Sources of Greenhouse Gas Emissions

On this page:

Overview

Greenhouse gases trap heat and make the planet warmer. Human activities are responsible for almost all of the increase in greenhouse gases in the atmosphere over the last 150 years.[1] The largest source of greenhouse gas emissions from human activities in the United States is from burning fossil fuels for electricity, heat, and transportation.

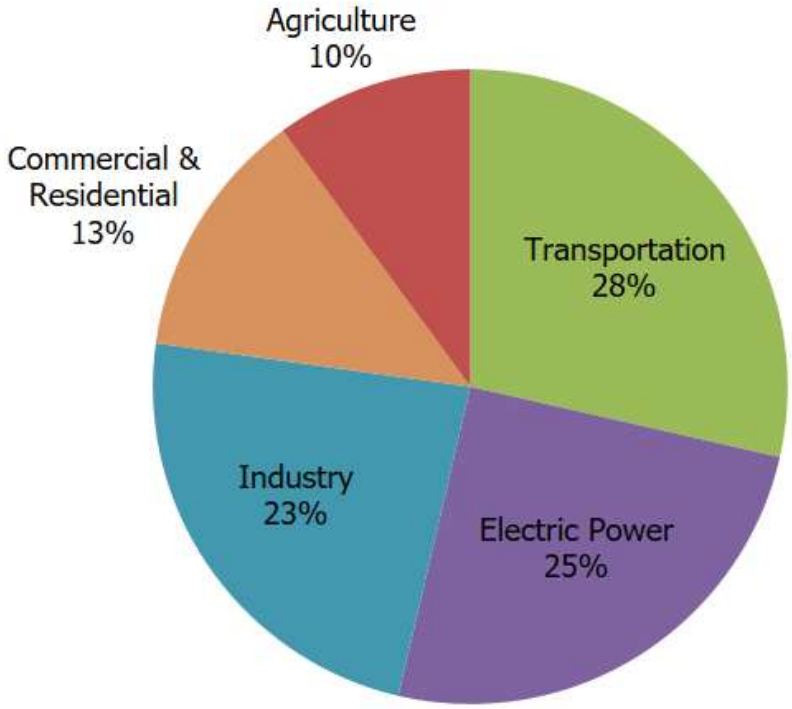
Total U.S. Greenhouse Gas Emissions by Economic Sector in

EPA tracks total U.S. emissions by publishing the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>. This annual report estimates the total national greenhouse gas emissions and removals associated with human activities across the United States.

The primary sources of greenhouse gas emissions by economic sector in the United States are:

- Transportation (28% of 2021 greenhouse gas emissions) – The transportation sector generates the largest share of greenhouse gas emissions. Greenhouse gas emissions from transportation primarily come from burning fossil fuel for our cars, trucks, ships, trains, and planes. Over 94% of the fuel used for transportation is petroleum based, which includes primarily gasoline and diesel.[2]
- Electricity production (25% of 2021 greenhouse gas emissions) – Electric power generates the second largest share of greenhouse gas emissions and includes emissions from electricity production used by other end use sectors (e.g. industry). 79% of our electricity comes from burning fossil fuels, mostly coal and natural gas.[3]

2021



Total Emissions in 2021 are 6,340 Million Metric Tons of CO_2 equivalent. Percentages may not add up to 100% due to independent rounding. Note that other sectors, particularly Industry and Commercial/Residential buildings, consume large amounts of electricity, and their share of overall emissions is significantly higher when these "indirect emissions" are included. More information is also in the electricity distributed section of this page. Land Use, Land-Use Change, and Forestry in the United States is a net sink and offsets 12%

- Industry (23% of 2021 greenhouse gas emissions) – Greenhouse gas emissions from industry primarily come from burning fossil fuels for energy, as well as greenhouse gas emissions from certain chemical reactions necessary to produce goods from raw materials. If emissions from electricity use are allocated to the industrial end-use sector, industrial activities account for a much larger share of U.S. greenhouse gas emissions.

of these greenhouse gas emissions. This net sink is not shown in the above diagram. All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021.* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>

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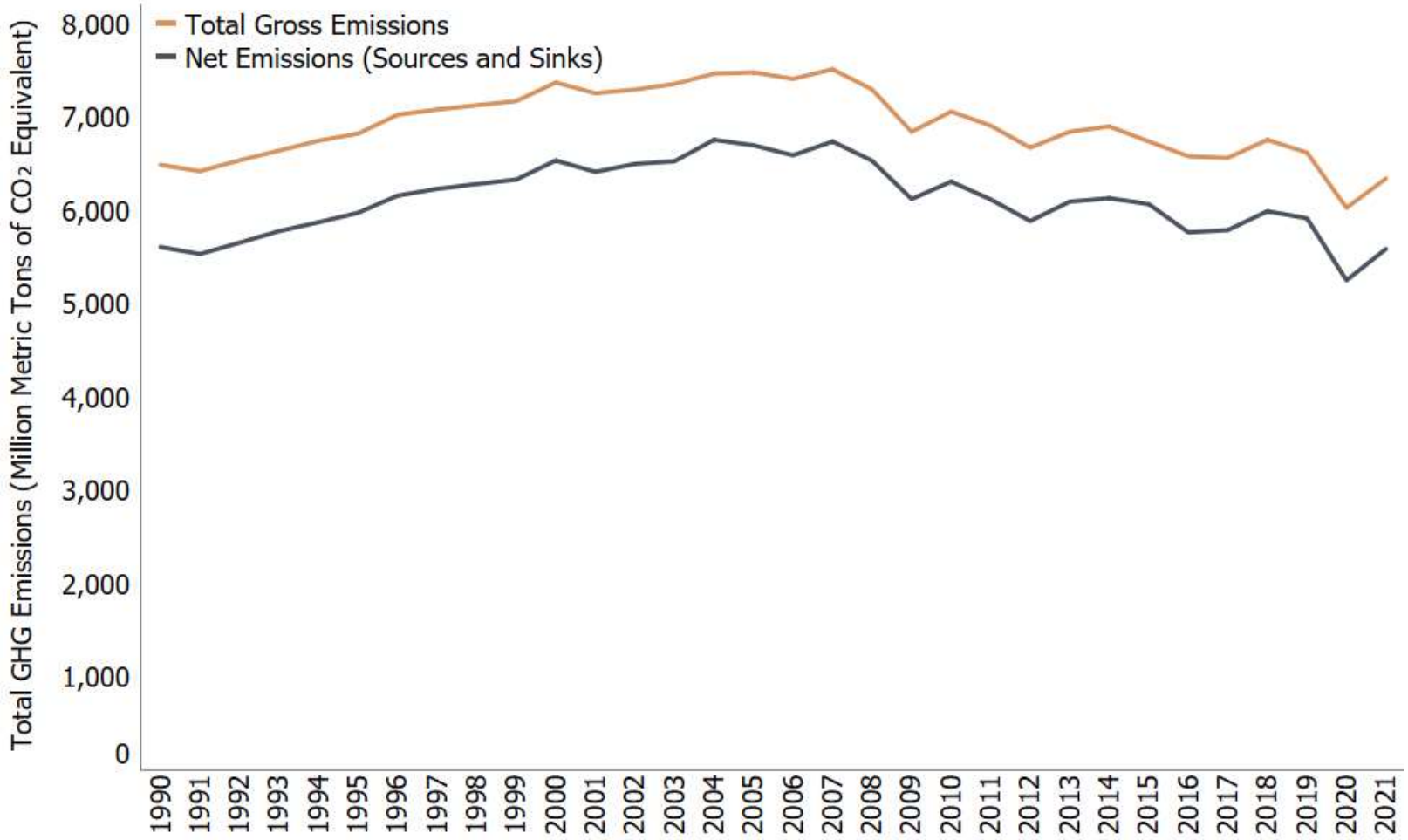
- Commercial and Residential (13% of 2021 greenhouse gas emissions) – Greenhouse gas emissions from the commercial and residential sector include fossil fuels burned for heat, lighting and the use of gases for refrigeration and cooling in businesses and homes, and non-building specific emissions such as the handling of waste. If emissions from electricity use are allocated to the commercial and residential end-use sector, commercial and residential activities account for a much larger share of U.S. greenhouse gas emissions.
- Agriculture (10% of 2021 greenhouse gas emissions) – Greenhouse gas emissions from agriculture come from livestock such as cows, agricultural soils, and rice production.
- Land Use and Forestry (offsets 12% of 2021 greenhouse gas emissions) – While not shown in the figure, land areas can act as a sink (absorbing CO_2 from the atmosphere) or a source of greenhouse gas emissions. In the United States, since 1990, managed forests and other lands are a net sink, i.e., they have absorbed more CO_2 from the atmosphere than they emit.

Trends

Since 1990, gross U.S. greenhouse gas emissions have decreased by just over 2%. From year to year, emissions can rise and fall due to changes in the economy, the price of fuel, and other factors. In 2021, U.S. greenhouse gas emissions increased 5% compared to 2020 levels. In 2020, there was a sharp decline in emissions largely due to the impacts of the coronavirus (COVID-19) pandemic on travel and other economic activity. In 2021, the increase in total greenhouse gas emissions was driven largely by an increase in CO_2 emissions from fossil fuel combustion due to economic activity rebounding after the height of the COVID-19 pandemic. In 2021, CO_2 emissions from fossil fuel combustion increased by 7% relative to the previous year. CO_2 emissions from natural gas consumption increased by less than 1 % relative to 2020. In a shift from recent trends, CO_2 emissions from coal consumption increased by 15% from 2020. The increase in natural gas consumption and emissions in 2021 is observed across all sectors except the Electric Power sector and U.S. Territories, while the coal increase is primarily in the Electric Power sector. Emissions from petroleum use also increased by 9% in 2021, and CO_2 emissions from fossil fuel combustion were 2% below emissions in 1990.

Total U.S. Greenhouse Gas Emissions, 1990–2021



Note: All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.

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References

1. IPCC (2013) Climate Change 2013: The Physical Science Basis <https://www.ipcc.ch/report/ar5/wg1/>. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [Stocker, T.F., D. Qin, G.K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp. .
2. IPCC (2022): Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926
3. U.S. Energy Information Administration (2022) . *Electricity Explained - Basics*

Electric Power Sector Emissions

The Electricity power sector involves the generation, transmission, and distribution of electricity. Carbon dioxide (CO_2) <https://epa.gov/ghgemissions/overview-greenhouse-gases#carbon-dioxide> makes up the vast majority of greenhouse gas emissions from the sector, but smaller amounts of methane (CH_4) <https://epa.gov/ghgemissions/overview-greenhouse-gases#methane> and nitrous oxide (N_2O) <https://epa.gov/ghgemissions/overview-greenhouse-gases#nitrous-

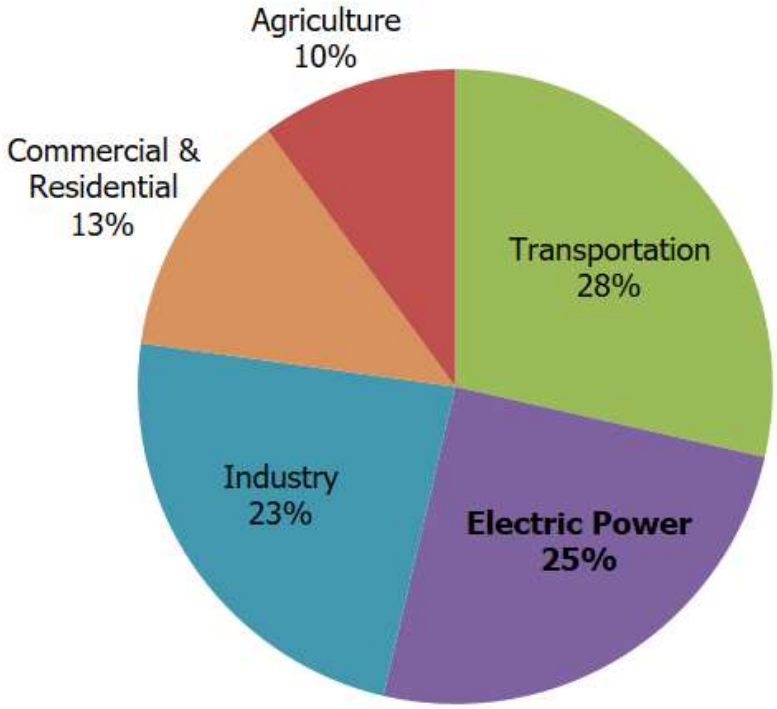
Total U.S. Greenhouse Gas Emissions by Economic Sector in

oxide> are also emitted. These gases are released during the combustion of fossil fuels, such as coal, oil, and natural gas, to produce electricity. Less than 1% of greenhouse gas emissions from the sector come from sulfur hexafluoride (SF_6) <https://epa.gov/ghgemissions/overview-greenhouse-gases#f-gases>, an insulating chemical used in electricity transmission and distribution equipment.

Greenhouse Gas Emissions in the Electric Power Sector by Fuel Source

Coal combustion is more carbon-intensive than burning natural gas or petroleum for electric power production. Although coal use accounted for 59% of CO_2 emissions from the sector, it represented only 23% of the electricity generated in the United States in 2021. Natural gas use accounted for 37% of electricity generation in 2021, and petroleum use accounted for less than 1%. The remaining generation in 2021 came from non-fossil fuel sources, including nuclear (20%) and renewable energy sources (20%), which include

2021



Total Emissions in 2021 = 6,340 Million Metric Tons of CO_2 equivalent. Percentages may not add up to 100% due to independent rounding. Land Use, Land-Use Change, and Forestry in the United States is a net sink and offsets 12% of these greenhouse gas emissions. This net sink is not shown in the above diagram. All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021.* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-

hydroelectricity, biomass, wind, and solar.[1] Most of these non-fossil sources, such as nuclear, hydroelectric, wind, and solar, are non-emitting.

emissions-and-sinks>

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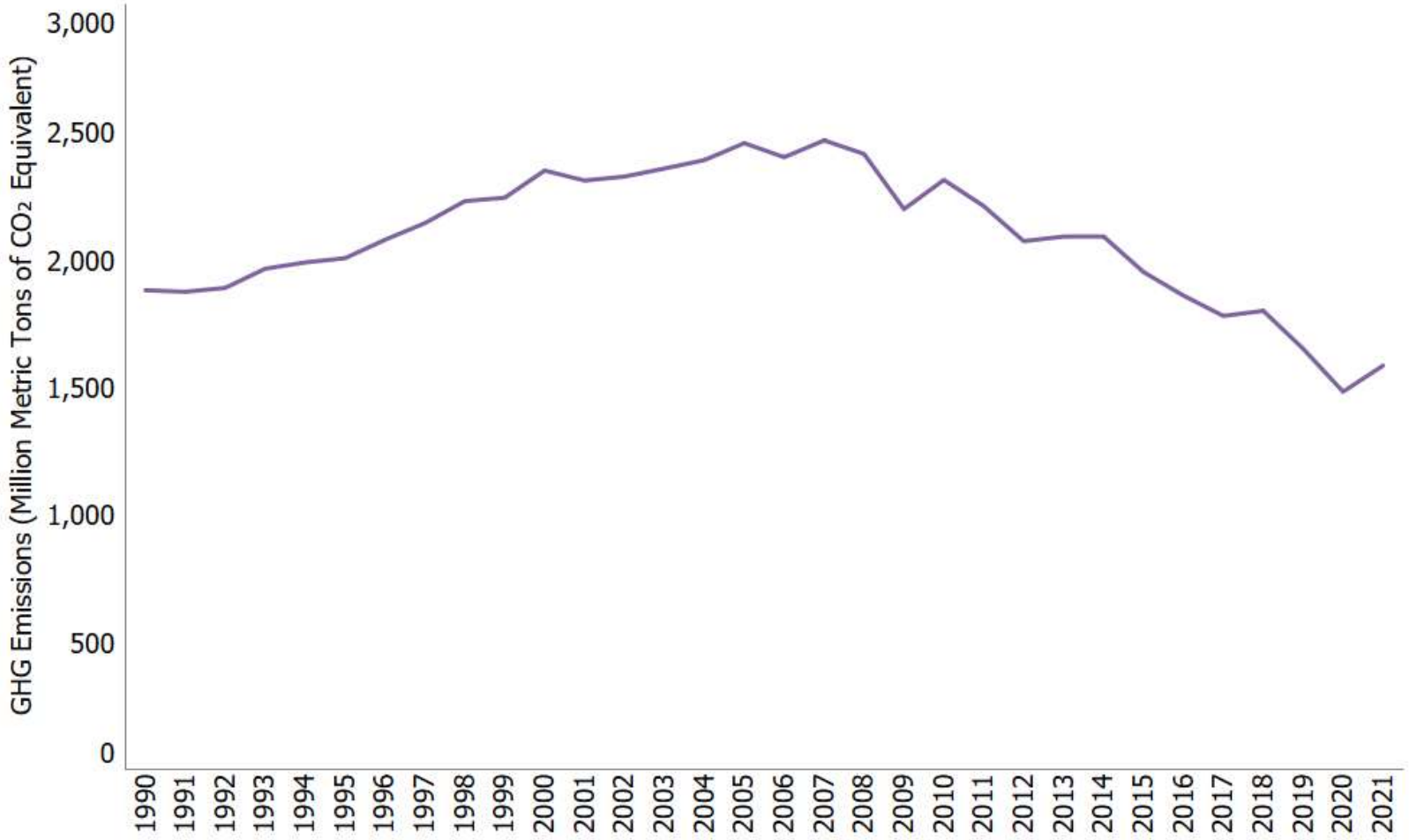
Trends

In 2021, the electric power sector was the second largest source of U.S. greenhouse gas emissions, accounting for 25% of the U.S. total. Electric power sector emissions increased 7% in 2021. Greenhouse gas emissions from electric power production have decreased by about 15% since 1990 due to a shift in generation to lower- and non-emitting sources of electricity generation and an increase in end-use energy efficiency.

Greenhouse Gas Emissions from Electric Power, 1990–2021



All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021 <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.*

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Greenhouse Gas Emissions by Electricity End-Use

Electricity is used by other sectors—in homes, businesses, and factories—and the greenhouse gas emissions from electricity generation can be attributed to the sectors that use the electricity. Looking at greenhouse gas emissions by end-use sector can help us understand energy demand across sectors and changes in energy use over time.

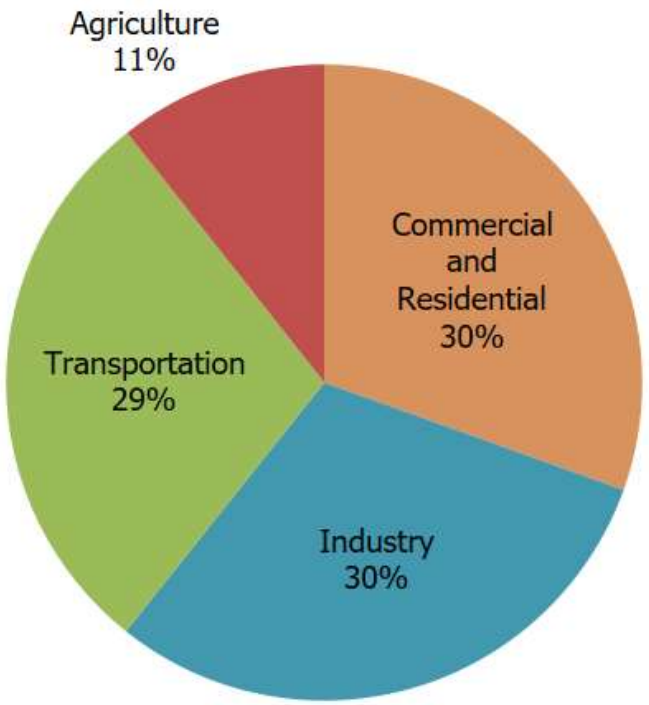
When emissions from electric power production are allocated to the industrial end-use sector, industrial activities account for a much larger share of U.S. greenhouse gas emissions. Greenhouse gas emissions from commercial and residential buildings also increase substantially when emissions from electricity end-use are included, due to the relatively large share of electricity use (e.g., heating, ventilation, and air conditioning; lighting; and appliances) in these sectors. The transportation sector currently has a relatively low percentage of electricity use, but it is growing due to the use of electric and plug-in vehicles.

Total U.S. Greenhouse Gas Emissions by Sector with

Reducing Emissions from Electric Power Production

There are a variety of opportunities to reduce greenhouse gas emissions associated with electric power production, transmission, and distribution. The table below categorizes these opportunities and provides examples. For a more comprehensive list, see Chapter 6 (PDF) <https://www.ipcc.ch/report/ar6/wg3/downloads/report/ipcc_ar6_wgiii_chapter06.pdf> (88 pp, 3.6MB) of the *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* <https://www.ipcc.ch/report/ar6/wg3/>.[2]

Electricity Distributed



Percentages may not add up to 100% due to independent rounding. Land Use, Land-Use Change, and Forestry in the United States is a net sink and offsets 12% of these greenhouse gas emissions. This net sink is not shown in the above diagram. All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021 <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.*

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Example Reduction Opportunities for the Electric Power Sector

Type	How Emissions Are Reduced	Examples
Increased Efficiency of Fossil-fired Power Plants and Fuel Switching	Increasing the efficiency of existing fossil fuel-fired power plants by using advanced technologies, substituting less carbon-intensive fuels, and shifting generation from higher-emitting to lower-emitting power plants.	• Converting a coal-fired boiler to use of natural gas, or co-firing natural gas. • Converting a single-cycle gas turbine into a combined-cycle turbine. • Shifting dispatch of electric generators to lower-emitting units or power plants.
Renewable Energy	Using renewable energy sources rather than fossil fuel to generate electricity.	Increasing the share of total electricity generated from wind, solar, hydro, and geothermal sources, as well as certain biofuel sources, through the addition of new renewable energy generating capacity.

Type	How Emissions Are Reduced	Examples
Increased End-Use Energy Efficiency	Reducing electricity use and peak demand by increasing energy efficiency and conservation in homes, businesses, and industry.	EPA's ENERGY STAR® <https://www.energystar.gov/> partners avoided over 400 million metric tons of greenhouse gases in 2020 alone, helped Americans save over $42 billion in energy costs, and reduced electricity use by 520 billion kWh.
Nuclear Energy	Generating electricity from nuclear energy rather than the combustion of fossil fuels.	Extending the life of existing nuclear plants and building new nuclear generating capacity.
Carbon Capture and Sequestration (CCS)	Capturing CO_2 as a byproduct of fossil fuel combustion before it enters the atmosphere, transporting the CO_2, injecting the CO_2 deep underground at a carefully selected and suitable subsurface geologic formation where it is securely stored.	Capturing CO_2 from the stack of a coal-fired power plant and then transferring the CO_2 via pipeline, injecting the CO_2 deep underground at a carefully selected and suitable nearby abandoned oil field where it is securely stored. Learn more about CCS <https://epa.gov/uic/class-vi-wells-used-geologic-sequestration-carbon-dioxide>.

References

1. U.S. Energy Information Administration (2022). Electricity Explained - Basics. <https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php>

2. IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926

Transportation Sector Emissions

The Transportation sector includes the movement of people and goods by cars, trucks, trains, ships, airplanes, and other vehicles. The majority of greenhouse gas emissions from transportation are carbon dioxide (CO_2) <https://epa.gov/ghgemissions/overview-greenhouse-gases#carbon-dioxide> emissions resulting from the combustion of petroleum-based products, like gasoline and diesel fuel, in internal combustion engines. The largest sources of transportation-related greenhouse gas emissions include passenger cars, medium- and heavy-duty trucks, and light-duty trucks, including sport utility vehicles, pickup trucks, and minivans. These sources account for over half of the emissions from the transportation sector. The remaining greenhouse gas emissions from the transportation sector come from other modes of transportation, including commercial aircraft, ships, boats, and trains, as well as pipelines and lubricants.

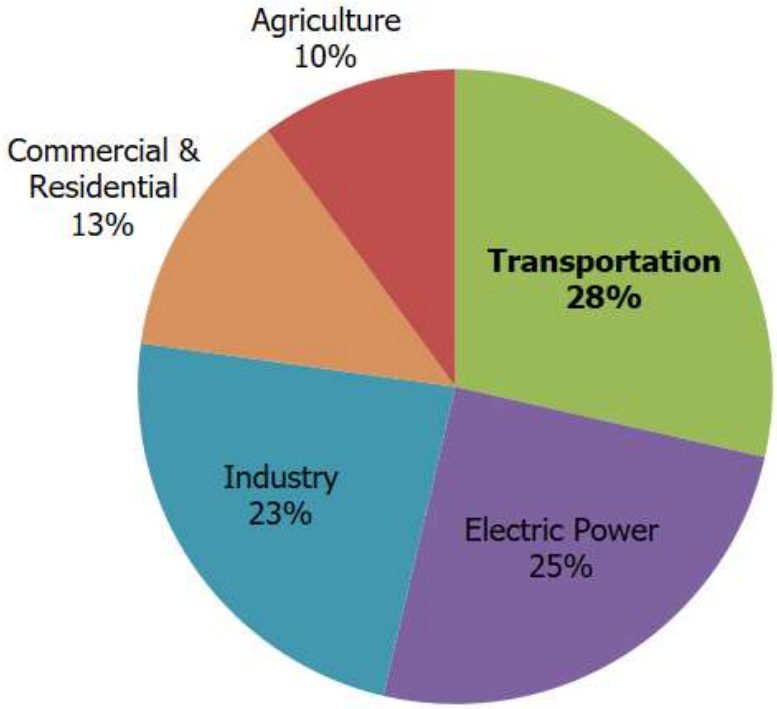
Total U.S. Greenhouse Gas Emissions by Economic Sector in

Relatively small amounts of methane (CH_4) <https://epa.gov/ghgemissions/overview-greenhouse-gases#methane> and nitrous oxide (N_2O) <https://epa.gov/ghgemissions/overview-greenhouse-gases#nitrous-oxide> are emitted during fuel combustion. In addition, hydrofluorocarbon (HFC) <https://epa.gov/ghgemissions/overview-greenhouse-gases#f-gases> emissions also occur from the Transportation sector. These emissions result from the use of mobile air conditioners and refrigerated transport.

Trends

In 2021, greenhouse gas emissions from transportation accounted for 28% of total U.S. greenhouse gas emissions, making it the largest contributor of U.S. greenhouse gas emissions. From 1990 to 2021, total transportation emissions from fossil fuel combustion increased by 19%. In 2021, emissions increased by 12%, which followed a decline of 13% in 2020 due to reduced travel demand during the height of the COVID-19 pandemic. The largest sources of transportation greenhouse gas emissions in 2021 were light-duty trucks, which include sport utility vehicles, pickup trucks, and minivans (37%); medium- and heavy-duty

2021



Total Emissions in 2021 = 6,340 Million Metric Tons of CO_2 equivalent. Percentages may not add up to 100% due to independent rounding. Land Use, Land-Use Change, and Forestry in the United States is a net sink and offsets 12% of these greenhouse gas emissions. This net sink is not shown in the above diagram. All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021.* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-

trucks (23%); passenger cars (21%); commercial aircraft (7%); other aircraft (2%); pipelines (4%); ships and boats (3%); and rail (2%). In terms of the overall trend, from 1990 to 2021, total transportation emissions have increased due, in large part, to increased demand for travel. The number of vehicle miles traveled (VMT) by light-duty motor vehicles (passenger cars and light-duty trucks) increased by 45% from 1990 to 2021, as a result of a confluence of factors including population growth, economic growth, urban sprawl, and periods of low fuel prices. Between 1990 and 2004, average fuel economy among new vehicles sold annually declined, as sales of light-duty trucks increased. Starting in 2005, average new vehicle fuel economy began to increase, while light-duty VMT grew only modestly for much of the period. Average new vehicle fuel economy has improved almost every year since 2005, slowing the rate of increase of CO_2 emissions.

Learn more about Greenhouse Gas Emissions from Transportation <https://epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions>.

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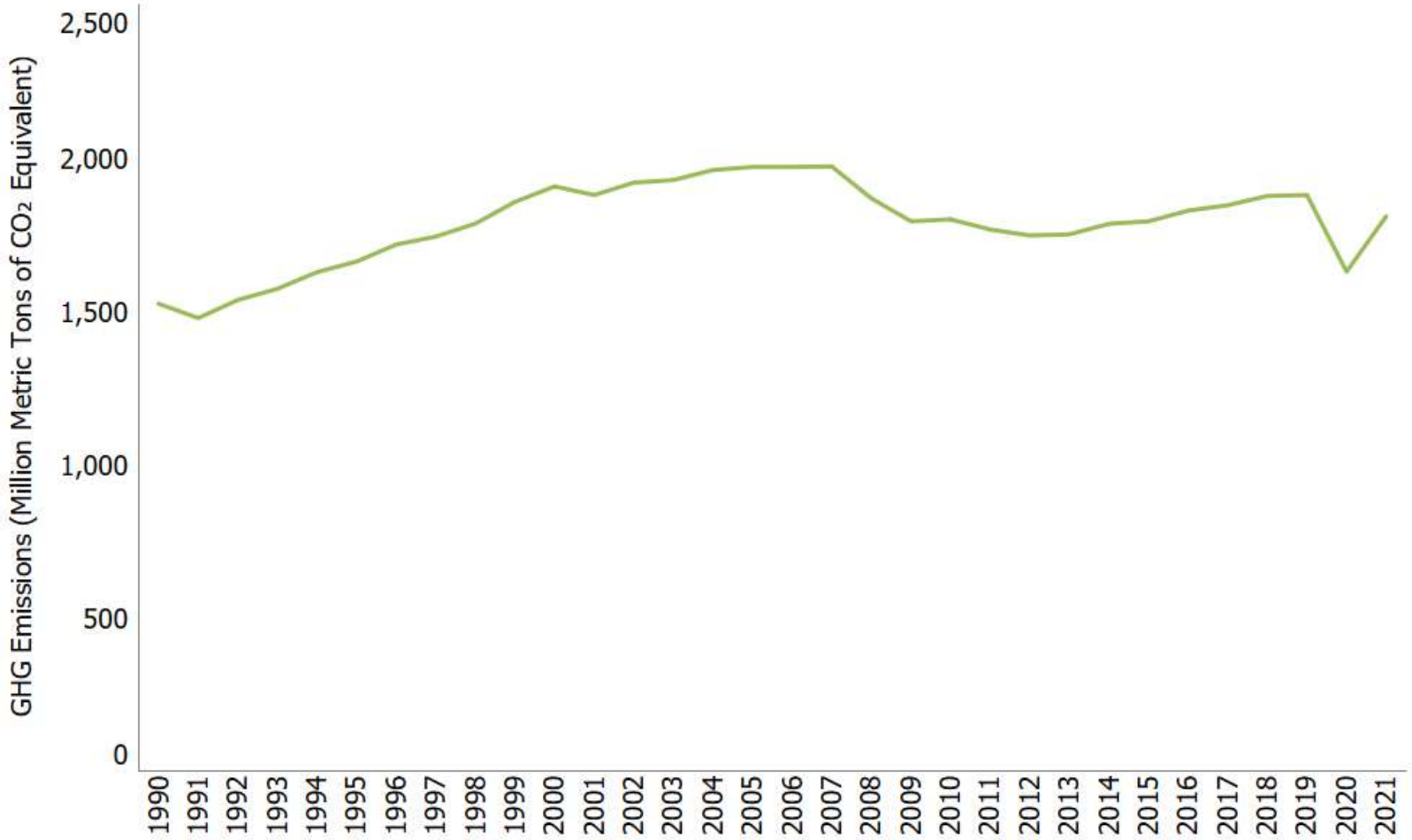
Related Links

- Carbon Pollution from Transportation <https://epa.gov/transportation-air-pollution-and-climate-change/carbon-pollution-transportation>
- EPA and U.S. DOE Fuel Economy <https://fueleconomy.gov/>
- SmartWay <https://epa.gov/smartway>
- Smart Growth <https://epa.gov/smartgrowth>
- Renewable Fuel Standard <https://epa.gov/renewable-fuel-standard-program>
- U.S. Inventory's section on Fossil Fuel Combustion <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>

Greenhouse Gas Emissions from Transportation, 1990-2021



Emissions involved in the use of electricity for transportation activities are included above, but not shown separately (as was done for other sectors). These indirect emissions are negligible, accounting for less than 1% of the total emissions shown in the graph. All emission

estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.

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Reducing Emissions from Transportation

There are a variety of opportunities to reduce greenhouse gas emissions associated with transportation. The table shown below categorizes these opportunities and provides examples. For a more comprehensive list, see Chapter 10 of the *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* <https://www.ipcc.ch/report/ar6/wg3/>.[1]

Examples of Reduction Opportunities in the Transportation Sector

Type	How Emissions Are Reduced	Examples

Type	How Emissions Are Reduced	Examples
Fuel Switching	Using fuels that emit less CO_2 than fuels currently being used. Alternative sources can include biofuels; hydrogen; electricity from renewable sources, such as wind and solar; or fossil fuels that are less CO_2-intensive than the fuels that they replace. Learn more about Green Vehicles and Alternative and Renewable Fuels <https://epa.gov/renewable-fuel-standard-program/alternative-fuels>.	• Using public buses that are powered by renewable fuels, electricity, or compressed natural gas rather than conventional gasoline or diesel. • Using electric, plug-in hybrid electric, or hydrogen fuel cell vehicles. • Using renewable fuels such as low-carbon biofuels.

Type	How Emissions Are Reduced	Examples
Improving Fuel Efficiency with Advanced Design, Materials, and Technologies	Using advanced technologies, design, and materials to develop more fuel-efficient vehicles. Learn about EPA's vehicle greenhouse gas rules <https://epa.gov/regulations-emissions-vehicles-and-engines/regulations-greenhouse-gas-ghg-emissions>.	• Developing advanced vehicle technologies such as hybrid vehicles and electric vehicles, that can store energy from braking and use it for power later. • Reducing the weight of materials used to build vehicles. • Reducing the aerodynamic resistance of vehicles through better shape design.

Type	How Emissions Are Reduced	Examples
Improving Operating Practices	Adopting practices that minimize fuel use. Improving driving practices and vehicle maintenance <https://epa.gov/transportation-air-pollution-and-climate-change/what-you-can-do-reduce-pollution-vehicles-and>. Learn about how the freight transportation industry can reduce emissions through EPA's SmartWay Program <https://epa.gov/smartway>.	• Reducing the average taxi time for aircraft. • Driving sensibly (avoiding rapid acceleration and braking, observing the speed limit). • Reducing engine-idling. • Improved voyage planning for ships, such as through improved weather routing, to increase fuel efficiency.
Reducing Travel Demand	Employing urban planning to reduce the number of miles that people drive each day. Reducing the need for driving through travel efficiency measures such as commuter, biking, and pedestrian programs. Learn about EPA's Smart Growth Program <https://epa.gov/smartgrowth>.	• Building public transportation, sidewalks, and bike paths to increase lower-emission transportation choices. • Zoning for mixed use areas, so that residences, schools, stores, and businesses are close together, reducing the need for driving.

References

1. IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926

Industry Sector Emissions

The Industry sector produces the goods and raw materials we use every day. The greenhouse gases emitted during industrial production are split into two categories: **direct emissions** that are produced at the facility, and **indirect emissions** that occur off site but are associated with the facility's use of electricity.

Direct emissions are produced by burning fuel for power or heat, through chemical reactions, and from leaks from industrial processes or equipment. Most direct emissions come from the consumption of fossil fuels for energy. A smaller amount of direct emissions, roughly one third, come from leaks from natural gas and petroleum systems, the use of fuels in production (e.g., petroleum products used to make plastics), and chemical reactions during the production of chemicals, metals (e.g., iron and steel), and minerals (e.g., cement).

Total U.S. Greenhouse Gas Emissions by Economic Sector in

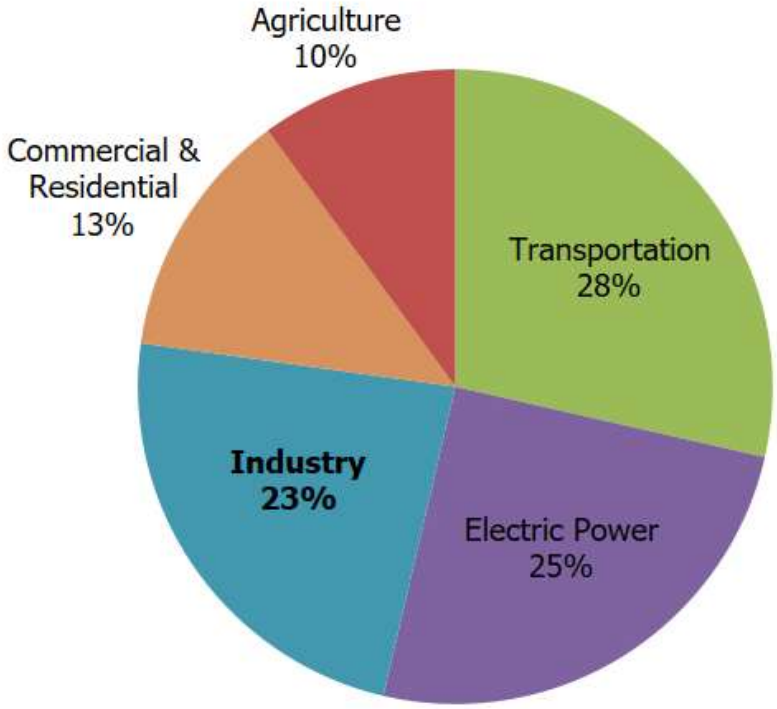
Indirect emissions are produced by burning fossil fuel at a power plant to make electricity, which is then used by an industrial facility to power industrial buildings and machinery.

More information about facility-level emissions from large industrial sources is available through EPA's Greenhouse Gas Reporting Program data publication tool <http://ghgdata.epa.gov/ghgp/main.do>. National-level information about emissions from industry as a whole can be found in the sections on Fossil Fuel Combustion and the Industrial Processes chapter in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.

Trends

In 2021, direct industrial greenhouse gas emissions accounted for 23% of total U.S. greenhouse gas emissions, making it the third largest contributor to U.S. greenhouse gas emissions, after the Transportation and Electric Power sectors. From 2020 to 2021, total energy use in the industrial sector increased by just over 1%. Including both direct emissions and indirect emissions associated with

2021



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electricity use, industry's share of total U.S. greenhouse gas emissions in 2021 was 30%, making it the largest contributor of greenhouse gas emissions of any sector. Total U.S. greenhouse gas emissions from industry, including electricity, have declined by 14% since 1990.

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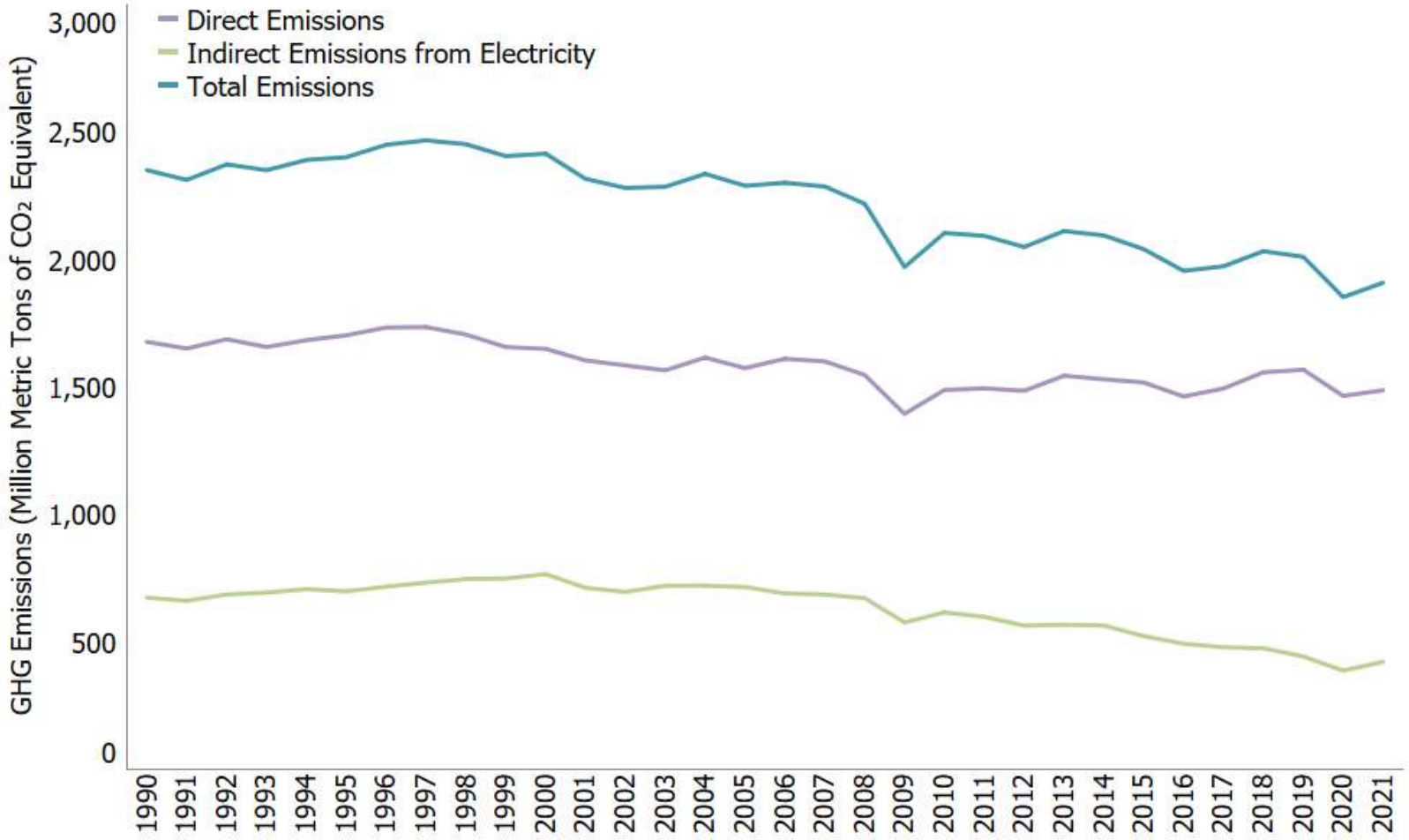
Greenhouse Gas Emissions from Industry, 1990–2021



All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.

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Reducing Emissions from Industry

There are a wide variety of industrial activities that cause greenhouse gas emissions, and many opportunities to reduce them. The table shown below provides some examples of opportunities for industry to reduce emissions. For a more comprehensive list, see Chapter 11 of the *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* <https://www.ipcc.ch/report/ar6/wg3/>. [1]

Examples of Reduction Opportunities for the Industry Sector

Type	How Emissions Are Reduced	Examples
Energy Efficiency	Upgrading to more efficient industrial technology. EPA's ENERGY STAR® program helps industries become more energy-efficient.	Identifying ways that manufacturers <https://www.energystar.gov/buildings/facility-owners-and-managers/industrial-plants> can use less energy for industrial processes and to run equipment.
Fuel Switching	Switching to fuels that result in less CO_2 emissions but the same amount of energy, when combusted.	Using natural gas instead of coal as process input.
Recycling	Producing industrial products from materials that are recycled or renewable, rather than producing new products from raw materials.	Using scrap steel and scrap aluminum as opposed to smelting new aluminum or forging new steel.

Type	How Emissions Are Reduced	Examples
Training and Awareness	Making companies and workers aware of the steps to reduce or prevent emissions leaks from equipment. EPA has a variety of resources for training and other steps for reducing emissions. EPA has experience working with the aluminum <https://epa.gov/f-gas-partnership-programs/aluminum-industry>, semiconductor <https://epa.gov/f-gas-partnership-programs/semiconductor-industry>, and magnesium <https://epa.gov/f-gas-partnership-programs/magnesium-industry> industries.	Instituting handling policies and procedures for perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF_6) that reduce occurrences of accidental releases and leaks from containers and equipment.

References

1. IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926

Commercial and Residential Sector Emissions

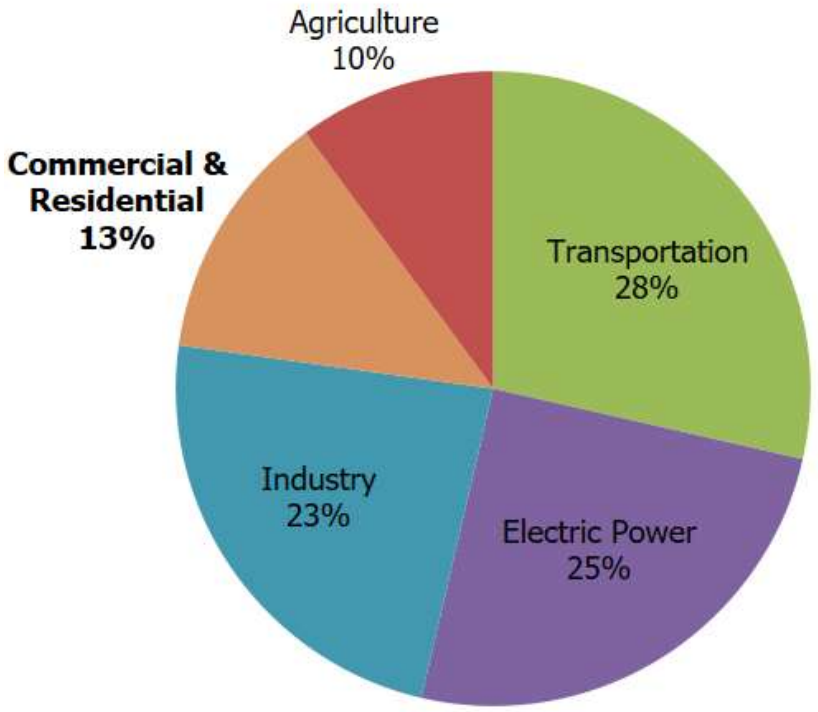
The Residential and Commercial sectors include all homes and commercial businesses (excluding agricultural and industrial activities). Greenhouse gas emissions from this sector come from **direct emissions** including fossil fuel combustion for heating and cooking needs, management of waste and wastewater, and leaks from refrigerants in homes

and businesses, as well as **indirect emissions** that occur offsite but are associated with use of electricity by homes and businesses.

Direct emissions are produced from residential and commercial activities in a variety of ways:

- Combustion of natural gas and petroleum products for heating and cooking emits carbon dioxide (CO_2) <https://epa.gov/ghgemissions/overview-greenhouse-gases#carbon-dioxide>, methane (CH_4) <https://epa.gov/ghgemissions/overview-greenhouse-gases#methane>, and nitrous oxide (N_2O) <https://epa.gov/ghgemissions/overview-greenhouse-gases#nitrous-oxide>. Emissions from natural gas consumption represent 80 % of the direct fossil fuel CO_2 emissions from the residential and commercial sector in 2021. Coal consumption is a minor component of energy use in both of these sectors.
- Organic waste sent to landfills emits CH_4.
- Wastewater treatment plants emit CH_4 and N_2O.
- Anaerobic digestion at biogas facilities emits CH_4.

Total U.S. Greenhouse Gas Emissions by Economic Sector in 2021



Total Emissions in 2021 = 6,340 Million Metric Tons of CO_2 equivalent. Percentages may not add up to 100% due to independent rounding. Land Use, Land-Use Change, and Forestry in the United States is a net

- Fluorinated gases <https://epa.gov/ghgemissions/overview-greenhouse-gases#f-gases> (mainly hydrofluorocarbons, or HFCs) used in air conditioning and refrigeration systems can be released during servicing or from leaking equipment.

Indirect emissions are produced by burning fossil fuel at a power plant to make electricity, which is then used in residential and commercial activities, such as lighting and for appliances.

sink and offsets 12% of these greenhouse gas emissions. This net sink is not shown in the above diagram. All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.

Image to save or print <https://epa.gov/system/files/images/2023-04/commercial-ghg-2023-caption.png>

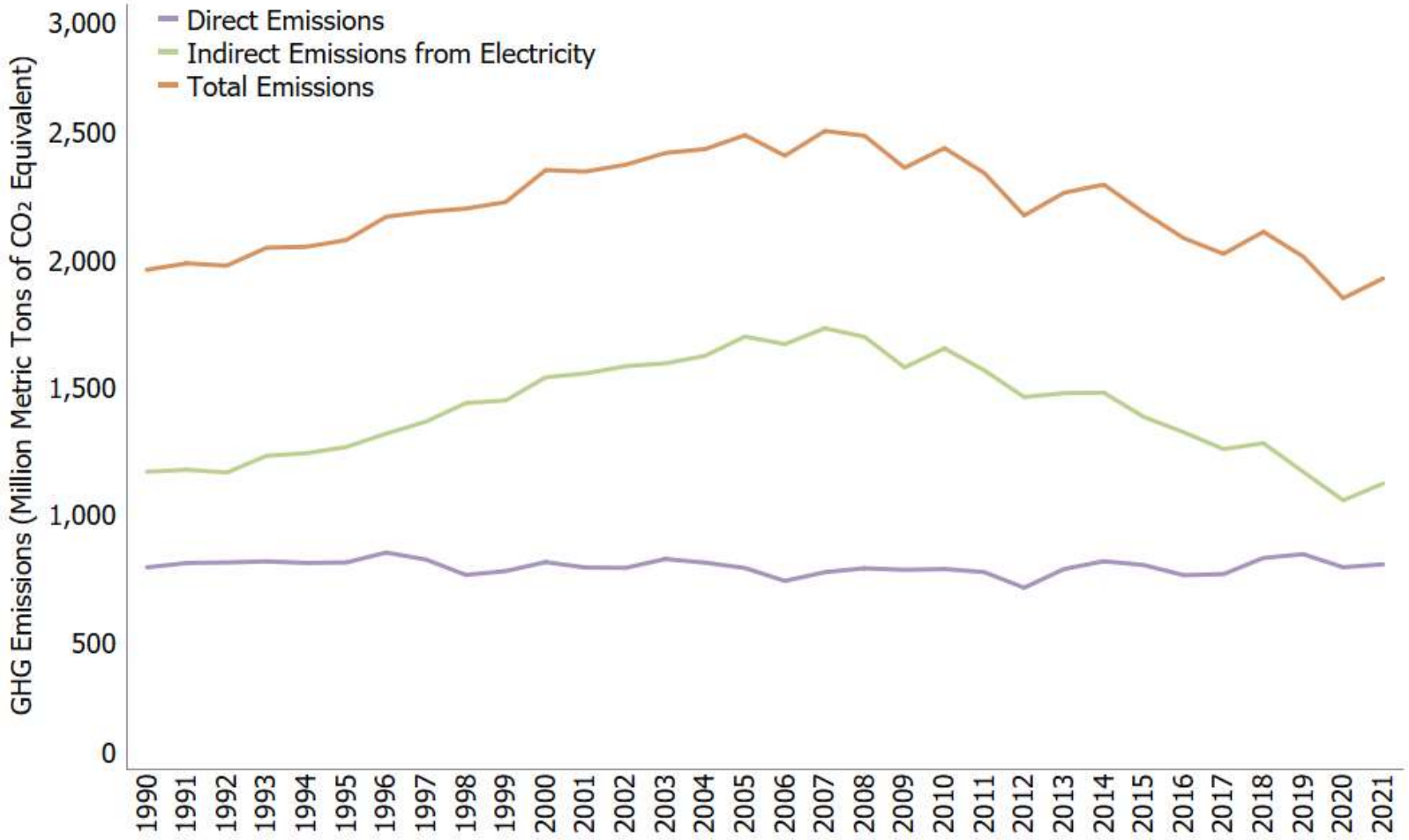
Note: Residential and commercial sector emissions presented here do not necessarily represent the full suite of emissions related to buildings and the broader built environment. The commercial and residential sectors numbers don't include any emissions/sinks from production of construction materials (e.g. upstream emissions from production of cement, emissions and sinks from land use changes, etc). Those would be reflected in other sectors. Also, as shown above, emissions from these sectors include other emissions that do not occur at the building site (i.e. landfills, etc.). Furthermore, energy use in these sectors may also include energy used for equipment (such as motor gasoline used for non-highway vehicles or lawn and garden equipment), exterior lighting, or construction. In addition, energy use for some large buildings, such as energy-intensive office buildings and factories with large onsite combustion, are typically included in industrial sector energy use.

More national-level information about emissions from the residential and commercial sector can be found in the U.S. Inventory's Trends in Greenhouse Gas Emissions and Energy chapters <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks> (Chapters 2 and 4 respectively).

Trends

In 2021, direct greenhouse gas emissions from homes and businesses accounted for 13% of total U.S. greenhouse gas emissions. Greenhouse gas emissions from homes and businesses vary from year to year, often correlated with annual fluctuations in energy use caused primarily by weather conditions. Total residential and commercial greenhouse gas emissions, including direct and indirect emissions, in 2021 have decreased by 2% since 1990. Greenhouse gas emissions from on-site direct emissions in homes and businesses have increased by 2% since 1990. Additionally, indirect emissions from electricity use by homes and businesses increased from 1990 to 2007 but have decreased since then to approximately 4% below 1990 levels in 2021.

Greenhouse Gas Emissions from Homes and Businesses, 1990–2021



All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.

Image to save or print <https://epa.gov/system/files/images/2023-04/commercial-timeline-2023-caption.png>

Reducing Emissions from Homes and Businesses

The table shown below provides examples of opportunities to reduce emissions from homes and businesses. For a more comprehensive list of options and a detailed assessment of how each option affects different gases, see Chapter 9 and Chapter 12 of the *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* <https://www.ipcc.ch/report/ar6/wg3/>.

Examples of Reduction Opportunities in the Residential and Commercial Sector

Type	How Emissions Are Reduced	Examples
Homes and Commercial Buildings	Reducing energy use through energy efficiency.	Homes and commercial buildings use large amounts of energy for heating, cooling, lighting, and other functions. Energy-efficient building practices and retrofits can allow new and existing buildings to use less energy to accomplish the same functions, leading to fewer greenhouse gas emissions. Techniques to improve building energy efficiency include better insulation and building envelope improvements; more energy-efficient heating, cooling, ventilation, and refrigeration systems; efficient LED lighting; passive heating and lighting to take advantage of sunlight; and the purchase of energy-efficient appliances and electronics. Learn more about ENERGY STAR® <https://www.energystar.gov/>.

Type	How Emissions Are Reduced	Examples
Wastewater Treatment	Making water and wastewater systems more energy-efficient.	Drinking water and wastewater systems account for approximately 2% of energy use in the United States. By incorporating energy efficiency practices into their water and wastewater plant, municipalities and utilities can save 15 to 30% in energy use. Learn more about Energy Efficiency for Water and Wastewater Utilities <https://epa.gov/sustainable-water-infrastructure/energy-efficiency-water-utilities>.
Waste Management	Reducing solid waste sent to landfills. Capturing and using methane produced in current landfills.	When solid waste decomposes in landfills, it creates landfill gas, which is primarily comprised of CO_2 and CH_4. There are a number of well established, low-cost methods to reduce greenhouse gases from consumer waste, including recycling programs, waste reduction programs, and landfill methane capture programs. • Learn about recycling <https://epa.gov/recycle> • Learn about WARM, EPA's Waste Reduction Model <https://epa.gov/warm>. • Learn about EPA's Landfill Methane Outreach Program <https://epa.gov/lmop>, which promotes the recovery and use of landfill gas. • Learn about appliance recycling from EPA's Responsible Appliance Disposal program <https://epa.gov/rad>.

Type	How Emissions Are Reduced	Examples
Air Conditioning and Refrigeration	Reducing leakage from air conditioning and refrigeration equipment. Using refrigerants with lower global warming potentials.	Commonly used refrigerants in homes and businesses include ozone-depleting refrigerants, and blends consisting entirely or primarily of hydrofluorocarbons (HFCs). Both HCFCs and HFCs are potent greenhouse gases. In recent years there have been several advancements in air conditioning and refrigeration technology that can help homes and businesses reduce both refrigerant charges and refrigerant emissions. For instance, in the retail food sector, learn more about EPA's GreenChill Program <https://epa.gov/greenchill> to reduce greenhouse gas emissions from supermarkets.

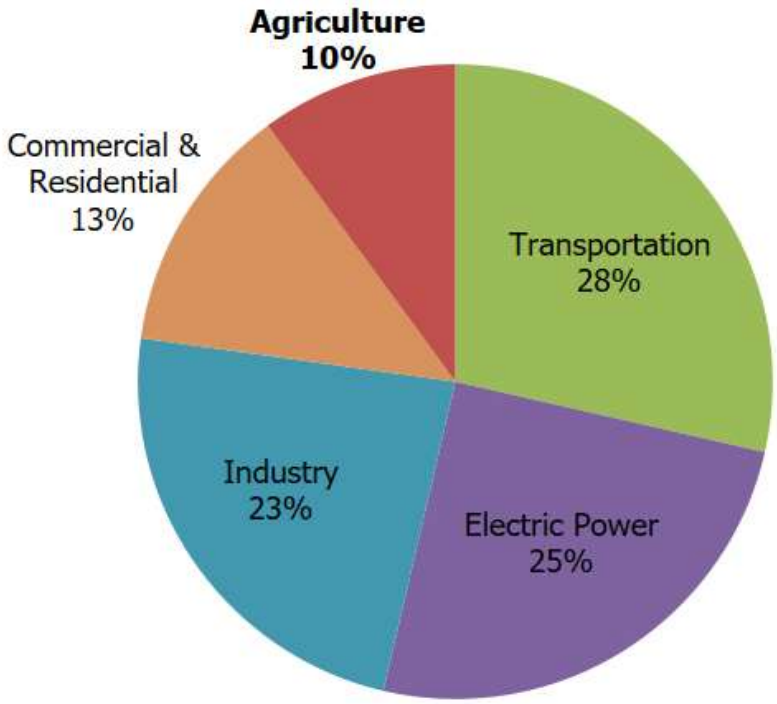
Agriculture Sector Emissions

Agricultural activities — crop and livestock production — contribute to emissions in a variety of ways:

Total U.S. Greenhouse Gas Emissions by Economic Sector in

- Various management practices on agricultural soils can lead to increased availability of nitrogen in the soil and result in emissions of nitrous oxide (N_2O) <https://epa.gov/ghgemissions/overview-greenhouse-gases#nitrous-oxide>. Specific activities that contribute to N_2O emissions from agricultural lands include the application of synthetic and organic fertilizers, the growth of nitrogen-fixing crops, the drainage of organic soils, and irrigation practices. Management of agricultural soils accounts for just over half of the greenhouse gas emissions from the Agriculture sector.*
- Livestock, especially ruminants such as cattle, produce methane (CH_4) <https://epa.gov/ghgemissions/overview-greenhouse-gases#methane> as part of their normal digestive processes. This process is called enteric fermentation, and it represents over a quarter of the greenhouse gas emissions from the Agriculture sector.

2021



Total Emissions in 2021 = 6,340 Million Metric Tons of CO_2 equivalent. Percentages may not add up to 100% due to independent rounding. Land Use, Land-Use Change, and Forestry in the United States is a net sink and offsets 12% of these greenhouse gas emissions. This net sink is not shown in the above diagram. All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-

and-sinks>.

Image to save or print <https://epa.gov/system/files/images/2023-04/agriculture-ghg-2023-caption.png>

- The way in which manure from livestock is managed also contributes to CH_4 and N_2O emissions. Different manure treatment and storage methods affect how much of these greenhouse gases are produced. Manure management accounts for about 11% of the total greenhouse gas emissions from the Agriculture sector in the United States.
- Smaller sources of agricultural emissions include CO_2 from liming and urea application, CH_4 from rice cultivation, and burning crop residues, which produces CH_4 and N_2O.

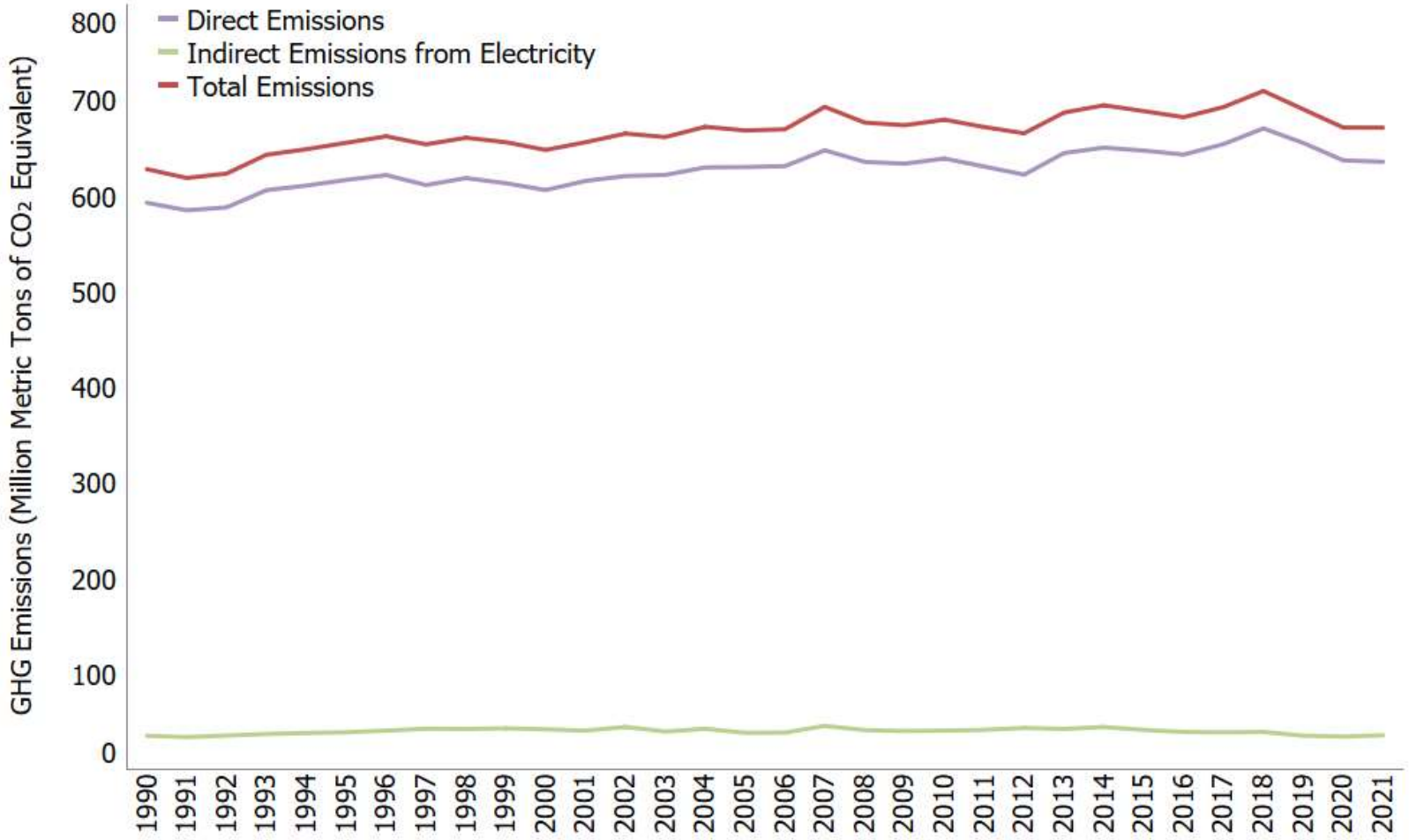
More information about emissions from agriculture can be found in the agriculture chapter in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.

* Management of croplands and grasslands can also lead to emissions or sequestration of carbon dioxide (CO_2) <https://epa.gov/ghgemissions/overview-greenhouse-gases#carbon-dioxide>. These emissions and removals are included under the Land Use, Land-Use Change, and Forestry sector <https://epa.gov/ghgemissions/sources-greenhouse-gas-emissions#land-use-and-forestry>.

Trends

In 2021, greenhouse gas emissions from the agriculture sector accounted for 10% of total U.S. greenhouse gas emissions. Greenhouse gas emissions from agriculture have increased by 7% since 1990. Agricultural soil management activities, such as application of synthetic and organic fertilizers, deposition of livestock manure, and growing nitrogen fixing plants, were the largest contributors to U.S. N_2O emissions in 2021, accounting for 75% of total N_2O emissions. Emissions from other agricultural sources have generally remained flat or changed by a relatively small amount since 1990.

Greenhouse Gas Emissions from Agriculture, 1990–2021



All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.

Image to save or print <https://epa.gov/system/files/images/2023-04/agriculture-timeline-2023-caption.png>

Reducing Emissions from Agriculture

The table shown below provides examples of opportunities to reduce emissions from agriculture. For a more comprehensive list of options and a detailed assessment of how each option affects different gases, see Chapter 7 of the *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* <https://www.ipcc.ch/report/ar5/wg3/>.

Examples of Reduction Opportunities for the Agriculture Sector

Type	How Emissions Are Reduced	Examples
Land and Crop Management	Adjusting the methods for managing land and growing crops.	• Fertilizing crops with the appropriate amount of nitrogen required for optimal crop production, since over-application of nitrogen can lead to higher nitrous oxide emissions without enhancing crop production. • Draining water from wetland rice soils during the growing season to reduce methane emissions.

Type	How Emissions Are Reduced	Examples
Livestock Management	Adjusting feeding practices and other management methods to reduce the amount of methane resulting from enteric fermentation.	• Improving pasture quality to increase animal productivity, which can reduce the amount of methane emitted per unit of animal product. Also, increased productivity in livestock can be introduced through improved breeding practices.
Manure Management	• Controlling the way in which manure decomposes to reduce nitrous oxide and methane emissions. • Capturing methane from manure decomposition to produce renewable energy.	• Handling manure as a solid or depositing it on pasture rather than storing it in a liquid-based system such as a lagoon would likely reduce methane emissions but may increase nitrous oxide emissions. • Storing manure in anaerobic lagoons to maximize methane production and then capturing the methane to use as an energy substitute for fossil fuels. • For more information on capturing methane from manure management systems, see EPA's AgSTAR <https://epa.gov/agstar> Program, a voluntary outreach and education program that promotes recovery and use of methane from animal manure.

Land Use, Land-Use Change, and Forestry Sector Emissions and Sequestration

Plants absorb carbon dioxide (CO_2) <https://epa.gov/ghgemissions/overview-greenhouse-gases#carbon-dioxide> from the atmosphere as they grow, and they store some of this carbon as perennial aboveground and belowground biomass throughout their lifetime. Soils and dead organic matter/litter can also store some of the carbon from these plants depending on how the soil is managed and other environmental conditions (e.g., climate). This storage of carbon in plants, dead organic matter/litter and soils is called biological carbon sequestration. Because biological sequestration takes CO_2 out of the atmosphere and stores it in these carbon pools, it is also called a carbon "sink."

Emissions or sequestration of CO_2, as well as emissions of CH_4 and N_2O, can occur from management of lands in their current use or as lands are converted to other land uses. Carbon dioxide is exchanged between the atmosphere and the plants and soils on land, for example, as cropland is converted into grassland, as lands are cultivated for crops, or as forests grow. In addition, using biological feedstocks (such as energy crops or wood) for purposes such as electricity generation, as inputs to processes that create liquid fuels, or as building materials can lead to emissions or sequestration.*

In the United States overall, Land Use, Land-Use Change, and Forestry (LULUCF) activities have resulted in more removal of CO_2 from the atmosphere than emissions. Because of this, the LULUCF sector in the United States is considered a net sink, rather than a source, of CO_2. In many areas of the world, the opposite is true, particularly in countries where large areas of forest land are cleared, often for conversion to agricultural purposes or for settlements. In these situations, the LULUCF sector can be a net source of greenhouse gas emissions.

- More national-level information about land use, land-use change, and forestry is available from the Land Use, Land-Use Change, and Forestry chapter in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>. For more information on emissions and sequestration from forest land and urban trees in settlement areas, see also the USDA's USFS Resource Bulletin <https://www.fs.usda.gov/research/treesearch/66035>.
- For more information about global emissions from land use and forestry activities, see EPA's Global Greenhouse Gas emissions page <https://epa.gov/ghgemissions/global-greenhouse-gas-emissions-data> and the *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* <https://www.ipcc.ch/report/ar5/wg3/>.

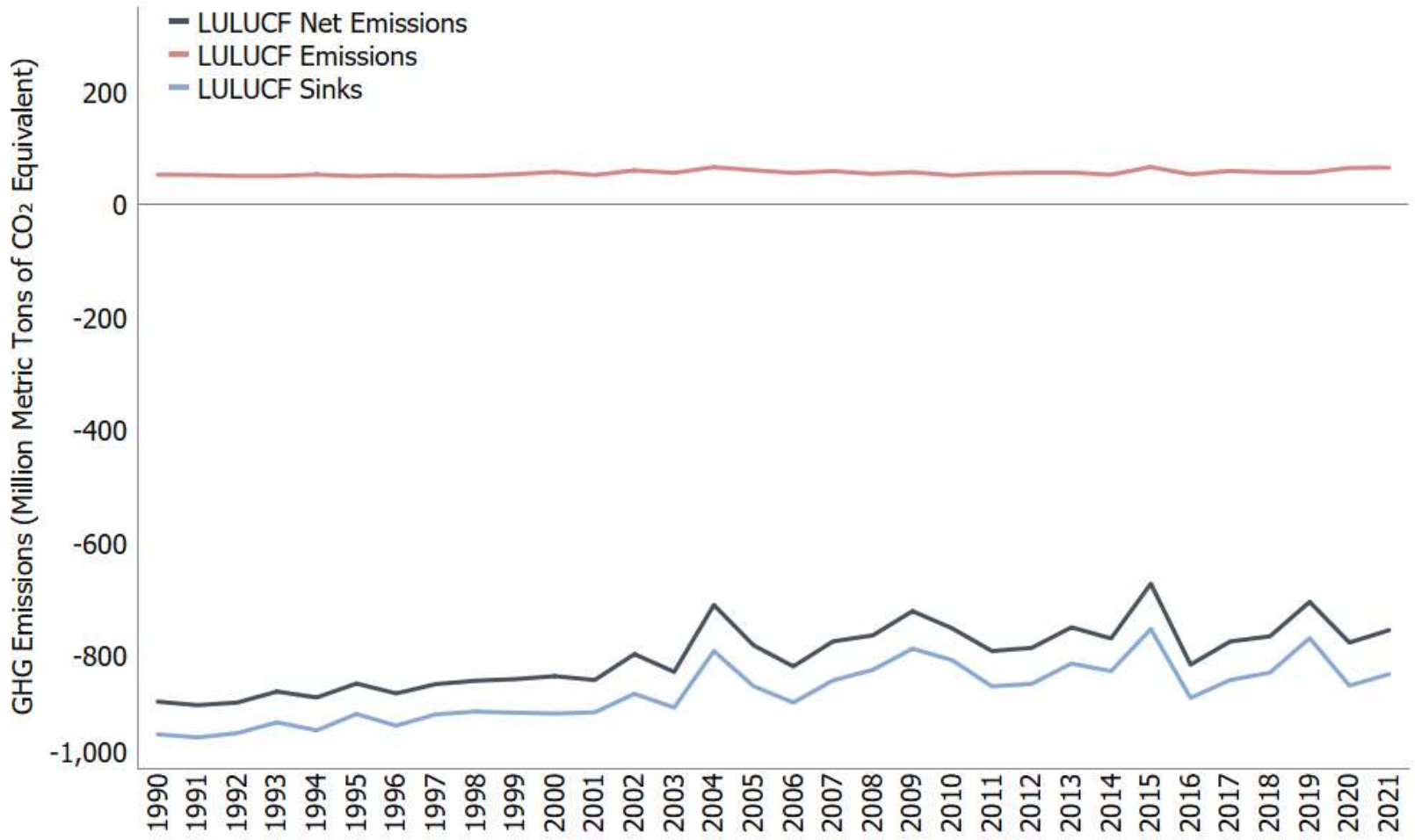
* Emissions and sequestration of CO_2 are presented under the Land Use, Land-Use Change, and Forestry sector in the Inventory. Emissions of methane (CH_4) and nitrous oxide (N_2O) also occur as a result of land use and management activities in the LULUCF sector. Other emissions from CH_4, and N_2O are also presented in the Energy sector.

Emissions and Trends

In 2021, the net CO_2 removed from the atmosphere from the LULUCF sector was 12% of total U.S. greenhouse gas emissions. Between 1990 and 2021, total carbon sequestration in the LULUCF sector decreased by 14%, primarily due to a decrease in the rate of net carbon accumulation in forests, as well as an increase in CO_2 emissions from urbanization. Additionally, while episodic in nature, increased CO_2, CH_4 and N_2O emissions from forest fires have also occurred over the time series.

Greenhouse Gas Emissions and Removals from U.S. Land Use, Land-Use

Change, and Forestry, 1990–2021*



*Note: The LULUCF sector is a net "sink" of emissions in the United States (e.g., more greenhouse gas emissions are sequestered than emitted from land use activities), so net greenhouse gas emissions from LULUCF are negative. All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021* <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>.

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Reducing Emissions and Enhancing Sinks from Land Use, Land-Use Change, and Forestry

In the LULUCF sector, opportunities exist to reduce greenhouse gas emissions and increase the potential to sequester carbon from the atmosphere by enhancing sinks. The table shown below provides some examples of opportunities for both reducing emissions and enhancing sinks. For a more comprehensive list, see Chapter 7 of the *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* <https://www.ipcc.ch/report/ar5/wg3/>.

Examples of Reduction Opportunities in the LULUCF Sector

Type	How Emissions Are Reduced or Sinks Are Enhanced	Examples
Change in Uses of Land	Increasing carbon storage by using land differently or maintaining carbon storage by avoiding land degradation.	• Afforestation and minimizing the conversion of forest land to other land uses, such as settlements, croplands, or grasslands.

Type	How Emissions Are Reduced or Sinks Are Enhanced	Examples
Changes in Land Management Practices	Improving management practices on existing land-use types.	• Utilizing reduced tillage practices on cropland and improved grazing management practices on grassland. • Planting after natural or human-induced forest disturbances to accelerate vegetation growth and minimize soil carbon losses.

6,340 million metric tons of CO_2: What does that mean?

An Explanation of Units

A million metric tons equals about 2.2 billion pounds, or 1 trillion grams. For comparison, a small car is likely to weigh a little more than 1 metric ton. Thus, a million metric tons are roughly the same mass as 1 million small cars!

The U.S. Inventory uses metric units for consistency and comparability with other countries. For reference, a metric ton is slightly more (approximately 10%) than a U.S. "short" ton.

Greenhouse gas emissions are often measured in carbon dioxide (*CO_2*) *equivalent*. To convert emissions of a gas into CO_2 equivalent, its emissions are multiplied by the gas's Global Warming Potential (GWP) <https://epa.gov/ghgemissions/understanding-global-warming-potentials>. The GWP takes into account the fact that many gases are more effective at warming Earth than CO_2, per unit mass.

The GWP values appearing in the Overview of Greenhouse Gases <https://epa.gov/ghgemissions/overview-greenhouse-gases> and Sources of Greenhouse Gas <https://epa.gov/ghgemissions/sources-greenhouse-gas-emissions> web pages reflect the values used in the U.S. Inventory, which are drawn from the IPCC's Fifth Assessment Report (AR5). For further discussion of GWPs and an estimate of greenhouse gas emissions using updated GWPs, see Annex 6 of the U.S. Inventory <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021> and the IPCC's discussion on GWPs (PDF) <https://www.ipcc.ch/site/assets/uploads/2018/02/syr_ar5_final_full.pdf> (106 pp, 7.7MB).

GHG Emissions and Removals Home <https://epa.gov/ghgemissions>

Overview of Greenhouse Gases <https://epa.gov/ghgemissions/overview-greenhouse-gases>

Sources of GHG Emissions and Removals

Global Emissions and Removals <https://epa.gov/ghgemissions/global-greenhouse-gas-emissions-data>

National Emissions and Removals <https://epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>

State and Tribal GHG Data and Resources <https://epa.gov/ghgemissions/state-and-tribal-greenhouse-gas-data-and-resources>

Facility-Level Emissions <https://epa.gov/ghgreporting>

Carbon Footprint Calculator <https://epa.gov/ghgemissions/household-carbon-footprint-calculator>

GHG Equivalencies Calculator <http://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

Capacity Building for GHG Inventories <https://epa.gov/ghgemissions/capacity-building-national-greenhouse-gas-inventories>

Contact Us <https://epa.gov/ghgemissions/forms/contact-us-about-greenhouse-gas-emissions> to ask a question, provide feedback, or report a problem.

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