

Executive Summary

Central to any study of climate change is the development of an emissions inventory that identifies and quantifies a country's primary anthropogenic¹ sources and sinks of greenhouse gases. This inventory adheres to both 1) a comprehensive and detailed methodology 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 2004. 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). 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.

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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

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>>.

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

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 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 2003) 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.

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ES.1. Background Information

Naturally occurring greenhouse gases include water vapor, carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and ozone (O₃). 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 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 (SF₆)—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-CH₄ volatile organic compounds (NMVOCs). Aerosols, which are extremely small particles or liquid droplets, such as those produced by sulfur dioxide (SO₂) or elemental carbon emissions, can also affect the absorptive characteristics of the atmosphere.

Although the direct greenhouse gases CO₂, CH₄, and N₂O occur naturally in the atmosphere, human activities have changed their atmospheric concentrations. From the pre-industrial era (i.e., ending about 1750) to 2004, concentrations of these greenhouse gases have increased globally by 35, 143, and 18 percent, respectively (IPCC 2001, Hofmann 2004).

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 HCFCs. Accordingly, atmospheric concentrations of these substitutes have been growing (IPCC 2001).

⁵ Emissions estimates of CFCs, HCFCs, halons and other ozone-depleting substances are included in the annexes of the Inventory report for informational purposes.

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 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 CO₂, and therefore GWP-weighted emissions are measured in teragrams of CO₂ equivalent (Tg CO₂ Eq.).⁷ All gases in this Executive Summary are presented in units of Tg CO₂ Eq.

The UNFCCC reporting guidelines for national inventories were updated in 2002,⁸ but continue to require the use of GWPs from the IPCC Second Assessment Report (SAR). This requirement ensures that current estimates of aggregate greenhouse gas emissions for 1990 to 2004 are consistent with estimates developed prior to the publication of the IPCC Third Assessment Report (TAR). 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 CO₂ equivalents and unweighted units. A comparison of emission values using the SAR GWPs versus the TAR 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 below 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 ₂ O | 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 ₂ F ₆ | 9,200 |
| C ₄ F ₁₀ | 7,000 |
| C ₆ F ₁₄ | 7,400 |
| SF ₆ | 23,900 |

Source: IPCC (1996)

* The CH₄ 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 CO₂ is not included.

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 12/44th of carbon dioxide by weight.

⁸ See <<http://unfccc.int/resource/docs/cop8/08.pdf>>.

Global warming potentials are not provided for CO, NO_x, NMVOCs, SO₂, 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 2004, total U.S. greenhouse gas emissions were 7,074.4 Tg CO₂ Eq. Overall, total U.S. emissions have risen by 15.8 percent from 1990 to 2004, while the U.S. gross domestic product has increased by 51 percent over the same period (BEA 2005). Emissions rose from 2003 to 2004, increasing by 1.7 percent (115.3 Tg CO₂ Eq.). The following factors were primary contributors to this increase: 1) robust economic growth in 2004, leading to increased demand for electricity and fossil fuels, 2) expanding industrial production in energy-intensive industries, also increasing demand for electricity and fossil fuels, and 3) increased travel, leading to higher rates of consumption of petroleum fuels.

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 2004.

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

Table ES-2: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks (Tg CO₂ Eq.)

| Gas/Source | 1990 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|--|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| CO₂ | 5,005.3 | 5,620.2 | 5,695.0 | 5,864.5 | 5,795.2 | 5,815.9 | 5,877.7 | 5,988.0 |
| Fossil Fuel Combustion | 4,696.6 | 5,271.8 | 5,342.4 | 5,533.7 | 5,486.9 | 5,501.8 | 5,571.1 | 5,656.6 |
| Non-Energy Use of Fuels | 117.2 | 152.8 | 160.6 | 140.7 | 131.0 | 136.5 | 133.5 | 153.4 |
| Iron and Steel Production | 85.0 | 67.7 | 63.8 | 65.3 | 57.8 | 54.6 | 53.3 | 51.3 |
| Cement Manufacture | 33.3 | 39.2 | 40.0 | 41.2 | 41.4 | 42.9 | 43.1 | 45.6 |
| Waste Combustion | 10.9 | 17.1 | 17.6 | 17.9 | 18.6 | 18.9 | 19.4 | 19.4 |
| Ammonia Production and Urea Application | 19.3 | 21.9 | 20.6 | 19.6 | 16.7 | 18.5 | 15.3 | 16.9 |
| Lime Manufacture | 11.2 | 13.9 | 13.5 | 13.3 | 12.8 | 12.3 | 13.0 | 13.7 |
| Limestone and Dolomite Use | 5.5 | 7.4 | 8.1 | 6.0 | 5.7 | 5.9 | 4.7 | 6.7 |
| Natural Gas Flaring | 5.8 | 6.6 | 6.9 | 5.8 | 6.1 | 6.2 | 6.1 | 6.0 |
| Aluminum Production | 7.0 | 6.4 | 6.5 | 6.2 | 4.5 | 4.6 | 4.6 | 4.3 |
| Soda Ash Manufacture and Consumption | 4.1 | 4.3 | 4.2 | 4.2 | 4.1 | 4.1 | 4.1 | 4.2 |
| Petrochemical Production | 2.2 | 3.0 | 3.1 | 3.0 | 2.8 | 2.9 | 2.8 | 2.9 |
| Titanium Dioxide Production | 1.3 | 1.8 | 1.9 | 1.9 | 1.9 | 2.0 | 2.0 | 2.3 |
| Phosphoric Acid Production | 1.5 | 1.6 | 1.5 | 1.4 | 1.3 | 1.3 | 1.4 | 1.4 |
| Ferroalloy Production | 2.0 | 2.0 | 2.0 | 1.7 | 1.3 | 1.2 | 1.2 | 1.3 |
| CO ₂ Consumption | 0.9 | 0.9 | 0.8 | 1.0 | 0.8 | 1.0 | 1.3 | 1.2 |
| Zinc Production | 0.9 | 1.1 | 1.1 | 1.1 | 1.0 | 0.9 | 0.5 | 0.5 |
| Lead Production | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Silicon Carbide Consumption | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| <i>Net CO₂ Flux from Land Use, Land-Use Change and Forestry^a</i> | <i>(910.4)</i> | <i>(744.0)</i> | <i>(765.7)</i> | <i>(759.5)</i> | <i>(768.0)</i> | <i>(768.6)</i> | <i>(774.8)</i> | <i>(780.1)</i> |

| | | | | | | | | |
|---|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| <i>International Bunker Fuels^b</i> | 113.5 | 114.6 | 105.2 | 101.4 | 97.8 | 89.5 | 84.1 | 94.5 |
| <i>Biomass Combustion^b</i> | 216.7 | 217.2 | 222.3 | 226.8 | 200.5 | 194.4 | 202.1 | 211.2 |
| CH₄ | 618.1 | 579.5 | 569.0 | 566.9 | 560.3 | 559.8 | 564.4 | 556.7 |
| Landfills | 172.3 | 144.4 | 141.6 | 139.0 | 136.2 | 139.8 | 142.4 | 140.9 |
| Natural Gas Systems | 126.7 | 125.4 | 121.7 | 126.7 | 125.6 | 125.4 | 124.7 | 118.8 |
| Enteric Fermentation | 117.9 | 116.7 | 116.8 | 115.6 | 114.6 | 114.7 | 115.1 | 112.6 |
| Coal Mining | 81.9 | 62.8 | 58.9 | 56.3 | 55.5 | 52.5 | 54.8 | 56.3 |
| Manure Management | 31.2 | 38.8 | 38.1 | 38.0 | 38.9 | 39.3 | 39.2 | 39.4 |
| Wastewater Treatment | 24.8 | 32.6 | 33.6 | 34.3 | 34.7 | 35.8 | 36.6 | 36.9 |
| Petroleum Systems | 34.4 | 29.7 | 28.5 | 27.8 | 27.4 | 26.8 | 25.9 | 25.7 |
| Rice Cultivation | 7.1 | 7.9 | 8.3 | 7.5 | 7.6 | 6.8 | 6.9 | 7.6 |
| Stationary Sources | 7.9 | 6.8 | 7.0 | 7.3 | 6.6 | 6.2 | 6.5 | 6.4 |
| Abandoned Coal Mines | 6.0 | 6.9 | 6.9 | 7.2 | 6.6 | 6.0 | 5.8 | 5.6 |
| Mobile Sources | 4.7 | 3.8 | 3.6 | 3.5 | 3.3 | 3.2 | 3.0 | 2.9 |
| Petrochemical Production | 1.2 | 1.7 | 1.7 | 1.7 | 1.4 | 1.5 | 1.5 | 1.6 |
| Iron and Steel Production | 1.3 | 1.2 | 1.2 | 1.2 | 1.1 | 1.0 | 1.0 | 1.0 |
| Agricultural Residue Burning | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 0.8 | 0.9 |
| Silicon Carbide Production | + | + | + | + | + | + | + | + |
| <i>International Bunker Fuels^b</i> | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| N₂O | 394.9 | 440.6 | 419.4 | 416.2 | 412.8 | 407.4 | 386.1 | 386.7 |
| Agricultural Soil Management | 266.1 | 301.1 | 281.2 | 278.2 | 282.9 | 277.8 | 259.2 | 261.5 |
| Mobile Sources | 43.5 | 54.8 | 54.1 | 53.1 | 50.0 | 47.5 | 44.8 | 42.8 |
| Manure Management | 16.3 | 17.4 | 17.4 | 17.8 | 18.1 | 18.0 | 17.5 | 17.7 |
| Nitric Acid Production | 17.8 | 20.9 | 20.1 | 19.6 | 15.9 | 17.2 | 16.7 | 16.6 |
| Human Sewage | 12.9 | 14.9 | 15.4 | 15.5 | 15.6 | 15.6 | 15.8 | 16.0 |
| Stationary Sources | 12.3 | 13.4 | 13.4 | 13.9 | 13.5 | 13.2 | 13.6 | 13.7 |
| Settlements Remaining Settlements | 5.6 | 6.2 | 6.2 | 6.0 | 5.8 | 6.0 | 6.2 | 6.4 |
| Adipic Acid Production | 15.2 | 6.0 | 5.5 | 6.0 | 4.9 | 5.9 | 6.2 | 5.7 |
| N ₂ O Product Usage | 4.3 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 |
| Waste Combustion | 0.5 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 |
| Agricultural Residue Burning | 0.4 | 0.5 | 0.4 | 0.5 | 0.5 | 0.4 | 0.4 | 0.5 |
| Forest Land Remaining Forest | | | | | | | | |
| Land | 0.1 | 0.4 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| <i>International Bunker Fuels^b</i> | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 0.8 | 0.8 | 0.9 |
| HFCs, PFCs, and SF₆ | 90.8 | 133.4 | 131.5 | 134.7 | 124.9 | 132.7 | 131.0 | 143.0 |
| Substitution of Ozone Depleting | | | | | | | | |
| Substances | 0.4 | 54.5 | 62.8 | 71.2 | 78.6 | 86.2 | 93.5 | 103.3 |
| HCFC-22 Production | 35.0 | 40.1 | 30.4 | 29.8 | 19.8 | 19.8 | 12.3 | 15.6 |
| Electrical Transmission and | | | | | | | | |
| Distribution | 28.6 | 16.7 | 16.1 | 15.3 | 15.3 | 14.5 | 14.0 | 13.8 |
| Semiconductor Manufacture | 2.9 | 7.1 | 7.2 | 6.3 | 4.5 | 4.4 | 4.3 | 4.7 |
| Aluminum Production | 18.4 | 9.1 | 9.0 | 9.0 | 4.0 | 5.3 | 3.8 | 2.8 |
| Magnesium Production and | | | | | | | | |
| Processing | 5.4 | 5.8 | 6.0 | 3.2 | 2.6 | 2.6 | 3.0 | 2.7 |
| Total | 6,109.0 | 6,773.7 | 6,814.9 | 6,982.3 | 6,893.1 | 6,915.8 | 6,959.1 | 7,074.4 |
| Net Emissions (Sources and Sinks) | 5,198.6 | 6,029.6 | 6,049.2 | 6,222.8 | 6,125.1 | 6,147.2 | 6,184.3 | 6,294.3 |

+ Does not exceed 0.05 Tg CO₂ Eq.

^a Parentheses indicate negative values or sequestration. The net CO₂ 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.

Note: Totals may not sum due to independent rounding.

Figure ES-4 illustrates the relative contribution of the direct greenhouse gases to total U.S. emissions in 2004. The primary greenhouse gas emitted by human activities in the United States was CO₂, representing approximately 85 percent of total greenhouse gas emissions. The largest source of CO₂, and of overall greenhouse gas emissions, was

fossil fuel combustion. CH₄ emissions, which have steadily declined since 1990, resulted primarily from decomposition of wastes in landfills, natural gas systems, and enteric fermentation associated with domestic livestock. Agricultural soil management and mobile source fossil fuel combustion were the major sources of N₂O 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 SF₆ emissions, while PFC emissions resulted from semiconductor manufacturing and as a by-product of primary aluminum production.

Figure ES-4: 2004 Greenhouse Gas Emissions by Gas

Overall, from 1990 to 2004, total emissions of CO₂ increased by 982.7 Tg CO₂ Eq. (20 percent), while CH₄ and N₂O emissions decreased by 61.3 Tg CO₂ Eq. (10 percent) and 8.2 Tg CO₂ Eq. (2 percent), respectively. During the same period, aggregate weighted emissions of HFCs, PFCs, and SF₆ rose by 52.2 Tg CO₂ Eq. (58 percent). Despite being emitted in smaller quantities relative to the other principal greenhouse gases, emissions of HFCs, PFCs, and SF₆ are significant because many of them have extremely high global warming potentials and, in the cases of PFCs and SF₆, 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 11 percent of total emissions in 2004. 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 CO₂ 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 CO₂ have risen about 35 percent (IPCC 2001, Hofmann 2004), principally due to the combustion of fossil fuels. Within the United States, fuel combustion accounted for 94 percent of CO₂ emissions in 2004. Globally, approximately 25,575 Tg of CO₂ were added to the atmosphere through the combustion of fossil fuels in 2002, of which the United States accounted for about 23 percent.⁹ Changes in land use and forestry practices can also emit CO₂ (e.g., through conversion of forest land to agricultural or urban use) or can act as a sink for CO₂ (e.g., through net additions to forest biomass).

Figure ES-5: 2004 Sources of CO₂

As the largest source of U.S. greenhouse gas emissions, CO₂ from fossil fuel combustion has accounted for approximately 80 percent of GWP weighted emissions since 1990, growing slowly from 77 percent of total GWP-weighted emissions in 1990 to 80 percent in 2004.. Emissions of CO₂ from fossil fuel combustion increased at an average annual rate of 1.3 percent from 1990 to 2004. The fundamental factors influencing this trend include (1) a generally growing domestic economy over the last 14 years, and (2) significant growth in emissions from transportation activities and electricity generation. Between 1990 and 2004, CO₂ emissions from fossil fuel combustion increased from 4,696.6 Tg CO₂ Eq. to 5,656.6 Tg CO₂ Eq.—a 20 percent total increase over the fourteen-year period. Historically, changes in emissions from fossil fuel combustion have been the dominant factor affecting U.S. emission trends.

From 2003 to 2004, these emissions increased by 85.5 Tg CO₂ Eq. (1.5 percent). A number of factors played a

⁹ Global CO₂ emissions from fossil fuel combustion were taken from Marland et al. (2005) <http://cdiac.esd.ornl.gov/trends/emis/tre_glob.htm>.

major role in the magnitude of this increase. Strong growth in the U.S. economy and industrial production, particularly in energy-intensive industries, caused an increase in the demand for electricity and fossil fuels. Demand for travel was also higher, causing an increase in petroleum consumed for transportation. In contrast, the warmer winter conditions led to decreases in demand for heating fuels in both the residential and commercial sectors. Moreover, much of the increased electricity demanded was generated by natural gas consumption and nuclear power, rather than more carbon intensive coal, moderating the increase in CO₂ emissions from electricity generation. Use of renewable fuels rose very slightly due to increases in the use of biofuels.

Figure ES-6: 2004 CO₂ Emissions from Fossil Fuel Combustion by Sector and Fuel Type

Figure ES-7: 2004 End-Use Sector Emissions of CO₂ from Fossil Fuel Combustion

The four major end-use sectors contributing to CO₂ emissions from fossil fuel combustion are industrial, transportation, residential, and commercial. Electricity generation also emits CO₂, although these 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 CO₂ emissions from fossil fuel combustion by end-use sector.

Table ES-3: CO₂ Emissions from Fossil Fuel Combustion by End-Use Sector (Tg CO₂ Eq.)

| End-Use Sector | 1990 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|-------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Transportation | 1,464.4 | 1,663.4 | 1,725.6 | 1,770.3 | 1,757.0 | 1,802.2 | 1,805.4 | 1,860.2 |
| Combustion | 1,461.4 | 1,660.3 | 1,722.4 | 1,766.9 | 1,753.6 | 1,798.8 | 1,801.0 | 1,855.5 |
| Electricity | 3.0 | 3.1 | 3.2 | 3.4 | 3.5 | 3.4 | 4.3 | 4.7 |
| Industrial | 1,528.3 | 1,634.5 | 1,613.5 | 1,642.8 | 1,574.9 | 1,542.8 | 1,572.4 | 1,595.0 |
| Combustion | 851.1 | 871.9 | 849.0 | 862.6 | 861.2 | 842.1 | 844.6 | 863.5 |
| Electricity | 677.2 | 762.6 | 764.5 | 780.3 | 713.7 | 700.7 | 727.7 | 731.5 |
| Residential | 922.8 | 1,044.5 | 1,064.0 | 1,123.2 | 1,123.2 | 1,139.8 | 1,166.6 | 1,166.8 |
| Combustion | 338.0 | 333.5 | 352.3 | 369.9 | 361.5 | 360.0 | 378.8 | 369.6 |
| Electricity | 584.8 | 711.0 | 711.7 | 753.3 | 761.7 | 779.8 | 787.9 | 797.2 |
| Commercial | 753.1 | 895.9 | 904.8 | 961.6 | 983.3 | 973.9 | 978.1 | 983.1 |
| Combustion | 222.6 | 217.7 | 218.6 | 229.3 | 224.9 | 224.3 | 235.8 | 226.0 |
| Electricity | 530.5 | 678.2 | 686.2 | 732.4 | 758.4 | 749.6 | 742.2 | 757.2 |
| U.S. Territories | 28.0 | 33.5 | 34.5 | 35.8 | 48.5 | 43.1 | 48.7 | 51.4 |
| Total | 4,696.6 | 5,271.8 | 5,342.4 | 5,533.7 | 5,486.9 | 5,501.8 | 5,571.1 | 5,656.6 |
| Electricity Generation | 1,795.5 | 2,154.9 | 2,165.6 | 2,269.3 | 2,237.3 | 2,233.5 | 2,262.2 | 2,290.6 |

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.

Transportation End-Use Sector. Transportation activities (excluding international bunker fuels) accounted for 33 percent of CO₂ emissions from fossil fuel combustion in 2004.¹⁰ Virtually all of the energy consumed in this end-

¹⁰ If emissions from international bunker fuels are included, the transportation end-use sector accounted for 34 percent of U.S.

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 CO₂ 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 CO₂ from fossil fuel combustion in 2004. About half of these emissions resulted from direct fossil fuel combustion to produce steam and/or heat for industrial processes. The other half of the 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 21 and 17 percent, respectively, of CO₂ emissions from fossil fuel combustion in 2004. Both sectors relied heavily on electricity for meeting energy demands, with 68 and 77 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 34 percent of U.S. energy from fossil fuels and emitted 40 percent of the CO₂ from fossil fuel combustion in 2004. The type of fuel combusted by electricity generators has a significant effect on their emissions. For example, some electricity is generated with low CO₂ 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 2004. Consequently, changes in electricity demand have a significant impact on coal consumption and associated CO₂ emissions.

Other significant CO₂ trends included the following:

- CO₂ emissions from iron and steel production decreased to 51.3 Tg CO₂ Eq. in 2004, and have declined by 33.7 Tg CO₂ Eq. (40 percent) from 1990 through 2004, due to reduced domestic production of pig iron, sinter, and coal coke.
- CO₂ emissions from cement production increased to 45.6 Tg CO₂ Eq. in 2004, a 37 percent increase in emissions since 1990. Emissions mirror growth in the construction industry. In contrast to many other manufacturing sectors, demand for domestic cement remains strong because it is not cost-effective to transport cement far from its point of manufacture.
- CO₂ emissions from waste combustion (19.4 Tg CO₂ Eq. in 2004) increased by 8.4 Tg CO₂ Eq. (77 percent) from 1990 through 2004, as the volume of plastics and other fossil carbon-containing materials in municipal solid waste grew.
- Net CO₂ sequestration from Land Use, Land-Use Change, and Forestry decreased by 130.3 Tg CO₂ Eq. (14 percent) from 1990 through 2004. This decline was primarily due to a decline in the rate of net carbon accumulation in forest carbon stocks. Annual carbon accumulation in landfilled yard trimmings and food scraps also slowed over this period, while the rate of carbon accumulation in agricultural soils and urban trees increased.

Methane Emissions

According to the IPCC, CH₄ is more than 20 times as effective as CO₂ at trapping heat in the atmosphere. Over the last two hundred and fifty years, the concentration of CH₄ in the atmosphere increased by 143 percent (IPCC 2001, Hofmann 2004). Experts believe that over half of this atmospheric increase was due to emissions from

emissions from fossil fuel combustion in 2004.

anthropogenic sources, such as landfills, natural gas and petroleum systems, agricultural activities, coal mining, wastewater treatment, stationary and mobile combustion, and certain industrial processes (see Figure ES-8).

Figure ES-8: 2004 U.S. Sources of CH₄

Some significant trends in U.S. emissions of CH₄ include the following:

- Landfills are the largest anthropogenic source of CH₄ emissions in the United States. In 2004, landfill CH₄ emissions were 140.9 Tg CO₂ Eq. (approximately 25 percent of total CH₄ emissions), which represents a decline of 31.4 Tg CO₂ Eq., or 18 percent, since 1990. Although the amount of solid waste landfilled each year continues to climb, the amount of CH₄ captured and burned at landfills has increased dramatically, countering this trend.
- CH₄ emissions from natural gas systems were 118.8 Tg CO₂ Eq. in 2004; emissions have declined by 7.9 Tg CO₂ Eq. (6 percent) since 1990. This decline has been due to improvements in technology and management practices, as well as some replacement of old equipment.
- Enteric fermentation was also a significant source of CH₄, accounting for 112.6 Tg CO₂ Eq. in 2004. This amount has declined by 5.3 Tg CO₂ Eq. (4 percent) since 1990, and by 10.4 Tg CO₂ Eq. (8 percent) from a high in 1995. Generally, emissions have been decreasing since 1995, mainly due to decreasing populations of both beef and dairy cattle and improved feed quality for feedlot cattle.

Nitrous Oxide Emissions

N₂O 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 N₂O emissions are much lower than CO₂ emissions, N₂O is approximately 300 times more powerful than CO₂ at trapping heat in the atmosphere. Since 1750, the global atmospheric concentration of N₂O has risen by approximately 18 percent (IPCC 2001, Hofmann 2004). The main anthropogenic activities producing N₂O in the United States are agricultural soil management, fuel combustion in motor vehicles, manure management, nitric acid production, human sewage, and stationary fuel combustion (see Figure ES-9).

Figure ES-9: 2004 U.S. Sources of N₂O

Some significant trends in U.S. emissions of N₂O include the following:

- Agricultural soil management activities such as fertilizer application and other cropping practices were the largest source of U.S. N₂O emissions, accounting for 68 percent (261.5 Tg CO₂ Eq.) of 2004 emissions. N₂O emissions from this source have not shown any significant long-term trend, as they are highly sensitive to such factors as temperature and precipitation, which have generally outweighed changes in the amount of nitrogen applied to soils.
- In 2004, N₂O emissions from mobile combustion were 42.8 Tg CO₂ Eq. (approximately 11 percent of U.S. N₂O emissions). From 1990 to 2004, N₂O emissions from mobile combustion decreased by 1 percent. However, from 1990 to 1998 emissions increased by 26 percent, due to control technologies that reduced CH₄ emissions while increasing N₂O emissions. Since 1998, new control technologies have led to a steady decline in N₂O from this source.

HFC, PFC, and SF₆ Emissions

HFCs and PFCs are families of synthetic chemicals that are being 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 SF₆, are potent greenhouse gases. In addition to having high global warming potentials, SF₆ 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).

Figure ES-10: 2004 U.S. Sources of HFCs, PFCs, and SF₆

Some significant trends in U.S. HFC, PFC, and SF₆ 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 103.3 Tg CO₂ Eq. in 2004. Emissions from substitutes for ozone depleting substances are both the largest and the fastest growing source of HFC, PFC and SF₆ 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.
- The increase in ODS emissions is offset substantially by decreases in emission of HFCs, PFCs, and SF₆ from other sources. Emissions from aluminum production decreased by 85 percent (15.6 Tg CO₂ Eq.) from 1990 to 2004, due to both industry emission reduction efforts and lower domestic aluminum production.
- Emissions from the production of HCFC-22 decreased by 55 percent (19.4 Tg CO₂ Eq.), due to a steady decline in the emission rate of HFC-23 (i.e., the amount of HFC-23 emitted per kilogram of HCFC-22 manufactured) and the use of thermal oxidation at some plants to reduce HFC-23 emissions.
- Emissions from electric power transmission and distribution systems decreased by 52 percent (14.8 Tg CO₂ Eq.) from 1990 to 2004, primarily because of higher purchase prices for SF₆ and efforts by industry to reduce emissions.

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.

Figure ES-11: U.S. Greenhouse Gas Emissions by Chapter/IPCC Sector

Table ES-4: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks by Chapter/IPCC Sector (Tg CO₂ Eq.)

| Chapter/IPCC Sector | 1990 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---------|---------|---------|---------|---------|---------|---------|---------|
| Energy | 5,148.3 | 5,752.3 | 5,822.3 | 5,994.3 | 5,931.6 | 5,944.6 | 6,009.8 | 6,108.2 |
| Industrial Processes | 301.1 | 335.1 | 327.5 | 329.6 | 300.7 | 310.9 | 304.1 | 320.7 |
| Solvent and Other Product Use | 4.3 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 |
| Agriculture | 439.6 | 483.2 | 463.1 | 458.4 | 463.4 | 457.8 | 439.1 | 440.1 |
| Land Use, Land-Use Change, and Forestry (Emissions) | 5.7 | 6.5 | 6.7 | 6.4 | 6.2 | 6.4 | 6.6 | 6.8 |
| Waste | 210.0 | 191.8 | 190.7 | 188.8 | 186.4 | 191.3 | 194.8 | 193.8 |

| | | | | | | | | |
|--|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Total | 6,109.0 | 6,773.7 | 6,814.9 | 6,982.3 | 6,893.1 | 6,915.8 | 6,959.1 | 7,074.4 |
| Net CO ₂ Flux from Land Use, Land-Use Change, and Forestry* | (910.4) | (744.0) | (765.7) | (759.5) | (768.0) | (768.6) | (774.8) | (780.1) |
| Net Emissions (Sources and Sinks) | 5,198.6 | 6,029.6 | 6,049.2 | 6,222.8 | 6,125.1 | 6,147.2 | 6,184.3 | 6,294.3 |

* The net CO₂ 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.

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. CO₂ emissions for the period of 1990 through 2004. In 2004, approximately 86 percent of the energy consumed in the United States was produced through the combustion of fossil fuels. The remaining 14 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 CH₄ and N₂O emissions (39 percent and 15 percent of total U.S. emissions of each gas, respectively). Overall, emission sources in the Energy chapter account for a combined 86 percent of total U.S. greenhouse gas emissions in 2004.

Figure ES-12: 2004 U.S. Energy Consumption by Energy Source

Industrial Processes

The Industrial Processes chapter contains by-product 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 CO₂, CH₄, and N₂O. The processes include iron and steel production, lead and zinc production, cement manufacture, ammonia manufacture and urea application, lime manufacture, limestone and dolomite use (e.g., flux stone, flue gas desulfurization, and glass manufacturing), soda ash manufacture and use, titanium dioxide production, phosphoric acid production, ferroalloy production, CO₂ consumption, aluminum production, petrochemical production, silicon carbide production, nitric acid production, and adipic acid production. Additionally, emissions from industrial processes release HFCs, PFCs and SF₆. Overall, emission sources in the Industrial Process chapter account for 4.5 percent of U.S. greenhouse gas emissions in 2004.

Solvent and Other Product Use

The Solvent and Other Product Use chapter contains greenhouse gas emissions that are produced as a by-product of various solvent and other product uses. In the United States, emissions from N₂O Product Usage, 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 2004.

Agriculture

The Agricultural chapter contains anthropogenic emissions from agricultural activities (except fuel combustion, which is addressed in the Energy 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. CH₄ and N₂O were the primary greenhouse gases emitted by agricultural activities. CH₄ emissions from enteric fermentation and manure management represented about 20 percent and 7 percent of total CH₄ emissions from anthropogenic activities, respectively, in 2004. Agricultural soil management activities such as fertilizer application and other cropping practices were the largest source of U.S. N₂O emissions in 2004, accounting for 68 percent. In 2004, emission sources accounted for in the Agricultural chapters were responsible

for 6.2 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 and removals of CO₂ 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 carbon in the United States. Forests (including vegetation, soils, and harvested wood) accounted for approximately 82 percent of total 2004 sequestration, urban trees accounted for 11 percent, agricultural soils (including mineral and organic soils and the application of lime) accounted for 6 percent, and landfilled yard trimmings and food scraps accounted for 1 percent of the total sequestration in 2004. 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 soils account for a net carbon sink that is almost two times larger than the sum of emissions from organic soils and liming. The mineral soil carbon sequestration is largely due to 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 2004 resulted in a net carbon sequestration of 780.1 Tg CO₂ Eq. (Table ES-5). This represents an offset of approximately 13 percent of total U.S. CO₂ emissions, or 11 percent of total greenhouse gas emissions in 2004. Total land use, land-use change, and forestry net carbon sequestration declined by approximately 14 percent between 1990 and 2004, which contributed to an increase in net U.S. emissions (all sources and sinks) of 21 percent from 1990 to 2004. This decline was primarily due to a decline in the rate of net carbon accumulation in forest carbon stocks. Annual carbon accumulation in landfilled yard trimmings and food scraps and agricultural soils also slowed over this period. However, the rate of annual carbon accumulation increased in both agricultural soils and urban trees.

Land use, land-use change, and forestry activities in 2004 also resulted in emissions of N₂O (6.8 Tg CO₂ Eq.). Total N₂O emissions from the application of fertilizers to forests and settlements increased by approximately 20 percent between 1990 and 2004.

Table ES-5: Net CO₂ Flux from Land Use, Land-Use Change, and Forestry (Tg CO₂ Eq.)

| Sink Category | 1990 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|--|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Forest Land Remaining Forest Land | (773.4) | (618.8) | (637.9) | (631.0) | (634.0) | (634.6) | (635.8) | (637.2) |
| Changes in Forest Carbon Stocks | (773.4) | (618.8) | (637.9) | (631.0) | (634.0) | (634.6) | (635.8) | (637.2) |
| Cropland Remaining Cropland | (33.1) | (24.6) | (24.6) | (26.1) | (27.8) | (27.5) | (28.7) | (28.9) |
| Changes in Agricultural Soil Carbon | | | | | | | | |
| Stocks and Liming Emissions | (33.1) | (24.6) | (24.6) | (26.1) | (27.8) | (27.5) | (28.7) | (28.9) |
| Land Converted to Cropland | 1.5 | (2.8) | (2.8) | (2.8) | (2.8) | (2.8) | (2.8) | (2.8) |
| Changes in Agricultural Soil Carbon | | | | | | | | |
| Stocks | 1.5 | (2.8) | (2.8) | (2.8) | (2.8) | (2.8) | (2.8) | (2.8) |
| Grassland Remaining Grassland | (4.5) | 7.5 | 7.5 | 7.4 | 7.4 | 7.4 | 7.3 | 7.3 |
| Changes in Agricultural Soil Carbon | | | | | | | | |
| Stocks | (4.5) | 7.5 | 7.5 | 7.4 | 7.4 | 7.4 | 7.3 | 7.3 |
| Land Converted to Grassland | (17.6) | (21.1) | (21.1) | (21.1) | (21.1) | (21.1) | (21.1) | (21.1) |
| Changes in Agricultural Soil Carbon | | | | | | | | |
| Stocks | (17.6) | (21.1) | (21.1) | (21.1) | (21.1) | (21.1) | (21.1) | (21.1) |
| Settlements Remaining Settlements | (83.2) | (84.2) | (86.8) | (85.9) | (89.7) | (89.9) | (93.8) | (97.3) |
| Urban Trees | (58.7) | (73.3) | (77.0) | (77.0) | (80.7) | (80.7) | (84.3) | (88.0) |
| Landfilled Yard Trimmings and Food | | | | | | | | |
| Scraps | (24.5) | (10.9) | (9.8) | (8.9) | (9.0) | (9.3) | (9.4) | (9.3) |
| Total | (910.4) | (744.0) | (765.7) | (759.5) | (768.0) | (768.6) | (774.8) | (780.1) |

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 CH₄ emissions, accounting for 25 percent of total U.S. CH₄ emissions.¹¹ Additionally, wastewater treatment accounts for 7 percent of U.S. CH₄ emissions. N₂O emissions from the discharge of wastewater treatment effluents into aquatic environments were estimated, as were N₂O emissions from the treatment process itself, using a simplified methodology. Wastewater treatment systems are a potentially significant source of N₂O emissions; however, methodologies are not currently available to develop a complete estimate. N₂O emissions from the treatment of the human sewage component of wastewater were estimated, however, using a simplified methodology. Overall, in 2004, emission sources accounted for in the Waste chapter generated 2.7 percent of total U.S. greenhouse gas emissions.

ES.4. Other Information

Emissions by Economic Sector

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

Table ES-6 summarizes emissions from each of these sectors, and Figure ES-13 shows the trend in emissions by sector from 1990 to 2004.

Figure ES-13: Emissions Allocated to Economic Sectors

Table ES-6: U.S. Greenhouse Gas Emissions Allocated to Economic Sectors (Tg CO₂ Eq.)

| Economic Sector | 1990 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|--|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Electric Power Industry | 1,846.4 | 2,202.4 | 2,213.3 | 2,315.9 | 2,284.4 | 2,280.1 | 2,308.5 | 2,337.8 |
| Transportation | 1,520.3 | 1,753.4 | 1,819.3 | 1,866.9 | 1,852.7 | 1,898.0 | 1,898.9 | 1,955.1 |
| Industry | 1,438.9 | 1,452.4 | 1,411.0 | 1,409.7 | 1,366.6 | 1,346.7 | 1,342.7 | 1,377.3 |
| Agriculture | 486.3 | 541.6 | 523.9 | 509.5 | 514.4 | 511.0 | 484.2 | 491.3 |
| Commercial | 433.6 | 428.0 | 430.6 | 443.0 | 439.5 | 447.5 | 466.5 | 459.9 |
| Residential | 349.4 | 353.3 | 372.6 | 390.4 | 381.6 | 380.1 | 399.8 | 391.1 |
| U.S. Territories | 33.8 | 42.7 | 44.2 | 46.9 | 54.0 | 52.4 | 58.6 | 61.9 |
| Total | 6,109.0 | 6,773.7 | 6,814.9 | 6,982.3 | 6,893.1 | 6,915.8 | 6,959.1 | 7,074.4 |
| Land Use, Land-Use Change, and Forestry Sinks | -910.4 | -744.0 | -765.7 | -759.5 | -768.0 | -768.6 | -774.8 | -780.1 |
| Net Emissions (Sources and Sinks) | 5,198.6 | 6,029.6 | 6,049.2 | 6,222.8 | 6,125.1 | 6,147.2 | 6,184.3 | 6,294.3 |

Note: Totals may not sum due to independent rounding. Emissions include CO₂, CH₄, N₂O, HFCs, PFCs, and SF₆. See Table 2-14 for more detailed data.

Using this categorization, emissions from electricity generation accounted for the largest portion (33 percent) of U.S. greenhouse gas emissions in 2004. 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 2004.

¹¹ 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 of the Inventory report.

In contrast to electricity generation and transportation, emissions from industry have in general declined over the past decade, although there was an increase in industrial emissions in 2004 (up 3 percent from 2003 levels). 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 efficiency improvements. The remaining 20 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 6 percent, and primarily consisted of CO₂ emissions from fossil fuel combustion. Activities related to agriculture accounted for roughly 7 percent of U.S. emissions; unlike other economic sectors, agricultural sector emissions were dominated by N₂O emissions from agricultural soil management and CH₄ emissions from enteric fermentation, rather than CO₂ from fossil fuel combustion. The commercial sector accounted for about 7 percent of emissions, while U.S. territories accounted for 1 percent.

CO₂ 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.

Electricity is ultimately consumed in the economic sectors described above. Table ES-7 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.¹² These source categories include CO₂ from fossil fuel combustion and the use of limestone and dolomite for flue gas desulfurization, CO₂ and N₂O from waste combustion, CH₄ and N₂O from stationary sources, and SF₆ 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 (30 percent) in 2004. 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, CO₂ 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 2004.

Table ES-7: U.S. Greenhouse Gas Emissions by Economic Sector with Electricity-Related Emissions Distributed (Tg CO₂ Eq.)

| Economic Sector | 1990 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Industry | 2,074.6 | 2,210.3 | 2,174.4 | 2,186.1 | 2,073.6 | 2,042.0 | 2,066.0 | 2,103.0 |
| Transportation | 1,523.4 | 1,756.5 | 1,822.5 | 1,870.3 | 1,856.2 | 1,901.4 | 1,903.2 | 1,959.8 |
| Commercial | 979.2 | 1,102.0 | 1,115.8 | 1,171.8 | 1,190.8 | 1,191.4 | 1,204.3 | 1,211.0 |
| Residential | 950.8 | 1,060.0 | 1,083.2 | 1,140.0 | 1,136.2 | 1,154.1 | 1,182.9 | 1,181.9 |
| Agriculture | 547.2 | 602.4 | 575.0 | 567.2 | 582.6 | 574.5 | 544.3 | 556.9 |
| U.S. Territories | 33.8 | 42.7 | 44.2 | 46.9 | 54.0 | 52.4 | 58.6 | 61.9 |
| Total | 6,109.0 | 6,773.7 | 6,814.9 | 6,982.3 | 6,893.1 | 6,915.8 | 6,959.1 | 7,074.4 |
| Land Use, Land-Use Change, and Forestry (Sinks) | -910.4 | -744.0 | -765.7 | -759.5 | -768.0 | -768.6 | -774.8 | -780.1 |
| Net Emissions (Sources and Sinks) | 5,198.6 | 6,029.6 | 6,049.2 | 6,222.8 | 6,125.1 | 6,147.2 | 6,184.3 | 6,294.3 |

See Table 2-16 for more detailed data.

¹² 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.

Figure ES-14: Emissions with Electricity Distributed to Economic Sectors

[BEGIN BOX]

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 2004; 4) emissions per unit of total gross domestic product as a measure of national economic activity; or 5) emissions per capita.

Table ES-8 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 1.1 percent since 1990. This rate is 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 more slowly than national population since 1990 (see Figure ES-15). Overall, global atmospheric CO₂ concentrations—a function of many complex anthropogenic and natural processes—are increasing at 0.4 percent per year.

Table ES-8: Recent Trends in Various U.S. Data (Index 1990 = 100) and Global Atmospheric CO₂ Concentration

| Variable | 1991 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | Growth Rate ^f |
|--|------|------|------|------|------|------|------|------|--------------------------|
| Greenhouse Gas Emissions ^a | 99 | 111 | 112 | 114 | 113 | 113 | 114 | 116 | 1.1% |
| Energy Consumption ^b | 100 | 112 | 114 | 117 | 114 | 116 | 116 | 118 | 1.2% |
| Fossil Fuel Consumption ^b | 99 | 113 | 114 | 117 | 115 | 116 | 117 | 118 | 1.2% |
| Electricity Consumption ^b | 102 | 121 | 123 | 127 | 125 | 128 | 129 | 131 | 2.0% |
| GDP ^c | 100 | 127 | 133 | 138 | 139 | 141 | 145 | 151 | 3.0% |
| Population ^d | 101 | 110 | 112 | 113 | 114 | 115 | 116 | 117 | 1.1% |
| Atmospheric CO ₂ Concentration ^e | 100 | 103 | 104 | 104 | 105 | 105 | 106 | 106 | 0.4% |

^a GWP weighted values

^b Energy content weighted values (EIA 2004a)

^c Gross Domestic Product in chained 2000 dollars (BEA 2005)

^d U.S. Census Bureau (2005)

^e Hofmann (2004)

^f Average annual growth rate

Figure ES-15: U.S. Greenhouse Gas Emissions Per Capita and Per Dollar of Gross Domestic Product

Source: BEA (2005), U.S. Census Bureau (2005), and emission estimates in this report.

[END BOX]

Indirect Greenhouse Gases (CO, NO_x, NMVOCs, and SO₂)

The reporting requirements of the UNFCCC¹³ request that information be provided on indirect greenhouse gases, which include CO, NO_x, NMVOCs, and SO₂. 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 SO₂, by affecting the absorptive characteristics of the atmosphere. Additionally, some of these gases may 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 SO₂ (EPA 2005),¹⁴ which are regulated under the Clean Air Act. Table ES-9 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.

Table ES-9: Emissions of NO_x, CO, NMVOCs, and SO₂ (Gg)

| Gas/Activity | 1990 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|-----------------------------------|----------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| NO_x | 22,860 | 21,964 | 20,530 | 20,288 | 19,414 | 18,850 | 17,995 | 17,076 |
| Stationary Fossil Fuel Combustion | 9,884 | 9,419 | 8,344 | 8,002 | 7,667 | 7,522 | 7,138 | 6,662 |
| Mobile Fossil Fuel Combustion | 12,134 | 11,592 | 11,300 | 11,395 | 10,823 | 10,389 | 9,916 | 9,465 |
| Oil and Gas Activities | 139 | 130 | 109 | 111 | 113 | 135 | 135 | 135 |
| Waste Combustion | 82 | 145 | 143 | 114 | 114 | 134 | 134 | 134 |
| Industrial Processes | 591 | 637 | 595 | 626 | 656 | 630 | 631 | 632 |
| Solvent Use | 1 | 3 | 3 | 3 | 3 | 6 | 6 | 6 |
| Agricultural Burning | 28 | 35 | 34 | 35 | 35 | 33 | 34 | 39 |
| Waste | 0 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| CO | 130,580 | 98,984 | 94,361 | 92,895 | 89,329 | 87,428 | 87,518 | 87,599 |
| Stationary Fossil Fuel Combustion | 4,999 | 3,927 | 5,024 | 4,340 | 4,377 | 4,020 | 4,020 | 4,020 |
| Mobile Fossil Fuel Combustion | 119,482 | 87,940 | 83,484 | 83,680 | 79,972 | 78,574 | 78,574 | 78,574 |
| Oil and Gas Activities | 302 | 332 | 145 | 146 | 147 | 116 | 116 | 116 |
| Waste Combustion | 978 | 2,826 | 2,725 | 1,670 | 1,672 | 1,672 | 1,672 | 1,672 |
| Industrial Processes | 4,124 | 3,163 | 2,156 | 2,217 | 2,339 | 2,286 | 2,286 | 2,286 |
| Solvent Use | 4 | 1 | 46 | 46 | 45 | 46 | 46 | 46 |
| Agricultural Burning | 689 | 789 | 767 | 790 | 770 | 706 | 796 | 877 |
| Waste | 1 | 5 | 13 | 8 | 8 | 8 | 8 | 8 |
| NMVOCs | 20,937 | 16,403 | 15,869 | 15,228 | 15,048 | 14,217 | 13,877 | 13,556 |
| Stationary Fossil Fuel Combustion | 912 | 1,016 | 1,045 | 1,077 | 1,080 | 923 | 922 | 922 |
| Mobile Fossil Fuel Combustion | 10,933 | 7,742 | 7,586 | 7,230 | 6,872 | 6,560 | 6,212 | 5,882 |
| Oil and Gas Activities | 555 | 440 | 414 | 389 | 400 | 340 | 341 | 341 |
| Waste Combustion | 222 | 326 | 302 | 257 | 258 | 281 | 282 | 282 |
| Industrial Processes | 2,426 | 2,047 | 1,813 | 1,773 | 1,769 | 1,723 | 1,725 | 1,727 |
| Solvent Use | 5,217 | 4,671 | 4,569 | 4,384 | 4,547 | 4,256 | 4,262 | 4,267 |
| Agricultural Burning | NA | NA | NA | NA | NA | NA | NA | NA |
| Waste | 673 | 161 | 140 | 119 | 122 | 133 | 134 | 134 |
| SO₂ | 20,936 | 17,189 | 15,917 | 14,829 | 14,452 | 13,928 | 14,208 | 13,910 |
| Stationary Fossil Fuel Combustion | 18,407 | 15,191 | 13,915 | 12,848 | 12,461 | 11,946 | 12,220 | 11,916 |
| Mobile Fossil Fuel Combustion | 793 | 665 | 704 | 632 | 624 | 631 | 637 | 644 |

¹³ See <<http://unfccc.int/resource/docs/cop8/08.pdf>>.

¹⁴ NO_x and CO emission estimates from field burning of agricultural residues were estimated separately, and therefore not taken from EPA (2004).

| | | | | | | | | |
|------------------------|-------|-----|-----|-------|-------|-------|-------|-------|
| Oil and Gas Activities | 390 | 310 | 283 | 286 | 289 | 315 | 315 | 315 |
| Waste Combustion | 39 | 30 | 30 | 29 | 30 | 24 | 24 | 24 |
| Industrial Processes | 1,306 | 991 | 984 | 1,031 | 1,047 | 1,009 | 1,009 | 1,009 |
| Solvent Use | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Agricultural Burning | NA | NA | NA | NA | NA | NA | NA | NA |
| Waste | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Source: (EPA 2005) except for estimates from field burning of agricultural residues.

+ Does not exceed 0.5 Gg

NA (Not Available)

Note: Totals may not sum due to independent rounding.

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.”¹⁵ 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 2004 emission estimates for the 2004 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 to source and sink category names which differ from those used elsewhere in the Inventory report. For more information regarding key categories, see section 1.5 and Annex 1 of the Inventory report.

Figure ES-16: 2004 Key Categories—Tier 1 Level Assessment

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 CO₂ 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

¹⁵ See Chapter 7 “Methodological Choice and Recalculation” in IPCC (2000).
<<http://www.ipcc-nggip.iges.or.jp/public/gp/gpqaum.htm>>

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.

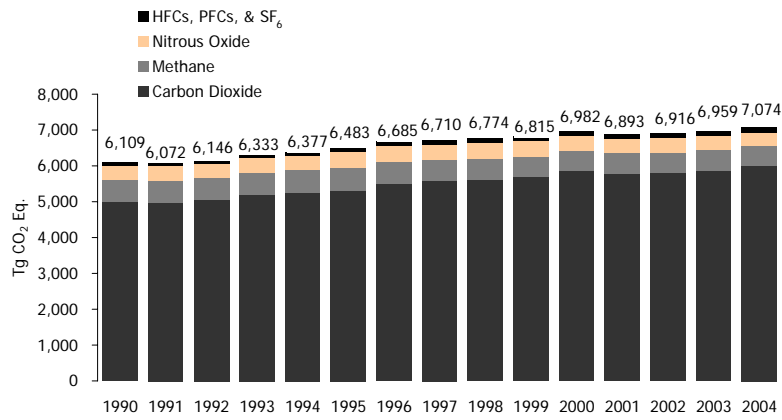


Figure ES-1: U.S. GHG Emissions by Gas

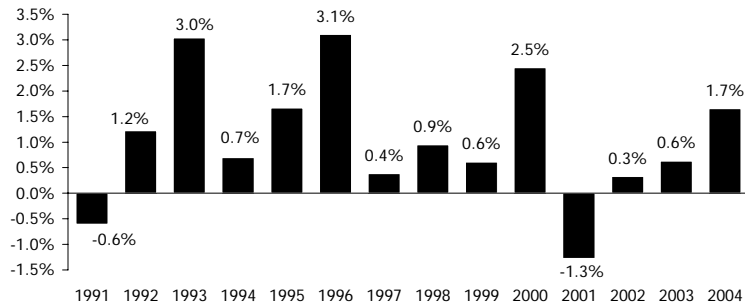


Figure ES-2: Annual Percent Change in U.S. Greenhouse Gas Emissions

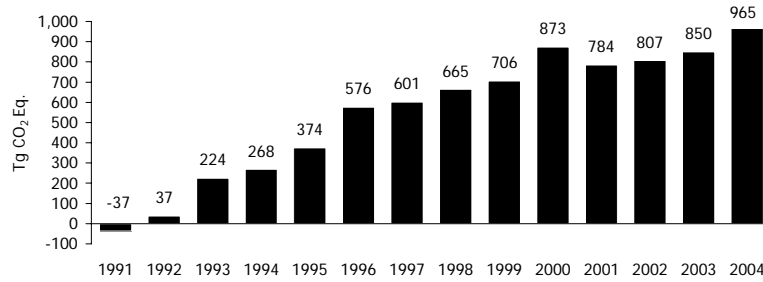


Figure ES-3: Cumulative Change in U.S. Greenhouse Gas Emissions Relative to 1990

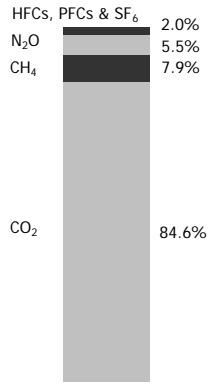


Figure ES-4: 2004 Greenhouse Gas Emissions by Gas

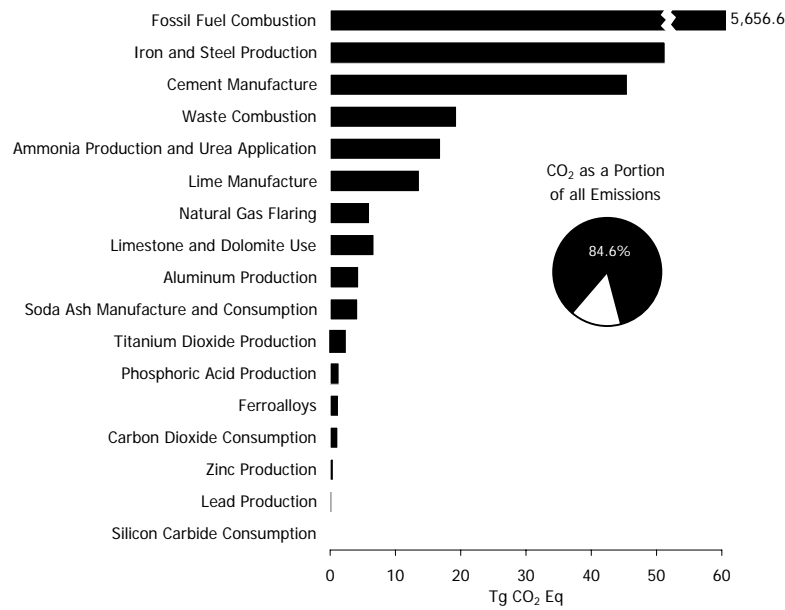


Figure ES-5: 2004 Sources of CO₂

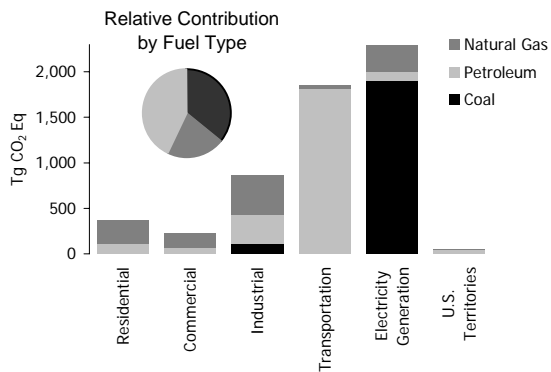


Figure ES-6: 2004 CO₂ Emissions from Fossil Fuel Combustion by Sector and Fuel Type
 Note: Electricity generation also includes emissions of less than 1 Tg CO₂ Eq. from geothermal-based electricity generation.

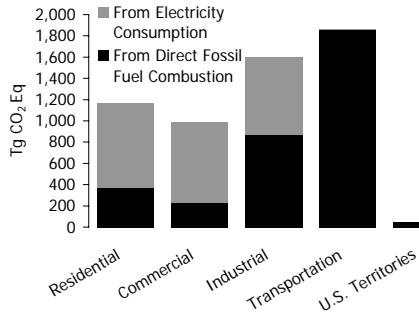


Figure ES-7: 2004 End-Use Sector Emissions of CO₂ from Fossil Fuel Combustion

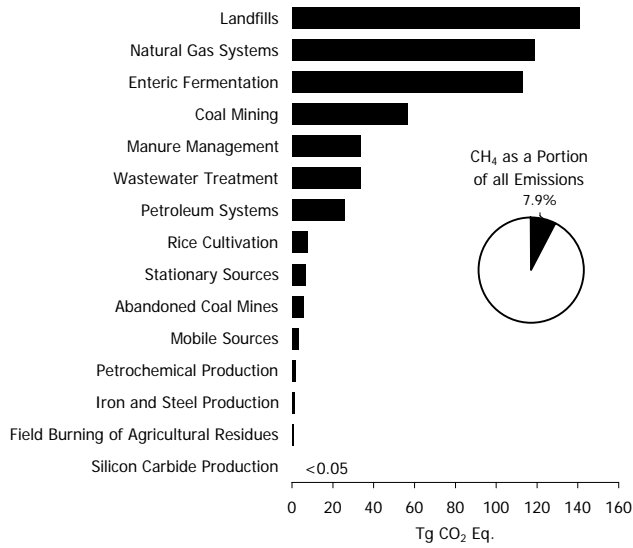


Figure ES-8: 2004 Sources of CH₄

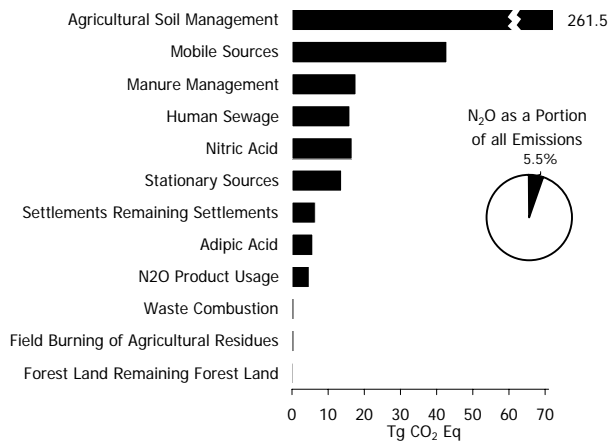


Figure ES-9: 2004 Sources of N₂O

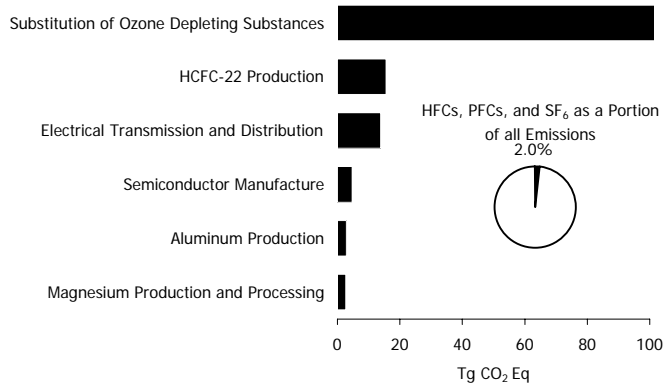
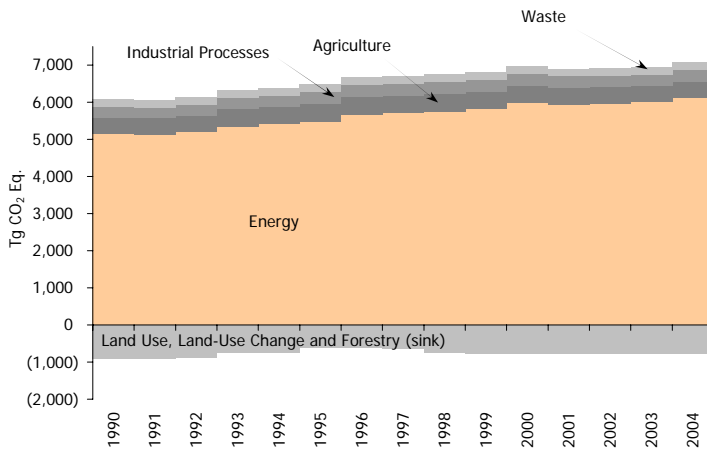


Figure ES-10: 2004 Sources of HFCs, PFCs, and SF₆



Note: Relatively smaller amounts of GWP-weighted emissions are also emitted from the Land-Use Change and Forestry sector and the Solvent and Other Product
 Figure ES-11: U.S. Greenhouse Gas Emissions and Sinks by Chapter/IPCC Sector

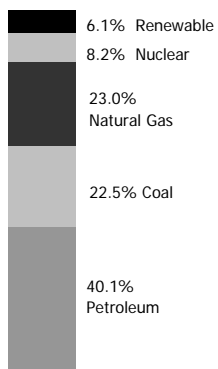


Figure ES-12: 2004 U.S. Energy Consumption by Energy Source

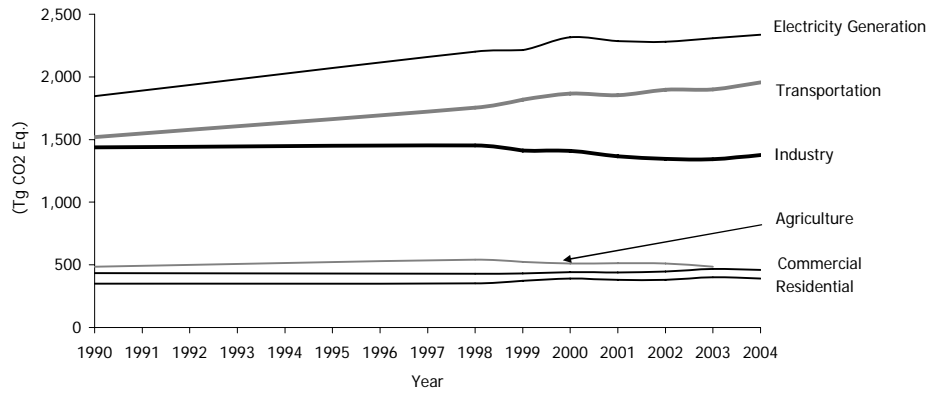


Figure ES-13: Emissions Allocated to Economic Sectors
 Note: Does not include U.S. territories.

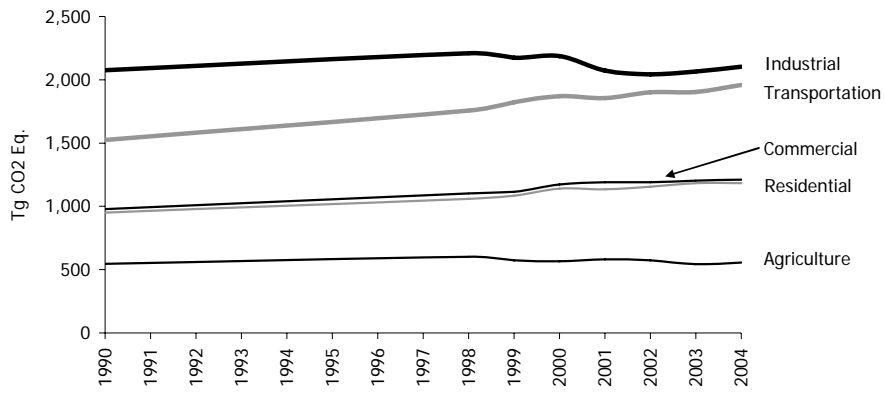


Figure ES-14: Emissions with Electricity Distributed to Economic Sectors
 Note: Does not include U.S. territories.

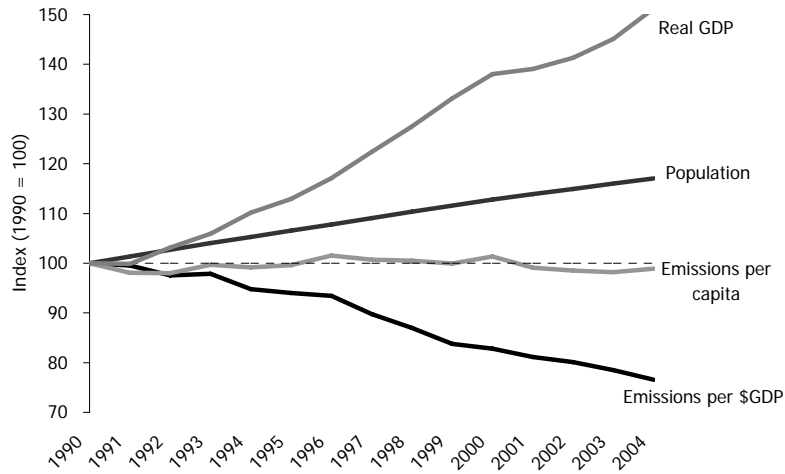


Figure ES-15: U.S. Greenhouse Gas Emissions Per Capita and Per Dollar of Gross Domestic Product

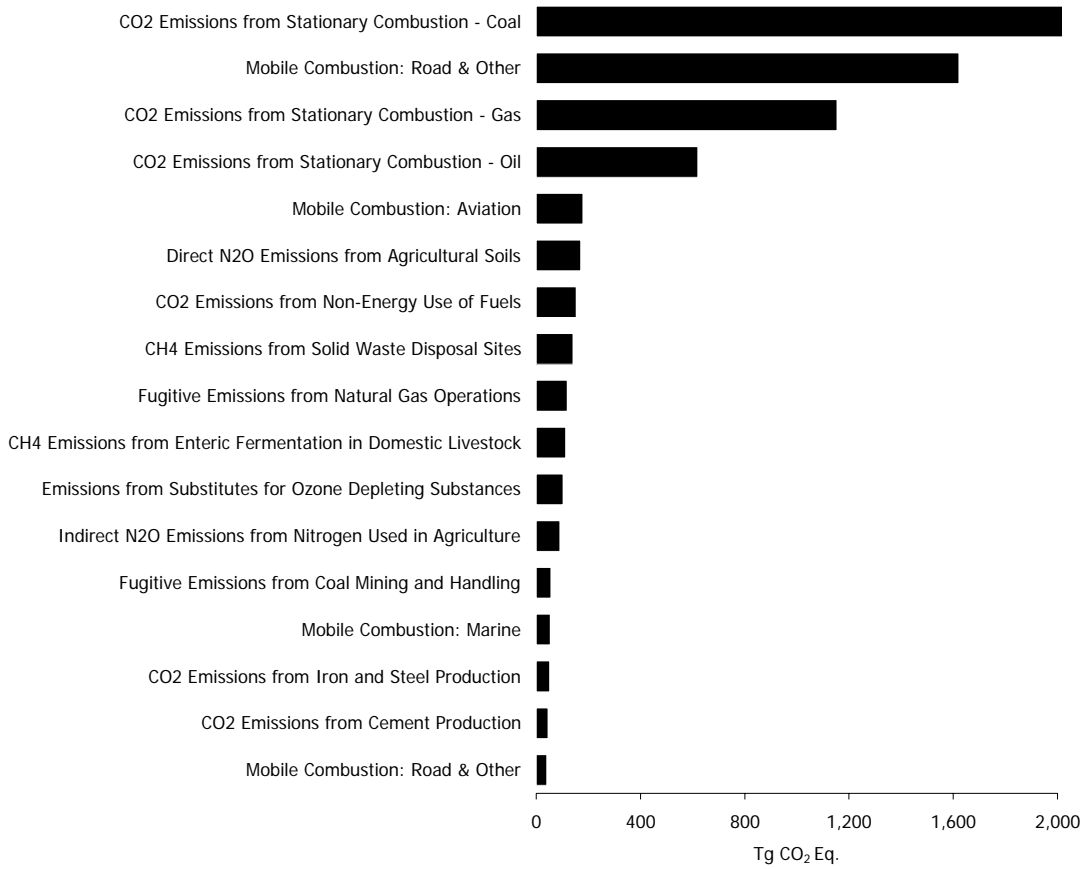


Figure ES-16: 2004 Key Categories - Tier 1 Level Assessment
 Note: For a complete discussion of the key source analysis see Annex 1.

Descriptions of Figures: Executive Summary

Figure ES-1 illustrates U.S. greenhouse gas emissions by gas, with a cumulative total of CO₂ equivalent. There is generally an upward trend, starting from 6,109 Tg CO₂ eq. in 1990 and ending with 7,074 Tg CO₂ eq. in 2004. The only exception to this trend is 1991, where emissions were 6,072 Tg CO₂ eq, down from 6,109 Tg CO₂ eq in 1990. They increased again in 1992 to 6,146 Tg CO₂ eq.

Figure ES-2 depicts the annual percent change in U.S. greenhouse gas emissions since 1990. The change in 1991 was -0.6%. In 1992, it was 1.2%. In 1993, it was 3.0%. In 1994, it was 0.7%. In 1995, it was 1.7%. In 1996, it was 3.1%. In 1997, it was 0.4%. In 1998, it was 0.9%. In 1999, it was 0.6%. In 2000, it was 2.5%. In 2001, it was -1.3%. In 2002, it was 0.3%, in 2003, it was 0.6%, and in 2004, it was 1.7%.

Figure ES-3 depicts the absolute change in U.S. greenhouse gas emissions since 1990. The change in 1991 was -37 Tg CO₂ Eq. In 1992, it was 37 Tg CO₂ Eq. In 1993, it was 224 Tg CO₂ Eq. In 1994, it was 268 Tg CO₂ Eq. In 1995, it was 374 Tg CO₂ Eq. In 1996, it was 576 Tg CO₂ Eq. In 1997, it was 601 Tg CO₂ Eq. In 1998, it was 665 Tg CO₂ Eq. In 1999, it was 706 Tg CO₂ Eq. In 2000, it was 873 Tg CO₂ Eq. In 2001, it was 784 Tg CO₂ Eq. In 2002, it was 807 Tg CO₂ Eq. In 2003, it was 850 Tg CO₂ Eq. and in 2004, it was 965 Tg CO₂ Eq.

Figure ES-4 illustrates the relative contribution of the direct greenhouse gases to total U.S. emissions in 2004. The primary greenhouse gas emitted by human activities in the United States was CO₂, representing 84.6 % of total greenhouse gas emissions. CH₄ represented 7.9 % of total greenhouse gas emissions, while N₂O represented 5.5 % and HFCs along with PFCs represented 2.0%.

Figure ES-5 illustrates sources of CO₂ emissions for 2004. Fossil fuel combustion is the greatest source with 5,656.6 Tg CO₂ Eq. The next greatest is iron and steel production which accounts for 51.3 Tg CO₂ Eq. The smallest source in Figure ES-5 is Silicon Carbide Consumption, which accounts for 0.1 Tg CO₂ Eq. There is also a pie chart indicating that CO₂ represents 84.6% of all greenhouse gas emissions.

Figure ES-6 illustrates 2004 CO₂ Emissions from Fossil Fuel Combustion by Sector and Fuel Type. There is also a pie chart indicating petroleum represents 43% of all fossil fuel combustion.

Figure ES-7 illustrates 2004 End-Use Sector Emissions of CO₂ from Fossil Fuel Combustion. Transportation is the largest sector with 1855.5 teragrams of CO₂ emissions, all from direct fossil fuel combustion. Industrial is next with 731.5 teragrams of CO₂ from electricity consumption and 863.5 teragrams of CO₂ from direct fossil fuel combustion.

Figure ES-8 illustrates sources of CH₄ emissions for 2004. There is also a pie chart indicating that CH₄ represents 7.9% of all greenhouse gas emissions.

Figure ES-9 illustrates sources of N₂O emissions for 2004. There is also a pie chart indicating that N₂O represents 5.5% of all greenhouse gas emissions.

Figure ES-10 illustrates sources of HFCs, PFCs, and SF₆ emissions for 2004. There is also a pie chart indicating that HFCs, PFCs, and SF₆ represent 2.0 percent of all greenhouse gas emissions.

Figure ES-11 depicts 2004 CO₂ emissions from fossil fuel combustion by sector and fuel type using the data presented in Table 3-3. In addition, there is a pie chart that indicates that petroleum accounted for 43% of emissions from fossil fuel combustion.

Figure ES-12 illustrates the data presented in Table 3-6, CO₂ emissions from fossil fuel combustion by end use sector.

For a detailed description of Figure ES-13, refer to the description of Figure 2-13 in Chapter 2.

For a detailed description of Figure ES-14, refer to the description of Figure 2-14 in Chapter 2.

For a detailed description of Figure ES-15, refer to the description of Figure 2-4 in Chapter 2.

Figure ES-16 illustrates sources identified as key using the Tier 1 Level assessment for 2004.

