# Executive Summary

An emissions inventory that identifies and quantifies a country's primary anthropogenic[1] sources and sinks of greenhouse gases is essential for addressing climate change. This Inventory adheres to both (1) a comprehensive and detailed set of methodologies for estimating sources and sinks of anthropogenic greenhouse gases, and (2) a common and consistent mechanism that enables Parties to the United Nations Framework Convention on Climate Change (UNFCCC) to compare the relative contribution of different emission sources and greenhouse gases to climate change.

In 1992, the United States signed and ratified the UNFCCC. As stated in Article 2 of the UNFCCC, "The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."[2]

Parties to the Convention, by ratifying, "shall develop, periodically update, publish and make available...national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the *Montreal Protocol*, using comparable methodologies..."[3] The United States views this report as an opportunity to fulfill these commitments.

This chapter summarizes the latest information on U.S. anthropogenic greenhouse gas emission trends from 1990 through 2006. To ensure that the U.S. emissions Inventory is comparable to those of other UNFCCC Parties, the estimates presented here were calculated using methodologies consistent with those recommended in the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC/UNEP/OECD/IEA 1997), the IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC 2000), and the IPCC *Good Practice Guidance for Land Use, Land-Use Change, and Forestry* (IPCC 2003). Additionally, the U.S. emission Inventory has begun to incorporate new methodologies and data from the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC

[1] The term "anthropogenic," in this context, refers to greenhouse gas emissions and removals that are a direct result of human activities or are the result of natural processes that have been affected by human activities (IPCC/UNEP/OECD/IEA 1997).

[2] Article 2 of the Framework Convention on Climate Change published by the UNEP/WMO Information Unit on Climate Change. See <http://unfccc.int>.

[3] Article 4(1)(a) of the United Nations Framework Convention on Climate Change (also identified in Article 12). Subsequent decisions by the Conference of the Parties elaborated the role of Annex I Parties in preparing national inventories. See <http://unfccc.int>.

**Box ES-1: Recalculations of Inventory Estimates**

Each year, emission and sink estimates are recalculated and revised for all years in the Inventory of U.S. Greenhouse Gas Emissions and Sinks, as attempts are made to improve both the analyses themselves, through the use of better methods or data, and the overall usefulness of the report. In this effort, the United States follows the IPCC *Good Practice Guidance* (IPCC 2000), which states, regarding recalculations of the time series, "It is good practice to recalculate historic emissions when methods are changed or refined, when new source categories are included in the national inventory, or when errors in the estimates are identified and corrected." In general, recalculations are made to the U.S. greenhouse gas emission estimates either to incorporate new methodologies or, most commonly, to update recent historical data.

In each Inventory report, the results of all methodology changes and historical data updates are presented in the "Recalculations and Improvements" chapter; detailed descriptions of each recalculation are contained within each source's description contained in the report, if applicable. In general, when methodological changes have been implemented, the entire time series (in the case of the most recent Inventory report, 1990 through 2005) has been recalculated to reflect the change, per IPCC *Good Practice Guidance*. Changes in historical data are generally the result of changes in statistical data supplied by other agencies. References for the data are provided for additional information.

2006). The structure of this report is consistent with the UNFCCC guidelines for inventory reporting.[4] For most source categories, the Intergovernmental Panel on Climate Change (IPCC) methodologies were expanded, resulting in a more comprehensive and detailed estimate of emissions.

## ES.1. Background Information

Naturally occurring greenhouse gases include water vapor, carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and ozone ($O_3$). Several classes of halogenated substances that contain fluorine, chlorine, or bromine are also greenhouse gases, but they are, for the most part, solely a product of industrial activities. Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are halocarbons that contain chlorine, while halocarbons that contain bromine are referred to as bromofluorocarbons (i.e., halons). As stratospheric ozone depleting substances, CFCs, HCFCs, and halons are covered under the *Montreal Protocol on Substances that Deplete the Ozone Layer*. The UNFCCC defers to this earlier international treaty. Consequently, Parties to the UNFCCC are not required to include these gases in their national greenhouse gas emission inventories.[5] Some other fluorine-containing halogenated substances—hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride ($SF_6$)—do not deplete stratospheric ozone but are potent greenhouse gases. These latter substances are addressed by the UNFCCC and accounted for in national greenhouse gas emission inventories.

There are also several gases that do not have a direct global warming effect but indirectly affect terrestrial and/or solar radiation absorption by influencing the formation or destruction of greenhouse gases, including tropospheric and stratospheric ozone. These gases include carbon monoxide (CO), oxides of nitrogen ($NO_x$), and non-$CH_4$ volatile organic compounds (NMVOCs). Aerosols, which are extremely small particles or liquid droplets, such as those produced by sulfur dioxide ($SO_2$) or elemental carbon emissions, can also affect the absorptive characteristics of the atmosphere.

Although the direct greenhouse gases $CO_2$, $CH_4$, and $N_2O$ occur naturally in the atmosphere, human activities have changed their atmospheric concentrations. From the pre-industrial era (i.e., ending about 1750) to 2005, concentrations of these greenhouse gases have increased globally by 36, 148, and 18 percent, respectively (IPCC 2007).

Beginning in the 1950s, the use of CFCs and other stratospheric ozone depleting substances (ODS) increased by nearly 10 percent per year until the mid-1980s, when international concern about ozone depletion led to the entry into force of the *Montreal Protocol*. Since then, the production of ODS is being phased out. In recent years, use of ODS substitutes such as HFCs and PFCs has grown as they begin to be phased in as replacements for CFCs and

[4] See <http://unfccc.int/resource/docs/cop8/08.pdf>.

[5] Emission estimates of CFCs, HCFCs, halons and other ozone depleting substances are included in the annexes of this report for informational purposes.

HCFCs. Accordingly, atmospheric concentrations of these substitutes have been growing (IPCC 2007).

## Global Warming Potentials

Gases in the atmosphere can contribute to the greenhouse effect both directly and indirectly. Direct effects occur when the gas itself absorbs radiation. Indirect radiative forcing occurs when chemical transformations of the substance produce other greenhouse gases, when a gas influences the atmospheric lifetimes of other gases, and/or when a gas affects atmospheric processes that alter the radiative balance of the earth (e.g., affect cloud formation or albedo).[6] The IPCC developed the Global Warming Potential (GWP) concept to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas.

The GWP of a greenhouse gas is defined as the ratio of the time-integrated radiative forcing from the instantaneous release of 1 kilogram (kg) of a trace substance relative to that of 1 kg of a reference gas (IPCC 2001). Direct radiative effects occur when the gas itself is a greenhouse gas. The reference gas used is $CO_2$, and therefore GWP-weighted emissions are measured in teragrams of $CO_2$ equivalents (Tg $CO_2$ Eq.).[7,8] All gases in this Executive Summary are presented in units of Tg $CO_2$ Eq.

The UNFCCC reporting guidelines for national inventories were updated in 2002,[9] but continue to require the use of GWPs from the IPCC Second Assessment Report (SAR) (IPCC 1996). This requirement ensures that current estimates of aggregate greenhouse gas emissions for 1990 to 2006 are consistent with estimates developed prior to the publication of the IPCC Third Assessment Report (TAR) and the IPCC Fourth Assessment Report (AR4). Therefore, to comply with international reporting standards under the UNFCCC, official emission estimates are reported by the United States using SAR GWP values. All estimates are provided throughout the report in both $CO_2$ equivalents and unweighted units. A comparison of emission values using the SAR GWPs versus the TAR and AR4 GWPs can be found in Chapter 1 and, in more detail, in Annex 6.1 of this report. The GWP values used in this report are listed in Table ES-1.

**Table ES-1: Global Warming Potentials (100-Year Time Horizon) Used in This Report**

| Gas | GWP |
|---|---|
| $CO_2$ | 1 |
| $CH_4$* | 21 |
| $N_2O$ | 310 |
| HFC-23 | 11,700 |
| HFC-32 | 650 |
| HFC-125 | 2,800 |
| HFC-134a | 1,300 |
| HFC-143a | 3,800 |
| HFC-152a | 140 |
| HFC-227ea | 2,900 |
| HFC-236fa | 6,300 |
| HFC-4310mee | 1,300 |
| $CF_4$ | 6,500 |
| $C_2F_6$ | 9,200 |
| $C_4F_{10}$ | 7,000 |
| $C_6F_{14}$ | 7,400 |
| $SF_6$ | 23,900 |

Source: IPCC (1996)

* The $CH_4$ GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of $CO_2$ is not included.

Global warming potentials are not provided for CO, $NO_x$, NMVOCs, $SO_2$, and aerosols because there is no agreed-upon method to estimate the contribution of gases that are short-lived in the atmosphere, spatially variable, or have only indirect effects on radiative forcing (IPCC 1996).

# ES.2. Recent Trends in U.S. Greenhouse Gas Emissions and Sinks

In 2006, total U.S. greenhouse gas emissions were 7,054.2 Tg $CO_2$ Eq. Overall, total U.S. emissions have risen by 14.7 percent from 1990 to 2006, while the U.S. gross domestic product has increased by 59 percent over the same period (BEA 2007). Emissions fell from 2005 to 2006, decreasing by 1.1 percent (75.7 Tg $CO_2$ Eq.). The following factors were primary contributors to this decrease: (1) compared to 2005, 2006 had warmer winter conditions, which decreased consumption of heating fuels, as well as cooler summer conditions, which reduced demand for

[6] Albedo is a measure of the Earth's reflectivity, and is defined as the fraction of the total solar radiation incident on a body that is reflected by it.

[7] Carbon comprises 12/44$^{ths}$ of carbon dioxide by weight.

[8] One teragram is equal to $10^{12}$ grams or one million metric tons.

[9] See <http://unfccc.int/resource/docs/cop8/08.pdf>.

**Figure ES-1**

**U.S. Greenhouse Gas Emissions by Gas**

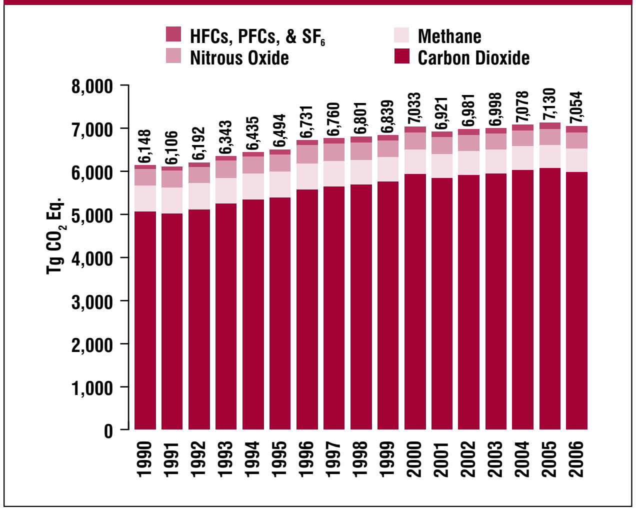



**Figure ES-2**

**Annual Percent Change in U.S. Greenhouse Gas Emissions**

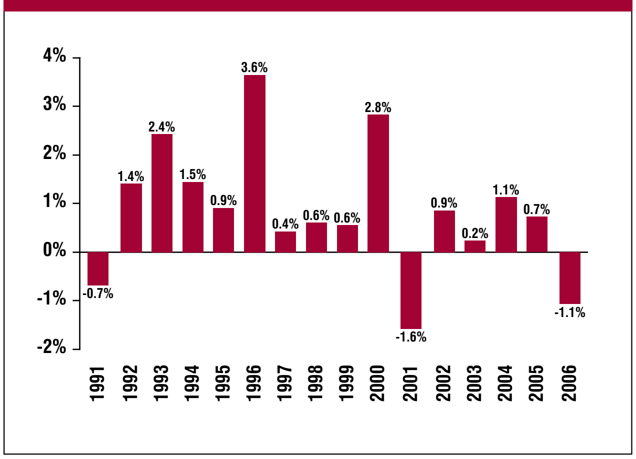
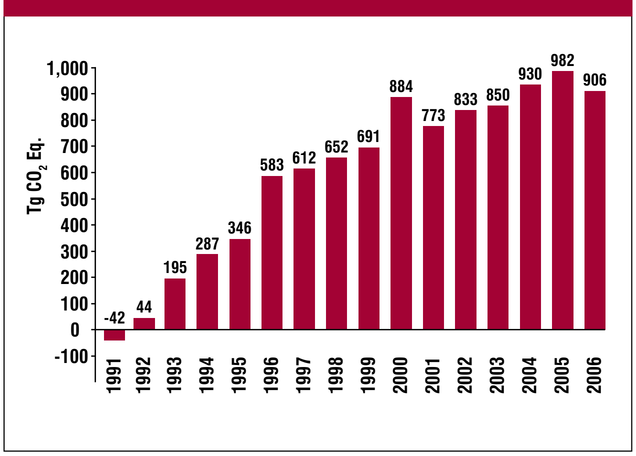



**Figure ES-3**

**Cumulative Change in U.S. Greenhouse Gas Emissions Relative to 1990**




electricity, (2) restraint on fuel consumption caused by rising fuel prices, primarily in the transportation sector and (3) increased use of natural gas and renewables in the electric power sector.

Figure ES-1 through Figure ES-3 illustrate the overall trends in total U.S. emissions by gas, annual changes, and absolute change since 1990. Table ES-2 provides a detailed summary of U.S. greenhouse gas emissions and sinks for 1990 through 2006.

Figure ES-4 illustrates the relative contribution of the direct greenhouse gases to total U.S. emissions in 2006. The primary greenhouse gas emitted by human activities in the United States was $CO_2$, representing approximately 84.8 percent of total greenhouse gas emissions. The largest source of $CO_2$, and of overall greenhouse gas emissions, was fossil fuel combustion. $CH_4$ emissions, which have declined from 1990 levels, resulted primarily from enteric fermentation associated with domestic livestock, decomposition of wastes in landfills, and natural gas systems. Agricultural soil management and mobile source fossil fuel combustion were the major sources of $N_2O$ emissions. The emissions of substitutes for ozone depleting substances and emissions of HFC-23 during the production of HCFC-22 were the primary contributors to aggregate HFC emissions. Electrical transmission and distribution systems accounted for most $SF_6$ emissions, while PFC emissions resulted from semiconductor manufacturing and as a byproduct of primary aluminum production.

**Figure ES-4**

**2006 Greenhouse Gas Emissions by Gas**

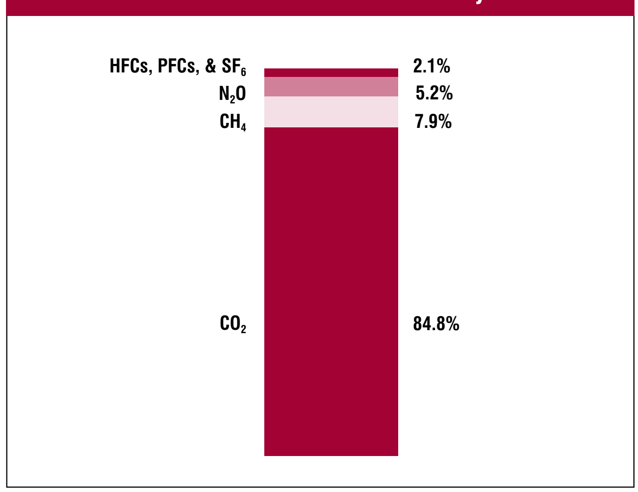


**Table ES-2: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks (Tg $CO_2$ Eq.)**

| Gas/Source | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| **$CO_2$** | **5,068.5** | **5,394.2** | **5,939.7** | **5,846.2** | **5,908.6** | **5,952.7** | **6,038.2** | **6,074.3** | **5,983.1** |
| Fossil Fuel Combustion | 4,724.1 | 5,032.4 | 5,577.1 | 5,507.4 | 5,564.8 | 5,617.0 | 5,681.4 | 5,731.0 | 5,637.9 |
| Electricity Generation | 1,809.6 | 1,939.3 | 2,282.3 | 2,244.3 | 2,253.7 | 2,283.1 | 2,314.9 | 2,380.2 | 2,328.2 |
| Transportation | 1,485.1 | 1,599.4 | 1,798.2 | 1,775.6 | 1,828.9 | 1,807.6 | 1,856.4 | 1,869.8 | 1,856.0 |
| Industrial | 844.9 | 876.5 | 860.3 | 852.5 | 854.8 | 856.0 | 857.7 | 847.3 | 862.2 |
| Residential | 340.1 | 356.5 | 372.1 | 363.6 | 360.5 | 382.9 | 368.3 | 358.5 | 326.5 |
| Commercial | 216.1 | 225.8 | 228.0 | 222.3 | 222.8 | 236.5 | 230.6 | 221.9 | 210.1 |
| U.S. Territories | 28.3 | 35.0 | 36.2 | 49.0 | 44.0 | 51.0 | 53.5 | 53.2 | 54.9 |
| Non-Energy Use of Fuels | 117.2 | 133.2 | 141.4 | 131.9 | 135.9 | 131.8 | 148.9 | 139.1 | 138.0 |
| Iron and Steel Production | 86.2 | 74.7 | 66.6 | 59.2 | 55.9 | 54.7 | 52.8 | 46.6 | 49.1 |
| Cement Production | 33.3 | 36.8 | 41.2 | 41.4 | 42.9 | 43.1 | 45.6 | 45.9 | 45.7 |
| Natural Gas Systems | 33.7 | 33.8 | 29.4 | 28.8 | 29.6 | 28.4 | 28.1 | 29.5 | 28.5 |
| Municipal Solid Waste Combustion | 10.9 | 15.7 | 17.5 | 18.0 | 18.5 | 19.1 | 20.1 | 20.7 | 20.9 |
| Lime Production | 12.0 | 14.0 | 14.9 | 14.3 | 13.7 | 14.5 | 15.2 | 15.1 | 15.8 |
| Ammonia Production and Urea Consumption | 16.9 | 17.8 | 16.4 | 13.3 | 14.2 | 12.5 | 13.2 | 12.8 | 12.4 |
| Limestone and Dolomite Use | 5.5 | 7.4 | 6.0 | 5.7 | 5.9 | 4.8 | 6.7 | 7.4 | 8.6 |
| Cropland Remaining Cropland | 7.1 | 7.0 | 7.5 | 7.8 | 8.5 | 8.3 | 7.6 | 7.9 | 8.0 |
| Soda Ash Production and Consumption | 4.1 | 4.3 | 4.2 | 4.1 | 4.1 | 4.1 | 4.2 | 4.2 | 4.2 |
| Aluminum Production | 6.8 | 5.7 | 6.1 | 4.4 | 4.5 | 4.5 | 4.2 | 4.2 | 3.9 |
| Petrochemical Production | 2.2 | 2.8 | 3.0 | 2.8 | 2.9 | 2.8 | 2.9 | 2.8 | 2.6 |
| Titanium Dioxide Production | 1.2 | 1.5 | 1.8 | 1.7 | 1.8 | 1.8 | 2.1 | 1.8 | 1.9 |
| Carbon Dioxide Consumption | 1.4 | 1.4 | 1.4 | 0.8 | 1.0 | 1.3 | 1.2 | 1.3 | 1.6 |
| Ferroalloy Production | 2.2 | 2.0 | 1.9 | 1.5 | 1.3 | 1.3 | 1.4 | 1.4 | 1.5 |
| Phosphoric Acid Production | 1.5 | 1.5 | 1.4 | 1.3 | 1.3 | 1.4 | 1.4 | 1.4 | 1.2 |
| Zinc Production | 0.9 | 1.0 | 1.1 | 1.0 | 0.9 | 0.5 | 0.5 | 0.5 | 0.5 |
| Petroleum Systems | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Lead Production | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Silicon Carbide Production and Consumption | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| *Land Use, Land-Use Change, and Forestry (Sink)*[a] | *(737.7)* | *(775.3)* | *(673.6)* | *(750.2)* | *(826.8)* | *(860.9)* | *(873.7)* | *(878.6)* | *(883.7)* |
| *Biomass—Wood*[b] | *215.2* | *229.1* | *218.1* | *193.5* | *192.8* | *193.8* | *205.1* | *204.8* | *204.4* |
| *International Bunker Fuels*[b] | *113.7* | *100.6* | *101.1* | *97.6* | *89.1* | *103.6* | *119.0* | *122.6* | *127.1* |
| *Biomass—Ethanol*[b] | *4.2* | *7.7* | *9.2* | *9.7* | *11.5* | *15.7* | *19.7* | *22.6* | *30.3* |
| **$CH_4$** | **606.1** | **598.9** | **574.3** | **558.8** | **563.5** | **559.4** | **545.6** | **539.7** | **555.3** |
| Enteric Fermentation | 126.9 | 132.3 | 124.6 | 123.6 | 123.8 | 124.6 | 122.4 | 124.5 | 126.2 |
| Landfills | 149.6 | 144.0 | 120.8 | 117.6 | 120.1 | 125.6 | 122.6 | 123.7 | 125.7 |
| Natural Gas Systems | 124.7 | 128.1 | 126.5 | 125.3 | 124.9 | 123.3 | 114.0 | 102.5 | 102.4 |
| Coal Mining | 84.1 | 67.1 | 60.4 | 60.3 | 56.8 | 56.9 | 59.8 | 57.1 | 58.5 |
| Manure Management | 31.0 | 35.2 | 38.8 | 40.2 | 41.3 | 40.7 | 40.1 | 41.8 | 41.4 |
| Petroleum Systems | 33.9 | 32.0 | 30.3 | 30.2 | 29.9 | 29.2 | 28.7 | 28.3 | 28.4 |
| Forest Land Remaining Forest Land | 4.5 | 4.7 | 19.0 | 9.4 | 16.4 | 8.7 | 6.9 | 12.3 | 24.6 |
| Wastewater Treatment | 23.0 | 24.3 | 24.6 | 24.2 | 24.1 | 23.9 | 24.0 | 23.8 | 23.9 |
| Stationary Combustion | 7.4 | 7.2 | 6.6 | 6.2 | 6.2 | 6.4 | 6.5 | 6.5 | 6.2 |
| Rice Cultivation | 7.1 | 7.6 | 7.5 | 7.6 | 6.8 | 6.9 | 7.6 | 6.8 | 5.9 |
| Abandoned Underground Coal Mines | 6.0 | 8.2 | 7.4 | 6.7 | 6.2 | 6.0 | 5.8 | 5.6 | 5.4 |
| Mobile Combustion | 4.7 | 4.3 | 3.4 | 3.3 | 3.0 | 2.7 | 2.6 | 2.5 | 2.4 |

**Table ES-2: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks (Tg $CO_2$ Eq.)** (continued)

| Gas/Source | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| Composting | 0.3 | 0.7 | 1.3 | 1.3 | 1.3 | 1.5 | 1.6 | 1.6 | 1.6 |
| Petrochemical Production | 0.9 | 1.1 | 1.2 | 1.1 | 1.1 | 1.1 | 1.2 | 1.1 | 1.0 |
| Iron and Steel Production | 1.3 | 1.3 | 1.2 | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 |
| Field Burning of Agricultural Residues | 0.7 | 0.7 | 0.8 | 0.8 | 0.7 | 0.8 | 0.9 | 0.9 | 0.8 |
| Ferroalloy Production | + | + | + | + | + | + | + | + | + |
| Silicon Carbide Production and Consumption | + | + | + | + | + | + | + | + | + |
| *International Bunker Fuels[b]* | *0.2* | *0.1* | *0.1* | *0.1* | *0.1* | *0.1* | *0.1* | *0.2* | *0.2* |
| **$N_2O$** | **383.4** | **395.6** | **385.9** | **392.9** | **376.1** | **356.6** | **353.5** | **370.1** | **367.9** |
| Agricultural Soil Management | 269.4 | 264.8 | 262.1 | 277.0 | 262.0 | 247.3 | 246.9 | 265.2 | 265.0 |
| Mobile Combustion | 43.5 | 53.4 | 52.5 | 49.9 | 45.9 | 42.3 | 39.7 | 36.3 | 33.1 |
| Nitric Acid Production | 17.0 | 18.9 | 18.6 | 15.1 | 16.4 | 15.4 | 15.2 | 15.8 | 15.6 |
| Stationary Combustion | 12.8 | 13.4 | 14.6 | 14.1 | 14.0 | 14.3 | 14.6 | 14.8 | 14.5 |
| Manure Management | 12.1 | 12.8 | 13.7 | 14.0 | 14.0 | 13.6 | 13.8 | 13.9 | 14.3 |
| Wastewater Treatment | 6.3 | 6.9 | 7.6 | 7.8 | 7.6 | 7.7 | 7.8 | 8.0 | 8.1 |
| Adipic Acid Production | 15.3 | 17.3 | 6.2 | 5.1 | 6.1 | 6.3 | 5.9 | 5.9 | 5.9 |
| $N_2O$ from Product Uses | 4.4 | 4.6 | 4.9 | 4.9 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 |
| Forest Land Remaining Forest Land | 0.5 | 0.6 | 2.2 | 1.3 | 2.0 | 1.2 | 1.1 | 1.6 | 2.8 |
| Composting | 0.4 | 0.8 | 1.4 | 1.4 | 1.4 | 1.6 | 1.7 | 1.7 | 1.8 |
| Settlements Remaining Settlements | 1.0 | 1.2 | 1.2 | 1.4 | 1.5 | 1.5 | 1.6 | 1.5 | 1.5 |
| Field Burning of Agricultural Residues | 0.4 | 0.4 | 0.5 | 0.5 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 |
| Municipal Solid Waste Combustion | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| *International Bunker Fuels[b]* | *1.0* | *0.9* | *0.9* | *0.9* | *0.8* | *0.9* | *1.1* | *1.1* | *1.1* |
| **HFCs** | **36.9** | **61.8** | **100.1** | **97.9** | **106.3** | **104.5** | **116.6** | **121.4** | **124.5** |
| Substitution of Ozone Depleting Substances[c] | 0.3 | 28.5 | 71.2 | 78.0 | 85.0 | 92.0 | 99.1 | 105.4 | 110.4 |
| HCFC-22 Production | 36.4 | 33.0 | 28.6 | 19.7 | 21.1 | 12.3 | 17.2 | 15.8 | 13.8 |
| Semiconductor Manufacture | 0.2 | 0.3 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 |
| **PFCs** | **20.8** | **15.6** | **13.5** | **7.0** | **8.7** | **7.1** | **6.1** | **6.2** | **6.0** |
| Semiconductor Manufacture | 2.2 | 3.8 | 4.9 | 3.5 | 3.5 | 3.3 | 3.3 | 3.2 | 3.6 |
| Aluminum Production | 18.5 | 11.8 | 8.6 | 3.5 | 5.2 | 3.8 | 2.8 | 3.0 | 2.5 |
| **$SF_6$** | **32.7** | **28.0** | **19.1** | **18.7** | **18.0** | **18.1** | **18.0** | **18.2** | **17.3** |
| Electrical Transmission and Distribution | 26.7 | 231.5 | 15.1 | 15.0 | 14.4 | 13.8 | 13.9 | 14.0 | 13.2 |
| Magnesium Production and Processing | 5.4 | 5.6 | 3.0 | 2.9 | 2.9 | 3.4 | 3.2 | 3.3 | 3.2 |
| Semiconductor Manufacture | 0.5 | 0.9 | 1.1 | 0.7 | 0.7 | 0.8 | 0.8 | 1.0 | 1.0 |
| **Total** | **6,148.3** | **6,494.0** | **7,032.6** | **6,921.3** | **6,981.2** | **6,998.2** | **7,078.0** | **7,129.9** | **7,054.2** |
| **Net Emissions (Sources and Sinks)** | **5,410.6** | **5,718.7** | **6,359.0** | **6,171.1** | **6,154.4** | **6,137.3** | **6,204.3** | **6,251.3** | **6,170.5** |

+ Does not exceed 0.05 Tg $CO_2$ Eq.

[a] Parentheses indicate negative values or sequestration. The net $CO_2$ flux total includes both emissions and sequestration, and constitutes a sink in the United States. Sinks are only included in net emissions total.

[b] Emissions from International Bunker Fuels and Biomass Combustion are not included in totals.

[c] Small amounts of PFC emissions also result from this source.

Note: Totals may not sum due to independent rounding.

Note: One teragram (Tg) equals one million metric tons.

Overall, from 1990 to 2006, total emissions of $CO_2$ increased by 914.6 Tg $CO_2$ Eq. (18.0 percent), while $CH_4$ and $N_2O$ emissions decreased by 50.8 Tg $CO_2$ Eq. (8.4 percent) and 15.5 Tg $CO_2$ Eq. (4.0 percent), respectively. During the same period, aggregate weighted emissions of HFCs, PFCs, and $SF_6$ rose by 57.6 Tg $CO_2$ Eq. (63.7 percent). From 1990 to 2006, HFCs increased by 87.6 Tg $CO_2$ Eq. (237.3 percent), PFCs decreased by 14.7 Tg $CO_2$ Eq. (70.9 percent), and $SF_6$ decreased by 15.3 Tg $CO_2$ Eq. (47.0 percent). Despite being emitted in smaller quantities relative to the other principal greenhouse gases, emissions of HFCs, PFCs, and $SF_6$ are significant because many of them have extremely high global warming potentials and, in the cases of PFCs and $SF_6$, long atmospheric lifetimes. Conversely, U.S. greenhouse gas emissions were partly offset by carbon sequestration in forests, trees in urban areas, agricultural soils, and landfilled yard trimmings and food scraps, which, in aggregate, offset 12.5 percent of total emissions in 2006. The following sections describe each gas' contribution to total U.S. greenhouse gas emissions in more detail.

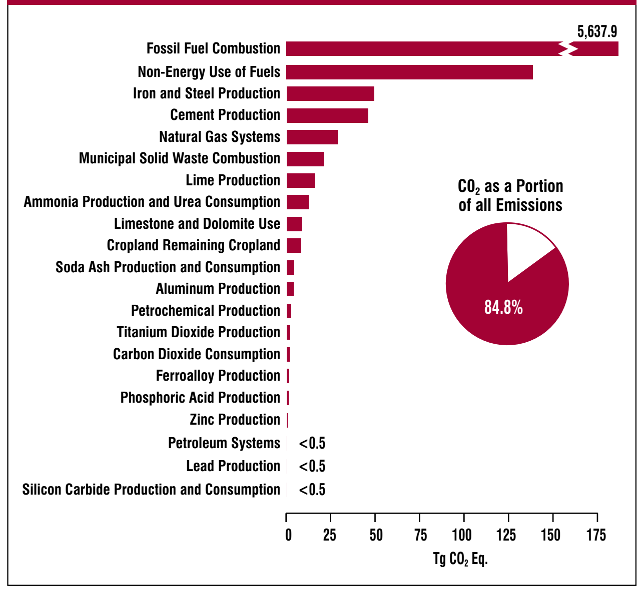
## Carbon Dioxide Emissions

The global carbon cycle is made up of large carbon flows and reservoirs. Billions of tons of carbon in the form of $CO_2$ are absorbed by oceans and living biomass (i.e., sinks) and are emitted to the atmosphere annually through natural processes (i.e., sources). When in equilibrium, carbon fluxes among these various reservoirs are roughly balanced. Since the Industrial Revolution (i.e., about 1750), global atmospheric concentrations of $CO_2$ have risen about 36 percent (IPCC 2007), principally due to the combustion of fossil fuels. Within the United States, fuel combustion accounted for 94.2 percent of $CO_2$ emissions in 2006. Globally, approximately 28,193 Tg of $CO_2$ were added to the atmosphere through the combustion of fossil fuels in 2005, of which the United States accounted for about 20 percent.[10] Changes in land use and forestry practices can also emit $CO_2$ (e.g., through conversion of forest land to agricultural or urban use) or can act as a sink for $CO_2$ (e.g., through net additions to forest biomass).

U.S. anthropogenic sources of $CO_2$ are shown in Figure ES-5. As the largest source of U.S. greenhouse gas emissions, $CO_2$ from fossil fuel combustion has accounted for approximately 79 percent of GWP-weighted emissions since 1990, growing slowly from 77 percent of total GWP-weighted emissions in 1990 to 80 percent in 2006. Emissions of $CO_2$ from fossil fuel combustion increased at an average annual rate of 1.1 percent from 1990 to 2006. The fundamental factors influencing this trend include (1) a generally growing domestic economy over the last 16 years, and (2) significant overall growth in emissions from electricity generation and transportation activities. Between 1990 and 2006, $CO_2$ emissions from fossil fuel combustion increased from 4,724.1 Tg $CO_2$ Eq. to 5,637.9 Tg $CO_2$ Eq.—a 19.3 percent total increase over the sixteen-year period. From 2005 to 2006, these emissions decreased by 93.1 Tg $CO_2$ Eq. (1.6 percent).

**Figure ES-5**

**2006 Sources of $CO_2$ Emissions**



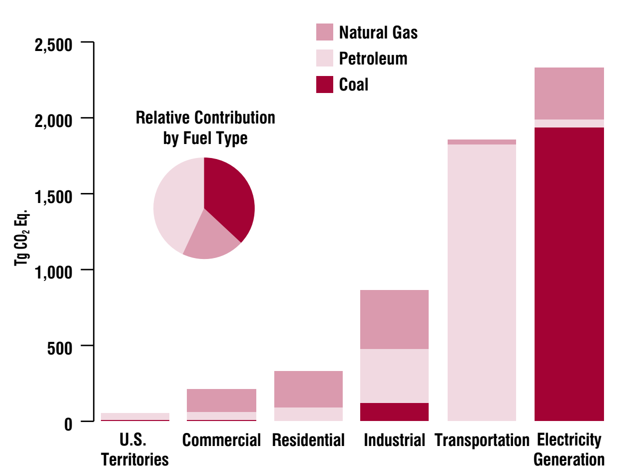

Historically, changes in emissions from fossil fuel combustion have been the dominant factor affecting U.S. emission trends. Changes in $CO_2$ emissions from fossil fuel combustion are influenced by many long-term and short-term factors, including population and economic growth, energy price fluctuations, technological changes, and seasonal temperatures. On an annual basis, the overall consumption of fossil fuels in the United States generally fluctuates in response to changes in general economic conditions, energy prices, weather, and the availability of non-fossil alternatives. For example, in a year with increased consumption of goods and services, low fuel prices, severe summer and winter weather conditions, nuclear plant closures, and lower precipitation feeding hydroelectric dams, there would likely be proportionally greater fossil fuel consumption than a year with poor economic performance, high fuel prices, mild temperatures, and increased output from nuclear and hydroelectric plants.

The four major fuel consuming end-use sectors contributing to $CO_2$ emissions from fossil fuel combustion are industrial, transportation, residential, and commercial. Electricity generation also emits $CO_2$, although these

[10] Global $CO_2$ emissions from fossil fuel combustion were taken from Energy Information Administration *International Energy Annual 2005* (EIA 2007).

**Figure ES-6**

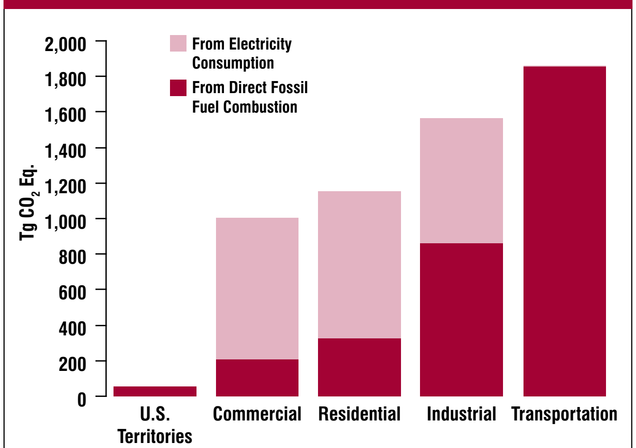
**2006 $CO_2$ Emissions from Fossil Fuel Combustion by Sector and Fuel Type**




Note: Electricity generation also includes emissions of less than 0.5 Tg $CO_2$ Eq. from geothermal-based electricity generation.

**Figure ES-7**

**2006 End-Use Sector Emissions of $CO_2$ from Fossil Fuel Combustion**




emissions are produced as they consume fossil fuel to provide electricity to one of the four end-use sectors. For the discussion below, electricity generation emissions have been distributed to each end-use sector on the basis of each sector's share of aggregate electricity consumption. This method of distributing emissions assumes that each end-use sector consumes electricity that is generated from the national average mix of fuels according to their carbon intensity. Emissions from electricity generation are also addressed separately after the end-use sectors have been discussed.

Note that emissions from U.S. territories are calculated separately due to a lack of specific consumption data for the individual end-use sectors.

Figure ES-6, Figure ES-7, and Table ES-3 summarize $CO_2$ emissions from fossil fuel combustion by end-use sector.

*Transportation End-Use Sector.* Transportation activities (excluding international bunker fuels) accounted for 33 percent of $CO_2$ emissions from fossil fuel combustion in 2006.[11] Virtually all of the energy consumed in this end-use sector came from petroleum products. Over 60 percent of the emissions resulted from gasoline consumption for personal vehicle use. The remaining emissions came from other transportation activities, including the combustion of diesel fuel in heavy-duty vehicles and jet fuel in aircraft.

*Industrial End-Use Sector.* Industrial $CO_2$ emissions, resulting both directly from the combustion of fossil fuels and indirectly from the generation of electricity that is consumed by industry, accounted for 28 percent of $CO_2$ from fossil fuel combustion in 2006. Just over half of these emissions resulted from direct fossil fuel combustion to produce steam and/or heat for industrial processes. The remaining emissions resulted from consuming electricity for motors, electric furnaces, ovens, lighting, and other applications.

*Residential and Commercial End-Use Sectors.* The residential and commercial end-use sectors accounted for 20 and 18 percent, respectively, of $CO_2$ emissions from fossil fuel combustion in 2006. Both sectors relied heavily on electricity for meeting energy demands, with 72 and 79 percent, respectively, of their emissions attributable to electricity consumption for lighting, heating, cooling, and operating appliances. The remaining emissions were due to the consumption of natural gas and petroleum for heating and cooking.

*Electricity Generation.* The United States relies on electricity to meet a significant portion of its energy demands, especially for lighting, electric motors, heating, and air conditioning. Electricity generators consumed 36 percent of U.S. energy from fossil fuels and emitted 41 percent of the $CO_2$ from fossil fuel combustion in 2006. The type of fuel combusted by electricity generators has a significant effect on their emissions. For example, some electricity is generated

[11] If emissions from international bunker fuels are included, the transportation end-use sector accounted for 35 percent of U.S. emissions from fossil fuel combustion in 2006.

**Table ES-3: $CO_2$ Emissions from Fossil Fuel Combustion by Fuel Consuming End-Use Sector (Tg $CO_2$ Eq.)**

| End-Use Sector | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| **Transportation** | **1,488.1** | **1,602.5** | **1,801.6** | **1,779.2** | **1,832.3** | **1,811.8** | **1,860.9** | **1,874.5** | **1,861.0** |
| Combustion | 1,485.1 | 1,599.4 | 1,798.2 | 1,775.6 | 1,828.9 | 1,807.6 | 1,856.4 | 1,869.8 | 1,856.0 |
| Electricity | 3.0 | 3.0 | 3.4 | 3.6 | 3.4 | 4.2 | 4.5 | 4.7 | 4.9 |
| **Industrial** | **1,527.5** | **1,589.5** | **1,645.1** | **1,583.9** | **1,572.5** | **1,592.1** | **1,596.8** | **1,579.6** | **1,567.1** |
| Combustion | 844.9 | 876.5 | 860.3 | 852.5 | 854.8 | 856.0 | 857.7 | 847.3 | 862.2 |
| Electricity | 682.5 | 713.1 | 784.7 | 731.4 | 717.7 | 736.1 | 739.0 | 732.3 | 704.9 |
| **Residential** | **929.5** | **995.5** | **1,129.7** | **1,121.8** | **1,145.6** | **1,178.3** | **1,173.1** | **1,206.4** | **1,151.9** |
| Combustion | 340.1 | 356.5 | 372.1 | 363.6 | 360.5 | 382.9 | 368.3 | 358.5 | 326.5 |
| Electricity | 589.4 | 639.0 | 757.6 | 758.1 | 785.1 | 795.4 | 804.9 | 847.9 | 825.4 |
| **Commercial** | **750.8** | **810.0** | **964.6** | **973.5** | **970.3** | **983.8** | **997.1** | **1,017.3** | **1,003.0** |
| Combustion | 216.1 | 225.8 | 228.0 | 222.3 | 222.8 | 236.5 | 230.6 | 221.9 | 210.1 |
| Electricity | 534.7 | 584.2 | 736.6 | 751.1 | 747.5 | 747.3 | 766.5 | 795.4 | 792.9 |
| **U.S. Territories** | **28.3** | **35.0** | **36.2** | **49.0** | **44.0** | **51.0** | **53.5** | **53.2** | **54.9** |
| **Total** | **4,724.1** | **5,032.4** | **5,577.1** | **5,507.4** | **5,564.8** | **5,617.0** | **5,681.4** | **5,731.0** | **5,637.9** |
| **Electricity Generation** | **1,809.6** | **1,939.3** | **2,282.3** | **2,244.3** | **2,253.7** | **2,283.1** | **2,314.9** | **2,380.2** | **2,328.2** |

Note: Totals may not sum due to independent rounding. Combustion-related emissions from electricity generation are allocated based on aggregate national electricity consumption by each end-use sector.

with low $CO_2$ emitting energy technologies, particularly non-fossil options such as nuclear, hydroelectric, or geothermal energy. However, electricity generators rely on coal for over half of their total energy requirements and accounted for 94 percent of all coal consumed for energy in the United States in 2006. Consequently, changes in electricity demand have a significant impact on coal consumption and associated $CO_2$ emissions.

Other significant $CO_2$ trends included the following:

- $CO_2$ emissions from non-energy use of fossil fuels have increased 20.8 Tg $CO_2$ Eq. (18 percent) from 1990 through 2006. Emissions from non-energy uses of fossil fuels were 138.0 Tg $CO_2$ Eq. in 2006, which constituted 2.4 percent of overall fossil fuel $CO_2$ emissions and 2.3 percent of total national $CO_2$ emissions, approximately the same proportion as in 1990.
- $CO_2$ emissions from iron and steel production increased by 5.3 percent to 49.1 Tg $CO_2$ Eq. in 2006, but have declined overall by 37.1 Tg $CO_2$ Eq. (43 percent) from 1990 through 2006, due to restructuring of the industry, technological improvements, and increased scrap utilization.
- In 2006, $CO_2$ emissions from cement production decreased slightly by 0.2 Tg $CO_2$ Eq. (0.4 percent) from 2005 to 2006. This decrease occurs despite the overall increase over the time series. After falling in 1991 by two percent from 1990 levels, cement production emissions grew every year through 2005. Overall, from 1990 to 2006, emissions from cement production increased by 37 percent, an increase of 12.5 Tg $CO_2$ Eq.
- $CO_2$ emissions from municipal solid waste combustion (20.9 Tg $CO_2$ Eq. in 2006) increased by 10.0 Tg $CO_2$ Eq. (91 percent) from 1990 through 2006, as the volume of plastics and other fossil carbon-containing materials in municipal solid waste grew.
- $CO_2$ emissions from ammonia production and urea consumption (12.4 Tg $CO_2$ Eq. in 2006) have decreased by 4.5 Tg $CO_2$ Eq. (27 percent) since 1990. The decrease in emissions from ammonia production and urea consumption is associated with an overall decrease in domestic ammonia production, and is due to several factors including market fluctuations and high natural gas prices.
- Net $CO_2$ sequestration from Land Use, Land-Use Change, and Forestry increased by 146.0 Tg $CO_2$ Eq. (20 percent) from 1990 through 2006. This increase was primarily due to an increase in the rate of net carbon accumulation in forest carbon stocks, particularly in aboveground and belowground tree biomass. Annual carbon accumulation in landfilled yard trimmings and food scraps slowed over this period, while the rate of carbon accumulation in urban trees increased.

## Methane Emissions

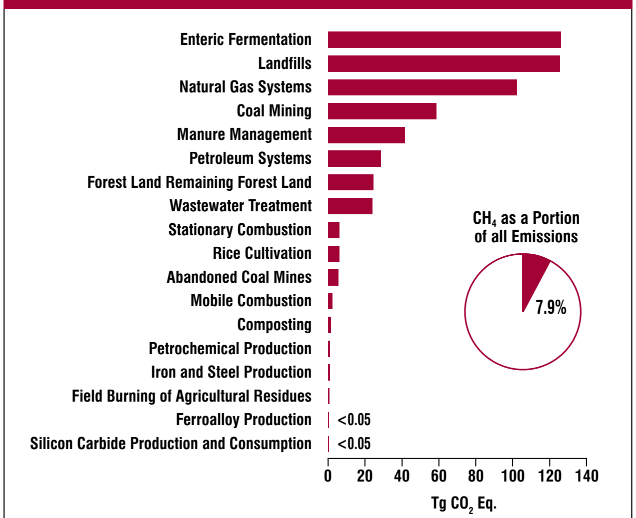
According to the IPCC, $CH_4$ is more than 20 times as effective as $CO_2$ at trapping heat in the atmosphere. Over the last two hundred and fifty years, the concentration of $CH_4$ in the atmosphere increased by 148 percent (IPCC 2007). Anthropogenic sources of $CH_4$ include landfills, natural gas and petroleum systems, agricultural activities, coal mining, wastewater treatment, stationary and mobile combustion, and certain industrial processes (see Figure ES-8).

Some significant trends in U.S. emissions of $CH_4$ include the following:

- Enteric fermentation is the largest anthropogenic source of $CH_4$ emissions in the United States. In 2006, enteric fermentation $CH_4$ emissions were 126.2 Tg $CO_2$ Eq. (approximately 22.7 percent of total $CH_4$ emissions), which represents a decline of 0.7 Tg $CO_2$ Eq., or 0.6 percent, since 1990. Despite this overall decline in emissions, the last two years have shown a slight increase in emissions.
- Landfills are the second largest anthropogenic source of $CH_4$ emissions in the United States, accounting for approximately 22.6 percent of total $CH_4$ emissions (125.7 Tg $CO_2$ Eq.) in 2006. From 1990 to 2006, net $CH_4$ emissions from landfills decreased by 23.9 Tg $CO_2$ Eq. (16 percent), with small increases occurring in some interim years, including 2006. This downward trend in overall emissions is the result of increases in the amount of landfill gas collected and combusted,[12] which has more than offset the additional $CH_4$ emissions resulting from an increase in the amount of municipal solid waste landfilled.
- $CH_4$ emissions from natural gas systems were 102.4 Tg $CO_2$ Eq. in 2006; emissions have declined by 22.3 Tg $CO_2$ Eq. (18 percent) since 1990. This decline has been due to improvements in technology and management practices, as well as some replacement of old equipment.
- In 2006, $CH_4$ emissions from coal mining were 58.5 Tg $CO_2$ Eq., a 1.4 Tg $CO_2$ Eq. (2.5 percent) increase over 2005 emission levels. The overall decline of 25.6 Tg $CO_2$ Eq. (30 percent) from 1990 results from the mining of less gassy coal from underground mines and the increased use of $CH_4$ collected from degasification systems.
- $CH_4$ emissions from manure management increased by 34 percent for $CH_4$, from 31.0 Tg $CO_2$ Eq. in 1990 to 41.4 Tg $CO_2$ Eq. in 2006. The majority of this increase was from swine and dairy cow manure, since the general trend in manure management is one of increasing use of liquid systems, which tends to produce greater $CH_4$ emissions. The increase in liquid systems is the combined result of a shift to larger facilities, and to facilities in the West and Southwest, all of which tend to use liquid systems. Also, new regulations limiting the application of manure nutrients have shifted manure management practices at smaller dairies from daily spread to manure managed and stored on site.

**Figure ES-8**

**2006 Sources of $CH_4$ Emissions**

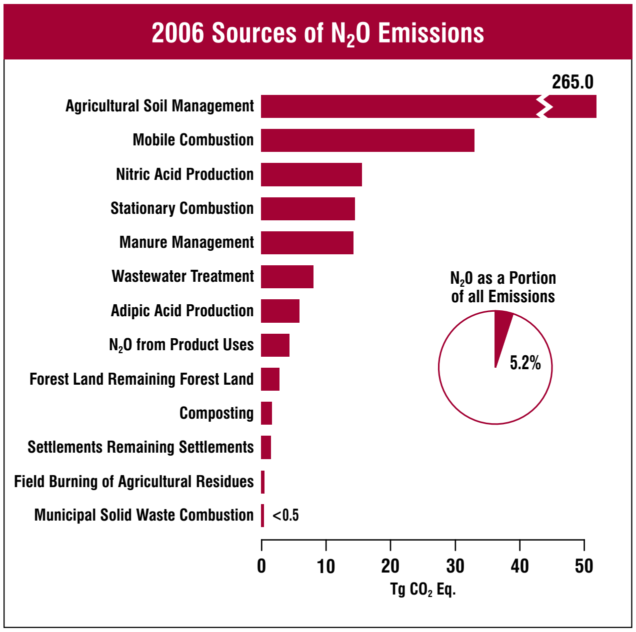



## Nitrous Oxide Emissions

$N_2O$ is produced by biological processes that occur in soil and water and by a variety of anthropogenic activities in the agricultural, energy-related, industrial, and waste management fields. While total $N_2O$ emissions are much lower than $CO_2$ emissions, $N_2O$ is approximately 300 times more powerful than $CO_2$ at trapping heat in the atmosphere. Since 1750, the global atmospheric concentration of $N_2O$ has risen by approximately 18 percent (IPCC 2007). The main anthropogenic activities producing $N_2O$ in the United States are agricultural soil management, fuel combustion

[12] The $CO_2$ produced from combusted landfill $CH_4$ at landfills is not counted in national inventories as it is considered part of the natural C cycle of decomposition.

**Figure ES-9**




in motor vehicles, nitric acid production, stationary fuel combustion, manure management, and wastewater treatment (see Figure ES-9).

Some significant trends in U.S. emissions of $N_2O$ include the following:

- Agricultural soils produced approximately 72 percent of $N_2O$ emissions in the United States in 2006. Estimated emissions from this source in 2006 were 265.0 Tg $CO_2$ Eq. Annual $N_2O$ emissions from agricultural soils fluctuated between 1990 and 2006, although overall emissions were 1.6 percent lower in 2006 than in 1990. $N_2O$ emissions from this source have not shown any significant long-term trend, as they are highly sensitive to the amount of N applied to soils, which has not changed significantly over the time-period, and to weather patterns and crop type.
- In 2006, $N_2O$ emissions from mobile combustion were 33.1 Tg $CO_2$ Eq. (approximately 9 percent of U.S. $N_2O$ emissions). From 1990 to 2006, $N_2O$ emissions from mobile combustion decreased by 24 percent. However, from 1990 to 1998 emissions increased by 26 percent, due to control technologies that reduced $NO_x$ emissions while increasing $N_2O$ emissions. Since 1998, newer control technologies have led to a steady decline in $N_2O$ from this source.
- $N_2O$ emissions from adipic acid production were 5.9 Tg $CO_2$ Eq. in 2006, and have decreased significantly in recent years from the widespread installation of pollution control measures. Emissions from adipic acid production have decreased 61 percent since 1990, and emissions from adipic acid production have fluctuated by less than 1 Tg $CO_2$ Eq. annually since 1998.

## HFC, PFC, and $SF_6$ Emissions

HFCs and PFCs are families of synthetic chemicals that are used as alternatives to the ODSs, which are being phased out under the *Montreal Protocol* and Clean Air Act Amendments of 1990. HFCs and PFCs do not deplete the stratospheric ozone layer, and are therefore acceptable alternatives under the *Montreal Protocol*.

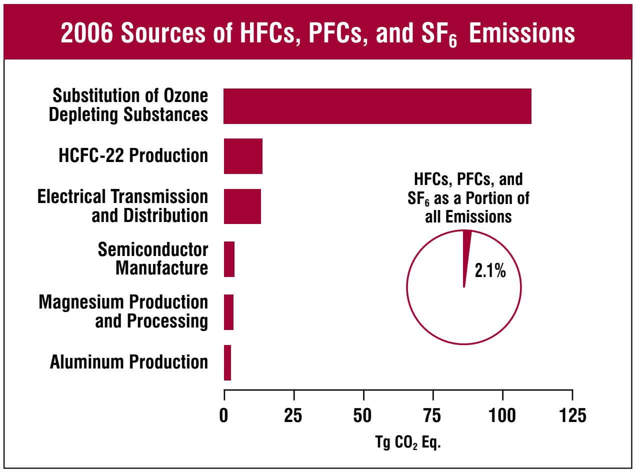
These compounds, however, along with $SF_6$, are potent greenhouse gases. In addition to having high global warming potentials, $SF_6$ and PFCs have extremely long atmospheric lifetimes, resulting in their essentially irreversible accumulation in the atmosphere once emitted. Sulfur hexafluoride is the most potent greenhouse gas the IPCC has evaluated.

Other emissive sources of these gases include HCFC-22 production, electrical transmission and distribution systems, semiconductor manufacturing, aluminum production, and magnesium production and processing (see Figure ES-10).

Some significant trends in U.S. HFC, PFC, and $SF_6$ emissions include the following:

- Emissions resulting from the substitution of ozone depleting substances (e.g., CFCs) have been increasing from small amounts in 1990 to 110.4 Tg $CO_2$ Eq. in 2006. Emissions from substitutes for ozone depleting substances are both the largest and the fastest growing source of HFC, PFC, and $SF_6$ emissions. These emissions have been increasing as phase-outs required under the *Montreal Protocol* come into effect, especially after 1994 when full market penetration was made for the first generation of new technologies featuring ODS substitutes.
- HFC emissions from the production of HCFC-22 decreased by 62 percent (22.6 Tg $CO_2$ Eq.) from 1990 through 2006, due to a steady decline in the emission rate of HFC-23 (i.e., the amount of HFC-23

**Figure ES-10**



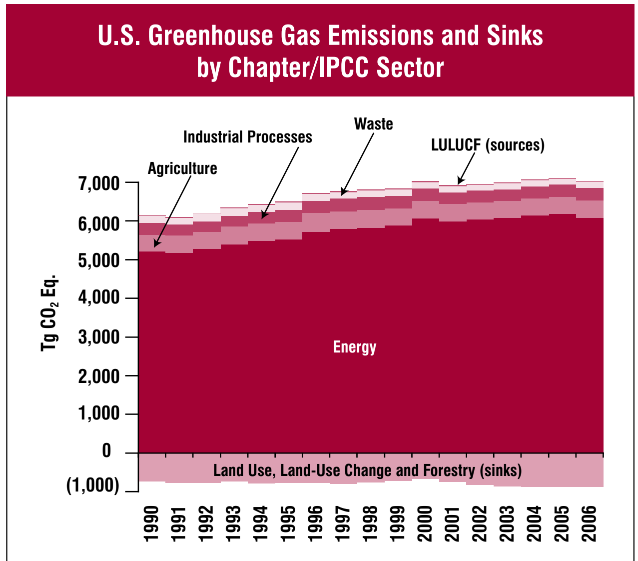

emitted per kilogram of HCFC-22 produced) and the use of thermal oxidation at some plants to reduce HFC-23 emissions.

- $SF_6$ emissions from electric power transmission and distribution systems decreased by 51 percent (13.5 Tg $CO_2$ Eq.) from 1990 to 2006, primarily because of higher purchase prices for $SF_6$ and efforts by industry to reduce emissions.
- PFC emissions from aluminum production decreased by 87 percent (16.1 Tg $CO_2$ Eq.) from 1990 to 2006, due to both industry emission reduction efforts and lower domestic aluminum production.

## ES.3. Overview of Sector Emissions and Trends

In accordance with the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC/UNEP/OECD/IEA 1997), and the 2003 *UNFCCC Guidelines on Reporting and Review* (UNFCCC 2003), the Inventory of U.S. Greenhouse Gas Emissions and Sinks report is segregated into six sector-specific chapters. Figure ES-11 and Table ES-4 aggregate emissions and sinks by these chapters. Emissions of all gases can be summed from each source category from IPCC guidance. Over the sixteen-year period of 1990 to 2006, total emissions in the Energy, Industrial Processes, and Agriculture sectors climbed by 873.0 Tg $CO_2$ Eq. (17 percent), 21.0 Tg $CO_2$ Eq. (7 percent), and 6.6 Tg $CO_2$ Eq. (1 percent), respectively. Emissions decreased in the Waste and Solvent and Other Product Use sectors by 18.6 Tg $CO_2$ Eq. (10 percent) and less than 0.1 Tg $CO_2$ Eq. (less than 1 percent), respectively. Over the same period, estimates of net C sequestration in the Land Use, Land-Use Change, and Forestry sector increased by 122.2 Tg $CO_2$ Eq. (17 percent).

**Figure ES-11**




Note: Relatively smaller amounts of GWP-weighted emissions are also emitted from the Solvent and Other Product Use sector.

### Energy

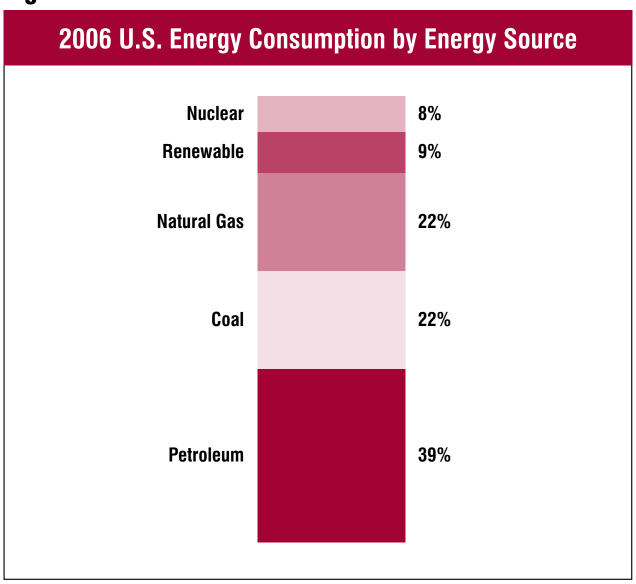
The Energy chapter contains emissions of all greenhouse gases resulting from stationary and mobile energy activities including fuel combustion and fugitive fuel emissions. Energy-related activities, primarily fossil fuel combustion, accounted for the vast majority of U.S. $CO_2$ emissions for the period of 1990 through 2006. In 2006, approximately 83 percent of the energy consumed in the United States (on a Btu basis) was produced through the combustion of fossil fuels. The remaining 17 percent came from other energy sources such as hydropower, biomass, nuclear, wind, and solar energy (see Figure ES-12). Energy-related activities are also responsible for $CH_4$ and $N_2O$ emissions (37 percent and 13 percent of total U.S. emissions of each gas, respectively). Overall, emission sources in the Energy chapter account for a combined 86.1 percent of total U.S. greenhouse gas emissions in 2006.

**Table ES-4: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks by Chapter/IPCC Sector (Tg $CO_2$ Eq.)**

| Chapter/IPCC Sector | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| Energy | 5,203.9 | 5,529.6 | 6,067.8 | 5,982.8 | 6,036.3 | 6,078.3 | 6,150.9 | 6,174.4 | 6,076.9 |
| Industrial Processes | 299.9 | 315.7 | 326.5 | 297.9 | 308.6 | 301.2 | 315.9 | 315.5 | 320.9 |
| Solvent and Other Product Use | 4.4 | 4.6 | 4.9 | 4.9 | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 |
| Agriculture | 447.5 | 453.8 | 447.9 | 463.7 | 449.0 | 434.3 | 432.1 | 453.6 | 454.1 |
| Land Use, Land-Use Change, and Forestry (Emissions) | 13.1 | 13.6 | 30.0 | 20.0 | 28.4 | 19.7 | 17.1 | 23.2 | 36.9 |
| Waste | 179.6 | 176.8 | 155.6 | 152.1 | 154.5 | 160.3 | 157.7 | 158.7 | 161.0 |
| **Total Emissions** | **6,148.3** | **6,494.0** | **7,032.6** | **6,921.3** | **6,981.2** | **6,998.2** | **7,078.0** | **7,129.9** | **7,054.2** |
| Net $CO_2$ Flux from Land Use, Land-Use Change, and Forestry (Sinks)* | (737.7) | (775.3) | (673.6) | (750.2) | (826.8) | (860.9) | (873.7) | (878.6) | (883.7) |
| **Net Emissions (Sources and Sinks)** | **5,410.6** | **5,718.7** | **6,359.0** | **6,171.1** | **6,154.4** | **6,137.3** | **6,204.3** | **6,251.3** | **6,170.5** |

* The net $CO_2$ flux total includes both emissions and sequestration, and constitutes a sink in the United States. Sinks are only included in net emissions total.
Note: Totals may not sum due to independent rounding. Parentheses indicate negative values or sequestration.

**Figure ES-12**




## Industrial Processes

The Industrial Processes chapter contains byproduct or fugitive emissions of greenhouse gases from industrial processes not directly related to energy activities such as fossil fuel combustion. For example, industrial processes can chemically transform raw materials, which often release waste gases such as $CO_2$, $CH_4$, and $N_2O$. These processes include iron and steel production, cement production, ammonia production and urea consumption, lime production, limestone and dolomite use (e.g., flux stone, flue gas desulfurization, and glass manufacturing), soda ash production and use, titanium dioxide production, phosphoric acid production, ferroalloy production, $CO_2$ consumption, silicon carbide production and consumption, aluminum production, petrochemical production, nitric acid production, adipic acid production, lead production, and zinc production. Additionally, emissions from industrial processes release HFCs, PFCs, and $SF_6$. Overall, emission sources in the Industrial Processes chapter account for 4.5 percent of U.S. greenhouse gas emissions in 2006.

## Solvent and Other Product Use

The Solvent and Other Product Use chapter contains greenhouse gas emissions that are produced as a byproduct of various solvent and other product uses. In the United States, emissions from $N_2O$ from Product Uses, the only source of greenhouse gas emissions from this sector, accounted for less than 0.1 percent of total U.S. anthropogenic greenhouse gas emissions on a carbon equivalent basis in 2006.

## Agriculture

The Agriculture chapter contains anthropogenic emissions from agricultural activities (except fuel combustion, which is addressed in the Energy chapter, and agricultural $CO_2$ fluxes, which are addressed in the Land Use, Land-Use Change, and Forestry Chapter). Agricultural activities contribute directly to emissions of greenhouse gases through a variety of processes, including the following source categories: enteric fermentation in domestic livestock, livestock manure management, rice cultivation, agricultural soil management, and field burning of agricultural residues. $CH_4$ and $N_2O$ were the primary greenhouse gases emitted by agricultural activities. $CH_4$ emissions from enteric fermentation and manure management represented about 23 percent and 7 percent of total $CH_4$ emissions from anthropogenic activities, respectively, in 2006. Agricultural soil management activities such as fertilizer application and other cropping practices were the largest source of U.S. $N_2O$ emissions in 2006, accounting for 72 percent. In 2006, emission sources accounted for in the Agricultural chapters were responsible for 6.4 percent of total U.S. greenhouse gas emissions.

## Land Use, Land-Use Change, and Forestry

The Land Use, Land-Use Change, and Forestry chapter contains emissions of $CH_4$ and $N_2O$, and emissions and removals of $CO_2$ from forest management, other land-use activities, and land-use change. Forest management practices, tree planting in urban areas, the management of agricultural soils, and the landfilling of yard trimmings and food scraps have resulted in a net uptake (sequestration) of C in the United States. Forests (including vegetation, soils, and harvested wood) accounted for approximately 84 percent of total 2006 net $CO_2$ flux, urban trees accounted for 11 percent, mineral and organic soil carbon stock changes accounted for 5 percent, and landfilled yard trimmings and food scraps accounted for 1 percent of the total net flux in 2006. The net forest sequestration is a result of net forest growth and increasing forest area, as well as a net accumulation of carbon stocks in harvested wood pools. The net sequestration in urban forests is a result of net tree growth in these areas. In agricultural soils, mineral and organic soils sequester approximately 70 percent more C than is emitted through these soils, liming, and urea fertilization, combined. The mineral soil C sequestration is largely due to the conversion of cropland to permanent pastures and hay production, a reduction in summer fallow areas in semi-arid areas, an increase in the adoption of conservation tillage practices, and an increase in the amounts of organic fertilizers (i.e., manure and sewage sludge) applied to agriculture lands. The landfilled yard trimmings and food scraps net sequestration is due to the long-term accumulation of yard trimming carbon and food scraps in landfills. Land use, land-use change, and forestry activities in 2006 resulted in a net C sequestration of 883.7 Tg $CO_2$ Eq. (Table ES-5). This represents an offset of approximately 14.8 percent of total U.S. $CO_2$ emissions, or 12.5 percent of total greenhouse gas emissions in 2006. Between 1990 and 2006, total land use, land-use change, and forestry net C flux resulted in a 20 percent increase in $CO_2$ sequestration, primarily due to an increase in the rate of net C accumulation in forest C stocks, particularly in aboveground and belowground tree biomass. Annual C accumulation in landfilled yard trimmings and food scraps slowed over this period, while the rate of annual C accumulation increased in urban trees.

Emissions from Land Use, Land-Use Change, and Forestry are shown in Table ES-6. The application of crushed limestone and dolomite to managed land (i.e., soil liming) and urea fertilization resulted in $CO_2$ emissions of 8.0 Tg $CO_2$ Eq. in 2006, an increase of 13 percent relative to 1990. The application of synthetic fertilizers to forest and settlement soils in 2006 resulted in direct $N_2O$ emissions of 1.8 Tg $CO_2$ Eq. Direct $N_2O$ emissions from fertilizer application increased by approximately 74 percent between 1990 and 2006. Non-$CO_2$ emissions from forest fires in 2006 resulted in $CH_4$ emissions of 24.6 Tg $CO_2$ Eq., and in $N_2O$ emissions of 2.5 Tg $CO_2$ Eq.

**Table ES-5: Net $CO_2$ Flux from Land Use, Land-Use Change, and Forestry (Tg $CO_2$ Eq.)**

| Sink Category | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| Forest Land Remaining Forest Land | (621.7) | (659.9) | (550.7) | (623.4) | (697.3) | (730.9) | (741.4) | (743.6) | (745.1) |
| Cropland Remaining Cropland | (30.1) | (39.4) | (38.4) | (40.0) | (40.3) | (40.5) | (40.9) | (41.0) | (41.8) |
| Land Converted to Cropland | 14.7 | 9.4 | 9.4 | 9.4 | 9.4 | 9.4 | 9.4 | 9.4 | 9.4 |
| Grassland Remaining Grassland | (1.9) | 16.6 | 16.4 | 16.4 | 16.4 | 16.4 | 16.3 | 16.3 | 16.2 |
| Land Converted to Grassland | (14.3) | (16.3) | (16.3) | (16.3) | (16.3) | (16.3) | (16.3) | (16.3) | (16.3) |
| Settlements Remaining Settlements | (60.6) | (71.5) | (82.4) | (84.6) | (86.8) | (88.9) | (91.1) | (93.3) | (95.5) |
| Other (Landfilled Yard Trimmings and Food Scraps) | (23.9) | (14.1) | (11.5) | (11.6) | (11.8) | (10.0) | (9.6) | (10.0) | (10.5) |
| **Total** | **(737.7)** | **(775.3)** | **(673.6)** | **(750.2)** | **(826.8)** | **(860.9)** | **(873.7)** | **(878.6)** | **(883.7)** |

Note: Totals may not sum due to independent rounding. Parentheses indicate net sequestration.

**Table ES-6: Emissions from Land Use, Land-Use Change, and Forestry (Tg $CO_2$ Eq.)**

| Source Category | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| **$CO_2$** | **7.1** | **7.0** | **7.5** | **7.8** | **8.5** | **8.3** | **7.6** | **7.9** | **8.0** |
| Cropland Remaining Cropland: Liming of Agricultural Soils & Urea Fertilization | 7.1 | 7.0 | 7.5 | 7.8 | 8.5 | 8.3 | 7.6 | 7.9 | 8.0 |
| **$CH_4$** | **4.5** | **4.7** | **19.0** | **9.4** | **16.4** | **8.7** | **6.9** | **12.3** | **24.6** |
| Forest Land Remaining Forest Land: Forest Fires | 4.5 | 4.7 | 19.0 | 9.4 | 16.4 | 8.7 | 6.9 | 12.3 | 24.6 |
| **$N_2O$** | **1.5** | **1.8** | **3.5** | **2.7** | **3.5** | **2.7** | **2.6** | **3.1** | **4.3** |
| Forest Land Remaining Forest Land: Forest Fires | 0.5 | 0.5 | 1.9 | 1.0 | 1.7 | 0.9 | 0.7 | 1.2 | 2.5 |
| Forest Land Remaining Forest Land: Forest Soils | 0.1 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Settlements Remaining Settlements: Settlement Soils | 1.0 | 1.2 | 1.2 | 1.4 | 1.5 | 1.5 | 1.6 | 1.5 | 1.5 |
| **Total** | **13.1** | **13.6** | **30.0** | **20.0** | **28.4** | **19.7** | **17.1** | **23.2** | **36.9** |

Note: Totals may not sum due to independent rounding. Parentheses indicate net sequestration.

## Waste

The Waste chapter contains emissions from waste management activities (except waste incineration, which is addressed in the Energy chapter). Landfills were the largest source of anthropogenic $CH_4$ emissions in the Waste chapter, accounting for 23 percent of total U.S. $CH_4$ emissions.[13] Additionally, wastewater treatment accounts for 4 percent of U.S. $CH_4$ emissions. $N_2O$ emissions from the discharge of wastewater treatment effluents into aquatic environments were estimated, as were $N_2O$ emissions from the treatment process itself. Emissions of $CH_4$ and $N_2O$ from composting grew from 1990 to 2006, and resulted in emissions of 1.6 Tg $CO_2$ Eq. and 1.8 Tg $CO_2$ Eq., respectively. Overall, in 2006, emission sources accounted for in the Waste chapter generated 2.3 percent of total U.S. greenhouse gas emissions.

# ES.4. Other Information

## Emissions by Economic Sector

Throughout this report, emission estimates are grouped into six sectors (i.e., chapters) defined by the IPCC: Energy; Industrial Processes; Solvent Use; Agriculture; Land Use, Land-Use Change, and Forestry; and Waste. While it is important to use this characterization for consistency with UNFCCC reporting guidelines, it is also useful to allocate

[13] Landfills also store carbon, due to incomplete degradation of organic materials such as wood products and yard trimmings, as described in the Land-Use, Land-Use Change, and Forestry chapter.

**Table ES-7: U.S. Greenhouse Gas Emissions Allocated to Economic Sectors (Tg $CO_2$ Eq.)**

| Implied Sectors | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| Electric Power Industry | 1,859.1 | 1,989.7 | 2,328.9 | 2,290.9 | 2,300.4 | 2,329.4 | 2,363.4 | 2,430.0 | 2,377.8 |
| Transportation | 1,544.1 | 1,685.8 | 1,917.5 | 1,895.8 | 1,948.5 | 1,925.9 | 1,975.4 | 1,987.2 | 1,969.5 |
| Industry | 1,460.3 | 1,478.0 | 1,432.9 | 1,384.3 | 1,384.9 | 1,375.5 | 1,388.9 | 1,354.3 | 1,371.5 |
| Agriculture | 506.8 | 524.1 | 528.0 | 533.4 | 529.3 | 498.0 | 499.2 | 521.3 | 533.6 |
| Commercial | 396.9 | 404.5 | 390.3 | 383.0 | 388.1 | 410.2 | 404.6 | 400.4 | 394.6 |
| Residential | 346.9 | 370.9 | 387.7 | 379.3 | 376.6 | 399.6 | 385.5 | 376.0 | 344.8 |
| U.S. Territories | 34.1 | 41.1 | 47.3 | 54.5 | 53.3 | 59.7 | 61.0 | 60.5 | 62.4 |
| **Total Emissions** | **6,148.3** | **6,494.0** | **7,032.6** | **6,921.3** | **6,981.2** | **6,998.2** | **7,078.0** | **7,129.9** | **7,054.2** |
| Land Use, Land-Use Change, and Forestry (Sinks) | (737.7) | (775.3) | (673.6) | (750.2) | (826.8) | (860.9) | (873.7) | (878.6) | (883.7) |
| **Net** | **5,410.6** | **5,718.7** | **6,359.0** | **6,171.1** | **6,154.4** | **6,137.3** | **6,204.3** | **6,251.3** | **6,170.5** |

Note: Totals may not sum due to independent rounding. Emissions include $CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, and $SF_6$. See Table 2-12 for more detailed data.

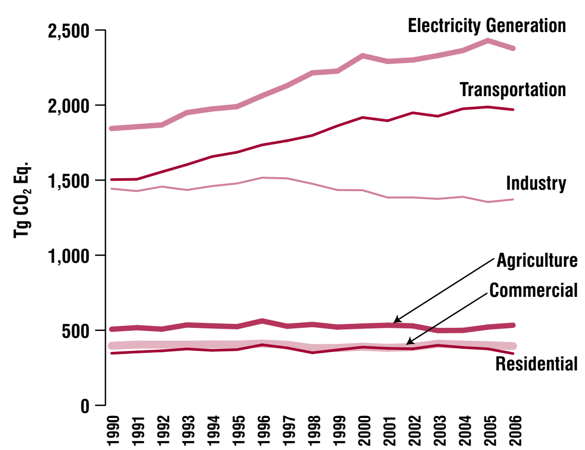
emissions into more commonly used sectoral categories. This section reports emissions by the following economic sectors: Residential, Commercial, Industry, Transportation, Electricity Generation, Agriculture, and U.S. Territories.

Table ES-7 summarizes emissions from each of these sectors, and Figure ES-13 shows the trend in emissions by sector from 1990 to 2006.

Using this categorization, emissions from electricity generation accounted for the largest portion (34 percent) of U.S. greenhouse gas emissions in 2006. Transportation activities, in aggregate, accounted for the second largest portion (28 percent). Emissions from industry accounted for 19 percent of U.S. greenhouse gas emissions in 2006. In contrast to electricity generation and transportation, emissions from industry have in general declined over the past decade. The long-term decline in these emissions has been due to structural changes in the U.S. economy (i.e., shifts from a manufacturing-based to a service-based economy), fuel switching, and energy efficiency improvements. The remaining 19 percent of U.S. greenhouse gas emissions were contributed by the residential, agriculture, and commercial sectors, plus emissions from U.S. territories. The residential sector accounted for about 5 percent, and primarily consisted of $CO_2$ emissions from fossil fuel combustion. Activities related to agriculture accounted for roughly 8 percent of U.S. emissions; unlike other economic sectors, agricultural sector emissions were dominated by $N_2O$ emissions from agricultural soil management and $CH_4$ emissions from enteric fermentation, rather than $CO_2$ from fossil fuel combustion. The commercial sector accounted for about 6 percent of emissions, while U.S. territories accounted for 1 percent.

**Figure ES-13**

**Emissions Allocated to Economic Sectors**




Note: Does not include U.S. territories.

$CO_2$ was also emitted and sequestered by a variety of activities related to forest management practices, tree planting in urban areas, the management of agricultural soils, and landfilling of yard trimmings.

**Table ES-8: U.S. Greenhouse Gas Emissions by Economic Sector with Electricity-Related Emissions Distributed (Tg $CO_2$ Eq.)**

| Implied Sectors | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| Industry | 2,100.4 | 2,141.1 | 2,174.3 | 2,061.1 | 2,051.6 | 2,064.0 | 2,075.4 | 2,038.3 | 2,029.2 |
| Transportation | 1,547.2 | 1,688.9 | 1,921.0 | 1,899.4 | 1,952.0 | 1,930.2 | 1,980.0 | 1,992.0 | 1,974.5 |
| Commercial | 946.3 | 1,003.8 | 1,141.9 | 1,149.8 | 1,151.1 | 1,172.7 | 1,187.2 | 1,212.5 | 1,204.4 |
| Residential | 952.4 | 1,026.5 | 1,160.7 | 1,153.2 | 1,178.0 | 1,211.2 | 1,207.2 | 1,241.7 | 1,187.8 |
| Agriculture | 567.9 | 592.5 | 587.4 | 603.2 | 595.1 | 560.5 | 567.2 | 584.9 | 595.8 |
| U.S. Territories | 34.1 | 41.1 | 47.3 | 54.5 | 53.3 | 59.7 | 61.0 | 60.5 | 62.4 |
| **Total Emissions** | **6,148.3** | **6,494.0** | **7,032.6** | **6,921.3** | **6,981.2** | **6,998.2** | **7,078.0** | **7,129.9** | **7,054.2** |
| Land Use, Land-Use Change, and Forestry (Sinks) | (737.7) | (775.3) | (673.6) | (750.2) | (826.8) | (860.9) | (873.7) | (878.6) | (883.7) |
| **Net Emissions (Sources and Sinks)** | **5,410.6** | **5,718.7** | **6,359.0** | **6,171.1** | **6,154.4** | **6,137.3** | **6,204.3** | **6,251.3** | **6,170.5** |

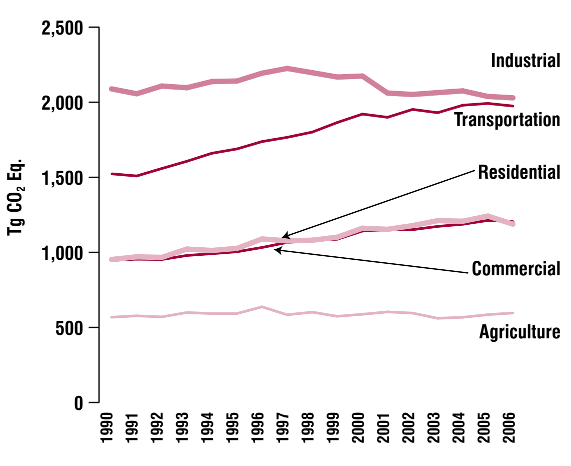
See Table 2-14 of this report for more detailed data.

Electricity is ultimately consumed in the economic sectors described above. Table ES-8 presents greenhouse gas emissions from economic sectors with emissions related to electricity generation distributed into end-use categories (i.e., emissions from electricity generation are allocated to the economic sectors in which the electricity is consumed). To distribute electricity emissions among end-use sectors, emissions from the source categories assigned to electricity generation were allocated to the residential, commercial, industry, transportation, and agriculture economic sectors according to retail sales of electricity.[14] These source categories include $CO_2$ from fossil fuel combustion and the use of limestone and dolomite for flue gas desulfurization, $CO_2$ and $N_2O$ from waste combustion, $CH_4$ and $N_2O$ from stationary sources, and $SF_6$ from electrical transmission and distribution systems.

When emissions from electricity are distributed among these sectors, industry accounts for the largest share of U.S. greenhouse gas emissions (29 percent) in 2006. Emissions from the residential and commercial sectors also increase substantially when emissions from electricity are included, due to their relatively large share of electricity consumption (e.g., lighting, appliances, etc.). Transportation activities remain the second largest contributor to total U.S. emissions (28 percent). In all sectors except agriculture, $CO_2$ accounts for more than 80 percent of greenhouse gas emissions, primarily from the combustion of fossil fuels. Figure ES-14 shows the trend in these emissions by sector from 1990 to 2006.

**Figure ES-14**

**Emissions with Electricity Distributed to Economic Sectors**




Note: Does not include U.S. territories.

[14] Emissions were not distributed to U.S. territories, since the electricity generation sector only includes emissions related to the generation of electricity in the 50 states and the District of Columbia.

## Box ES-2: Recent Trends in Various U.S. Greenhouse Gas Emissions-Related Data

Total emissions can be compared to other economic and social indices to highlight changes over time. These comparisons include: (1) emissions per unit of aggregate energy consumption, because energy-related activities are the largest sources of emissions, (2) emissions per unit of fossil fuel consumption, because almost all energy-related emissions involve the combustion of fossil fuels, (3) emissions per unit of electricity consumption, because the electric power industry—utilities and nonutilities combined—was the largest source of U.S. greenhouse gas emissions in 2006, (4) emissions per unit of total gross domestic product as a measure of national economic activity, or (5) emissions per capita.

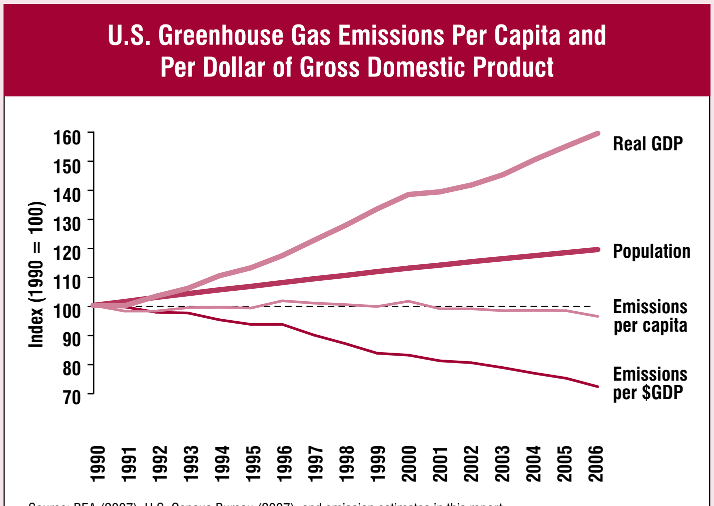
Table ES-9 provides data on various statistics related to U.S. greenhouse gas emissions normalized to 1990 as a baseline year. Greenhouse gas emissions in the United States have grown at an average annual rate of 0.9 percent since 1990. This rate is slightly slower than that for total energy or fossil fuel consumption and much slower than that for either electricity consumption or overall gross domestic product. Total U.S. greenhouse gas emissions have also grown slightly slower than national population since 1990 (see Figure ES-15).

### Table ES-9: Recent Trends in Various U.S. Data (Index 1990 = 100)

| Variable | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Growth Rate[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP[b] | 100 | 113 | 138 | 139 | 141 | 145 | 150 | 155 | 159 | 3.0% |
| Electricity Consumption[c] | 100 | 112 | 127 | 125 | 128 | 129 | 131 | 134 | 135 | 1.9% |
| Fossil Fuel Consumption[c] | 100 | 107 | 117 | 115 | 116 | 116 | 119 | 119 | 117 | 1.0% |
| Energy Consumption[c] | 100 | 108 | 116 | 112 | 115 | 115 | 118 | 118 | 117 | 1.0% |
| Population[d] | 100 | 107 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 1.1% |
| Greenhouse Gas Emissions[e] | 100 | 106 | 114 | 113 | 114 | 114 | 115 | 116 | 115 | 0.9% |

[a] Average annual growth rate
[b] Gross Domestic Product in chained 2000 dollars (BEA 2007)
[c] Energy content-weighted values (EIA 2007)
[d] U.S. Census Bureau (2007)
[e] GWP-weighted values

**Figure ES-15**




Source: BEA (2007), U.S. Census Bureau (2007), and emission estimates in this report.

## Indirect Greenhouse Gases (CO, $NO_x$, NMVOCs, and $SO_2$)

The reporting requirements of the UNFCCC[15] request that information be provided on indirect greenhouse gases, which include CO, $NO_x$, NMVOCs, and $SO_2$. These gases do not have a direct global warming effect, but indirectly affect terrestrial radiation absorption by influencing the formation and destruction of tropospheric and stratospheric ozone, or, in the case of $SO_2$, by affecting the absorptive characteristics of the atmosphere. Additionally, some of these gases may

**Table ES-10: Emissions of $NO_x$, CO, NMVOCs, and $SO_2$ (Gg)**

| Gas/Activity | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|
| **$NO_x$** | **21,645** | **21,272** | **19,203** | **18,410** | **17,938** | **17,043** | **16,177** | **15,569** | **14,869** |
| Mobile Fossil Fuel Combustion | 10,920 | 10,622 | 10,310 | 9,819 | 10,154 | 9,642 | 9,191 | 8,739 | 8,287 |
| Stationary Fossil Fuel Combustion | 9,883 | 9,821 | 8,002 | 7,667 | 6,791 | 6,419 | 6,004 | 5,853 | 5,610 |
| Industrial Processes | 591 | 607 | 626 | 656 | 534 | 528 | 524 | 519 | 515 |
| Oil and Gas Activities | 139 | 100 | 111 | 113 | 321 | 316 | 316 | 316 | 315 |
| Municipal Solid Waste Combustion | 82 | 88 | 114 | 114 | 98 | 97 | 97 | 97 | 97 |
| Agricultural Burning | 28 | 29 | 35 | 35 | 33 | 34 | 39 | 39 | 38 |
| Solvent Use | 1 | 3 | 3 | 3 | 5 | 5 | 5 | 5 | 5 |
| Waste | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO** | **130,461** | **109,032** | **92,777** | **89,212** | **84,609** | **80,221** | **76,342** | **72,365** | **68,372** |
| Mobile Fossil Fuel Combustion | 119,360 | 97,630 | 83,559 | 79,851 | 75,421 | 71,038 | 67,096 | 63,154 | 59,213 |
| Stationary Fossil Fuel Combustion | 5,000 | 5,383 | 4,340 | 4,377 | 4,965 | 4,893 | 4,876 | 4,860 | 4,844 |
| Industrial Processes | 4,125 | 3,959 | 2,217 | 2,339 | 1,744 | 1,724 | 1,724 | 1,724 | 1,724 |
| Municipal Solid Waste Combustion | 978 | 1,073 | 1,670 | 1,672 | 1,439 | 1,437 | 1,437 | 1,437 | 1,437 |
| Agricultural Burning | 691 | 663 | 792 | 774 | 709 | 800 | 879 | 860 | 825 |
| Oil and Gas Activities | 302 | 316 | 146 | 147 | 323 | 321 | 321 | 321 | 322 |
| Waste | 1 | 2 | 8 | 8 | 7 | 7 | 7 | 7 | 7 |
| Solvent Use | 5 | 5 | 46 | 45 | 1 | 1 | 1 | 1 | 1 |
| **NMVOCs** | **20,930** | **19,520** | **15,228** | **15,048** | **15,640** | **15,170** | **14,807** | **14,444** | **14,082** |
| Mobile Fossil Fuel Combustion | 10,932 | 8,745 | 7,230 | 6,872 | 7,235 | 6,885 | 6,587 | 6,289 | 5,991 |
| Solvent Use | 5,216 | 5,609 | 4,384 | 4,547 | 3,881 | 3,862 | 3,854 | 3,846 | 3,839 |
| Industrial Processes | 2,422 | 2,642 | 1,773 | 1,769 | 2,036 | 1,972 | 1,931 | 1,890 | 1,849 |
| Stationary Fossil Fuel Combustion | 912 | 973 | 1,077 | 1,080 | 1,585 | 1,560 | 1,553 | 1,545 | 1,538 |
| Oil and Gas Activities | 554 | 582 | 389 | 400 | 545 | 538 | 533 | 528 | 523 |
| Municipal Solid Waste Combustion | 222 | 237 | 257 | 258 | 243 | 239 | 237 | 235 | 232 |
| Waste | 673 | 731 | 119 | 122 | 115 | 114 | 112 | 111 | 110 |
| Agricultural Burning | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **$SO_2$** | **20,935** | **16,891** | **14,829** | **14,452** | **13,403** | **13,631** | **13,232** | **13,114** | **12,258** |
| Stationary Fossil Fuel Combustion | 18,407 | 14,724 | 12,848 | 12,461 | 11,613 | 11,956 | 11,625 | 11,573 | 10,784 |
| Industrial Processes | 1,307 | 1,117 | 1,031 | 1,047 | 850 | 804 | 800 | 797 | 793 |
| Mobile Fossil Fuel Combustion | 793 | 672 | 632 | 624 | 683 | 621 | 564 | 508 | 451 |
| Oil and Gas Activities | 390 | 335 | 286 | 289 | 233 | 226 | 220 | 213 | 207 |
| Municipal Solid Waste Combustion | 38 | 42 | 29 | 30 | 23 | 22 | 22 | 22 | 22 |
| Waste | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Solvent Use | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Agricultural Burning | NA | NA | NA | NA | NA | NA | NA | NA | NA |

Source: (EPA 2008, disaggregated based on EPA 2003) except for estimates from field burning of agricultural residues.
NA (Not Available)
Note: Totals may not sum due to independent rounding.

[15] See <http://unfccc.int/resource/docs/cop8/08.pdf>.

react with other chemical compounds in the atmosphere to form compounds that are greenhouse gases.

Since 1970, the United States has published estimates of annual emissions of CO, $NO_x$, NMVOCs, and $SO_2$ (EPA 2008),[16] which are regulated under the Clean Air Act. Table ES-10 shows that fuel combustion accounts for the majority of emissions of these indirect greenhouse gases. Industrial processes—such as the manufacture of chemical and allied products, metals processing, and industrial uses of solvents—are also significant sources of CO, $NO_x$, and NMVOCs.

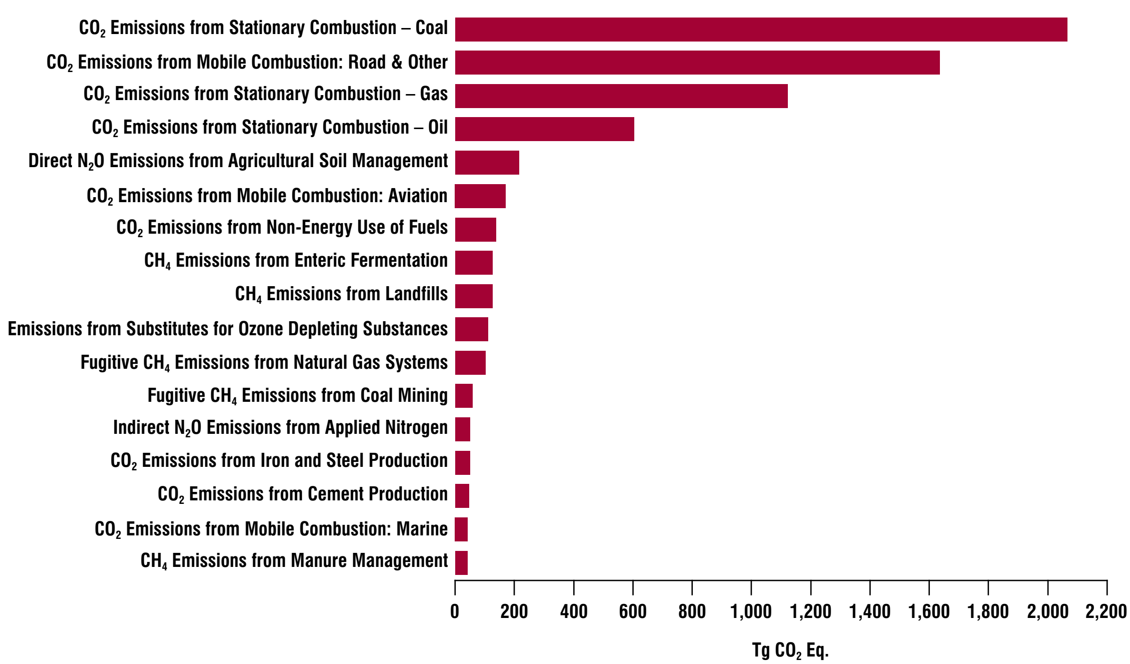
## Key Categories

The IPCC's *Good Practice Guidance* (IPCC 2000) defines a key category as a "[source or sink category] that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of direct greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both."[17] By definition, key categories are sources or sinks that have the greatest contribution to the absolute overall level of national emissions in any of the years covered by the time series. In addition, when an entire time series of emission estimates is prepared, a thorough investigation of key categories must also account for the influence of trends of individual source and sink categories. Finally, a qualitative evaluation of key categories should be performed, in order to capture any key categories that were not identified in either of the quantitative analyses.

Figure ES-16 presents 2006 emission estimates for the key categories as defined by a level analysis (i.e., the contribution of each source or sink category to the total inventory level). The UNFCCC reporting guidelines request that key category analyses be reported at an appropriate level of disaggregation, which may lead

**Figure ES-16**

**2006 Key Categories-Tier 1 Level Assessment**




Note: For a complete discussion of the key source analysis see Annex 1.

[16] $NO_x$ and CO emission estimates from field burning of agricultural residues were estimated separately, and therefore not taken from EPA (2008).

[17] See Chapter 7 "Methodological Choice and Recalculation" in IPCC (2000). <http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm>

to source and sink category names which differ from those used elsewhere in this report. For more information regarding key categories, see Section 1.5 and Annex 1 of this report.

## Quality Assurance and Quality Control (QA/QC)

The United States seeks to continually improve the quality, transparency, and credibility of the Inventory of U.S. Greenhouse Gas Emissions and Sinks. To assist in these efforts, the United States implemented a systematic approach to QA/QC. While QA/QC has always been an integral part of the U.S. national system for inventory development, the procedures followed for the current Inventory have been formalized in accordance with the QA/QC plan and the UNFCCC reporting guidelines.

## Uncertainty Analysis of Emission Estimates

While the current U.S. emissions inventory provides a solid foundation for the development of a more detailed and comprehensive national inventory, there are uncertainties associated with the emission estimates. Some of the current estimates, such as those for $CO_2$ emissions from energy-related activities and cement processing, are considered to have low uncertainties. For some other categories of emissions, however, a lack of data or an incomplete understanding of how emissions are generated increases the uncertainty associated with the estimates presented. Acquiring a better understanding of the uncertainty associated with inventory estimates is an important step in helping to prioritize future work and improve the overall quality of the Inventory. Recognizing the benefit of conducting an uncertainty analysis, the UNFCCC reporting guidelines follow the recommendations of the IPCC *Good Practice Guidance* (IPCC 2000) and require that countries provide single estimates of uncertainty for source and sink categories.

Currently, a qualitative discussion of uncertainty is presented for all source and sink categories. Within the discussion of each emission source, specific factors affecting the uncertainty surrounding the estimates are discussed. Most sources also contain a quantitative uncertainty assessment, in accordance with UNFCCC reporting guidelines.