface leakage, mostly due to the accuracy of the reported data.

For this *GHGIA*, the overall uncertainty associated with national estimates of CO_2 emissions from TIGS are assumed to be similar to prior estimates (EPA, 2025) given the use of the same basic methodology and data sources for most years, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). This confidence level indicates a range of approximately 51 percent below and 51 percent above the CO_2 emission level in 2024. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 3-43. Some differences in reporting methodologies, coverage, and data gaps may introduce additional uncertainty for the 2024 estimate and may affect consistency with prior years.

3.10 International Bunker Fuels (Source Category 1: Memo Items)

According to IPCC methodological guidance, countries should report emissions from ships or aircraft that depart from their ports with fuel purchased within national boundaries and are engaged in international transport separately from national totals. Therefore, emissions resulting from the combustion of fuels used for international transport activities, termed international bunker fuels, are not included in national emission totals, but are reported separately based upon location of fuel sales (IPCC, 2006). Emissions from road vehicles and trains, even when crossing international borders, are allocated to the country where the fuel was purchased or loaded into the vehicle and are not considered bunker fuel emissions.

Two main modes of transport are addressed as part of international bunker fuel estimates: aviation and marine. Within each, fuel use and emissions can occur from civil (commercial and general) and military operations. The calculation of greenhouse gas (GHG) emissions from the combustion of international bunker fuels is the same as for other fossil fuels and includes CO_2, based on fuel carbon content, and non-CO_2 emissions (CH_4 and N_2O) based on combustion technologies.[25]

In 2024, emissions from the combustion of international bunker fuels from both aviation and marine activities were 98.6 MMT CO_2 Eq. (see Table 3-36). Aviation-related emissions decreased by 0.4 percent from 2023 but have increased by 73.5 percent from 1990. Marine emissions increased by 6.2 percent from 2023 but have decreased by 51.9 percent from 1990. The majority of emissions were in the form of CO_2.

[25] Data suggest that little or no CH_4 is emitted by modern aircraft engines so those emissions are reported as not occurring.

Table 3-36: CO_2, CH_4, and N_2O Emissions from International Bunker Fuels (MMT CO_2 Eq.)

Gas/Mode	1990	2005	2020	2021	2022	2023	2024
CO_2	**103.6**	**113.3**	**69.6**	**80.2**	**98.2**	**96.2**	**97.8**
Aviation	38.2	60.2	39.8	50.8	66.6	66.5	66.3
Commercial	*30.0*	*55.6*	*36.7*	*47.6*	*63.5*	*63.5*	*63.5*
Military	*8.2*	*4.6*	*3.1*	*3.2*	*3.1*	*3.0*	*2.8*
Marine	*65.4*	*53.1*	*29.9*	*29.4*	*31.6*	*29.6*	31.5
CH_4	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Aviation	NO	NO	NO	NO	NO	NO	0.0
Marine	0.2	0.1	0.1	0.1	0.1	0.1	0.1
N_2O	**0.8**	**0.9**	**0.5**	**0.6**	**0.8**	**0.8**	**0.8**
Aviation	0.3	0.5	0.3	0.4	0.6	0.6	0.6
Marine	0.4	0.4	0.2	0.2	0.2	0.2	0.2
Total	**104.6**	**114.3**	**70.3**	**80.9**	**99.1**	**97.0**	**98.6**

NO (Not Occurring)

Notes: Totals may not sum due to independent rounding. Includes aircraft cruise altitude emissions.

Jet fuel consumption estimates used in the analysis are presented in Table 3-37.

Table 3-37: Aviation Jet Fuel Consumption for International Transport (TBtu)

Source	1990	2005	2020	2021	2022	2023	2024
U.S. and Foreign Carriers	426	791	521	677	902	902	902
U.S. Military	116	64	43	44	44	42	39
Total	**542**	**854**	**564**	**721**	**946**	**944**	**941**

Note: Totals may not sum due to independent rounding.

Marine fuel consumption estimates are presented in Table 3-38.

Table 3-38: Marine Fuel Consumption for International Transport (Million Gallons)

Fuel Type	1990	2005	2020	2021	2022	2023	2024
Residual Fuel Oil	4,781	3,881	1,964	1,953	2,172	2,016	2,182
Distillate Diesel Fuel & Other	617	444	461	437	435	423	410
U.S. Military Naval Fuels	522	471	296	285	263	255	265
Total	**5,920**	**4,796**	**2,721**	**2,674**	**2,870**	**2,694**	**2,857**

Note: Totals may not sum due to independent rounding.

Methods

Methods are consistent with those described in the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025).

Data on civilian marine bunkers has historically been available from the Foreign Trade Division of the U.S. Department of Commerce's Bureau of the Census. Because the same data was not available at the time of analysis, total civilian marine bunkers for 2024 were extrapolated based on recent year's ratio of bunkers to total marine diesel and residual fuel use.

Data on military use of domestic fuel and percent bunkers for aviation and marine use historically comes from Department of Defense's Defense Logistics Agency Energy. Because the same data was not available at the time of analysis, total military domestic fuel use in 2024 was estimated based on data from the Federal Energy Management Program (FEMP) (DOE, 2022). The FEMP data is available on total worldwide military transportation fuel use. It was assumed that domestic use changed at the same rate as international fuel use from 2023 to 2024 and that the percentage used in bunkers was the same as 2023.

Data on civilian aviation total and bunker fuel use has historically been available from the Federal Aviation Administration (FAA). The same data has not been available since 2022. Therefore, total civilian aviation bunkers for 2023 and 2024 were proxied to the 2022 value.

Recalculations

Methods and activity data are consistent with the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025) and no updates were available; therefore, no recalculations were implemented for 1990–2023 for this source category.

Uncertainty

Emission estimates related to the combustion of international bunker fuels are subject to the same uncertainties as those from domestic aviation and marine mobile combustion emissions. However, some additional uncertainties could result from the difficulty in accurately estimating the share of total fuel consumption activity data used for international transport activities (separate from domestic transport activities). This challenge occurs with both civilian and military fuel use.

There are also uncertainties in fuel end-uses by fuel type, emissions factors, fuel densities, diesel fuel sulfur content, aircraft and vessel engine characteristics, and fuel efficiencies, which could all impact emission estimates.

For this *GHGIA*, no uncertainties have been recalculated for international bunker fuels.

3.11 Biomass and Biofuel Consumption (Source Category 1A)

Combustion of biomass and biofuels generates CO_2 and non-CO_2 emissions (CH_4 and N_2O). In accordance with IPCC inventory guidelines, CO_2 emissions from biomass and biofuel combustion are estimated separately from fossil fuel CO_2 emissions and are excluded from energy sector totals to avoid double counting. These emissions are instead accounted for within the land use, land-use change, and forestry (LULUCF) sector through estimates of net carbon stock changes in biogenic carbon pools associated with forest and cropland systems (see Chapter 6).

Accordingly, CO_2 emissions from biomass and biofuel combustion are provided here for informational transparency regarding biomass and biofuel use. Non-CO_2 emissions (CH_4 and N_2O) from biomass and biofuel combustion are included in energy sector totals and are reported in Section 3.1 as part of stationary and mobile combustion source categories.

In 2024, total CO_2 emissions from the combustion of biomass and biofuels in all end-use sectors were approximately 298.7 MMT CO_2 Eq. (see Table 3-39).

Table 3-39: CO_2 Emissions from Biomass and Biofuel Consumption (MMT CO_2 Eq.)

Sector/Fuel Type	1990	2005	2020	2021	2022	2023	2024
Transportation	4.1	22.5	85.8	91.5	90.6	95.7	92.9
Ethanol	4.1	21.6	68.1	75.4	75.0	77.5	74.7
Biodiesel	0.0	0.9	17.7	16.1	15.6	18.2	18.2
Industrial	135.5	137.4	128.9	129.7	134.6	127.2	127.3
Ethanol	0.1	1.2	1.6	1.5	1.8	1.3	2.6
Wood	135.3	136.3	127.3	128.2	132.8	125.9	124.7
Commercial	6.8	7.4	9.7	9.6	10.4	9.3	11.0
Ethanol	0.1	0.2	2.2	2.1	2.8	1.9	3.6
Wood	6.8	7.2	7.5	7.5	7.5	7.4	7.4
Residential	59.8	44.3	35.6	36.8	46.4	39.4	36.9
Wood	59.8	44.3	35.6	36.8	46.4	39.4	36.9
Electric Power	31.8	33.8	34.7	35.6	35.2	31.9	30.6
Wood	13.3	19.1	19.1	20.3	20.4	17.9	16.7
MSW	18.5	14.7	15.6	15.3	14.9	13.9	13.9
Total	**237.9**	**245.4**	**294.7**	**303.3**	**317.2**	**303.5**	**298.7**

The CO_2 emission estimates for biomass and biofuels were calculated in a similar way to fossil fuel combustion estimates and are dependent on the amount of fuel combusted and its carbon content. For the biogenic component of MSW, CO_2 emissions were estimated based on the tons of waste combusted and a calculated carbon factor, see Section 3.3 Incineration of Waste for more details. Emissions for the other biomass and biofuel sources were based on the energy content of the fuels combusted.

Table 3-40 provides wood consumption in energy units for the industrial, residential, commercial, and electric power sectors. Table 3-41 provides ethanol consumption estimates for the industrial, commercial, and transportation sectors and Table 3-42 provides biodiesel consumption in energy units for the transportation sector.

Table 3-40: Woody Biomass Consumption by Sector (Trillion Btu)

End-Use Sector	1990	2005	2020	2021	2022	2023	2024
Industrial	1,441.9	1,451.7	1,356.2	1,365.9	1,415.0	1,341.1	1,328.2
Residential	580.0	430.0	345.1	356.8	449.5	382.1	358.2
Commercial	65.7	70.0	72.9	72.6	73.0	71.8	71.7
Electric Power	128.5	185.0	185.4	196.7	197.7	174.1	161.7
Total	**2,216.2**	**2,136.7**	**1,959.5**	**1,992.0**	**2,135.2**	**1,969.0**	**1,919.9**

Note: Totals may not sum due to independent rounding.

Table 3-41: Ethanol Consumption by Sector (Trillion Btu)

End-Use Sector	1990	2005	2020	2021	2022	2023	2024
Transportation	59.3	315.8	994.6	1,101.7	1,094.9	1,132.2	1,091.0
Industrial	1.5	17.2	23.1	22.0	26.2	19.5	37.7
Commercial	0.9	2.2	31.9	31.2	41.6	27.3	52.8
Total	**61.7**	**335.1**	**1,049.5**	**1,155.0**	**1,162.7**	**1,179.0**	**1,181.5**

Note: Totals may not sum due to independent rounding.

Table 3-42: Biodiesel Consumption by Sector (Trillion Btu)

End-Use Sector	1990	2005	2020	2021	2022	2023	2024
Transportation	NO	11.6	239.4	218.2	211.6	246.3	246.4

NO (Not Occurring)

Methods

Methods are consistent with those described in the *Inventory of Greenhouse Gas Emissions and Sinks: 1990–2023* (EPA, 2025).

Recalculations

There were updates to some of the data sources used, therefore recalculations were implemented for 1990–2023 for this source category. Updates included the historical data on wood combustion from EIA. The updated data resulted in an annual average change in wood CO_2 emissions of 1.1 percent over the 2016 to 2023 time period. The sector allocation of ethanol use in 2023 was also updated to reflect the updated fuel used data from FHWA for 2023.

Uncertainty

There are uncertainties in biofuel consumption data that impact the results of the biomass and biofuel emission estimates. There is also uncertainty in the composition of the fuels and the carbon content of fuels combusted.

For this *GHGIA*, the overall uncertainty associated with national estimates of CO_2 emissions from biomass and biofuel combustion are assumed to be similar to prior estimates (EPA, 2025) given the use of the same basic methodology and data sources for most years, calculated using the 2006 IPCC Guidelines Approach 2 methodology for uncertainty at the 95 percent confidence level (IPCC, 2006). This confidence level indicates a range of approximately 9 percent below and 12 percent above the CO_2 emissions in 2024. Uncertainty assessments for 2024 are summarized at the end of this chapter in Table 3-43. Some differences in reporting methodologies, coverage, and data gaps may introduce additional uncertainty for the 2024 estimate and may affect consistency with prior years.

3.12 Energy Uncertainty Summary

Table 3-43 shows the uncertainty summary for each energy sector source. A discussion of the uncertainty ranges is included in each source category's respective chapter section.

Table 3-43: Quantitative Uncertainty Summary by Energy Sector Source

Source	Gas	2024 Estimate (MMT CO_2 Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO_2 Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
Fossil Fuel Combustion CO_2						
Coal	CO_2	**710.5**	689.2	774.4	-3%	9%
Residential	CO_2	NO	NO	NO	NO	NO
Commercial	CO_2	1.1	1.0	1.2	-5%	15%
Industrial	CO_2	34.9	33.2	40.5	-5%	16%
Transportation	CO_2	NO	NO	NO	NO	NO
Electric Power	CO_2	672.0	645.1	739.2	-4%	10%
U.S. Territories	CO_2	2.5	2.2	3.0	-12%	19%
Natural Gas	CO_2	**1,765.1**	1,747.5	1,853.4	-1%	5%
Residential	CO_2	240.5	233.3	257.3	-3%	7%
Commercial	CO_2	181.8	176.3	194.5	-3%	7%
Industrial	CO_2	529.8	513.9	566.9	-3%	7%
Transportation	CO_2	73.7	71.5	78.9	-3%	7%
Electric Power	CO_2	734.8	712.8	771.6	-3%	5%
U.S. Territories	CO_2	4.5	3.9	5.2	-12%	17%
Petroleum	CO_2	**2,092.1**	1,966.6	2,217.6	-6%	6%
Residential	CO_2	50.1	47.1	52.6	-6%	5%
Commercial	CO_2	67.6	64.2	71.0	-5%	5%
Industrial	CO_2	225.0	173.2	276.7	-23%	23%
Transportation	CO_2	1,714.8	1,611.9	1,817.7	-6%	6%

(continued)

Table 3-43: Quantitative Uncertainty Summary by Energy Sector Source

Source	Gas	2024 Estimate (MMT CO_2 Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO_2 Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
Electric Power	CO_2	13.7	13.1	14.6	-4%	7%
U.S. Territories	CO_2	20.9	19.4	23.0	-7%	10%
Geothermal	CO_2	0.3	0.2	1.0	-46%	187%
Electric Power	CO_2	0.3	0.2	1.0	-46%	187%
Total	CO_2	4,568.1	4,476.7	4,750.8	-2%	4%
Fossil Fuel Combustion Non-CO_2						
Stationary Combustion	CH_4	8.1	5.4	18.3	-34%	125%
Stationary Combustion	N_2O	19.0	14.6	28.7	-23%	51%
Mobile Sources	CH_4	2.7	2.6	3.5	-4%	30%
Mobile Sources	N_2O	17.0	15.8	20.7	-7%	22%
Non-Energy Use of Fuels						
Feedstocks	CO_2	78.2	45.3	138.4	-42%	77%
Asphalt	CO_2	0.3	0.1	0.6	-58%	116%
Lubricants	CO_2	11.8	9.8	13.7	-17%	16%
Waxes	CO_2	0.3	0.3	0.7	-26%	103%
Other	CO_2	5.4	1.0	6.3	-81%	17%
Total	CO_2	96.0	61.4	155.5	-36%	62%
Waste Incineration						
Incineration of Waste	CO_2	11.9	9.9	14.3	-17%	20%
Incineration of Waste	CH_4	+	-+	+	-102%	103%
Incineration of Waste	N_2O	0.3	0.1	0.8	-53%	161%
Coal Mining						
Coal Mining	CO_2	44.3	39.8	53.6	-10%	21%
Coal Mining	CH_4	2.3	0.7	4.0	-68%	76%

(continued)

Table 3-43: Quantitative Uncertainty Summary by Energy Sector Source

Source	Gas	2024 Estimate (MMT CO_2 Eq.)	Uncertainty Range Relative to Emission Estimate (MMT CO_2 Eq.)		Uncertainty Range Relative to Emission Estimate (%)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
Abandoned Underground Coal Mines						
Abandoned Underground Coal Mines	CH_4	6.4	5.2	8.0	-20%	24%
Petroleum Systems						
Petroleum Systems	CH_4	36.5	31.7	45.2	-13%	24%
Petroleum Systems	CO_2	22.3	18.3	27.3	-18%	22%
Petroleum Systems	N_2O	+	+	+	-18%	22%
Natural Gas Systems						
Natural Gas Systems	CH_4	169.8	152.8	188.5	-10%	11%
Natural Gas Systems	CO_2	37.4	32.2	43.8	-14%	17%
Natural Gas Systems	N_2O	+	+	+	-14%	17%
Abandoned Oil and Gas Wells						
Abandoned Oil Wells	CH_4	6.5	1.1	20.9	-83%	223%
Abandoned Gas Wells	CH_4	1.9	0.3	6.7	-83%	255%
Abandoned Oil Wells	CO_2	+	+	+	-83%	223%
Abandoned Gas Wells	CO_2	+	+	+	-83%	255%
CO_2 Transport, Injection, and Geological Storage						
Total Emissions from TIGS	CO_2	0.1	+	0.1	-51%	51%
International Bunker Fuels						
N/A						
Biomass and Biofuel Combustion						
Biomass and Biofuel Combustion	CO_2	298.7	271.8	334.5	-9%	12%

References

Energy Chapter Upfront

Intergovernmental Panel on Climate Change (IPCC) (2006). *2006 IPCC guidelines for national greenhouse gas inventories: Volume 2—Energy*. Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

Intergovernmental Panel on Climate Change (IPCC) (2019). *2019 refinement to the 2006 IPCC guidelines for national greenhouse gas inventories.* Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize S., Osako, A., Pyrozhenko, Y., Shermanau, P. and Federici, S. (eds). Published: IPCC, Switzerland.

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990-2023* (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request].

Fossil Fuel Combustion

Browning, L. (2024). Memo: Updated methodology for estimating VMT from highway electric vehicles, August 24, 2024.

Federal Highway Administration (FHWA) (1996 through 2026). *Highway statistics*., U.S. Department of Transportation, Washington, D.C. January 2026, annual. Available online at: http://www.fhwa.dot.gov/policy/ohpi/hss/hsspubs.htm.

Intergovernmental Panel on Climate Change (IPCC) (2006). *2006 IPCC guidelines for national greenhouse gas inventories: Volume 2—Energy*. Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

Nadel, S., Elliot, N., & Langer, T. (2015). *Energy efficiency in the united states: 35 years and counting.* American Council for Energy-Efficient Economy (ACEEE), pg. iv-vi, 1-5. Available online at: https://www.aceee.org/sites/default/files/publications/researchreports/e1502.pdf.

National Renewable Energy Lab (NREL) (2023). *NREL researchers reveal how buildings across United States do—And could—Use energy*. Available online at: https://www.nrel.gov/news/features/2023/nrel-researchers-revealhow-buildings-across-the-united-states-do-and-could-use

U.S. Energy Information Administration (EIA) (1991 through 2022). *Fuel oil and kerosene sales.* Energy Information Administration, U.S. Department of Energy. Washington, D.C. Available online at: http://www.eia.gov/petroleum/fueloilkerosene.

U.S. Energy Information Administration (EIA) (2023). "Energy use in homes." *Use of energy explained.* Available online at: https://www.eia.gov/energyexplained/use-of-energy/homes.php.

U.S. Energy Information Administration (EIA) (2025). *Natural gas annual 2024.* Energy Information Administration, U.S. Department of Energy. Washington, D.C. November 2025. Available online at: https://www.eia.gov/naturalgas/annual/.

U.S. Energy Information Administration (EIA) (2026a). *Monthly* Energy Re*view, February 2026*. Energy Information Administration, U.S. Department of Energy, Washington, DC. DOE/EIA-0035 (2026/02).

U.S. Energy Information Administration (EIA) (2026b). *International energy statistics 1980-2024*. Energy Information Administration, U.S. Department of Energy. Washington, DC. Available online at: https://www.eia.gov/beta/international/.

U.S. Energy Information Administration (EIA) (2026c). *Electric power monthly, February 2026, Appendix D electric vehicle consumption*. Energy Information Administration, U.S. Department of Energy, Washington, (2026/02). Available online at: https://www.eia.gov/electricity/monthly/

U.S. Environmental Protection Agency (EPA) (2024). *Methodology report: Inventory of U.S. greenhouse gas emissions and sinks by state: 1990-2022* (EPA-430-R-24-006).

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023* (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request].

U.S. Environmental Protection Agency (EPA) (2026). *The 2025 EPA automotive trends report: Fuel economy and technology since 1975*. Office of Transportation and Air Quality (EPA-420-R-26-001). Available online at: https://www.epa.gov/automotive-trends.

NEU

Intergovernmental Panel on Climate Change (IPCC) (2006). *2006 IPCC guidelines for national greenhouse gas inventories: Volume 2—Energy*. Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

U.S. Energy Information Administration (EIA) (2025). *Manufacturing consumption of energy (MECS) 2022*. U.S. Department of Energy, Energy Information Administration, Washington, DC. Released August 2025.

U.S. Environmental Protection Agency (EPA) (2024). *Methodology report: Inventory of U.S. greenhouse gas emissions and sinks by state: 1990-2022* (EPA-430-R-24-006).

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023* (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request].

Waste Incineration

De Soete, G.G. (1993). *Nitrous oxide from combustion and industry: Chemistry, emissions and control*. In A. R. Van Amstel, (ed.) Proc. of the International Workshop Methane and Nitrous Oxide: Methods in National Emission Inventories and Options for Control, Amersfoort, NL. February 3-5, 1993.

Intergovernmental Panel on Climate Change (IPCC) (2006). *2006 IPCC guidelines for national greenhouse gas inventories: Volume 2—Energy*. Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

U.S. Energy Information Administration (EIA) (2025). *Form EIA-923 detailed 2024 data with previous form data* (EIA-906/920), Energy Information Administration, U.S. Department of Energy. Washington, DC. DOE/EIA. September 2025.

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023* (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request].

Coal Mining

Intergovernmental Panel on Climate Change (IPCC) (2006). *2006 IPCC guidelines for national greenhouse gas inventories: Volume 2—Energy*. Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

Intergovernmental Panel on Climate Change (IPCC) (2019). *2019 refinement to the 2006 IPCC guidelines for national greenhouse gas inventories*. Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize S., Osako, A., Pyrozhenko, Y., Shermanau, P. and Federici, S. (eds). Published: IPCC, Switzerland.

Mine Safety and Health Administration (MSHA) (2025). *Data Transparency at MSHA*. Mine Safety and Health Administration. Available online at http://www.msha.gov/.

U.S. Energy Information Administration (EIA) (2025). *Annual Coal Report 2024*. Energy Information Administration, U.S. Department of Energy. Washington, DC. November 2025.

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023* (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request].

Abandoned Underground Coal Mines

Intergovernmental Panel on Climate Change (IPCC) (2006). *2006 IPCC guidelines for national greenhouse gas inventories: Volume 2—Energy*. Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023* (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request].

Petroleum Systems

Intergovernmental Panel on Climate Change (IPCC) (2006). *2006 IPCC guidelines for national greenhouse gas inventories: Volume 2—Energy*. Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023* (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request].

Natural Gas Systems

Intergovernmental Panel on Climate Change (IPCC) (2006). *2006 IPCC guidelines for national greenhouse gas inventories: Volume 2—Energy*. Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023* (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request].

Abandoned Oil and Gas Wells

Intergovernmental Panel on Climate Change (IPCC) (2006). *2006 IPCC guidelines for national greenhouse gas inventories: Volume 2—Energy*. Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023* (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request].

CO_2 TIGS

Intergovernmental Panel on Climate Change (IPCC) (2005). *Special report on carbon dioxide capture and storage (SRCCS)*. Institute for Global Environmental Strategies.

Intergovernmental Panel on Climate Change (IPCC) (2006). *2006 IPCC guidelines for national greenhouse gas inventories: Volume 2—Energy*. Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

Pipeline and Hazardous Materials Safety Administration (PHMSA) (2026). *2010+ pipeline miles and facilities data, hazardous liquid pipeline miles and tanks by commodity*. Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation, Washington, DC. Available online at: https://www.phmsa.dot.gov/data-andstatistics/pipeline/data-and-statistics-overview.

U.S. Environmental Protection Agency (EPA) (2024). *Greenhouse Gas Reporting Program (GHGRP). Aggregation of reported facility level data under Subpart PP for calendar years 2010 through 2023*. Office of Air and Radiation, Office of Atmospheric Programs, U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023* (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request].

International Bunker Fuel

Intergovernmental Panel on Climate Change (IPCC) (2006). *2006 IPCC guidelines for national greenhouse gas inventories: Volume 2—Energy*. Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

U.S. Department of Energy (DOE) (2022). *Federal Energy Management Program (FEMP*). Available online at: https://www.energy.gov/femp/federal-comprehensive-annual-energy-reportingrequirements.

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023* (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request].

Biomass and Biofuel Consumption

Intergovernmental Panel on Climate Change (IPCC) (2006). *2006 IPCC guidelines for national greenhouse gas inventories: Volume 2—Energy*. Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023* (EPA 430-R-25-003) [Unpublished annual report released via Freedom of Information Act Request].