EPA
United States
Environmental Protection
Agency
430-F-24-003

DATA HIGHLIGHTS

Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022

HIGHLIGHTS OF RECENT TRENDS

- In 2022, net U.S. greenhouse gas emissions were 5,489 million metric tons of carbon dioxide equivalent (MMT CO_2 Eq.).
- Overall, net emissions increased by 1 percent since 2021 due to the continued rebound of economic activity after the height of the COVID-19 pandemic.
- Net emissions were 17 percent below 2005 levels. The decline is mostly due to a shift to less CO_2intensive natural gas and a rapid increase in the use of renewable energy in the electric power sector.
- Transportation activities accounted for the largest portion (28 percent) of total U.S. greenhouse gas emissions in 2022.
- Emissions from electric power accounted for the second largest portion (25 percent), while emissions from industry accounted for the third largest portion (23 percent).
- Carbon sequestration from the Land Use, Land-Use Change and Forestry (LULUCF) sector offset 15 percent of total emissions in 2022.

TRENDS IN U.S. GREENHOUSE GAS EMISSIONS AND SINKS

Overall, from 1990 to 2022, total emissions of carbon dioxide (CO_2) decreased by 2 percent, total emissions of methane (CH_4) decreased by 19 percent, and total emissions of nitrous oxide (N_2O) decreased by 5 percent. During the same period, emissions of fluorinated gases including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3) rose by 58 percent. From 2021 to 2022, total emissions of CO_2 increased by 1 percent, emissions of CH_4 decreased 3 percent, and N_2O emissions decreased by 2 percent. U.S. greenhouse gas emissions were partly offset by carbon sequestration in managed forests, trees in urban areas, agricultural soils, landfilled yard trimmings, and coastal wetlands. These were estimated to offset 15 percent of total gross emissions in 2022.

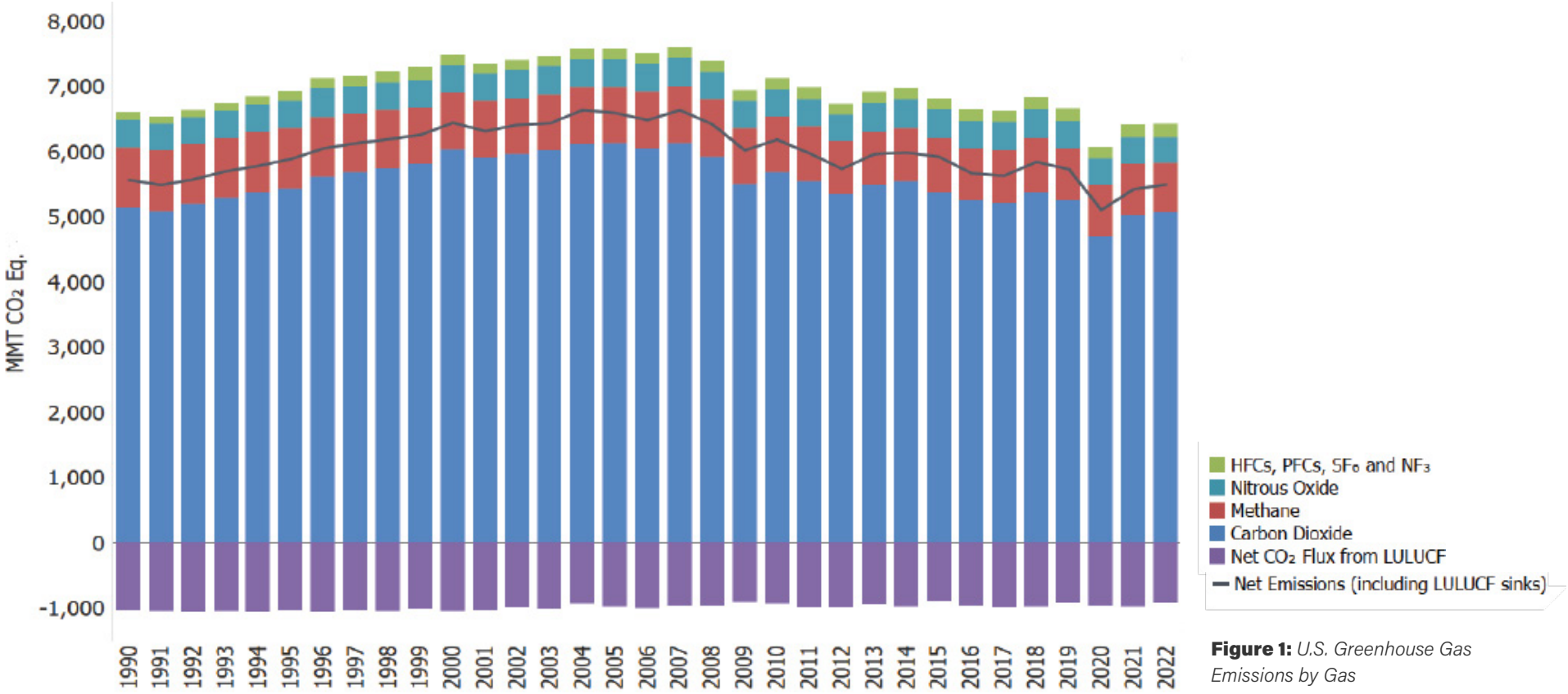


Figure 1: *U.S. Greenhouse Gas Emissions by Gas*

OVERVIEW OF U.S. EMISSION SOURCES BY GREENHOUSE GAS

Carbon Dioxide (CO2)

Carbon dioxide (CO_2) accounted for 80 percent of total U.S. emissions in 2022. CO_2 emissions have decreased by 18 percent since 2005, decreased by 2 percent since 1990, and increased by 1 percent from 2021 to 2022. Changes in emissions from fossil fuel combustion drive U.S. emission trends and are influenced by many long- and short-term factors, including changes in demand for energy, a general decline in the overall carbon intensity of fuels combusted for energy in recent years by non-transport sectors of the economy, population and economic trends, technological changes (including energy efficiency), energy prices, and policies. Net carbon fluxes from the Land Use, Land-Use Change, and Forestry (LULUCF) sector provided a steady sink over the time series, equivalent to 15 percent of total U.S. emissions in 2022, shown by Figure 7.

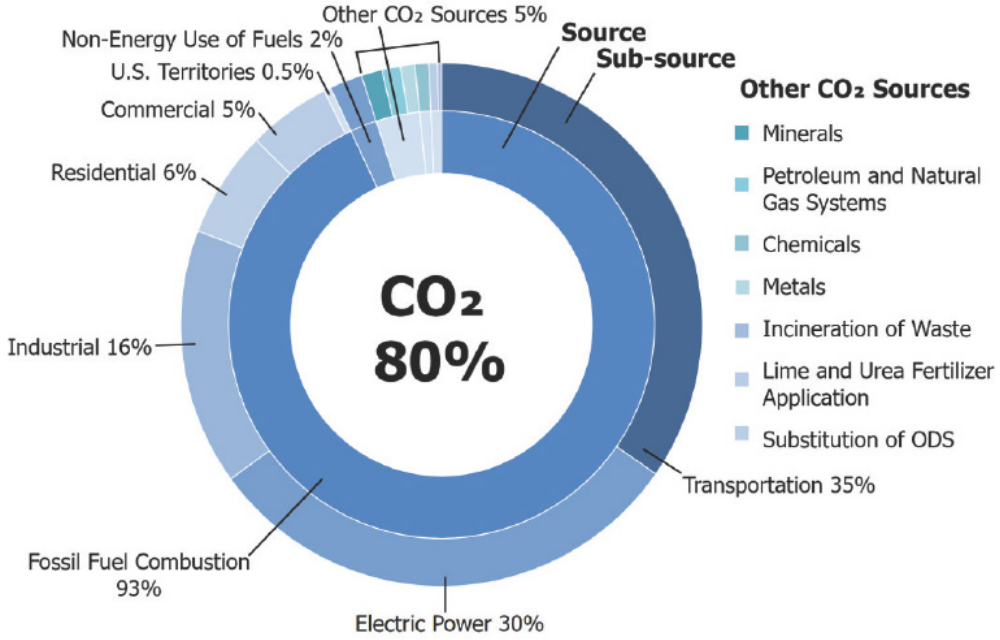


Figure 2: *2022 U.S. Sources of Carbon Dioxide (CO_2) Emissions*

Methane (CH4)

Methane (CH_4) accounted for 11 percent of emissions in 2022. CH_4 emissions have decreased by 12 percent since 2005, by 19 percent since 1990, and by 3 percent from 2021 to 2022. Key trends include reduced emissions from natural gas systems due to decreases in emissions from distribution, transmission, and storage; decreased emissions from landfills due to increased landfill gas collection and fewer decomposable materials discarded in landfills; and increased emissions from livestock in line with increasing cattle populations.

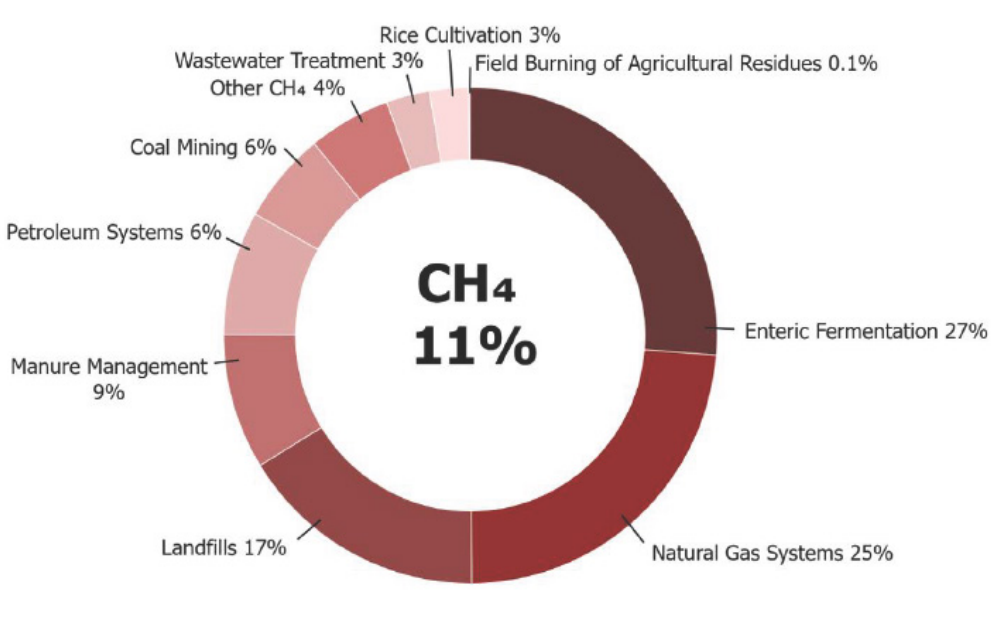


Figure 3: *2022 U.S. Sources of Methane (CH_4) Emissions, excluding CH_4 emissions from LULUCF sector from flooded lands, forest, and grassland fires.*

OVERVIEW OF U.S. EMISSION SOURCES BY GREENHOUSE GAS

Nitrous Oxide (N2O)

Nitrous oxide (N_2O) accounted for 6 percent of emissions in 2022. N_2O emissions have decreased by 7 percent since 2005, by 5 percent since 1990, and by 2 percent from 2021 to 2022. In 2022, emissions were influenced by changes in emissions from agricultural soils due to interannual weather patterns, fertilizer use, and crop production; growing population and protein consumption impacting wastewater treatment industrial wastewater; changes in livestock populations and manure management systems; and impacts of national emission control standards on mobile combustion in on-road vehicles.

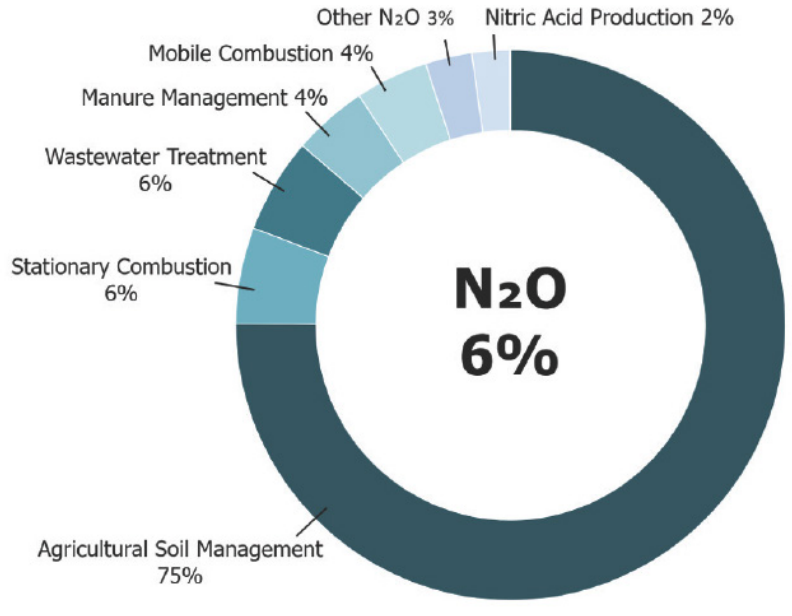


Figure 4: *2022 U.S. Sources of Nitrous Oxide (N_2O) Emissions, excluding N_2O emissions from LULUCF sources, e.g. forest, and grassland fires.*

Fluorinated Gases (F-gases)

Emissions of fluorinated gases (F-gases) accounted for 3 percent of emissions in 2022, and have increased by 58 percent since 1990, primarily due to the substitution of ozone depleting substances (ODS) as a result of efforts to phase out CFCs and other ODS in the United States. Emissions of F-gases have increased by 29 percent since 2005 and have increased by 3 percent from 2021 to 2022. Despite being emitted in smaller quantities relative to the other greenhouse gases, emissions of F-gases are significant because many of them have extremely high global warming potentials (GWPs), and, for some F-gases, very long atmospheric lifetimes. ODS substitute emissions are the primary contributor to F-gas emissions. Other key sources include electrical equipment, fluorochemical production, and aluminum production.

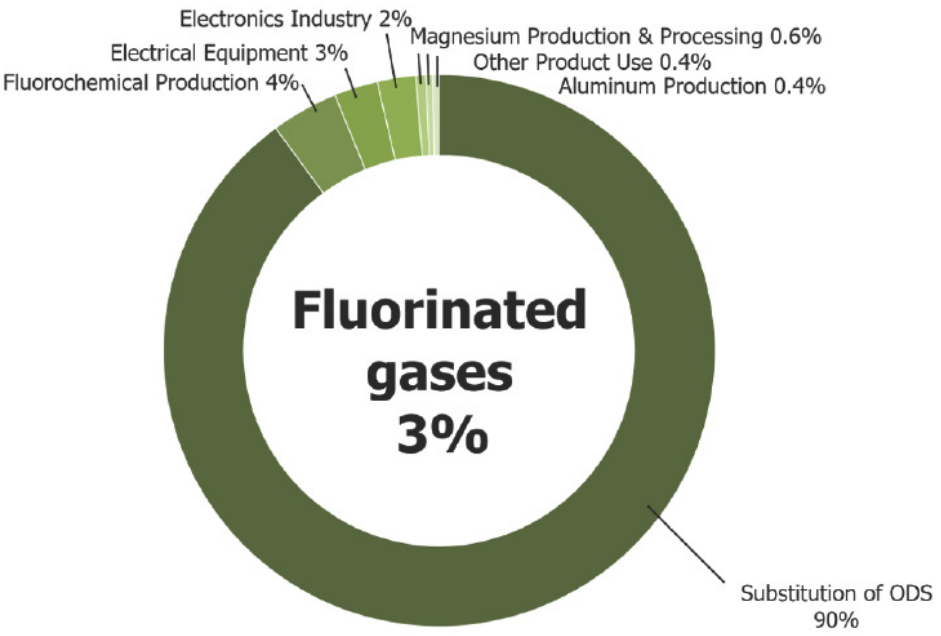


Figure 5: *2022 U.S. Sources of fluorinated gases (F-gases).*

EMISSIONS BY ECONOMIC SECTOR

Greenhouse gases are emitted across five economic sectors: transportation, electric power (electricity generation), residential/commercial (homes and businesses), industry, and agriculture (Figure 6). If emissions from electricity use are allocated to end-use sectors, emissions from the commercial and residential and industrial activities account for a much larger share of U.S. greenhouse gas, due to the relatively large share of electricity use in these sectors (e.g., heating, ventilation, and air conditioning; lighting; appliances; powering industrial machinery). U.S. territories are excluded from this figure, values, and associated percentages. The LULUCF sector, also excluded from Figure 6, is explained following the other economic sector summaries, as shown in Figure 7.

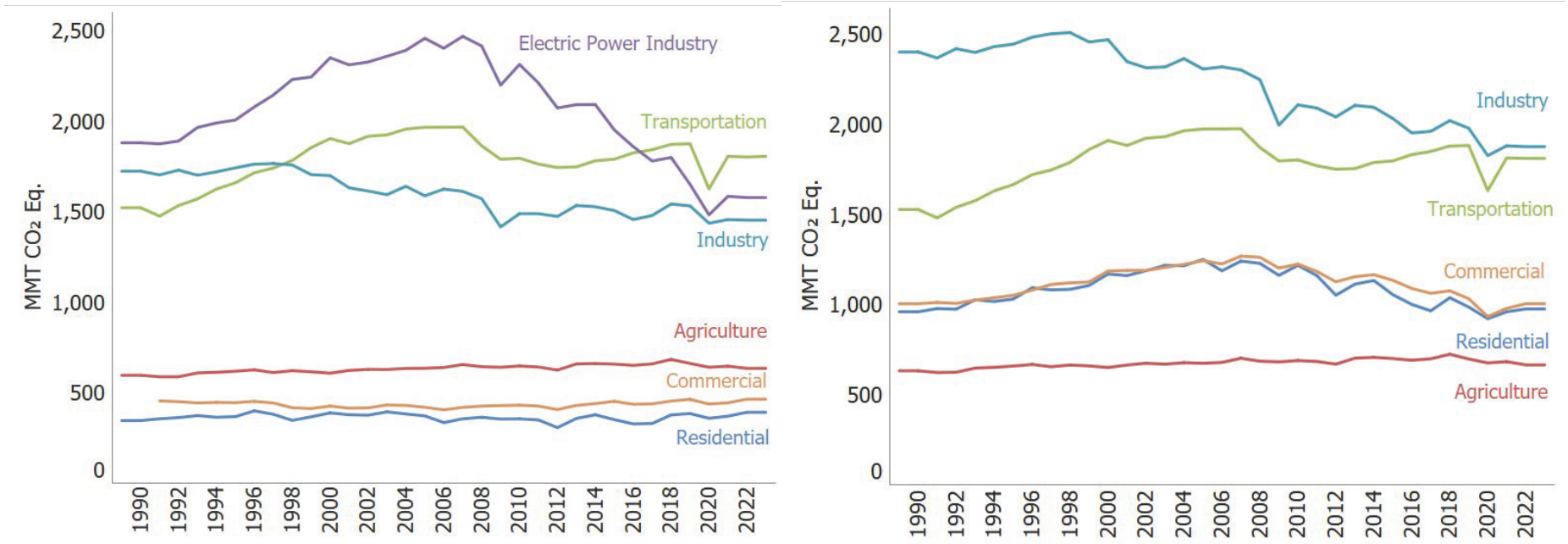
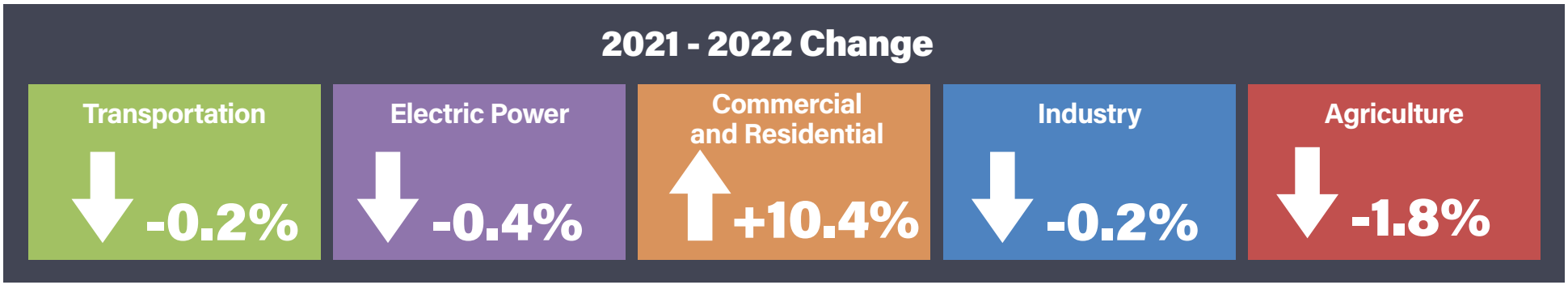


Figure 6: *U.S. Greenhouse Gas Emissions Allocated to Economic Sectors and Greenhouse Gas Emissions with Electricity-Related Emissions Distributed to Economic Sectors*

EMISSIONS BY ECONOMIC SECTOR



Transportation

Transportation activities were the largest source (28 percent) of total U.S. greenhouse gas emissions in 2022. From 1990 to 2022, transportation CO_2 emissions from fossil fuel combustion increased by 19 percent. The increase in transportation emissions from 1990 to 2022 was due in large part to increased demand to travel. In 2022, light-duty vehicles represented 37 percent of CO_2 emissions from transportation fossil fuel combustion and medium- and heavy-duty trucks and buses represented 23 percent. The remainder of emissions were due to off-road sources. Indirect emissions from electricity represent less than 1 percent of total transportation end-use sector emissions.

Electric Power

The electric power sector accounted for 25 percent of total U.S. greenhouse gas emissions in 2022. Emissions from this sector have decreased by approximately 16 percent since 1990, and the carbon intensity of the sector, in terms of emissions (CO_2 Eq.) per QBtu input, has decreased by 28 percent. Total electric power generation increased by 3 percent in 2022 while electric power-related emissions decreased by less than 1 percent due in part to a decrease in coal consumed to produce electricity and an increase in renewable generation. In 2022, the consumption of natural gas and petroleum for electric power generation increased by 7 percent and 19 percent, respectively, while the consumption of coal decreased by 7 percent.

Commercial and Residential

The commercial and residential sectors accounted for 7 and 6 percent, respectively, of total U.S. greenhouse gas emissions in 2022 excluding indirect emissions from electricity end-use. Emissions from the this sectors are primarily from to building-related activities such as heating and cooking and have increased since 1990. Short-term trends are often correlated with seasonal fluctuations in energy use caused by weather conditions. Emissions from commercial and residential buildings also increase substantially when emissions from electricity end-use are included, because the building sector uses 75 percent of the electricity generated in the United States (e.g., for heating, ventilation, and air conditioning; lighting; and appliances) (NREL 2023). Total residential and commercial greenhouse gas emissions, including direct and indirect emissions, have decreased by 1 percent since 1990. In 2022, a 7.9 percent increase in heating degree days increased energy demand for heating in the residential and commercial sectors, and a 4.3 percent increase in cooling degree days compared to 2021 increased energy demand for air conditioning in these sectors.

Industry

The industrial sector accounted for 23 percent of U.S. greenhouse gas emissions in 2022 excluding indirect emissions from electricity end-use. If indirect emissions from electricity use are distributed to the industrial end-use sector (e.g., powering equipment and industrial buildings), industrial activities account for a much larger share (30 percent) of U.S. greenhouse gas emissions. Since 1990, emissions from industry have declined by 16 percent. Structural changes within the U.S. economy that led to shifts in industrial output away from energy-intensive manufacturing products to less energy-intensive products (e.g., from steel to computer equipment) have had a significant effect on industrial emissions. In 2022, total energy use in the industrial sector increased by 3 percent due to an increase in total industrial production and manufacturing output. EPA's GHGRP data provide additional insights into underlying trends in the industrial sector.

Agriculture

Agriculture accounted for about 10 percent of U.S. greenhouse gas emissions in 2022 and includes sources such as livestock enteric fermentation and manure management, N_2O emitted from managed agricultural soils from fertilizers and other management practices, and fossil fuel combustion from agricultural equipment. Indirect emissions from electricity in the agricultural sector are about 5 percent of sector emissions. In 2022, agricultural soil management was the largest source of N_2O emissions, and enteric fermentation was the largest source of CH_4 emissions in the United States. Carbon stock changes from agricultural soils (i.e., croplands and grasslands) are described in the LULUCF sector discussed on the next page.

LAND USE, LAND-USE CHANGE AND FORESTRY

LULUCF activities include fluxes of carbon resulting from land use conversions (e.g., emissions from the conversion of forest land to agricultural or urban use) or land-use management practices that remove CO_2 from the atmosphere and store it in long-term carbon sinks (e.g., through net forest growth). Key sources of emission fluxes on managed lands, including CH_4 and N_2O emissions, include forest management practices, land- use conversion, long-term storage of carbon in harvested wood products, fires, tree planting in urban areas, existing and new reservoirs and other constructed waterbodies, landfilling of yard trimmings and food scraps, and management of coastal wetland ecosystems (e.g., engineered restoration, and other sediment diversion). In 2022, net CO_2 removed from the atmosphere from the LULUCF sector was 15 percent of total gross U.S. greenhouse gas emissions. Between 1990 and 2022, total carbon sequestration in the LULUCF sector decreased by 11 percent, primarily due to a decrease in the rate of net carbon accumulation in forests and an increase in CO_2 emissions from urbanization.

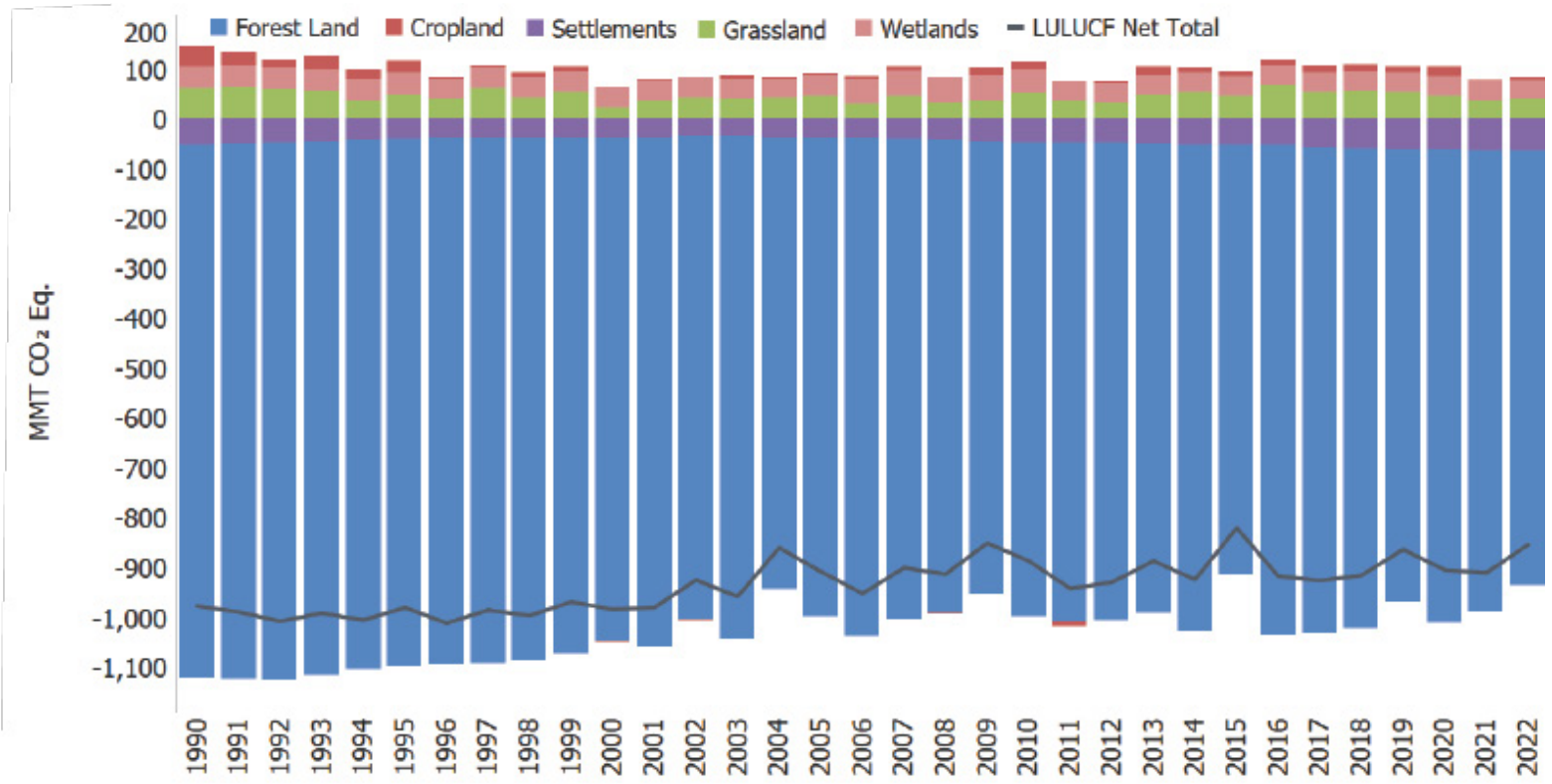
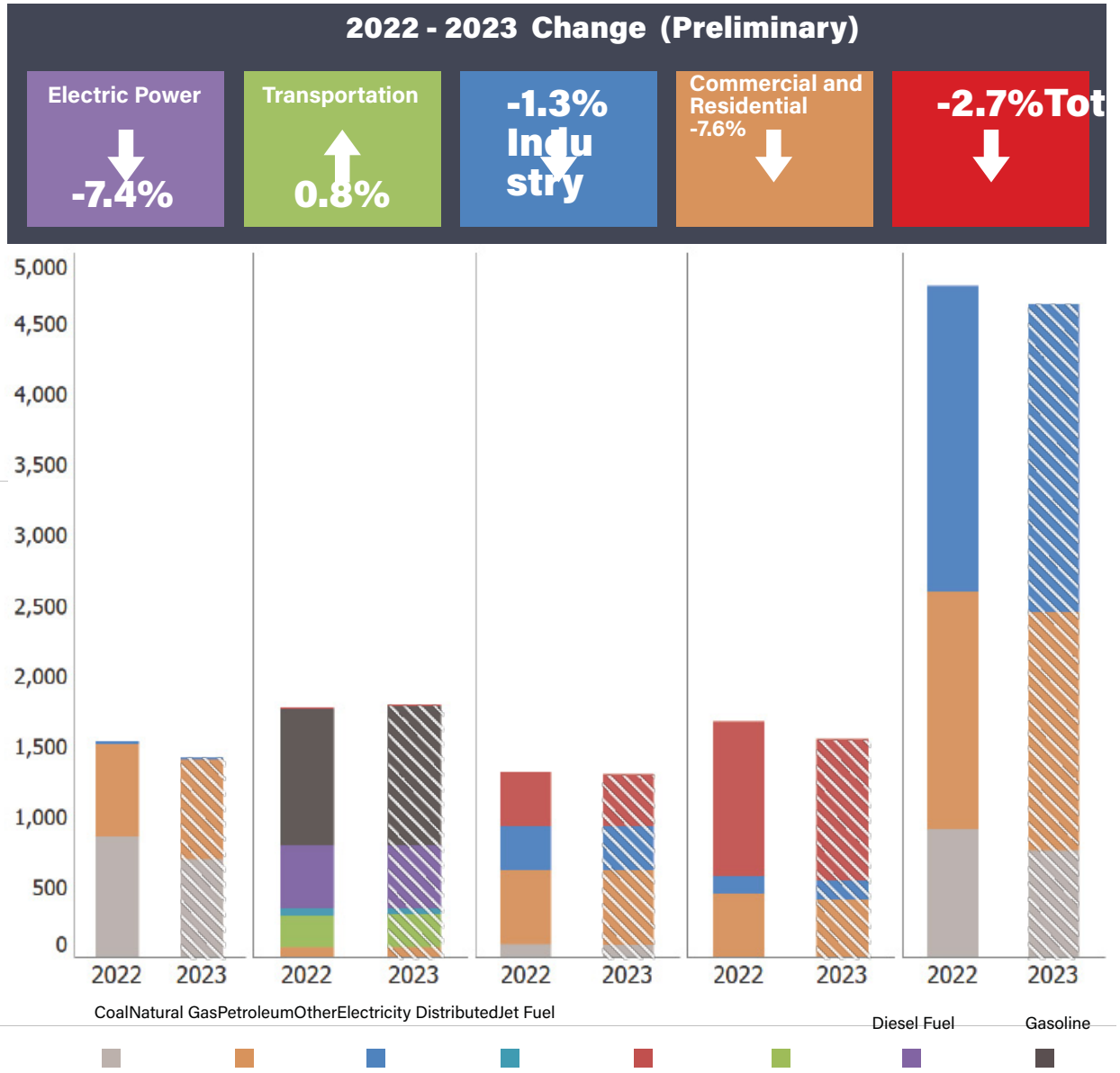


Figure 7: *Trends in Emissions and Removals (Net CO_2 Flux) from Land Use, Land-Use Change, and Forestry. The term "flux" is used to describe the exchange of CO_2 to and from the atmosphere, with net flux being either positive or negative depending on the overall balance. Removal and long-term storage of CO_2 from the atmosphere is also referred to as "carbon sequestration."*

PRELIMINARY ENERGY SECTOR EMISSION DATA FOR 2023



While the current Inventory does not include 2023 estimates, preliminary energy data are available and can be used to assess likely results for energy-related CO2 emissions. Preliminary 2023 data are not available for other sectors to provide overall projections. The preliminary energy estimates indicate that in 2023 total primary energy use decreased by 1 percent and emissions from energy use decreased by 3 percent compared to 2022 (EIA 2024). Transportation sector emissions increased 1 percent in 2023 compared to 2022. Overall U.S. net electricity production from the electric power sector decreased by 1 percent and emissions decreased by 7 percent in part due to decreased coal use. In 2023, coal use decreased by about 17 percent, and natural gas use increased by about 1 percent in the electric power sector (EIA 2024). The growth in renewable sources continued with electricity production from renewable energy use increasing by about 2 percent in 2023 (EIA 2024). Emissions from the combined residential and commercial sector and from the industry sector including indirect emissions from electricity production decreased by 8 percent and 1 percent, respectively, in 2023.Figure 8: Comparison of Fossil Fuel CO2 Combustion Emissions

BACKGROUND

EPA's annual *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (the *Inventory*) provides a comprehensive account of emissions and removals by source, economic sector, and greenhouse gas (GHG), annually since 1990. The Data Highlights are a summary of the latest information on U.S. anthropogenic greenhouse gas emission trends from 1990 through 2022 and include a preliminary outlook on anticipated 2023 emissions. The estimates presented are calculated using methodologies consistent with those recommended by the Intergovernmental Panel on Climate Change (IPCC). In preparing the annual *Inventory,* EPA collaborates with hundreds of experts representing more than a dozen U.S. government agencies, academic institutions, industry associations, consultants, and environmental organizations. EPA also collects greenhouse gas emission data from individual facilities and suppliers of certain fossil fuels and industrial gases through its Greenhouse Gas Reporting Program (GHGRP). The GHGRP does not provide full coverage of total annual U.S. greenhouse emissions and sinks (e.g., the GHGRP excludes emissions from the agricultural, land use, and forestry sectors), but it is an important input to the calculations of national-level emissions in the *Inventory*. For this latest release, EPA has made several important improvements, including updates to estimates for oil and gas and forested land incorporating long-term research.

FOR MORE INFORMATION

Additional resources and tools with more information and data related to the U.S. Greenhouse Gas Inventory are available at: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks. These include:

- The Greenhouse Gas Inventory Data Explorer allows users to visualize the data underlying U.S. Inventory estimates,
- The full *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022* report provides access to in-depth information on data sources and methodologies, and
- CSVs of the *Inventory* report tables available for download for your own use.

REFERENCES

IPCC (2006), *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* The National Greenhouse Gas Inventories Programme, The Intergovernmental Panel on Climate Change, H.S. Eggleston, L. Buendia, K. Miwa, T Ngara, and K. Tanabe (eds.). Hayama, Kanagawa, Japan. Available online at: https://www.ipcc-nggip.iges.or.jp/support/Primer_2006GLs.pdf

IPCC (2014), *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands,* Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G. (eds). Published: IPCC, Switzerland. Available online at: https://www.ipcc.ch/publication/2013-supplement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories-wetlands/

IPCC (2014), *Climate Change 2014: Synthesis Report.* Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.). IPCC, Switzerland. Available online at: https://www.ipcc.ch/report/ar5/syr/

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. Available online at: https://www.ipcc.ch/site/assets/uploads/2019/12/19R_V0_01_Overview.pdf

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-reveal-how-buildings-across-the-united-states-do-and-could-use-energy.html#:~:text=Buildings%20are%20responsible%20for%2040,building%20 stock%20is%20also%20essential

U.S. Energy Information Administration (EIA) (2024) March 2024 Monthly Energy Review. Available online at: https://www.eia.gov/totalenergy/data/monthly/previous.php