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 2012. 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 Intergovernmental Panel on Climate Change (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 continued to incorporate new methodologies and data from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006). The use of the most recently published calculation methodologies by the IPCC, as contained in the 2006 IPCC Guidelines, is considered to improve the rigor and accuracy of this inventory and is fully in line with the prior IPCC guidance. The structure of this report is consistent with the UNFCCC guidelines for inventory reporting.[4] For most

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[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/2006/sbsta/eng/09.pdf>.

source categories, the IPCC methodologies were expanded, resulting in a more comprehensive and detailed estimate of emissions.

Box ES- 1: Methodological Approach for Estimating and Reporting U.S. Emissions and Sinks

In following the UNFCCC requirement under Article 4.1 to develop and submit national greenhouse gas emissions inventories, the emissions and sinks presented in this report are organized by source and sink categories and calculated using internationally-accepted methods provided by the IPCC.[5] Additionally, the calculated emissions and sinks in a given year for the United States are presented in a common manner in line with the UNFCCC reporting guidelines for the reporting of inventories under this international agreement.[6] The use of consistent methods to calculate emissions and sinks by all nations providing their inventories to the UNFCCC ensures that these reports are comparable. In this regard, U.S. emissions and sinks reported in this inventory report are comparable to emissions and sinks reported by other countries. Emissions and sinks provided in this inventory do not preclude alternative examinations, but rather this inventory report presents emissions and sinks in a common format consistent with how countries are to report inventories under the UNFCCC. The report itself follows this standardized format, and provides an explanation of the IPCC methods used to calculate emissions and sinks, and the manner in which those calculations are conducted.

On October 30, 2009, the U.S. Environmental Protection Agency (EPA) published a rule for the mandatory reporting of greenhouse gases (GHG) from large GHG emissions sources in the United States. Implementation of 40 CFR Part 98 is referred to as the Greenhouse Gas Reporting Program (GHGRP). 40 CFR part 98 applies to direct greenhouse gas emitters, fossil fuel suppliers, industrial gas suppliers, and facilities that inject CO_2 underground for sequestration or other reasons.[7] Reporting is at the facility level, except for certain suppliers of fossil fuels and industrial greenhouse gases. The GHGRP dataset and the data presented in this inventory report are complementary and, as indicated in the respective methodological and planned improvements sections in this report's chapters, EPA is using the data, as applicable, to improve the national estimates presented in this inventory.

ES.1. Background Information

Greenhouse gases trap heat and make the planet warmer. The most important greenhouse gases directly emitted by humans include CO_2, CH_4, N_2O, and several other fluorine-containing halogenated substances. 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 2012, concentrations of these greenhouse gases have increased globally by 40, 151, and 20 percent, respectively (IPCC 2007 and NOAA/ESLR 2013). This annual report estimates the total national greenhouse gas emissions and removals associated with human activities across the United States.

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

[5] See < http://www.ipcc-nggip.iges.or.jp/public/index.html>.
[6] See < http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5270.php>.
[7] See <http://www.epa.gov/climatechange/emissions/ghgrulemaking.html> and <http://ghgdata.epa.gov/ghgp/main.do>.

albedo).[8] 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 (or million metric tons) of CO_2 equivalent (Tg CO_2 Eq.).[9,10] 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 2006,[11] but continue to require the use of GWP values from the *IPCC Second Assessment Report (SAR)* (IPCC 1996). This requirement ensures that current estimates of aggregate greenhouse gas emissions for 1990 to 2012 are consistent with estimates developed prior to the publication of the *IPCC Third Assessment Report (TAR)* (IPCC 2001), the *IPCC Fourth Assessment Report (AR4)* (IPCC 2007) and the *IPCC Fifth Assessment Report (AR5)* (IPCC 2013). 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 GWP values versus the TAR, AR4 and AR5 GWP values 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.

The official greenhouse gas emissions presented in this report using the SAR GWP values are the final time the SAR GWP values will be used in the U.S. inventory. The United States and other developed countries have agreed to submit annual inventories in 2015 and future years to the UNFCCC using GWP values from the IPCC AR4, which will replace the current use of SAR GWP values in their annual greenhouse gas inventories.[12] The use of IPCC AR4 GWP values in future year inventories will apply across the entire time series of the inventory (i.e., from 1990 to 2013 in next year's report).

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

Gas	GWP
CO_2	1
CH_4[a]	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

8 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.

9 Carbon comprises 12/44[ths] of carbon dioxide by weight.

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

11 See <http://unfccc.int/resource/docs/2006/sbsta/eng/09.pdf>.

12 ''Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention,'' FCCC/CP/2011/9/Add.2, Decision 6/CP 17, 15 March 2012, available at <http://unfccc.int/resource/docs/2011/cop17/eng/09a02.pdf#page=23>

SF_6	23,900

Source: IPCC (1996)
[a] 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 production of CO_2 is not included.

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

In 2012, total U.S. greenhouse gas emissions were 6,525.6 Tg, or million metric tons, CO_2 Eq. Total U.S. emissions have increased by 4.7 percent from 1990 to 2012, and emissions decreased from 2011 to 2012 by 3.4 percent (227.4 Tg CO_2 Eq.). The decrease from 2011 to 2012 was due to a decrease in the carbon intensity of fuels consumed by power producers to generate electricity due to a decrease in the price of natural gas, a decrease in transportation sector emissions attributed to a small increase in fuel efficiency across different transportation modes and limited new demand for passenger transportation, and much warmer winter conditions resulting in a decreased demand for heating fuel in the residential and commercial sectors. Since 1990, U.S. emissions have increased at an average annual rate of 0.2 percent. 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 2012.

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

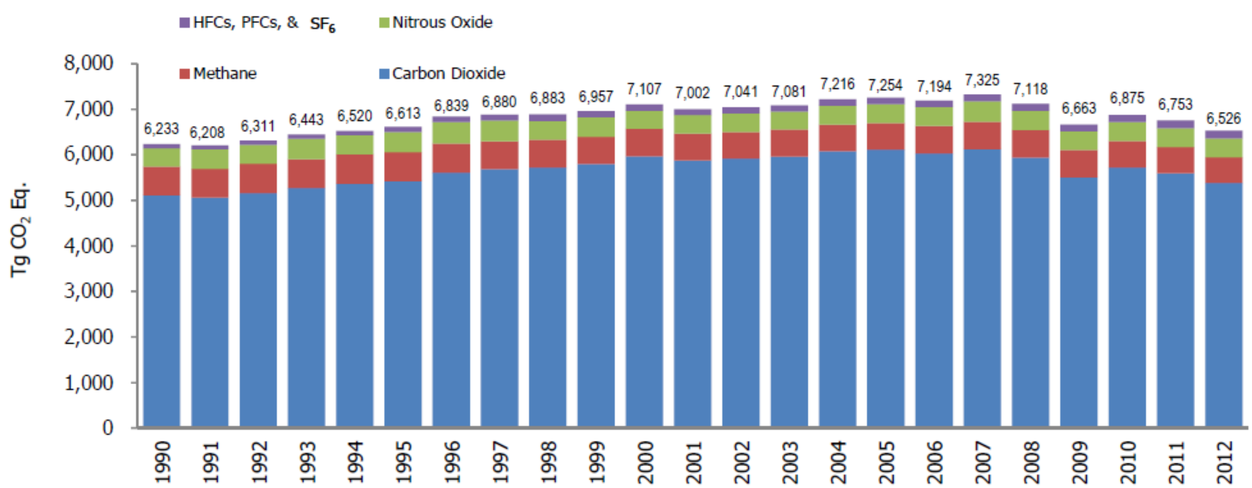


Figure ES-2: Annual Percent Change in U.S. Greenhouse Gas Emissions

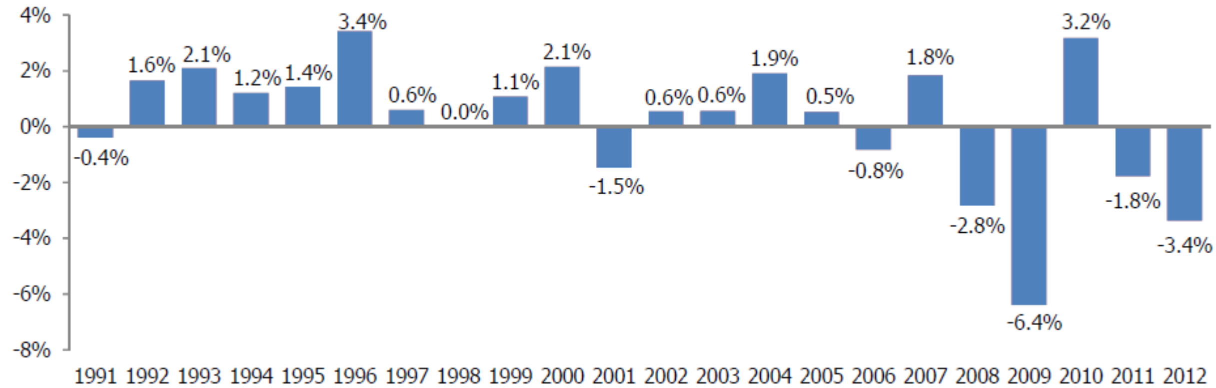


Figure ES-3: Annual Greenhouse Gas Emissions Relative to 1990 (1990=0)

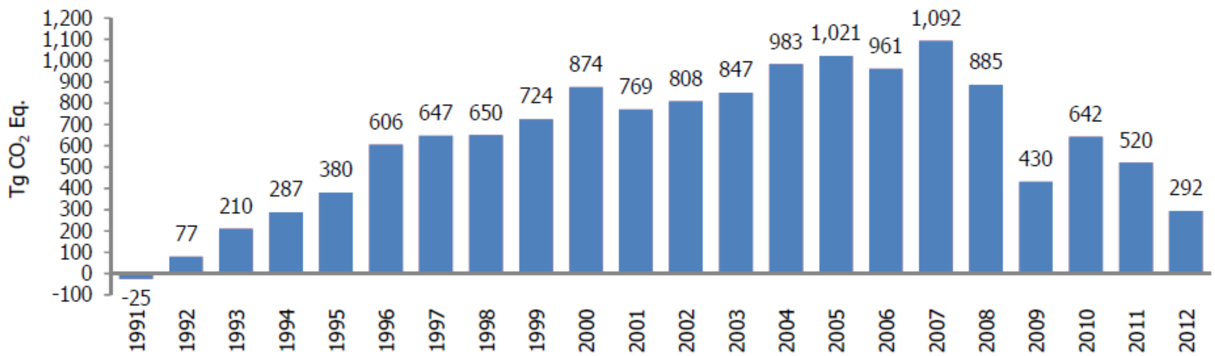


Table ES-2: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks (Tg or million metric tons CO_2 Eq.)

Gas/Source	1990	2005	2008	2009	2010	2011	2012
CO_2	**5,108.7**	**6,112.2**	**5,936.9**	**5,506.1**	**5,722.3**	**5,592.2**	**5,383.2**
Fossil Fuel Combustion	4,745.1	5,752.9	5,593.4	5,225.7	5,404.9	5,271.1	5,072.3
Electricity Generation	1,820.8	2,402.1	2,360.9	2,146.4	2,259.2	2,158.5	2,022.7
Transportation	1,494.0	1,891.7	1,816.5	1,747.7	1,765.0	1,747.9	1,739.5
Industrial	845.1	827.6	804.1	727.5	775.6	768.7	774.2
Residential	338.3	357.9	346.2	336.4	334.8	324.9	288.9
Commercial	219.0	223.5	224.7	223.9	220.7	221.5	197.4
U.S. Territories	27.9	50.0	41.0	43.8	49.6	49.6	49.6
Non-Energy Use of Fuels	120.8	141.0	128.0	108.1	120.8	117.3	110.3
Iron and Steel Production & Metallurgical Coke Production	99.8	66.7	66.8	43.0	55.7	60.0	54.3
Natural Gas Systems	37.7	30.0	32.7	32.2	32.4	35.1	35.2
Cement Production	33.3	45.9	41.2	29.4	31.3	32.0	35.1
Lime Production	11.4	14.0	14.0	10.9	12.8	13.5	13.3
Incineration of Waste	8.0	12.5	11.9	11.7	12.0	12.1	12.2
Ammonia Production	13.0	9.2	8.4	8.5	9.2	9.4	9.4
Other Process Uses of Carbonates	4.9	6.3	5.9	7.6	9.6	9.3	8.0
Cropland Remaining Cropland	7.1	7.9	8.6	7.2	8.6	7.9	7.4

Urea Consumption for Non-Agricultural Purposes	3.8	3.7	4.1	3.4	4.7	4.0	5.2
Petrochemical Production	3.4	4.3	3.6	2.8	3.5	3.5	3.5
Aluminum Production	6.8	4.1	4.5	3.0	2.7	3.3	3.4
Soda Ash Production and Consumption	2.7	2.9	2.9	2.5	2.6	2.6	2.7
Carbon Dioxide Consumption	1.4	1.3	1.8	1.8	2.3	1.8	1.8
Titanium Dioxide Production	1.2	1.8	1.8	1.6	1.8	1.7	1.7
Ferroalloy Production	2.2	1.4	1.6	1.5	1.7	1.7	1.7
Zinc Production	0.6	1.0	1.2	0.9	1.2	1.3	1.4
Glass Production	1.5	1.9	1.5	1.0	1.5	1.3	1.2
Phosphoric Acid Production	1.6	1.4	1.2	1.0	1.1	1.2	1.1
Wetlands Remaining Wetlands	1.0	1.1	1.0	1.1	1.0	0.9	0.8
Lead Production	0.5	0.6	0.5	0.5	0.5	0.5	0.5
Petroleum Systems	0.4	0.3	0.3	0.3	0.3	0.3	0.4
Silicon Carbide Production and Consumption	0.4	0.2	0.2	0.1	0.2	0.2	0.2
Land Use, Land-Use Change, and Forestry (Sink)[a]	*(831.1)*	*(1,030.7)*	*(981.0)*	*(961.6)*	*(968.0)*	*(980.3)*	*(979.3)*
Wood Biomass and Ethanol Consumption[b]	*219.4*	*229.8*	*254.7*	*250.5*	*265.1*	*268.1*	*266.8*
International Bunker Fuels[c]	*103.5*	*113.1*	*114.3*	*106.4*	*117.0*	*111.7*	*105.8*
CH_4	**635.7**	**585.7**	**606.0**	**596.5**	**585.5**	**578.3**	**567.3**
Enteric Fermentation	137.9	142.5	147.0	146.1	144.9	143.0	141.0
Natural Gas Systems	156.4	152.0	151.6	142.9	134.7	133.2	129.9
Landfills	147.8	112.1	114.3	115.3	109.9	107.4	102.8
Coal Mining	81.1	53.6	63.5	67.1	69.2	59.8	55.8
Manure Management	31.5	47.6	51.5	50.5	51.8	52.0	52.9
Petroleum Systems	35.8	28.8	28.8	29.1	29.5	30.5	31.7
Forest Land Remaining Forest Land	2.5	8.1	8.7	5.8	4.7	14.0	15.3
Wastewater Treatment	13.2	13.3	13.3	13.1	13.0	12.8	12.8
Rice Cultivation	7.7	7.5	7.8	7.9	9.3	7.1	7.4
Stationary Combustion	7.5	6.6	6.6	6.6	6.4	6.3	5.7
Abandoned Underground Coal Mines	6.0	5.5	5.3	5.1	5.0	4.8	4.7
Petrochemical Production	2.3	3.1	2.9	2.9	3.1	3.1	3.1
Mobile Combustion	4.6	2.4	1.9	1.8	1.8	1.7	1.7
Composting	0.3	1.6	1.7	1.6	1.5	1.6	1.6
Iron and Steel Production & Metallurgical Coke Production	1.0	0.7	0.6	0.4	0.5	0.6	0.6
Field Burning of Agricultural Residues	0.3	0.2	0.3	0.2	0.2	0.3	0.3
Ferroalloy Production	+	+	+	+	+	+	+
Silicon Carbide Production and Consumption	+	+	+	+	+	+	+
Incineration of Waste	+	+	+	+	+	+	+
International Bunker Fuels[c]	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
N_2O	**398.6**	**415.8**	**423.3**	**412.2**	**409.3**	**417.2**	**410.1**
Agricultural Soil Management	282.1	297.3	319.0	316.4	310.1	307.8	306.6
Stationary Combustion	12.3	20.6	21.1	20.8	22.5	21.6	22.0
Manure Management	14.4	17.1	17.8	17.7	17.8	18.0	18.0
Mobile Combustion	44.0	36.9	25.5	22.7	20.7	18.5	16.5
Nitric Acid Production	18.2	16.9	16.9	14.0	16.7	15.8	15.3
Forest Land Remaining Forest Land	2.1	7.0	7.5	5.1	4.2	11.8	12.8

Adipic Acid Production	15.8	7.4	2.6	2.8	4.4	10.6	5.8
Wastewater Treatment	3.5	4.5	4.8	4.8	4.9	5.0	5.0
N_2O from Product Uses	4.4	4.4	4.4	4.4	4.4	4.4	4.4
Composting	0.4	1.7	1.9	1.8	1.7	1.7	1.8
Settlements Remaining Settlements	1.0	1.5	1.5	1.4	1.5	1.5	1.5
Incineration of Waste	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Field Burning of Agricultural Residues	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Wetlands Remaining Wetlands	+	+	+	+	+	+	+
International Bunker Fuels[c]	*0.9*	*1.0*	*1.0*	*0.9*	*1.0*	*1.0*	*1.0*
HFCs	**36.9**	**119.8**	**136.0**	**135.1**	**144.0**	**148.6**	**151.2**
Substitution of Ozone Depleting Substances[d]	0.3	103.8	122.2	129.6	137.5	141.5	146.8
HCFC-22 Production	36.4	15.8	13.6	5.4	6.4	6.9	4.3
Semiconductor Manufacture	0.2	0.2	0.2	0.1	0.2	0.2	0.2
PFCs	**20.6**	**5.6**	**5.1**	**3.3**	**3.8**	**6.0**	**5.4**
Semiconductor Manufacture	2.2	2.6	2.4	1.7	2.2	3.0	2.9
Aluminum Production	18.4	3.0	2.7	1.6	1.6	2.9	2.5
SF_6	**32.6**	**14.7**	**10.7**	**9.6**	**9.8**	**10.8**	**8.4**
Electrical Transmission and Distribution	26.7	11.0	8.4	7.5	7.2	7.2	6.0
Magnesium Production and Processing	5.4	2.9	1.9	1.7	2.2	2.9	1.7
Semiconductor Manufacture	0.5	0.7	0.5	0.3	0.4	0.7	0.7
Total	**6,233.2**	**7,253.8**	**7,118.1**	**6,662.9**	**6,874.7**	**6,753.0**	**6,525.6**
Net Emissions (Sources and Sinks)	**5,402.1**	**6,223.1**	**6,137.1**	**5,701.2**	**5,906.7**	**5,772.7**	**5,546.3**

+ 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 net sink in the United States. Sinks are only included in net emissions total.

[b] Emissions from Wood Biomass and Ethanol Consumption are not included specifically in summing energy sector totals. Net carbon fluxes from changes in biogenic carbon reservoirs are accounted for in the estimates for Land Use, Land-Use Change, and Forestry.

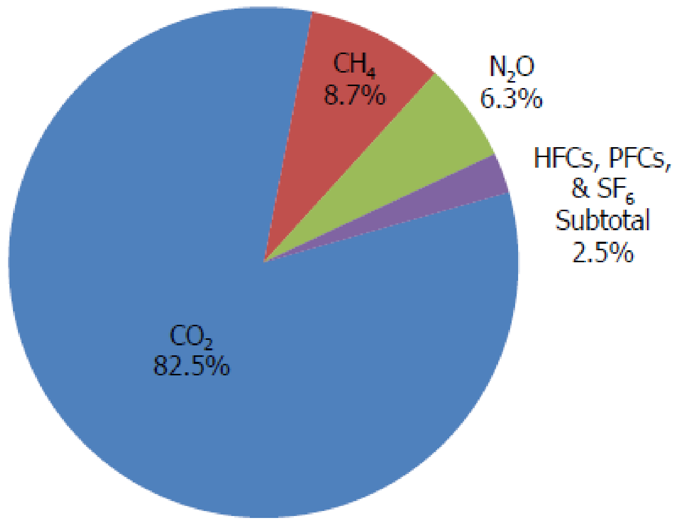
[c] Emissions from International Bunker Fuels are not included in totals.

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

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 2012. The primary greenhouse gas emitted by human activities in the United States was CO_2, representing approximately 82.5 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 decreased by 10.8 percent since 1990, resulted primarily from enteric fermentation associated with domestic livestock, natural gas systems, and decomposition of wastes in landfills. Agricultural soil management, manure management, mobile source fuel combustion and stationary fuel combustion were the major sources of N_2O emissions. Ozone depleting substance substitute emissions and emissions of HFC-23 during the production of HCFC-22 were the primary contributors to aggregate HFC emissions. PFC emissions resulted as a by-product of primary aluminum production and from semiconductor manufacturing, while electrical transmission and distribution systems accounted for most SF_6 emissions.

Figure ES-4: 2012 Greenhouse Gas Emissions by Gas (Percentages based on Tg CO_2 Eq.)



Overall, from 1990 to 2012, total emissions of CO_2 increased by 274.5 Tg CO_2 Eq. (5.4 percent), while total emissions of CH_4 decreased by 68.4 Tg CO_2 Eq. (10.8 percent), and N_2O increased by 11.5 Tg CO_2 Eq. (2.9 percent). During the same period, aggregate weighted emissions of HFCs, PFCs, and SF_6 rose by 74.8 Tg CO_2 Eq. (83.0 percent). From 1990 to 2012, HFCs increased by 114.3 Tg CO_2 Eq. (309.6 percent), PFCs decreased by 15.2 Tg CO_2 Eq. (73.8 percent), and SF_6 decreased by 24.2 Tg CO_2 Eq. (74.3 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 these gases 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 15.0 percent of total emissions in 2012. The following sections describe each gas's 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 approximately 40 percent (IPCC 2007 and NOAA/ESLR 2013), principally due to the combustion of fossil fuels. Within the United States, fossil fuel combustion accounted for 94.2 percent of CO_2 emissions in 2012. Globally, approximately 32,579 Tg of CO_2 were added to the atmosphere through the combustion of fossil fuels in 2011, of which the United States accounted for about 17 percent.[13] 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). In addition to fossil fuel combustion, several other sources emit significant quantities of CO_2. These sources include, but are not limited to non-energy use of fuels, iron and steel production and cement production (Figure ES-5).

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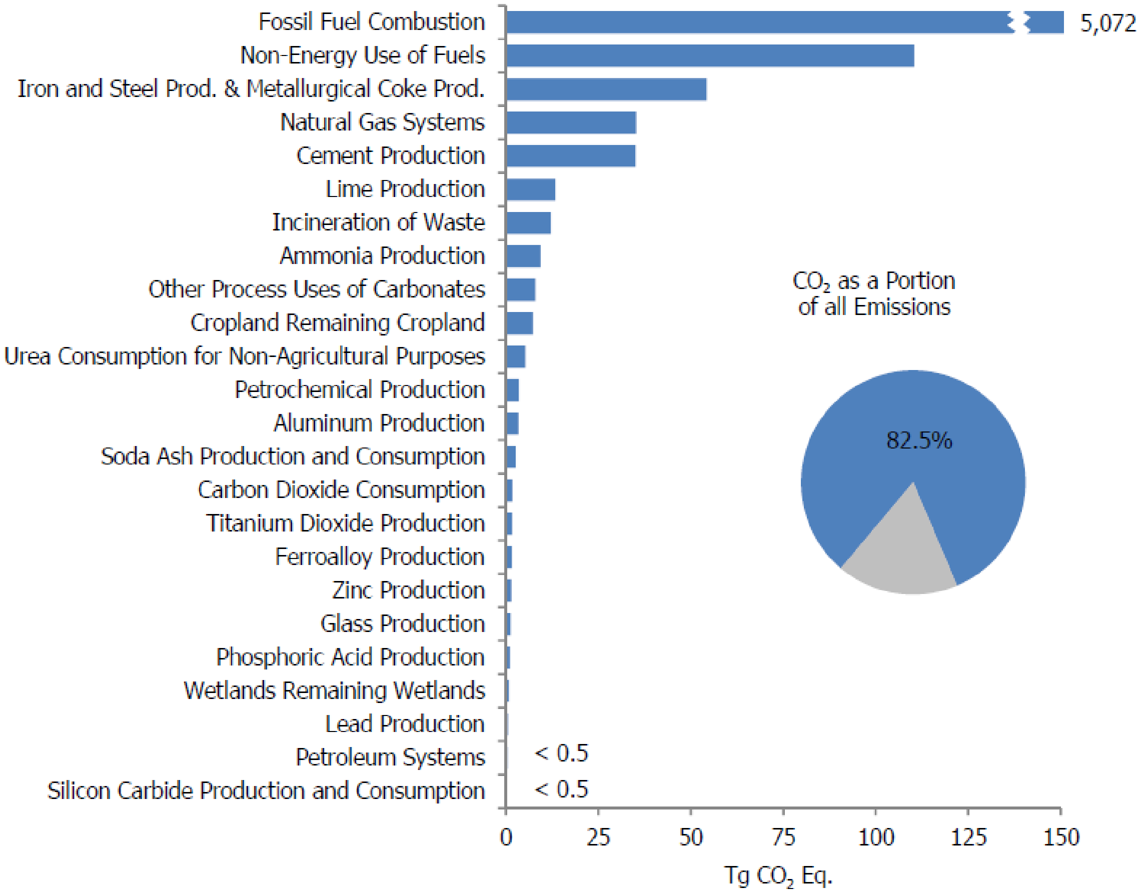
[13] Global CO_2 emissions from fossil fuel combustion were taken from Energy Information Administration *International Energy Statistics 2011* < http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm> EIA (2014).

Figure ES-5: 2012 Sources of CO_2 Emissions



Note: Electricity generation also includes emissions of less than 0.05 Tg CO_2 Eq. from geothermal-based generation.

As the largest source of U.S. greenhouse gas emissions, CO_2 from fossil fuel combustion has accounted for approximately 78 percent of GWP-weighted emissions since 1990, and is approximately 78 percent of total GWP-weighted emissions in 2012. Emissions of CO_2 from fossil fuel combustion increased at an average annual rate of 0.3 percent from 1990 to 2012. The fundamental factors influencing this trend include (1) a generally growing domestic economy over the last 23 years, (2) an overall growth in emissions from electricity generation and transportation activities, along with (3) a general decline in the carbon intensity of fuels combusted for energy in recent years by most sectors of the economy. Between 1990 and 2012, CO_2 emissions from fossil fuel combustion increased from 4,745.1 Tg CO_2 Eq. to 5,072.3 Tg CO_2 Eq.—a 6.9 percent total increase over the twenty-three-year period. From 2011 to 2012, these emissions decreased by 198.8 Tg CO_2 Eq. (3.8 percent).

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, energy fuel choices, and seasonal temperatures. In the short term, the overall consumption of fossil fuels in the United States fluctuates primarily 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. In the long term, energy consumption patterns respond to changes that affect the scale of consumption (e.g., population, number of cars, and size of houses), the efficiency with which energy is used in equipment (e.g., cars, power plants, steel mills, and light bulbs) and behavioral choices (e.g., walking, bicycling, or telecommuting to work instead of driving).

Figure ES-6: 2012 CO_2 Emissions from Fossil Fuel Combustion by Sector and Fuel Type

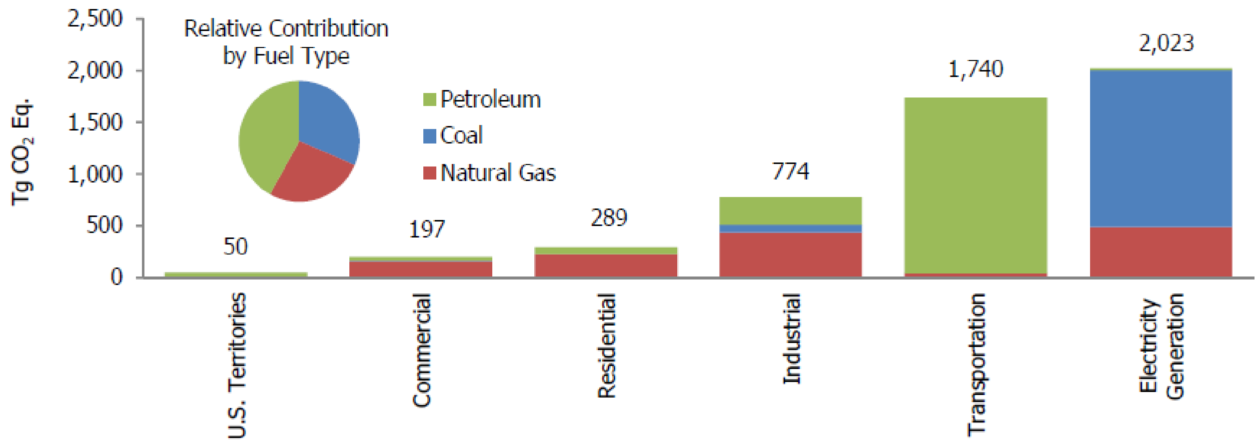
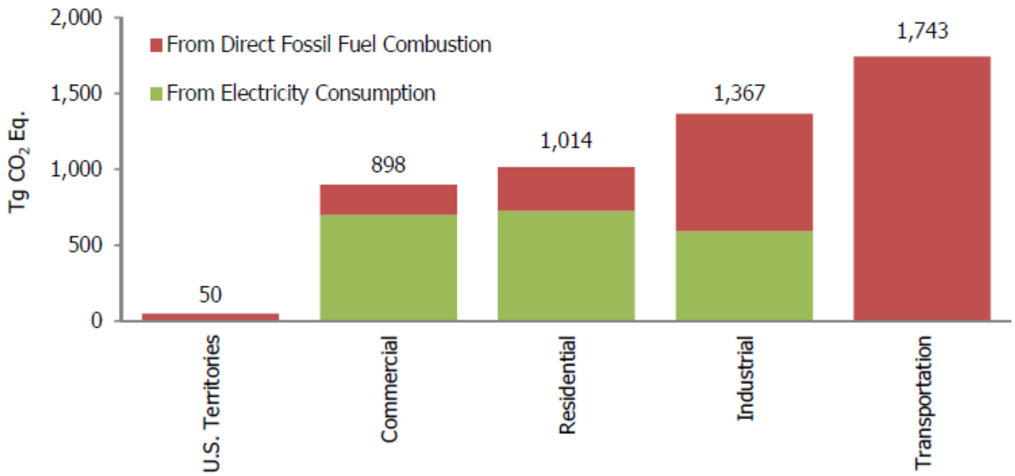


Figure ES-7: 2012 End-Use Sector Emissions of CO_2 from Fossil Fuel Combustion



The five major fuel consuming sectors contributing to CO_2 emissions from fossil fuel combustion are electricity generation, transportation, industrial, residential, and commercial. CO_2 emissions are produced by the electricity generation sector as they consume fossil fuel to provide electricity to one of the other four sectors, or "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.

Table ES-3: CO_2 Emissions from Fossil Fuel Combustion by Fuel Consuming End-Use Sector (Tg or million metric tons CO_2 Eq.)

End-Use Sector	1990	2005	2008	2009	2010	2011	2012
Transportation	**1,497.0**	**1,896.5**	**1,821.2**	**1,752.2**	**1,769.5**	**1,752.1**	**1,743.4**
Combustion	1,494.0	1,891.7	1,816.5	1,747.7	1,765.0	1,747.9	1,739.5
Electricity	3.0	4.7	4.7	4.5	4.5	4.3	3.9
Industrial	**1,531.8**	**1,564.6**	**1,501.4**	**1,329.5**	**1,416.6**	**1,393.6**	**1,367.1**
Combustion	845.1	827.6	804.1	727.5	775.6	768.7	774.2
Electricity	686.7	737.0	697.3	602.0	641.1	624.9	592.9
Residential	**931.4**	**1,214.7**	**1,189.2**	**1,122.9**	**1,175.2**	**1,115.9**	**1,014.3**
Combustion	338.3	357.9	346.2	336.4	334.8	324.9	288.9
Electricity	593.0	856.7	842.9	786.5	840.4	791.0	725.5
Commercial	**757.0**	**1,027.2**	**1,040.8**	**977.4**	**993.9**	**959.8**	**897.9**
Combustion	219.0	223.5	224.7	223.9	220.7	221.5	197.4
Electricity	538.0	803.7	816.0	753.5	773.3	738.3	700.4
U.S. Territories[a]	**27.9**	**50.0**	**41.0**	**43.8**	**49.6**	**49.6**	**49.6**
Total	**4,745.1**	**5,752.9**	**5,593.4**	**5,225.7**	**5,404.9**	**5,271.1**	**5,072.3**
Electricity Generation	**1,820.8**	**2,402.1**	**2,360.9**	**2,146.4**	**2,259.2**	**2,158.5**	**2,022.7**

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.
[a] Fuel consumption by U.S. territories (i.e., American Samoa, Guam, Puerto Rico, U.S. Virgin Islands, Wake Island, and other U.S. Pacific Islands) is included in this report.

Transportation End-Use Sector. When electricity-related emissions are distributed to economic end-use sectors, transportation activities accounted for 34.4 percent of U.S. CO_2 emissions from fossil fuel combustion in 2012. The largest sources of transportation greenhouse gases in 2012 were passenger cars (43.1 percent); light duty trucks, which include sport utility vehicles, pickup trucks, and minivans (18.4 percent), freight trucks (21.9 percent), commercial aircraft (6.2 percent), rail (2.5 percent), and ships and boats (2.2 percent). These figures include direct emissions from fossil fuel combustion used in transportation and emissions from non-energy use (i.e. lubricants) used in transportation, as well as HFC emissions from mobile air conditioners and refrigerated transport allocated to these vehicle types.

In terms of the overall trend, from 1990 to 2012, total transportation emissions rose by 18 percent due, in large part, to increased demand for travel with limited gains in fuel efficiency over the same time period. The number of vehicle miles traveled by light-duty motor vehicles (passenger cars and light-duty trucks) increased 35 percent from 1990 to 2012, as a result of a confluence of factors including population growth, economic growth, urban sprawl, and low fuel prices during the beginning of this period. Almost all of the energy consumed for transportation was supplied by petroleum-based products, with more than half being related to gasoline consumption in automobiles and other highway vehicles. Other fuel uses, especially diesel fuel for freight trucks and jet fuel for aircraft, accounted for the remainder. The primary driver of transportation-related emissions was CO_2 from fossil fuel combustion, which increased by 16 percent from 1990 to 2012. This rise in CO_2 emissions, combined with an increase in HFCs from close to zero emissions in 1990 to 72.9 Tg CO_2 Eq. in 2012, led to an increase in overall emissions from transportation activities of 18 percent.

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 27 percent of CO_2 from fossil fuel combustion in 2012. Approximately 57 percent 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. In contrast to the other end-use sectors, emissions from industry have steadily declined since 1990. This decline is 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.

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 2012. Both sectors relied heavily on electricity for meeting energy demands, with 72 and 78 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. Emissions from the residential and commercial end-use sectors have increased by 9 percent and 19 percent since 1990, respectively, due to increasing electricity consumption for lighting, heating, air conditioning, and operating appliances.

Electricity Generation. The United States relies on electricity to meet a significant portion of its energy demands. Electricity generators consumed 35 percent of total U.S. energy uses from fossil fuels and emitted 40 percent of the CO_2 from fossil fuel combustion in 2012. The type of fuel combusted by electricity generators has a significant effect on their emissions. For example, some electricity is generated through non-fossil fuel options such as nuclear, hydroelectric, or geothermal energy. Including all electricity generation modes, generators relied on coal for approximately 39 percent their total energy requirements in 2012.[14] In addition, the coal used by electricity generators accounted for 93 percent of all coal consumed for energy in the United States in 2012.[15] Recently a decrease in the carbon intensity of fuels consumed to generate electricity has occurred due to a decrease in coal consumption, and increased natural gas consumption and other generation sources. Including all electricity generation modes, electricity generators used natural gas for approximately 29 percent of their total energy requirements in 2012. Across the time series, changes in electricity demand and the carbon intensity of fuels used for electricity generation have a significant impact on CO_2 emissions.

Other significant CO_2 trends included the following:

- CO_2 emissions from non-energy use of fossil fuels have decreased by 10.5 Tg CO_2 Eq. (8.7 percent) from 1990 through 2012. Emissions from non-energy uses of fossil fuels were 110.3 Tg CO_2 Eq. in 2012, which constituted 2.0 percent of total national CO_2 emissions, approximately the same proportion as in 1990.
- CO_2 emissions from iron and steel production and metallurgical coke production decreased by 5.7 Tg CO_2 Eq. (9.5 percent) from 2011 to 2012, reversing a two-year trend of increasing emissions primarily due to increased steel production associated with improved economic conditions. Despite this, from 1990 through 2012, emissions declined by 45.6 percent (45.5 Tg CO_2 Eq.). This overall decline is due to the restructuring of the industry, technological improvements, and increased scrap utilization.
- In 2012, CO_2 emissions from cement production increased by 3.0 Tg CO_2 Eq. (9.5 percent) from 2011. After decreasing in 1991 by 2.2 percent from 1990 levels, cement production emissions grew every year through 2006 except for a slight decrease in 1997. Since 2006, emissions have fluctuated through 2012 to the economic recession and associated decrease in demand for construction materials. Overall, from 1990 to 2012, emissions from cement production have increased by 5.3 percent, an increase of 1.8 Tg CO_2 Eq.
- Net CO_2 uptake from Land Use, Land-Use Change, and Forestry increased by 148.2 Tg CO_2 Eq. (17.8 percent) from 1990 through 2012. 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, and harvested wood pools. Annual carbon accumulation in landfilled yard trimmings and food scraps slowed over this period, while the rate of carbon accumulation in urban trees increased.

Box ES- 2: Use of ambient measurements systems for validation of emission inventories

In following the UNFCCC requirement under Article 4.1 to develop and submit national greenhouse gas emission inventories, the emissions and sinks presented in this report are organized by source and sink categories and calculated using internationally-accepted methods provided by the IPCC.[16] Several recent studies have measured emissions at the national or regional level (e.g., Petron 2012, Miller et al. 2013) with results that differ from EPA's estimate of emissions. A recent study (Brandt et al. 2014) reviewed technical literature on methane emissions and estimated methane emissions from all anthropogenic sources (e.g., livestock, oil and gas, waste emissions) to be

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[14] See Table 7.2b Electric Power Sector of EIA 2013.

[15] See Table 6.2 Coal Consumption by Sector of EIA 2013.

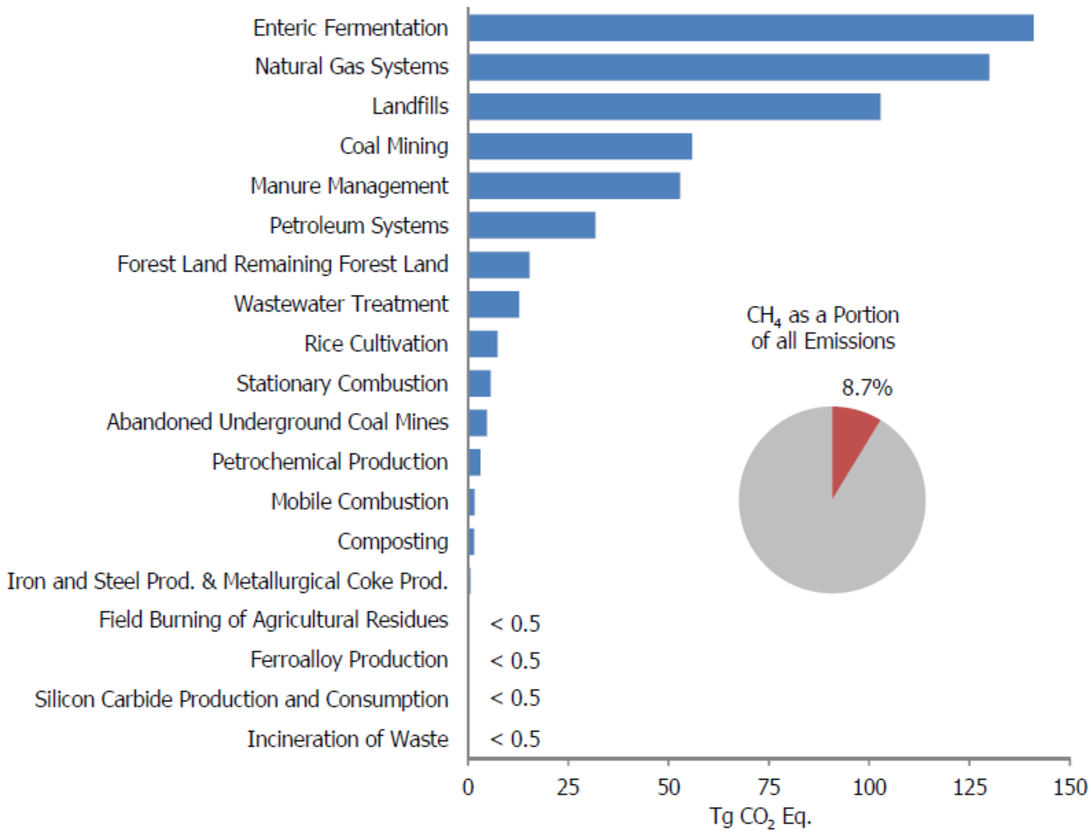
[16] See < http://www.ipcc-nggip.iges.or.jp/public/index.html>.

greater than EPA's estimate. EPA has engaged with researchers on how remote sensing, ambient measurement, and inverse modeling techniques for greenhouse gas emissions could assist in improving the understanding of inventory estimates. An area of particular interest in EPA's outreach efforts is how these data can be used in a manner consistent with this Inventory report's transparency on its calculation methodologies, and the ability of these techniques to attribute emissions and removals from remote sensing to anthropogenic sources, as defined by the IPCC for this report, versus natural sources and sinks. In working with the research community on ambient measurement and remote sensing techniques to improve national greenhouse gas inventories, EPA relies upon guidance from the IPCC on the use of measurements and modeling to validate emission inventories.[17]

Methane Emissions

Methane (CH_4) is more than 20 times as effective as CO_2 at trapping heat in the atmosphere (IPCC 1996). Over the last two hundred and fifty years, the concentration of CH_4 in the atmosphere increased by 151 percent (IPCC 2007). Anthropogenic sources of CH_4 include natural gas and petroleum systems, agricultural activities, landfills, coal mining, wastewater treatment, stationary and mobile combustion, and certain industrial processes (see Figure ES-8).

Figure ES-8: 2012 Sources of CH_4 Emissions



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 2012, enteric fermentation CH_4 emissions were 141.0 Tg CO_2 Eq. (24.9 percent of total CH_4 emissions), which

[17] See < http://www.ipcc-nggip.iges.or.jp/meeting/pdfiles/1003_Uncertainty%20meeting_report.pdf >.

represents an increase of 3.1 Tg CO_2 Eq. (2.3 percent) since 1990. This increase in emissions from 1990 to 2012 in enteric generally follows the increasing trends in cattle populations. From 1990 to 1995 emissions increased and then decreased from 1996 to 2001, mainly due to fluctuations in beef cattle populations and increased digestibility of feed for feedlot cattle. Emissions generally increased from 2005 to 2007, though with a slight decrease in 2004, as both dairy and beef populations underwent increases and the literature for dairy cow diets indicated a trend toward a decrease in feed digestibility for those years. Emissions decreased again from 2008 to 2012 as beef cattle populations again decreased.

- Natural gas systems were the second largest anthropogenic source category of CH_4 emissions in the United States in 2012 with129.9 Tg CO_2 Eq. of CH_4 emitted into the atmosphere. Those emissions have decreased by 26.6 Tg CO_2 Eq. (17.0 percent) since 1990. The decrease in CH_4 emissions is largely due to the decrease in emissions from production and distribution. The decrease in production emissions is due to increased voluntary reductions, from activities such as replacing high bleed pneumatic devices, and the increased use of plunger lifts for liquids unloading, and increased regulatory reductions. The decrease in distribution emissions is due to a decrease in cast iron and unprotected steel pipelines. Emissions from field production accounted for 32.2 percent of CH_4 emissions from natural gas systems in 2012. CH_4 emissions from field production decreased by 25.2 percent from 1990 through 2012; however, the trend was not stable over the time series-emissions from this source increased by 23.4 percent from 1990 through 2006 due primarily to increases in hydraulically fractured well completions and workovers, and then declined by 39.4 percent from 2006 to 2012. Reasons for the 2006-2012 trend include an increase in plunger lift use for liquids unloading, increased voluntary reductions over that time period (including those associated with pneumatic devices), and Reduced Emissions Completions (RECs) use for well completions and workovers with hydraulic fracturing.
- Landfills are the third largest anthropogenic source of CH_4 emissions in the United States (102.8 Tg CO_2 Eq.), accounting for 18.1 percent of total CH_4 emissions in 2012. From 1990 to 2012, CH_4 emissions from landfills decreased by 44.9 Tg CO_2 Eq. (30.4 percent), with small increases occurring in some interim years. This downward trend in overall emissions can be attributed to a 21 percent reduction in the amount of decomposable materials (i.e., paper and paperboard, food scraps, and yard trimmings) discarded in MSW landfills over the time series (EPA 2010) and an increase in the amount of landfill gas collected and combusted,[18] which has more than offset the additional CH_4 emissions resulting from an increase in the amount of municipal solid waste landfilled.
- In 2012, CH_4 emissions from coal mining were 55.8 Tg CO_2 Eq., a 4.0 Tg CO_2 Eq. (6.7 percent) decrease below 2011 emission levels. The overall decline of 25.2 Tg CO_2 Eq. (31.1 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.
- Methane emissions from manure management increased by 68.0 percent since 1990, from 31.5 Tg CO_2 Eq. in 1990 to 52.9 Tg CO_2 Eq. in 2012. 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.

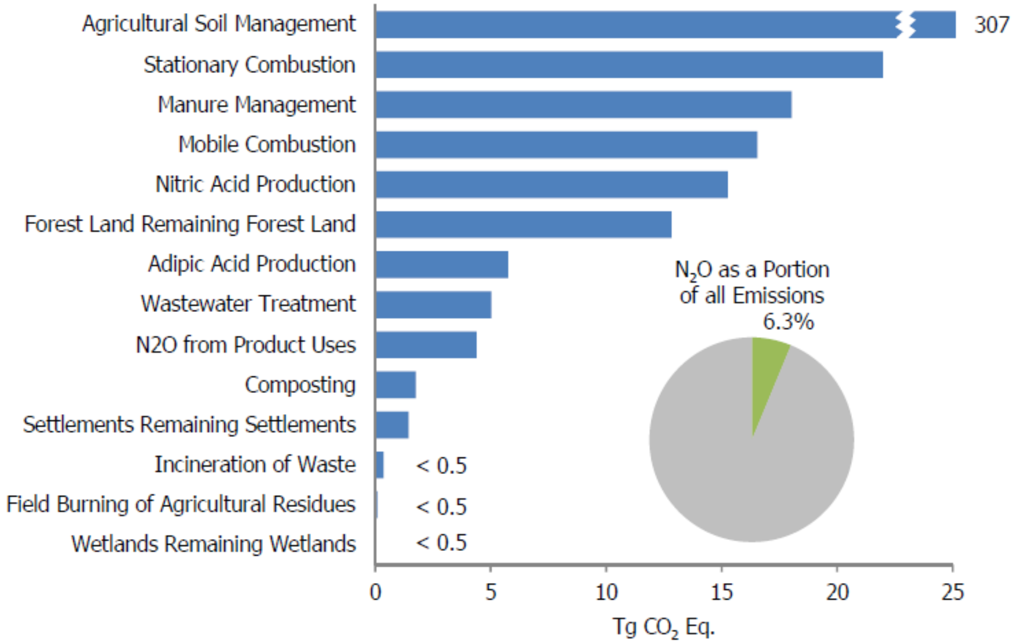
Nitrous Oxide Emissions

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 (IPCC 1996). Since 1750, the global atmospheric concentration of N_2O has risen by approximately 20 percent (IPCC 2007). The main anthropogenic activities producing N_2O in the United States are agricultural soil

[18] Carbon dioxide emissions from landfills are not included specifically in summing waste sector totals. Net carbon fluxes from changes in biogenic carbon reservoirs are accounted for in the estimates for Land Use, Land-Use Change, and Forestry.

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

Figure ES-9: 2012 Sources of N_2O Emissions



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

- Agricultural soils accounted for approximately 74.8 percent of N_2O emissions and 4.7 percent of total emissions in the United States in 2012. Estimated emissions from this source in 2012 were 306.6 Tg CO_2 Eq. Annual N_2O emissions from agricultural soils fluctuated between 1990 and 2012, largely as a reflection of annual variation in weather patterns, synthetic fertilizer use, and crop production, although overall emissions were 8.7 percent higher in 2012 than in 1990. Annual N_2O emissions from agricultural soils fluctuated between 1990 and 2012.

- N_2O emissions from stationary combustion increased 9.7 Tg CO_2 Eq. (79.3 percent) from 1990 through 2012. N_2O emissions from this source increased primarily as a result of an increase in the number of coal fluidized bed boilers in the electric power sector.

- In 2012, total N_2O emissions from manure management were estimated to be 18.0 Tg CO_2 Eq. (58 Gg); in 1990, emissions were 14.4 Tg CO_2 Eq. (46 Gg). These values include both direct and indirect N_2O emissions from manure management. Nitrous oxide emissions have remained fairly steady since 1990. Small changes in N_2O emissions from individual animal groups exhibit the same trends as the animal group populations, with the overall net effect that N_2O emissions showed a 25 percent increase from 1990 to 2012 and a 0.1 percent increase from 2011 through 2012. Overall shifts toward liquid systems have driven down the emissions per unit of nitrogen excreted.

- In 2012, N_2O emissions from mobile combustion were 16.5 Tg CO_2 Eq. (4.0 percent of N_2O emissions). From 1990 to 2012, N_2O emissions from mobile combustion decreased by 62.4 percent. However, from 1990 to 1998 emissions increased 25.6 percent, due to control technologies that reduced NO_x emissions while increasing N_2O emissions. Since 1998, newer control technologies have led to an overall decline of 38.7 Tg CO_2 Eq. (70.1 percent) in N_2O from this source.

- N_2O emissions from adipic acid production were 5.8 Tg CO_2 Eq. in 2012, and have decreased significantly in recent years due to the widespread installation of pollution control measures. Emissions from adipic acid production have decreased by 63.6 percent since 1990 and by 67.2 percent since a peak in 1995.

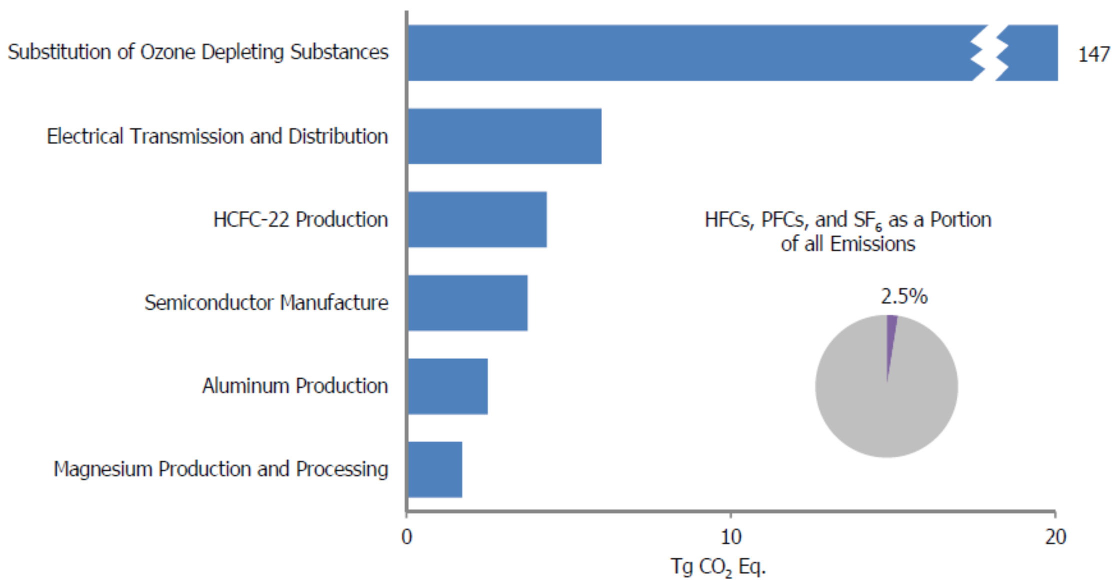
HFC, PFC, and SF_6 Emissions

HFCs and PFCs are families of synthetic chemicals that are used as alternatives to Ozone Depleting Substances, 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 (IPCC 1996).

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: 2012 Sources of HFCs, PFCs, and SF_6 Emissions



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

- Emissions resulting from the substitution of ozone depleting substances (ODS) (e.g., CFCs) have been consistently increasing, from small amounts in 1990 to 146.8 Tg CO_2 Eq. in 2012. Emissions from ODS substitutes are both the largest and the fastest growing source of HFC, PFC, and SF_6 emissions. These emissions have been increasing as phase-out of ODS required under the Montreal Protocol came into effect, especially after 1994, when full market penetration was made for the first generation of new technologies featuring ODS substitutes.

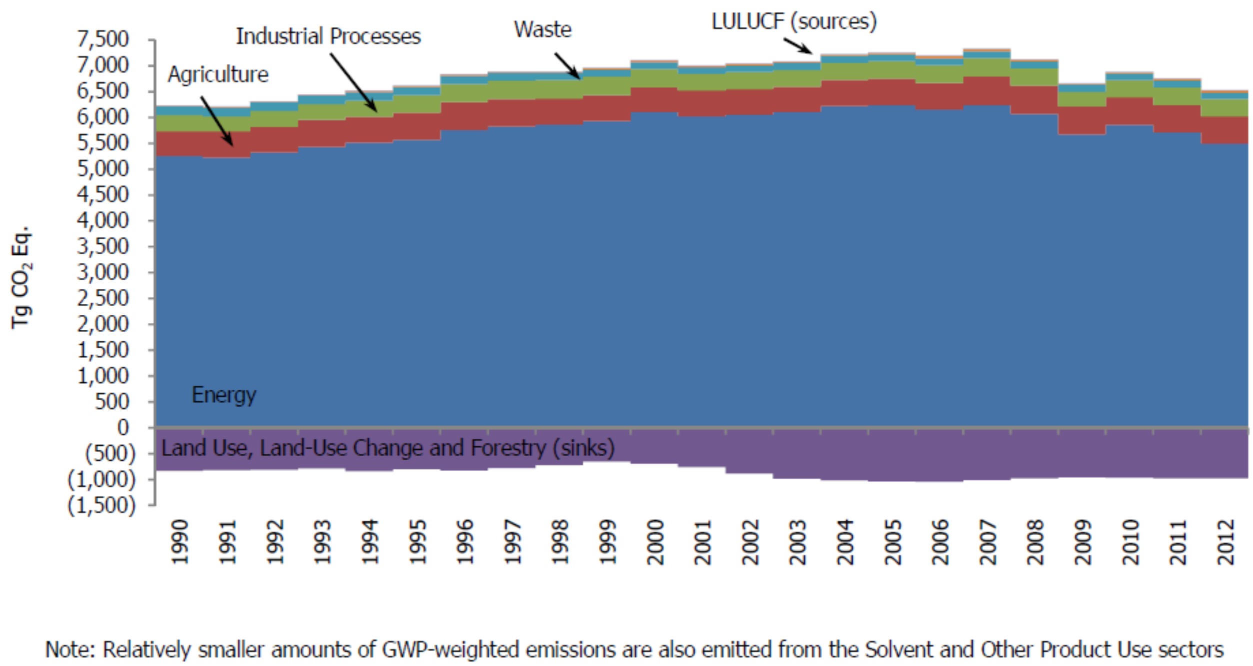
- GWP-weighted PFC, HFC, and SF6 emissions from semiconductor manufacture have increased by 28 percent from 1990 to 2012, due to the rapid growth of this industry and the increasing complexity of semiconductor products (more complex devices have a larger number of layers that require additional F-GHG using process steps). Within that time span, emissions peaked in 1999, the initial year of the EPA's PFC Reduction / Climate Partnership for the Semiconductor Industry, but have since declined to 3.7 Tg CO_2 Eq. in 2012 (a 48 percent decrease relative to 1999).

- SF_6 emissions from electric power transmission and distribution systems decreased by 77.5 percent (20.7 Tg CO_2 Eq.) from 1990 to 2012, primarily because of higher purchase prices for SF_6 and efforts by industry to reduce emissions.
- PFC emissions from aluminum production decreased by 86.4 percent (15.9 Tg CO_2 Eq.) from 1990 to 2012, due to both industry emission reduction efforts and declines in 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), 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 twenty-three-year period of 1990 to 2012, total emissions in the Energy, Industrial Processes, and Agriculture sectors grew by 238.8 Tg CO_2 Eq. (4.5 percent), 18.3 Tg CO_2 Eq. (5.8 percent), and 52.3 Tg CO_2 Eq. (11.0 percent), respectively. Emissions from the Waste and Solvent and Other Product Use sectors decreased by 41.1 Tg CO_2 Eq. (24.9 percent) and less than 0.1 Tg CO_2 Eq. (0.4 percent), respectively. Over the same period, estimates of net C sequestration in the Land Use, Land-Use Change, and Forestry (LULUCF) sector (magnitude of emissions plus CO_2 flux from all LULUCF source categories) increased by 124.1 Tg CO_2 Eq. (15.2 percent).

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



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

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

Chapter/IPCC Sector	1990	2005	2008	2009	2010	2011	2012
Energy	**5,260.1**	**6,243.5**	**6,071.1**	**5,674.6**	**5,860.6**	**5,712.9**	**5,498.9**

Fossil Fuel Combustion	4,745.1	5,752.9	5,593.4	5,225.7	5,404.9	5,271.1	5,072.3
Natural Gas Systems	194.2	182.0	184.3	175.2	167.0	168.3	165.1
Non-Energy Use of Fuels	120.8	141.0	128.0	108.1	120.8	117.3	110.3
Coal Mining	81.1	53.6	63.5	67.1	69.2	59.8	55.8
Petroleum Systems	36.2	29.1	29.1	29.5	29.9	30.9	32.1
Stationary Combustion	19.7	27.2	27.8	27.4	28.9	28.0	27.7
Mobile Combustion	48.6	39.3	27.4	24.5	22.5	20.2	18.2
Incineration of Waste	8.4	12.9	12.2	12.0	12.4	12.5	12.6
Abandoned Underground Coal Mines	6.0	5.5	5.3	5.1	5.0	4.8	4.7
Industrial Processes	**316.1**	**334.9**	**335.9**	**287.8**	**324.6**	**342.9**	**334.4**
Substitution of Ozone Depleting Substances	0.3	103.8	122.2	129.6	137.5	141.5	146.8
Iron and Steel Production & Metallurgical Coke Production	100.7	67.4	67.5	43.4	56.3	60.6	54.9
Cement Production	33.3	45.9	41.2	29.4	31.3	32.0	35.1
Nitric Acid Production	18.2	16.9	16.9	14.0	16.7	15.8	15.3
Lime Production	11.4	14.0	14.0	10.9	12.8	13.5	13.3
Ammonia Production	13.0	9.2	8.4	8.5	9.2	9.4	9.4
Other Process Uses of Carbonates	4.9	6.3	5.9	7.6	9.6	9.3	8.0
Petrochemical Production	5.7	7.5	6.5	5.7	6.5	6.6	6.6
Electrical Transmission and Distribution	26.7	11.0	8.4	7.5	7.2	7.2	6.0
Aluminum Production	25.3	7.1	7.2	4.6	4.3	6.2	5.9
Adipic Acid Production	15.8	7.4	2.6	2.8	4.4	10.6	5.8
Urea Consumption for Non-Agricultural Purposes	3.8	3.7	4.1	3.4	4.7	4.0	5.2
HCFC-22 Production	36.4	15.8	13.6	5.4	6.4	6.9	4.3
Semiconductor Manufacture	2.9	3.5	3.0	2.2	2.8	3.9	3.7
Soda Ash Production and Consumption	2.7	2.9	2.9	2.5	2.6	2.6	2.7
Carbon Dioxide Consumption	1.4	1.3	1.8	1.8	2.3	1.8	1.8
Titanium Dioxide Production	1.2	1.8	1.8	1.6	1.8	1.7	1.7
Magnesium Production and Processing	5.4	2.9	1.9	1.7	2.2	2.9	1.7
Ferroalloy Production	2.2	1.4	1.6	1.5	1.7	1.7	1.7
Zinc Production	0.6	1.0	1.2	0.9	1.2	1.3	1.4
Glass Production	1.5	1.9	1.5	1.0	1.5	1.3	1.2
Phosphoric Acid Production	1.6	1.4	1.2	1.0	1.1	1.2	1.1
Lead Production	0.5	0.6	0.5	0.5	0.5	0.5	0.5
Silicon Carbide Production and Consumption	0.4	0.2	0.2	0.2	0.2	0.2	0.2
Solvent and Other Product Use	**4.4**	**4.4**	**4.4**	**4.4**	**4.4**	**4.4**	**4.4**
Agriculture	**473.9**	**512.2**	**543.4**	**538.9**	**534.2**	**528.3**	**526.3**
Agricultural Soil Management	282.1	297.3	319.0	316.4	310.1	307.8	306.6
Enteric Fermentation	137.9	142.5	147.0	146.1	144.9	143.0	141.0
Manure Management	45.8	64.6	69.3	68.2	69.6	70.0	70.9
Rice Cultivation	7.7	7.5	7.8	7.9	9.3	7.1	7.4
Field Burning of Agricultural Residues	0.4	0.3	0.4	0.4	0.3	0.4	0.4
Land Use, Land-Use Change, and Forestry (Emissions)	**13.7**	**25.5**	**27.3**	**20.5**	**20.0**	**36.0**	**37.8**
Forest Land Remaining Forest Land	4.6	15.1	16.2	10.8	8.9	25.7	28.1
Cropland Remaining Cropland	7.1	7.9	8.6	7.2	8.6	7.9	7.4
Settlements Remaining Settlements	1.0	1.5	1.5	1.4	1.5	1.5	1.5
Wetlands Remaining Wetlands	1.0	1.1	1.0	1.1	1.0	0.9	0.8
Waste	**165.0**	**133.2**	**136.0**	**136.5**	**131.1**	**128.5**	**124.0**
Landfills	147.8	112.1	114.3	115.3	109.9	107.4	102.8
Wastewater Treatment	16.6	17.8	18.1	17.9	17.9	17.8	17.8
Composting	0.7	3.3	3.5	3.3	3.2	3.3	3.3
Total Emissions	**6,233.2**	**7,253.8**	**7,118.1**	**6,662.9**	**6,874.7**	**6,753.0**	**6,525.6**
Net CO_2 Flux From Land Use, Land-Use Change and Forestry (Sinks)*	*(831.1)*	*(1,030.7)*	*(981.0)*	*(961.6)*	*(968.0)*	*(980.3)*	*(979.3)*

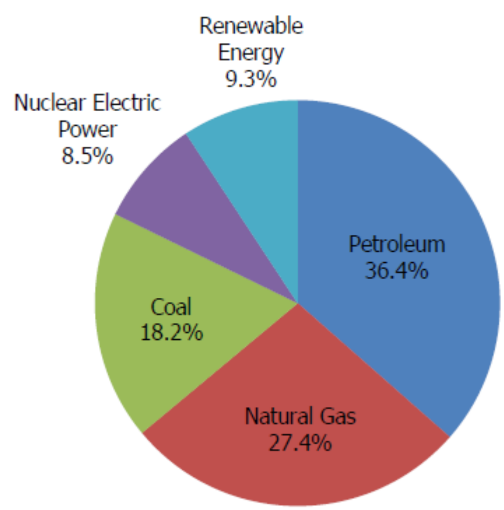
Net Emissions (Sources and Sinks)	**5,402.1**		**6,223.1**		**6,137.1**	**5,701.2**	**5,906.7**	**5,772.7**	**5,546.3**

* 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. Please refer to Table ES-5 for a breakout by source.
Note: Totals may not sum due to independent rounding.
Note: 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. CO_2 emissions for the period of 1990 through 2012. In 2012, approximately 82 percent of the energy consumed in the United States (on a Btu basis) was produced through the combustion of fossil fuels. The remaining 18 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 (40 percent and 9 percent of total U.S. emissions of each gas, respectively). Overall, emission sources in the Energy chapter account for a combined 84.3 percent of total U.S. greenhouse gas emissions in 2012.

Figure ES-12: 2012 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 CO_2, CH_4, and N_2O. These processes include iron and steel production and metallurgical coke production, cement production, ammonia production and urea consumption, lime production, other process uses of carbonates (e.g., flux stone, flue gas desulfurization, and glass manufacturing), soda ash production and consumption, titanium dioxide production, phosphoric acid production, ferroalloy production, glass 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 Process chapter account for 5.1 percent of U.S. greenhouse gas emissions in 2012.

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 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 2012.

Agriculture

The Agricultural 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 24.9 percent and 9.3 percent of total CH_4 emissions from anthropogenic activities, respectively, in 2012. Agricultural soil management activities such as fertilizer application and other cropping practices were the largest source of U.S. N_2O emissions in 2012, accounting for 74.8 percent. In 2012, emission sources accounted for in the Agricultural chapters were responsible for 8.1 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 resulted in a net uptake (sequestration) of C in the United States. Forests (including vegetation, soils, and harvested wood) accounted for 88 percent of total 2012 net CO_2 flux, urban trees accounted for 9 percent, mineral and organic soil carbon stock changes accounted for 1 percent, and landfilled yard trimmings and food scraps accounted for 1 percent of the total net flux in 2012. 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 4 times as much C as is emitted from these soils through liming and urea fertilization. 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 2012 resulted in a net C sequestration of 979.3 Tg CO_2 Eq. (Table ES-5). This represents an offset of 18.2 percent of total U.S. CO_2 emissions, or 15.0 percent of total greenhouse gas emissions in 2012. Between 1990 and 2012, total land use, land-use change, and forestry net C flux resulted in a 17.8 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, and harvested wood pools. 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.

Table ES-5: Net CO_2 Flux from Land Use, Land-Use Change, and Forestry (Tg or million metric tons CO_2 Eq.)

Sink Category	1990	2005	2008	2009	2010	2011	2012
Forest Land Remaining Forest Land	(704.6)	(927.2)	(871.0)	(849.4)	(855.7)	(867.1)	(866.5)
Cropland Remaining Cropland	(51.9)	(29.1)	(29.8)	(29.2)	(27.6)	(27.5)	(26.5)
Land Converted to Cropland	26.9	20.9	16.8	16.8	16.8	16.8	16.8
Grassland Remaining Grassland	(9.6)	5.6	6.8	6.8	6.7	6.7	6.7
Land Converted to Grassland	(7.3)	(8.3)	(8.7)	(8.7)	(8.6)	(8.6)	(8.5)

Settlements Remaining Settlements	(60.4)	(80.5)	(83.9)	(85.0)	(86.1)	(87.3)	(88.4)
Other (Landfilled Yard Trimmings and Food Scraps)	(24.2)	(12.0)	(11.2)	(12.9)	(13.6)	(13.5)	(13.0)
Total	**(831.1)**	**(1,030.7)**	**(981.0)**	**(961.6)**	**(968.0)**	**(980.3)**	**(979.3)**

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

Emissions from Land Use, Land-Use Change, and Forestry are shown in Table ES-6. Liming of agricultural soils and urea fertilization in 2012 resulted in CO_2 emissions of 7.4 Tg CO_2 Eq. (7,381 Gg). Lands undergoing peat extraction (i.e., *Peatlands Remaining Peatlands*) resulted in CO_2 emissions of 0.8 Tg CO_2 Eq. (830 Gg), and N_2O emissions of less than 0.1 Tg CO_2 Eq. The application of synthetic fertilizers to forest soils in 2012 resulted in direct N_2O emissions of 0.4 Tg CO_2 Eq. (1 Gg). Direct N_2O emissions from fertilizer application to forest soils have increased by 455 percent since 1990, but still account for a relatively small portion of overall emissions. Additionally, direct N_2O emissions from fertilizer application to settlement soils in 2012 accounted for 1.5 Tg CO_2 Eq. (5 Gg). This represents an increase of 48 percent since 1990. Forest fires in 2012 resulted in CH_4 emissions of 15.3 Tg CO_2 Eq. (727 Gg), and in N_2O emissions of 12.5 Tg CO_2 Eq. (40 Gg).

Table ES-6: Emissions from Land Use, Land-Use Change, and Forestry (Tg or million metric tons CO_2 Eq.)

Source Category	1990	2005	2008	2009	2010	2011	2012
CO_2	**8.1**	**8.9**	**9.6**	**8.3**	**9.6**	**8.8**	**8.2**
Cropland Remaining Cropland: Liming of Agricultural Soils	4.7	4.3	5.0	3.7	4.8	3.9	3.9
Cropland Remaining Cropland: Urea Fertilization	2.4	3.5	3.6	3.6	3.8	4.0	3.4
Wetlands Remaining Wetlands: Peatlands Remaining Peatlands	1.0	1.1	1.0	1.1	1.0	0.9	0.8
CH_4	**2.5**	**8.1**	**8.7**	**5.8**	**4.7**	**14.0**	**15.3**
Forest Land Remaining Forest Land: Forest Fires	2.5	8.1	8.7	5.8	4.7	14.0	15.3
N_2O	**3.1**	**8.4**	**9.0**	**6.5**	**5.7**	**13.3**	**14.3**
Forest Land Remaining Forest Land: Forest Fires	2.0	6.6	7.1	4.7	3.9	11.4	12.5
Forest Land Remaining Forest Land: Forest Soils	0.1	0.4	0.4	0.4	0.4	0.4	0.4
Settlements Remaining Settlements: Settlement Soils	1.0	1.5	1.5	1.4	1.5	1.5	1.5
Wetlands Remaining Wetlands: Peatlands Remaining Peatlands	+	+	+	+	+	+	+
Total	**13.7**	**25.5**	**27.3**	**20.5**	**20.0**	**36.0**	**37.8**

+ Less than 0.05 Tg CO_2 Eq.
Note: Totals may not sum due to independent rounding.

Waste

The Waste chapter contains emissions from waste management activities (except incineration of waste, which is addressed in the Energy chapter). Landfills were the largest source of anthropogenic greenhouse gas emissions in the Waste chapter, accounting for 82.9 percent of this chapter's emissions, and 18.1 percent of total U.S. CH_4 emissions.[19] Additionally, wastewater treatment accounts for 14.3 percent of Waste emissions, 2.2 percent of U.S. CH_4 emissions, and 1.2 percent of U.S. N_2O emissions. Emissions of CH_4 and N_2O from composting are also accounted for in this chapter, generating emissions of 1.6 Tg CO_2 Eq. and 1.8 Tg CO_2 Eq., respectively. Overall,

19 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.

emission sources accounted for in the Waste chapter generated 1.9 percent of total U.S. greenhouse gas emissions in 2012.

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, 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 2012.

Figure ES-13: Emissions Allocated to Economic Sectors

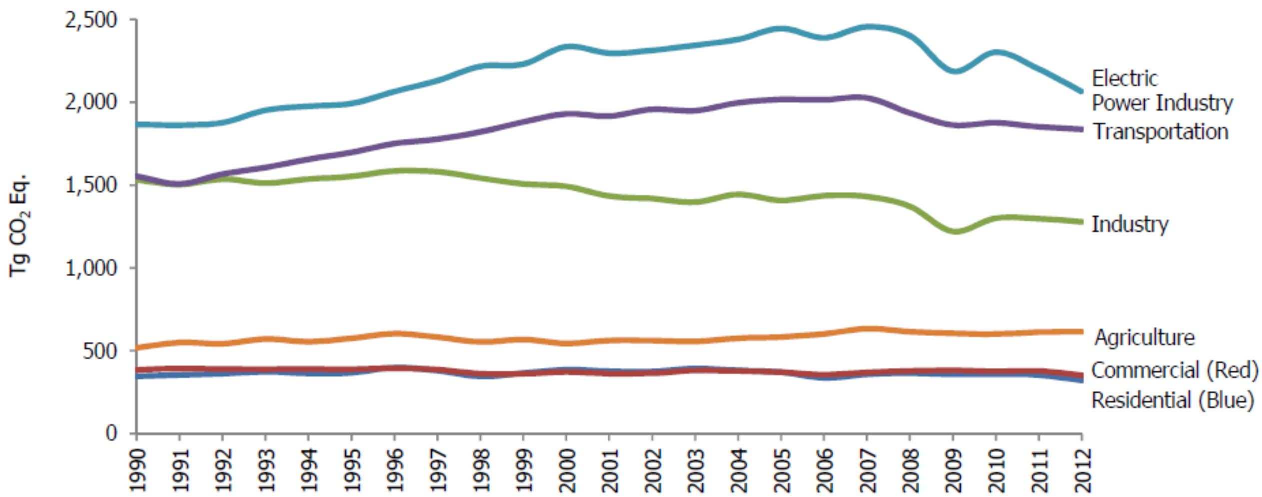


Table ES-7: U.S. Greenhouse Gas Emissions Allocated to Economic Sectors (Tg or million metric tons CO_2 Eq.)

Implied Sectors	**1990**	**2005**	**2008**	**2009**	**2010**	**2011**	**2012**
Electric Power Industry	1,866.1	2,445.7	2,401.8	2,187.0	2,302.5	2,200.9	2,064.0
Transportation	1,553.2	2,017.2	1,935.2	1,862.4	1,876.4	1,852.1	1,837.0
Industry	1,531.5	1,407.5	1,371.5	1,220.5	1,300.5	1,297.5	1,278.4
Agriculture	518.1	583.6	615.3	605.3	600.9	612.7	614.1
Commercial	385.3	370.4	379.2	381.9	376.6	378.3	352.7
Residential	345.4	371.3	365.4	357.9	360.0	353.6	321.4
U.S. Territories	33.7	58.2	49.8	47.9	58.0	57.9	57.9
Total Emissions	**6,233.2**	**7,253.8**	**7,118.1**	**6,662.9**	**6,874.7**	**6,753.0**	**6,525.6**
Land Use, Land-Use Change, and Forestry (Sinks)	*(831.1)*	*(1,030.7)*	*(981.0)*	*(961.6)*	*(968.0)*	*(980.3)*	*(979.3)*
Net Emissions (Sources and Sinks)	**5,402.1**	**6,223.1**	**6,137.1**	**5,701.2**	**5,906.7**	**5,772.7**	**5,546.3**

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.

Using this categorization, emissions from electricity generation accounted for the largest portion (32 percent) of U.S. greenhouse gas emissions in 2012. Transportation activities, in aggregate, accounted for the second largest portion (28 percent), while emissions from industry accounted for the third largest portion (20 percent) of U.S. greenhouse gas emissions in 2012. 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 21 percent of U.S. greenhouse gas emissions were contributed by, in order of importance, the agriculture, commercial, and residential sectors, plus emissions from U.S. Territories. Activities related to agriculture accounted for 9 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. The commercial and residential sectors each accounted for 5 percent of emissions and U.S. Territories accounted for 1 percent of emissions; emissions from these sectors primarily consisted of CO_2 emissions from fossil fuel combustion. 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.

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.[20] 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 incineration of waste, 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, industrial activities and transportation account for the largest shares of U.S. greenhouse gas emissions (each with 28 percent) in 2012. The residential and commercial sectors contributed the next largest shares of total U.S. greenhouse gas emissions in 2012. Emissions from these sectors increase substantially when emissions from electricity are included, due to their relatively large share of electricity consumption (e.g., lighting, appliances, etc.). 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 2012.

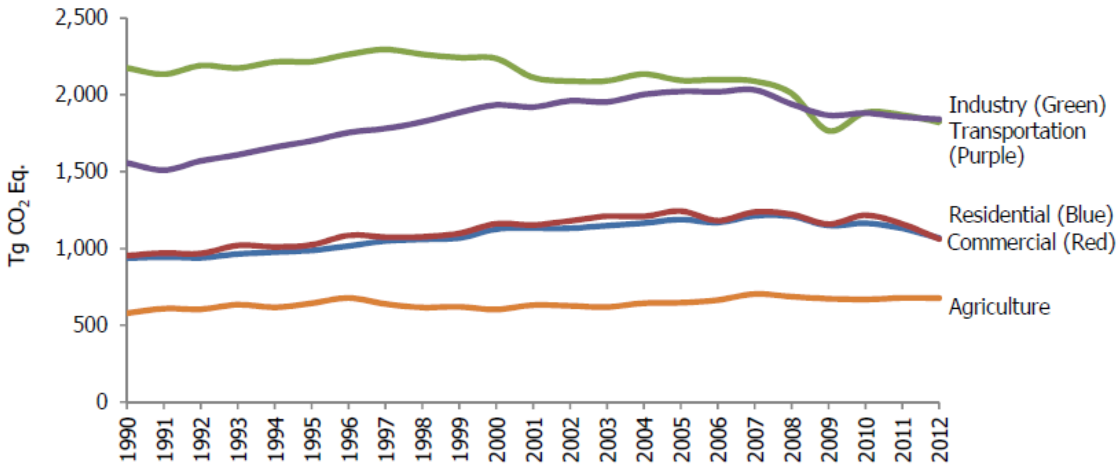
Table ES-8: U.S Greenhouse Gas Emissions by Economic Sector with Electricity-Related Emissions Distributed (Tg or million metric tons CO_2 Eq.)

Implied Sectors	1990	2005	2008	2009	2010	2011	2012
Industry	2,173.9	2,093.7	2,009.0	1,766.0	1,885.4	1,869.2	1,821.2
Transportation	1,556.3	2,022.0	1,939.9	1,866.9	1,880.9	1,856.4	1,841.0
Commercial	936.7	1,188.6	1,209.3	1,149.6	1,164.7	1,131.1	1,067.5
Residential	953.1	1,243.5	1,222.9	1,159.2	1,216.5	1,160.1	1,061.7
Agriculture	579.4	647.7	687.1	673.1	669.3	678.2	676.3
U.S. Territories	33.7	58.2	49.8	47.9	58.0	57.9	57.9
Total Emissions	**6,233.2**	**7,253.8**	**7,118.1**	**6,662.9**	**6,874.7**	**6,753.0**	**6,525.6**
Land Use, Land-Use Change, and Forestry (Sinks)	*(831.1)*	*(1,030.7)*	*(981.0)*	*(961.6)*	*(968.0)*	*(980.3)*	*(979.3)*
Net Emissions (Sources and Sinks)	**5,402.1**	**6,223.1**	**6,137.1**	**5,701.2**	**5,906.7**	**5,772.7**	**5,546.3**

See Table 2-14 for more detailed data.

[20] 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



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 2012; (4) emissions per unit of total gross domestic product as a measure of national economic activity; and (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 0.2 percent since 1990. This rate is slightly slower than that for total energy and for fossil fuel consumption, and much slower than that for electricity consumption, overall gross domestic product and national population (see Figure ES-15).

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

Variable	1990	2005	2008	2009	2010	2011	2012	Avg. Annual Growth Rate
Greenhouse Gas Emissions [a]	100	116	114	107	110	108	105	0.2%
Energy Consumption [b]	100	119	118	113	117	116	113	0.6%
Fossil Fuel Consumption [b]	100	119	116	109	113	111	108	0.4%
Electricity Consumption [b]	100	134	136	131	137	137	135	1.4%
GDP [c]	100	159	166	161	165	168	173	2.5%
Population [d]	100	118	122	123	124	125	125	1.0%

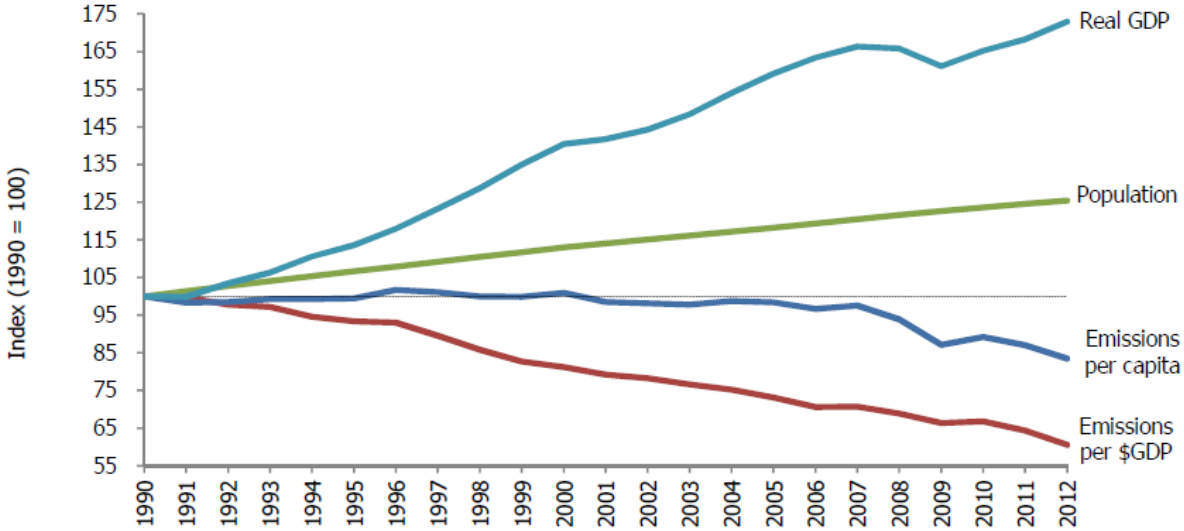
[a] GWP-weighted values

[b] Energy content-weighted values (EIA 2013)

[c] Gross Domestic Product in chained 2009 dollars (BEA 2013)

[d] U.S. Census Bureau (2013)

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



Source: BEA (2013), U.S. Census Bureau (2013), and emission estimates in this report.

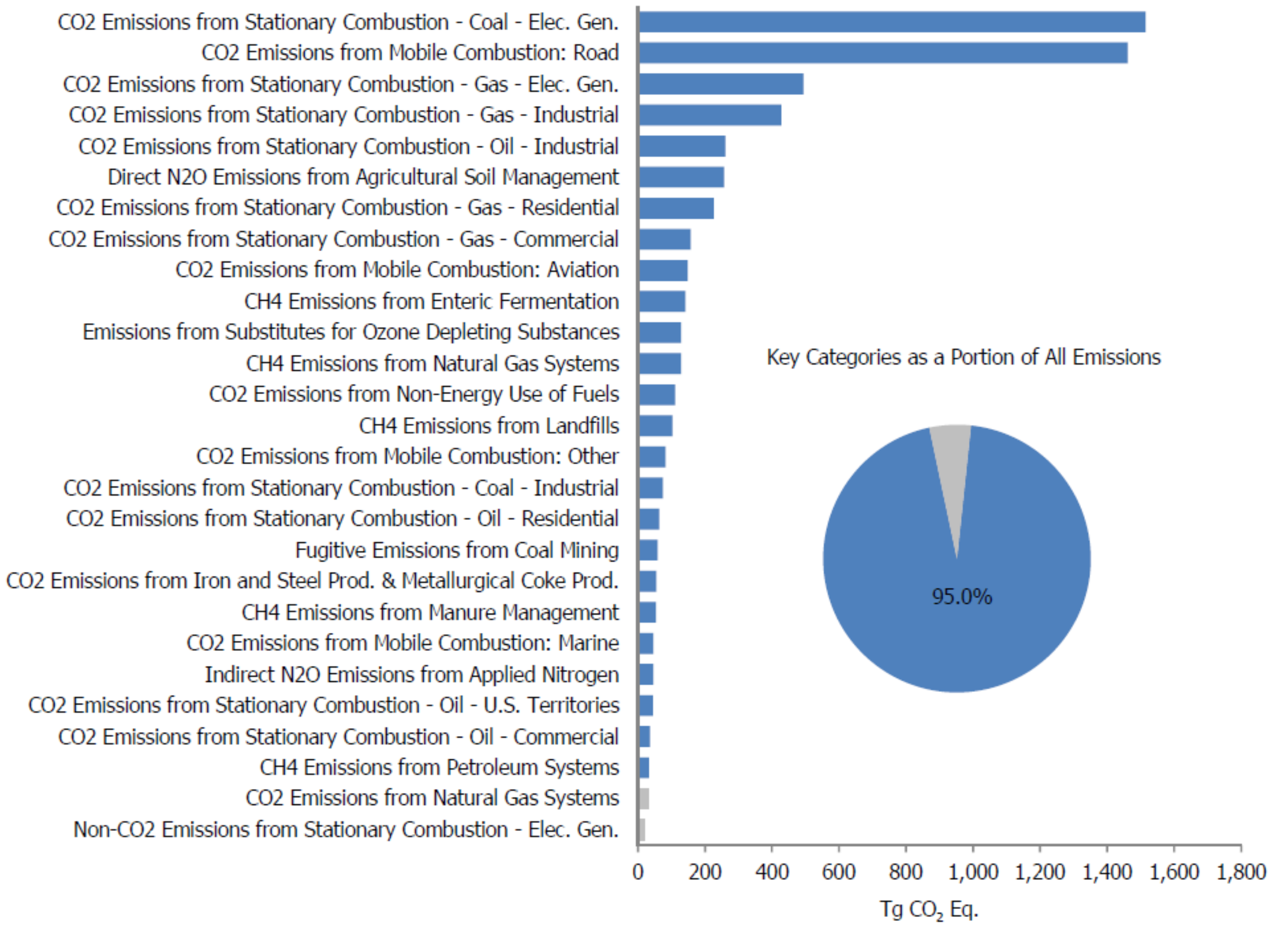
Key Categories

The IPCC *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."[21] 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 2012 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 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.

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

Figure ES-16: 2012 Key Categories



Note: For a complete discussion of the key category analysis, see Annex 1. Blue bars indicate a Tier 1 level assessment key category. Gray bars indicate a Tier 2 level assessment key category.

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.

Box ES- 3: 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 2006 IPCC Guidelines (IPCC 2006), which states, "Both methodological changes and refinements over time are an essential part of improving inventory quality. It is good practice to change or refine methods" when: available data have changed; the previously used method is not consistent with the IPCC guidelines for that category; a category has become key; the previously used method is insufficient to reflect mitigation activities in a transparent manner; the capacity for inventory preparation has increased; new inventory methods become available; and for correction of errors." 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 2012) has been recalculated to reflect the change, per the 2006 IPCC Guidelines (IPCC 2006). 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.