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 2013. 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 *2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories* (IPCC 2006). The structure of this report is consistent with the UNFCCC guidelines for inventory reporting.[4]

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

---

[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/2013/cop19/eng/10a03.pdf >.

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

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. The manner that emissions and sinks are provided in this Inventory is one of many ways U.S. emissions and sinks could be examined; 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 2013, concentrations of these greenhouse gases have increased globally by 42, 152, and 20 percent, respectively (IPCC 2007 and NOAA/ESRL 2015). 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 climate change 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).[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 2013). Direct radiative effects occur when the gas itself is a greenhouse gas. The reference gas used is CO_2, and therefore GWP-

[6] See < http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8108.php >.

[7] See <http://www.epa.gov/climatechange/emissions/ghgrulemaking.html> and <http://ghgdata.epa.gov/ghgp/main.do>.

[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.

weighted emissions are measured in million metric tons of CO_2 equivalent (MMT CO_2 Eq.).[9,10] All gases in this Executive Summary are presented in units of MMT CO_2 Eq.

Revised UNFCCC reporting guidelines for national inventories now require the use of GWP values from the *IPCC Fourth Assessment Report (AR4)* (IPCC 2007).[11] Therefore, to comply with international reporting standards under the UNFCCC, official emission estimates are reported by the United States using AR4 GWP values, which have replaced the previously required use of SAR GWP values in the U.S. Inventory. All estimates are provided throughout the report in both CO_2 equivalents and unweighted units. A comparison of emission values using the AR4 GWP values versus the *IPCC Second Assessment Report (SAR)* (IPCC 1996), *IPCC Third Assessment Report (TAR)* (IPCC 2001), and the *IPCC Fifth Assessment Report (AR5)* (IPCC 2013) 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 use of IPCC AR4 GWP values in this and in future year inventories will apply across the entire time series of the inventory (i.e., from 1990 to 2013 in this 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]	25
N_2O	298
HFC-23	14,800
HFC-32	675
HFC-125	3,500
HFC-134a	1,430
HFC-143a	4,470
HFC-152a	124
HFC-227ea	3,220
HFC-236fa	9,810
HFC-4310mee	1,640
CF_4	7,390
C_2F_6	12,200
C_4F_{10}	8,860
C_6F_{14}	9,300
SF_6	22,800
NF_3	17,200

Source: IPCC (2007)

[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.

[9] Carbon comprises 12/44ths 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/2013/cop19/eng/10a03.pdf >.

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

In 2013, total U.S. greenhouse gas emissions were 6,742.2 MMT, or million metric tons, CO_2 Eq. Total U.S. emissions have increased by 7.0 percent from 1990 to 2013, and emissions increased from 2012 to 2013 by 1.8 percent (118.8 MMT CO_2 Eq.). The increase from 2012 to 2013 was due to an increase in the carbon intensity of fuels consumed to generate electricity due to an increase in coal consumption, with decreased natural gas consumption. Additionally, relatively cool winter conditions led to an increase in fuels for the residential and commercial sectors for heating. Lastly, transportation emissions increased as a result of a small increase in vehicle miles traveled (VMT) and fuel use across on-road transportation modes. Since 1990, U.S. emissions have increased at an average annual rate of 0.3 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 2013.

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

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.

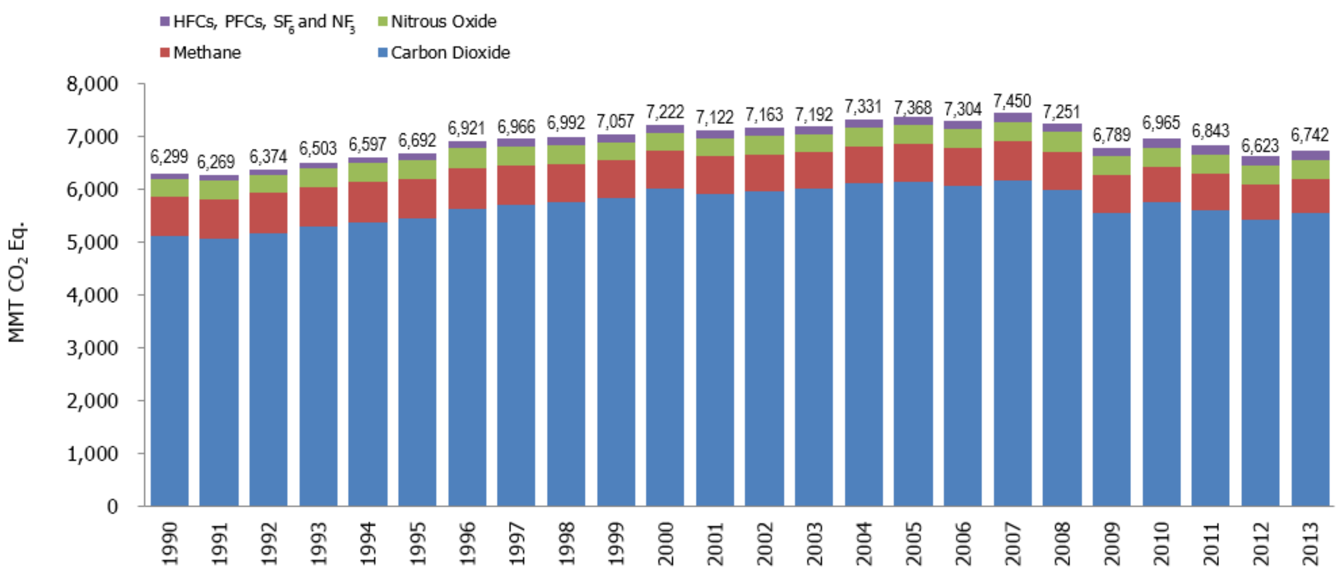


Figure ES-2: Annual Percent Change in U.S. Greenhouse Gas Emissions

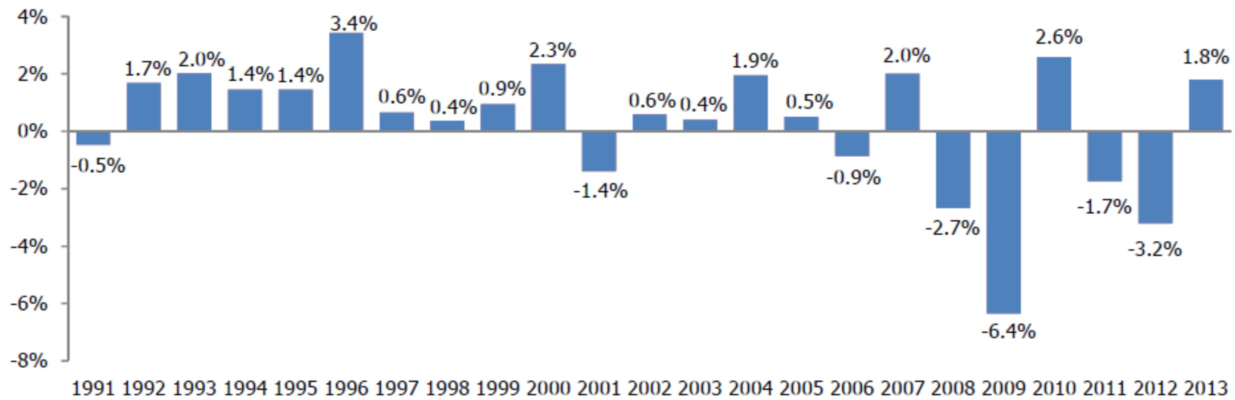


Figure ES-3: Annual Greenhouse Gas Emissions Relative to 1990 (1990=0)

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.

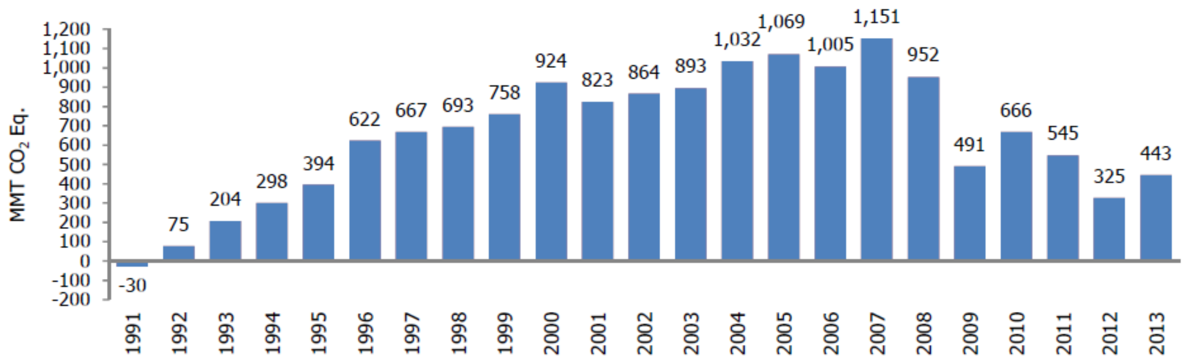


Table ES-2: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks (MMT CO_2 Eq.)

Gas/Source	1990	2005	2009	2010	2011	2012	2013
CO_2	**5,126.8**	**6,156.4**	**5,553.0**	**5,754.2**	**5,618.7**	**5,418.7**	**5,556.0**
Fossil Fuel Combustion	4,740.7	5,753.5	5,226.1	5,401.2	5,266.6	5,062.3	5,195.5
Electricity Generation	1,820.8	2,402.1	2,146.4	2,259.2	2,158.5	2,022.7	2,040.5
Transportation	1,493.8	1,891.0	1,747.0	1,764.1	1,745.4	1,735.9	1,754.0
Industrial	842.5	828.8	728.3	775.6	773.7	783.9	817.3
Residential	338.3	357.9	336.7	335.1	327.5	283.4	329.9
Commercial	217.4	223.7	223.8	220.5	221.3	197.5	221.5
U.S. Territories	27.9	50.0	43.8	46.6	40.2	39.0	32.3
Non-Energy Use of Fuels	120.8	155.5	129.3	130.1	122.9	128.9	133.0
Iron and Steel Production & Metallurgical Coke Production	99.8	66.7	43.0	55.7	60.0	54.3	52.3
Natural Gas Systems	37.6	30.0	32.2	32.3	35.6	34.8	37.8
Cement Production	33.3	45.9	29.4	31.3	32.0	35.1	36.1
Petrochemical Production	21.6	28.1	23.7	27.5	26.4	26.5	26.3
Lime Production	11.7	14.6	11.4	13.4	14.0	13.7	14.1
Ammonia Production	13.0	9.2	8.5	9.2	9.3	9.4	10.2
Incineration of Waste	8.0	12.5	11.3	11.0	10.5	10.4	10.1
Cropland Remaining Cropland	7.1	7.9	7.2	8.6	8.0	10.0	9.9
Petroleum Systems	4.4	4.9	4.7	4.2	4.5	5.1	6.0

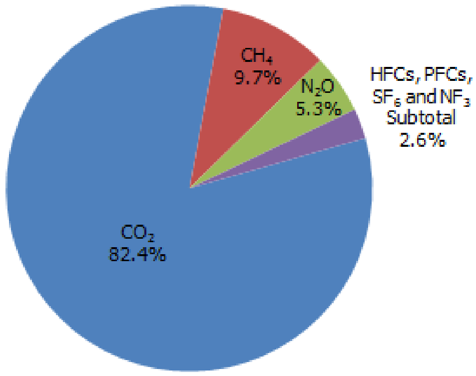
Urea Consumption for Non-Agricultural Purposes	3.8	3.7	3.4	4.7	4.0	4.4	4.7
Other Process Uses of Carbonates	4.9	6.3	7.6	9.6	9.3	8.0	4.4
Aluminum Production	6.8	4.1	3.0	2.7	3.3	3.4	3.3
Soda Ash Production and Consumption	2.7	2.9	2.5	2.6	2.6	2.7	2.7
Ferroalloy Production	2.2	1.4	1.5	1.7	1.7	1.9	1.8
Titanium Dioxide Production	1.2	1.8	1.6	1.8	1.7	1.5	1.6
Zinc Production	0.6	1.0	0.9	1.2	1.3	1.5	1.4
Phosphoric Acid Production	1.6	1.4	1.0	1.1	1.2	1.1	1.2
Glass Production	1.5	1.9	1.0	1.5	1.3	1.2	1.2
Carbon Dioxide Consumption	1.5	1.4	1.8	1.2	0.8	0.8	0.9
Wetlands Remaining Wetlands	1.0	1.1	1.0	1.0	0.9	0.8	0.8
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	0.1	0.2	0.2	0.2	0.2
Magnesium Production and Processing	+	+	+	+	+	+	+
Land Use, Land-Use Change, and Forestry (Sink)[a]	*(774.1)*	*(912.6)*	*(871.3)*	*(872.0)*	*(881.3)*	*(880.7)*	*(882.0)*
Wood Biomass and Ethanol Consumption[b]	*219.4*	*229.8*	*250.5*	*265.1*	*268.1*	*267.7*	*283.3*
International Bunker Fuels[c]	*103.5*	*113.1*	*106.4*	*117.0*	*111.7*	*105.8*	*99.8*
CH_4	**740.4**	**703.9**	**724.6**	**684.3**	**678.5**	**666.2**	**654.1**
Enteric Fermentation	164.2	168.9	172.7	171.1	168.7	166.3	164.5
Natural Gas Systems	175.1	171.8	170.3	162.2	162.2	157.5	159.9
Landfills	186.2	165.5	158.1	121.8	121.3	115.3	114.6
Coal Mining	96.5	64.1	79.9	82.3	71.2	66.5	64.6
Manure Management	37.2	56.3	59.7	60.9	61.4	63.7	61.4
Petroleum Systems	30.5	24.0	34.3	35.8	36.7	38.8	40.4
Wastewater Treatment	15.7	15.9	15.6	15.5	15.3	15.2	15.0
Rice Cultivation	9.2	8.9	9.4	11.1	8.5	9.3	8.3
Stationary Combustion	8.5	7.4	7.4	7.1	7.1	6.6	8.0
Abandoned Underground Coal Mines	7.2	6.6	6.4	6.6	6.4	6.2	6.2
Forest Land Remaining Forest Land	2.5	8.3	5.8	4.7	14.6	15.7	5.8
Mobile Combustion	5.6	3.0	2.3	2.3	2.3	2.2	2.1
Composting	0.4	1.9	1.9	1.8	1.9	1.9	2.0
Iron and Steel Production & Metallurgical Coke Production	1.1	0.9	0.4	0.6	0.7	0.7	0.7
Field Burning of Agricultural Residues	0.3	0.2	0.3	0.3	0.3	0.3	0.3
Petrochemical Production	0.2	0.1	0.1	0.1	+	0.1	0.1
Ferroalloy Production	+	+	+	+	+	+	+
Silicon Carbide Production and Consumption	+	+	+	+	+	+	+
Wetlands Remaining Wetlands	+	+	+	+	+	+	+
Incineration of Waste	+	+	+	+	+	+	+
International Bunker Fuels[c]	*0.2*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
N_2O	**329.5**	**355.2**	**355.4**	**359.4**	**371.1**	**364.9**	**354.5**
Agricultural Soil Management	224.0	243.6	264.1	264.3	265.8	266.0	263.7
Stationary Combustion	11.9	20.2	20.4	22.2	21.3	21.4	22.9
Mobile Combustion	41.2	38.1	24.6	23.7	22.5	20.2	18.4
Manure Management	13.8	16.4	17.0	17.1	17.3	17.3	17.3
Nitric Acid Production	12.1	11.3	9.6	11.5	10.9	10.5	10.7
Wastewater Treatment	3.4	4.3	4.6	4.7	4.8	4.9	4.9
N_2O from Product Uses	4.2	4.2	4.2	4.2	4.2	4.2	4.2

Forest Land Remaining Forest Land	1.7	5.8	4.2	3.5	10.0	10.7	4.2
Adipic Acid Production	15.2	7.1	2.7	4.2	10.2	5.5	4.0
Settlements Remaining Settlements	1.0	1.8	1.7	1.8	1.9	1.9	1.8
Composting	0.3	1.7	1.7	1.6	1.7	1.7	1.8
Incineration of Waste	0.5	0.4	0.3	0.3	0.3	0.3	0.3
Semiconductor Manufacture	+	0.1	0.1	0.1	0.2	0.2	0.2
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*	*0.9*	*1.0*	*1.0*	*0.9*	*0.9*
HFCs, PFCs, SF_6 and NF_3	**102.0**	**152.5**	**156.5**	**166.9**	**174.9**	**173.6**	**177.6**
HFCs	**46.6**	**131.4**	**142.9**	**152.6**	**157.4**	**159.2**	**164.3**
Substitution of Ozone Depleting Substances[d]	0.3	111.1	136.0	144.4	148.4	153.5	158.6
HCFC-22 Production	46.1	20.0	6.8	8.0	8.8	5.5	5.5
Semiconductor Manufacture	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Magnesium Production and Processing	0.0	0.0	+	+	+	+	0.1
PFCs	**24.3**	**6.6**	**3.9**	**4.4**	**6.9**	**6.0**	**5.8**
Aluminum Production	21.5	3.4	1.9	1.9	3.5	2.9	3.0
Semiconductor Manufacture	2.8	3.2	2.0	2.6	3.4	3.0	2.9
SF_6	**31.1**	**14.0**	**9.2**	**9.4**	**10.0**	**7.7**	**6.9**
Electrical Transmission and Distribution	25.4	10.6	7.3	6.9	6.8	5.7	5.1
Magnesium Production and Processing	5.2	2.7	1.6	2.1	2.8	1.6	1.4
Semiconductor Manufacture	0.5	0.7	0.3	0.4	0.4	0.4	0.4
NF_3	**+**	**0.5**	**0.4**	**0.5**	**0.7**	**0.6**	**0.6**
Semiconductor Manufacture	+	0.5	0.4	0.5	0.7	0.6	0.6
Total	**6,298.8**	**7,367.9**	**6,789.5**	**6,964.7**	**6,843.3**	**6,623.4**	**6,742.2**
Net Emissions (Sources and Sinks)	**5,524.7**	**6,455.4**	**5,918.2**	**6,092.7**	**5,962.0**	**5,742.7**	**5,860.2**

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.
+ Does not exceed 0.05 MMT CO_2 Eq.
[a] Parentheses indicate negative values or sequestration. 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 2013. The primary greenhouse gas emitted by human activities in the United States was CO_2, representing approximately 82.4 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 11.7 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 byproduct of primary aluminum production and from semiconductor manufacturing, while electrical transmission and distribution systems accounted for most SF_6 emissions.

Figure ES-4: 2013 Greenhouse Gas Emissions by Gas (Percentages based on MMT CO_2 Eq.)



Overall, from 1990 to 2013, total emissions of CO_2 increased by 429.2 MMT CO_2 Eq. (8.4 percent), while total emissions of CH_4 decreased by 86.4 MMT CO_2 Eq. (11.7 percent), and N_2O increased by 25.0 MMT CO_2 Eq. (7.6 percent). During the same period, aggregate weighted emissions of HFCs, PFCs, SF_6 and NF_3 rose by 75.7 MMT CO_2 Eq. (74.2 percent). From 1990 to 2013, HFCs increased by 117.7 MMT CO_2 Eq. (252.8 percent), PFCs decreased by 18.4 MMT CO_2 Eq. (76.0 percent), SF_6 decreased by 24.2 MMT CO_2 Eq. (77.7 percent), and NF_3 increased by 0.5 MMT CO_2 Eq. (1,070.1 percent). Despite being emitted in smaller quantities relative to the other principal greenhouse gases, emissions of HFCs, PFCs, SF_6 and NF_3 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 13.1 percent of total emissions in 2013. The following sections describe each gas's contribution to total U.S. greenhouse gas emissions in more detail.

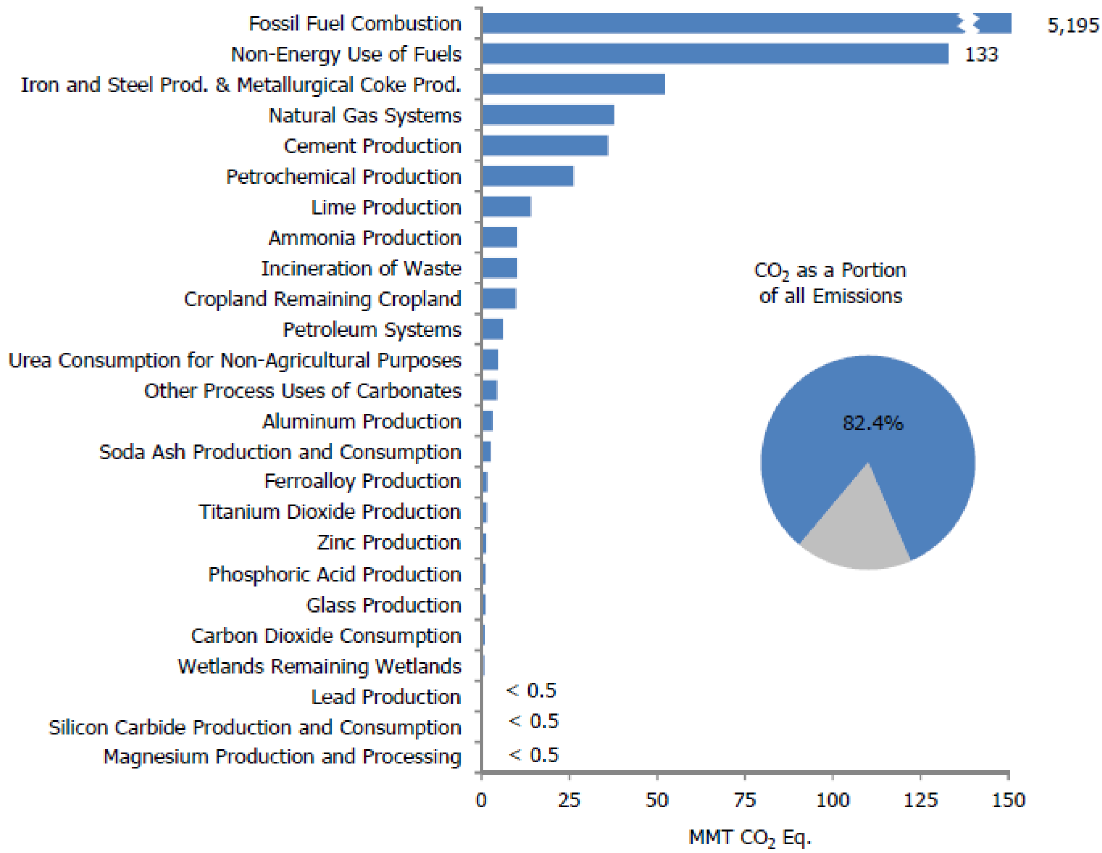
Carbon Dioxide Emissions

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 42 percent (IPCC 2007 and NOAA/ESRL 2015), principally due to the combustion of fossil fuels. Within the United States, fossil fuel combustion accounted for 93.5 percent of CO_2 emissions in 2013. Globally, approximately 32,723 MMT of CO_2 were added to the atmosphere through the combustion of fossil fuels in 2012, of which the United States accounted for about 16 percent.[12] 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). Although fossil fuel combustion is the greatest source of CO_2 emissions, there are 24 additional sources of CO_2 emissions (Figure ES-5).

[12] Global CO_2 emissions from fossil fuel combustion were taken from Energy Information Administration *International Energy Statistics 2013* < http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm> EIA (2013).

Figure ES-5: 2013 Sources of CO_2 Emissions

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.



Note: Electricity generation also includes emissions of less than 0.05 MMT 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 77 percent of GWP-weighted emissions since 1990, and is approximately 77 percent of total GWP-weighted emissions in 2013. Emissions of CO_2 from fossil fuel combustion increased at an average annual rate of 0.4 percent from 1990 to 2013. The fundamental factors influencing this trend include (1) a generally growing domestic economy over the last 24 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 2013, CO_2 emissions from fossil fuel combustion increased from 4,740.7 MMT CO_2 Eq. to 5,195.5 MMT CO_2 Eq.—a 9.6 percent total increase over the twenty-four-year period. From 2012 to 2013, these emissions increased by 133.2 MMT CO_2 Eq. (2.6 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: 2013 CO_2 Emissions from Fossil Fuel Combustion by Sector and Fuel Type

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.

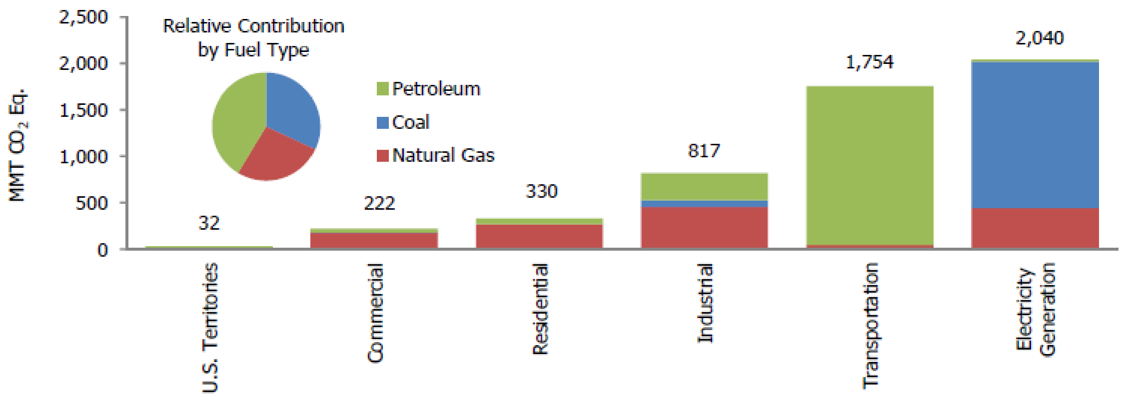
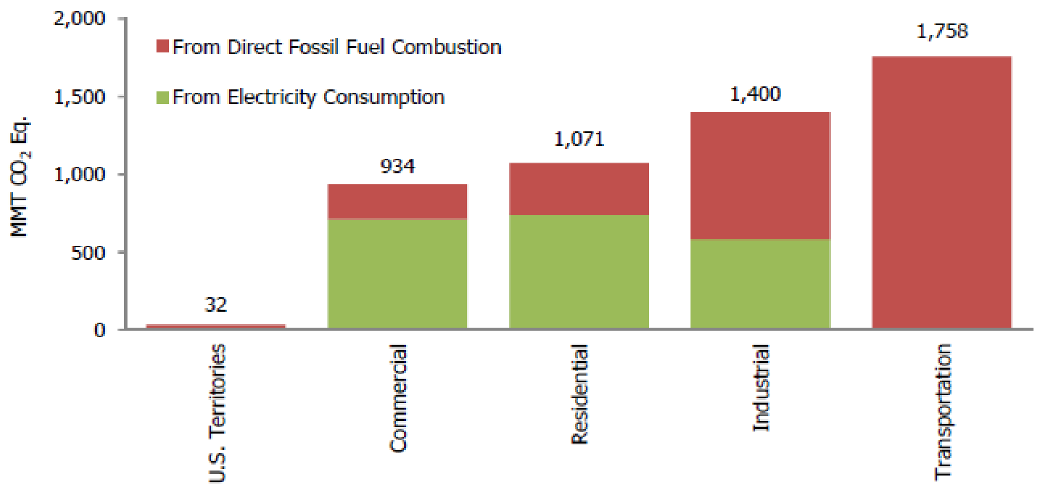


Figure ES-7: 2013 End-Use Sector Emissions of CO_2 from Fossil Fuel Combustion

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.



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 (MMT CO_2 Eq.)

End-Use Sector	1990	2005	2009	2010	2011	2012	2013
Transportation	**1,496.8**	**1,895.8**	**1,751.5**	**1,768.6**	**1,749.6**	**1,739.7**	**1,758.0**
Combustion	1,493.8	1,891.0	1,747.0	1,764.1	1,745.4	1,735.9	1,754.0
Electricity	3.0	4.7	4.5	4.5	4.3	3.9	4.0
Industrial	**1,529.2**	**1,565.7**	**1,330.3**	**1,416.7**	**1,398.6**	**1,376.8**	**1,400.0**
Combustion	842.5	828.8	728.3	775.6	773.7	783.9	817.3
Electricity	686.7	737.0	602.0	641.1	624.9	592.9	582.7
Residential	**931.4**	**1,214.7**	**1,123.2**	**1,175.5**	**1,118.5**	**1,008.9**	**1,070.8**
Combustion	338.3	357.9	336.7	335.1	327.5	283.4	329.9
Electricity	593.0	856.7	786.5	840.4	791.0	725.5	740.9
Commercial	**755.4**	**1,027.4**	**977.3**	**993.8**	**959.6**	**898.0**	**934.4**
Combustion	217.4	223.7	223.8	220.5	221.3	197.5	221.5
Electricity	538.0	803.7	753.5	773.3	738.3	700.4	712.8
U.S. Territories[a]	**27.9**	**50.0**	**43.8**	**46.6**	**40.2**	**39.0**	**32.3**
Total	**4,740.7**	**5,753.5**	**5,226.1**	**5,401.2**	**5,266.6**	**5,062.3**	**5,195.5**
Electricity Generation	**1,820.8**	**2,402.1**	**2,146.4**	**2,259.2**	**2,158.5**	**2,022.7**	**2,040.5**

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.
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 33.8 percent of U.S. CO_2 emissions from fossil fuel combustion in 2013. The largest sources of transportation CO_2 emissions in 2013 were passenger cars (43.3 percent), freight trucks (22.3 percent), light duty trucks, which include sport utility vehicles, pickup trucks, and minivans (17.2 percent), commercial aircraft (6.5 percent), pipelines (2.7 percent), rail (2.5 percent), and ships and boats (2.2 percent). Annex 3.2 presents the total emissions from all transportation and mobile sources, including CO_2, CH_4, N_2O, and HFCs.

In terms of the overall trend, from 1990 to 2013, total transportation CO_2 emissions rose by 17 percent due, in large part, to increased demand for travel as fleet wide light-duty vehicle fuel economy was relatively stable (average new vehicle fuel economy declined slowly from 1990 through 2004 and then increased more rapidly from 2005 through 2013). The number of vehicle miles traveled by light-duty motor vehicles (passenger cars and light-duty trucks) increased 36 percent from 1990 to 2013, 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.

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 2013. Approximately 58 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 21 and 18 percent, respectively, of CO_2 emissions from fossil fuel combustion in 2013. Both sectors relied heavily on electricity for meeting energy demands, with 69 and 76 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 15 percent and 24 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 34 percent of total U.S. energy uses from fossil fuels and emitted 39 percent of the CO_2 from fossil fuel combustion in 2013. 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 40 percent their total energy requirements in 2013.[13] In addition, the coal used by electricity generators accounted for 93 percent of all coal consumed for energy in the United States in 2013.[14] 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 26 percent of their total energy requirements in 2013. 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 increased by 12.2 MMT CO_2 Eq. (10.1 percent) from 1990 through 2013. Emissions from non-energy uses of fossil fuels were 133.0 MMT CO_2 Eq. in 2013, which constituted 2.4 percent of total national CO_2 emissions, approximately the same proportion as in 1990.

- CO_2 emissions from cement production increased every year from 1991 through 2006 (with the exception of a slight decrease in 1997), but decreased in the following years until 2009. Emissions from cement production were at their lowest levels in 2009 (2009 emissions are approximately 29 percent lower than 2008 emissions and 12 percent lower than 1990). Since 2010, emissions have increased slightly. In 2013, emissions from cement production increased by 3.1 percent from the 2012 levels.

- Net CO_2 uptake from Land Use, Land-Use Change, and Forestry increased by 107.9 MMT CO_2 Eq. (13.9 percent) from 1990 through 2013. 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.[15] 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 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

[13] See Table 7.2b Electric Power Sector of EIA 2015.

[14] See Table 6.2 Coal Consumption by Sector of EIA 2015.

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

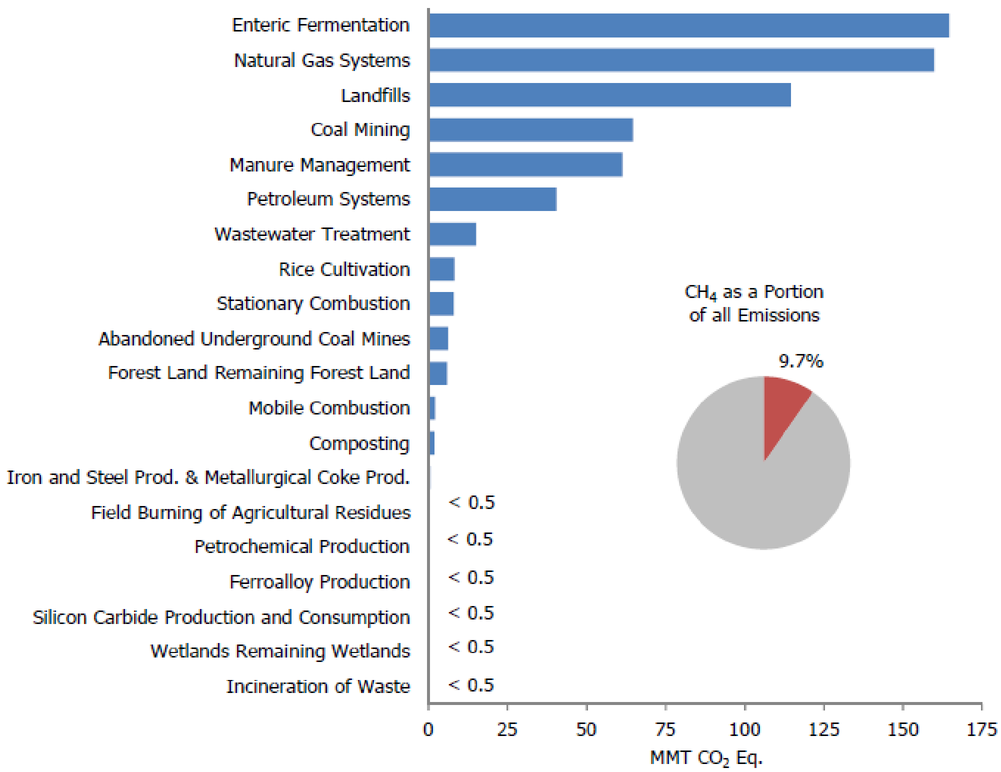
measurement and remote sensing techniques to improve national greenhouse gas inventories, EPA relies upon guidance from the IPCC on the use of measurements and modeling to validate emission inventories.[16]

Methane Emissions

Methane (CH_4) is 25 times as effective as CO_2 at trapping heat in the atmosphere (IPCC 2007). Over the last two hundred and fifty years, the concentration of CH_4 in the atmosphere increased by 152 percent (IPCC 2007 and NOAA/ESRL 2015). 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: 2013 Sources of CH_4 Emissions

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.



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 2013, enteric fermentation CH_4 emissions were 164.5 MMT CO_2 Eq. (25.2 percent of total CH_4 emissions), which represents an increase of 0.4 MMT CO_2 Eq. (0.2 percent) since 1990. This increase in emissions from 1990 to 2013 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

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

the literature for dairy cow diets indicated a trend toward a decrease in feed digestibility for those years. Emissions decreased again from 2008 to 2013 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 2013 with 159.9 MMT CO_2 Eq. of CH_4 emitted into the atmosphere. Those emissions have decreased by 15.2 MMT CO_2 Eq. (8.7 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 use of plunger lifts for liquids unloading, from regulatory reductions such as reductions from hydraulically fractured gas well completions and workovers resulting from the 2012 New Source Performance Standards (NSPS) for oil and gas, and from a variety of voluntary reduction activities. The decrease in distribution emissions is due to a decrease in unprotected steel and cast iron pipelines and their replacement with plastic pipelines. Emissions from field production account for 31 percent of CH_4 emissions and 42 percent of non-combustion CO_2 emissions from natural gas systems in 2013. CH_4 emissions from field production decreased by 11 percent from 1990 to 2013; however, the trend was not stable over the time series – emissions from field production increased 37 percent from 1990 to 2007 due primarily to increases in emissions from pneumatic devices and hydraulically fractured gas well completions and workovers, and then declined by 35 percent from 2007 to 2013. Reasons for the 2007 to 2013 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 increased Reduced Emission 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 (114.6 MMT CO_2 Eq.), accounting for 17.5 percent of total CH_4 emissions in 2013. From 1990 to 2013, CH_4 emissions from landfills decreased by 71.6 MMT CO_2 Eq. (38.4 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,[17] which has more than offset the additional CH_4 emissions resulting from an increase in the amount of municipal solid waste landfilled.

- Methane emissions from manure management increased by 65.2 percent since 1990, from 37.2 MMT CO_2 Eq. in 1990 to 61.4 MMT CO_2 Eq. in 2013. 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.

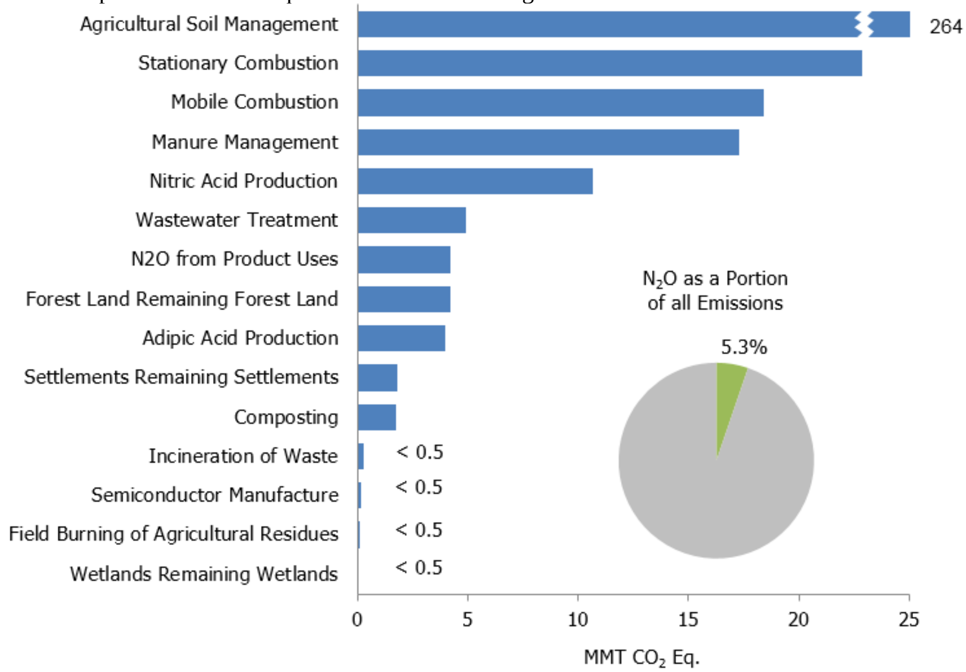
Nitrous Oxide Emissions

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 2007). Since 1750, the global atmospheric concentration of N_2O has risen by approximately 20 percent (IPCC 2007 and NOAA/ESRL 2015). The main anthropogenic activities producing N_2O in the United States are agricultural soil management, stationary fuel combustion, fuel combustion in motor vehicles, manure management and nitric acid production (see Figure ES-9).

[17] 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.

Figure ES-9: 2013 Sources of N_2O Emissions

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.



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

- Agricultural soils accounted for approximately 74.4 percent of N_2O emissions and 3.9 percent of total emissions in the United States in 2013. Estimated emissions from this source in 2013 were 263.7 MMT CO_2 Eq. Annual N_2O emissions from agricultural soils fluctuated between 1990 and 2013, although overall emissions were 17.7 percent higher in 2013 than in 1990. Year-to-year fluctuations are largely a reflection of annual variation in weather patterns, synthetic fertilizer use, and crop production.

- N_2O emissions from stationary combustion increased 11.0 MMT CO_2 Eq. (92.0 percent) from 1990 through 2013. 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 2013, total N_2O emissions from manure management were estimated to be 17.3 MMT CO_2 Eq. (58 kt); in 1990, emissions were 13.8 MMT CO_2 Eq. (46 kt). 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 2013 and a 0.1 percent decrease from 2012 through 2013. Overall shifts toward liquid systems have driven down the emissions per unit of nitrogen excreted.

- N_2O emissions from adipic acid production were 4.0 MMT CO_2 Eq. in 2013, and have decreased significantly since 1990 due to both the widespread installation of pollution control measures in the late 1990s and plant idling in the late 2000s. Emissions from adipic acid production have decreased by 73.8 percent since 1990 and by 76.4 percent since a peak in 1995.

HFC, PFC, SF_6, and NF_3 Emissions

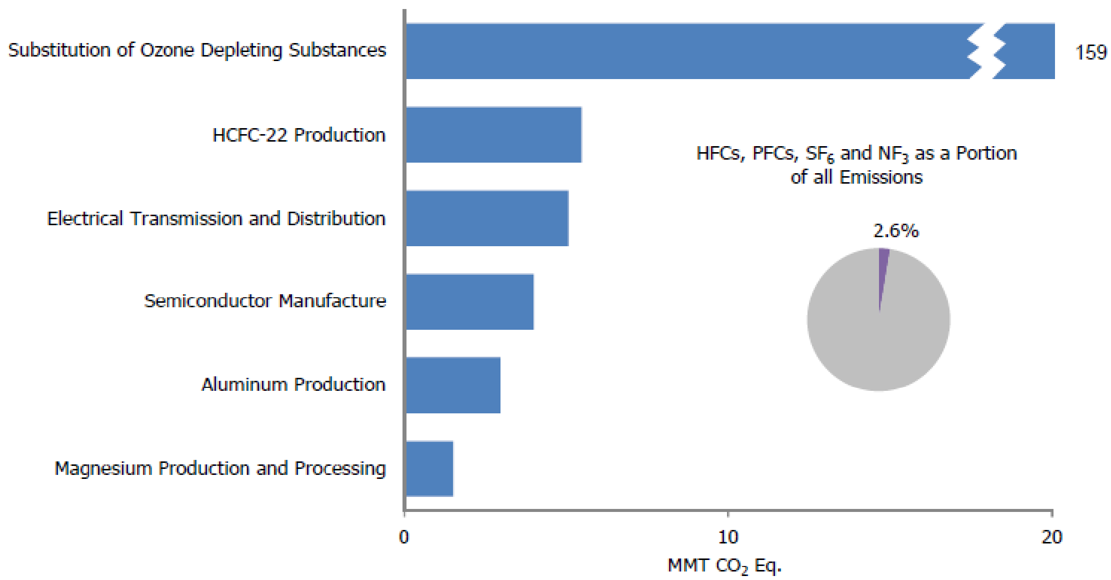
HFCs and PFCs are families of synthetic chemicals that are used as alternatives to Ozone Depleting Substances, which are being phased out under the Montreal Protocol and Clean Air Act Amendments of 1990. HFCs and PFCs do not deplete the stratospheric ozone layer, and are therefore acceptable alternatives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

These compounds, however, along with SF_6 and NF_3, 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 2013).

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: 2013 Sources of HFCs, PFCs, SF_6, and NF_3 Emissions

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.



Some significant trends in U.S. HFC, PFC, SF_6, and NF_3 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 158.6 MMT CO_2 Eq. in 2013. This increase was in large part the result of efforts to phase out CFCs and other ODSs in the United States. In the short term, this trend is expected to continue, and will likely continue over the next decade as HCFCs, which are interim substitutes in many applications, are themselves phased-out under the provisions of the Copenhagen Amendments to the *Montreal Protocol*.
- GWP-weighted PFC, HFC, SF_6, and NF_3 emissions from semiconductor manufacture have increased by 12 percent from 1990 to 2013, due to industrial growth and the adoption of emissions reduction technologies. 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 4.0 MMT CO_2 Eq. in 2013 (a 56 percent decrease relative to 1999).
- SF_6 emissions from electric power transmission and distribution systems decreased by 80.0 percent (20.3 MMT CO_2 Eq.) from 1990 to 2013. There are two potential causes for this decrease: (1) a sharp increase in the price of SF_6 during the 1990s and (2) a growing awareness of the environmental impact of SF_6 emissions through programs such as EPA's SF_6 Emission Reduction Partnership for Electric Power Systems.
- PFC emissions from aluminum production decreased by 86.2 percent (18.5 MMT CO_2 Eq.) from 1990 to 2013. This decline is due both to reductions in domestic aluminum production and to actions taken by aluminum smelting companies to reduce the frequency and duration of anode effects.

ES.3. Overview of Sector Emissions and Trends

In accordance with the UNFCCC decision to set the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006) as the standard for Annex I countries at the Nineteenth Conference of the Parties (UNFCCC 2014), 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-four-year period of 1990 to 2013, total emissions in the Energy, Industrial Processes and Product Use, and Agriculture sectors grew by 416.8 MMT CO_2 Eq. (7.9 percent), 18.2 MMT CO_2 Eq. (5.3 percent), and 67.0 MMT CO_2 Eq. (14.9 percent), respectively. Emissions from the Waste sector decreased by 67.7 MMT CO_2 Eq. (32.9 percent). 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 98.8 MMT CO_2 Eq. (13.0 percent).

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

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.

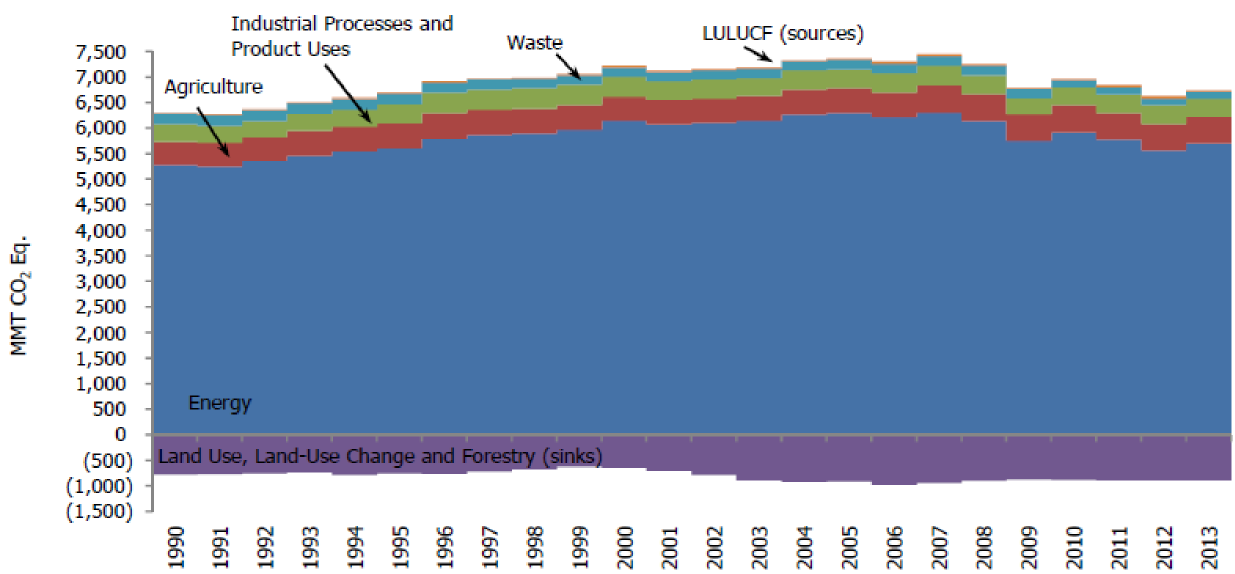


Table ES-4: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks by Chapter/IPCC Sector (MMT CO_2 Eq.)

Chapter/IPCC Sector	1990	2005	2009	2010	2011	2012	2013
Energy	**5,288.6**	**6,292.0**	**5,749.5**	**5,921.3**	**5,770.0**	**5,561.2**	**5,705.4**
Fossil Fuel Combustion	4,740.7	5,753.5	5,226.1	5,401.2	5,266.6	5,062.3	5,195.5
Natural Gas Systems	212.7	201.8	202.5	194.5	197.7	192.2	197.7
Non-Energy Use of Fuels	120.8	155.5	129.3	130.1	122.9	128.9	133.0
Coal Mining	96.5	64.1	79.9	82.3	71.2	66.5	64.6
Petroleum Systems	35.0	28.9	39.0	39.9	41.1	43.9	46.5
Stationary Combustion	20.4	27.6	27.8	29.3	28.4	28.0	30.8
Mobile Combustion	46.9	41.1	26.9	26.0	24.8	22.4	20.6
Incineration of Waste	8.4	12.8	11.6	11.4	10.9	10.7	10.4
Abandoned Underground Coal Mines	7.2	6.6	6.4	6.6	6.4	6.2	6.2
Industrial Processes	**342.1**	**367.4**	**314.8**	**353.6**	**371.0**	**361.2**	**360.3**
Substitution of Ozone Depleting Substances	0.3	111.1	136.0	144.4	148.4	153.5	158.6
Iron and Steel Production & Metallurgical Coke Production	100.9	67.5	43.5	56.4	60.7	55.1	53.0
Cement Production	33.3	45.9	29.4	31.3	32.0	35.1	36.1
Petrochemical Production	21.9	28.3	23.8	27.5	26.5	26.6	26.4
Lime Production	11.7	14.6	11.4	13.4	14.0	13.7	14.1

Nitric Acid Production	12.1	11.3	9.6	11.5	10.9	10.5	10.7
Ammonia Production	13.0	9.2	8.5	9.2	9.3	9.4	10.2
Aluminum Production	28.3	7.6	4.9	4.6	6.8	6.4	6.2
HCFC-22 Production	46.1	20.0	6.8	8.0	8.8	5.5	5.5
Electrical Transmission and Distribution	25.4	10.6	7.3	6.9	6.8	5.7	5.1
Urea Consumption for Non-Agricultural Purposes	3.8	3.7	3.4	4.7	4.0	4.4	4.7
Other Process Uses of Carbonates	4.9	6.3	7.6	9.6	9.3	8.0	4.4
N_2O from Product Uses	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Semiconductor Manufacture	3.6	4.7	3.1	3.8	4.9	4.5	4.2
Adipic Acid Production	15.2	7.1	2.7	4.2	10.2	5.5	4.0
Soda Ash Production and Consumption	2.7	2.9	2.5	2.6	2.6	2.7	2.7
Ferroalloy Production	2.2	1.4	1.5	1.7	1.7	1.9	1.8
Titanium Dioxide Production	1.2	1.8	1.6	1.8	1.7	1.5	1.6
Magnesium Production and Processing	5.2	2.7	1.6	2.1	2.8	1.7	1.5
Zinc Production	0.6	1.0	0.9	1.2	1.3	1.5	1.4
Phosphoric Acid Production	1.6	1.4	1.0	1.1	1.2	1.1	1.2
Glass Production	1.5	1.9	1.0	1.5	1.3	1.2	1.2
Carbon Dioxide Consumption	1.5	1.4	1.8	1.2	0.8	0.8	0.9
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
Agriculture	**448.7**	**494.5**	**523.3**	**524.8**	**522.1**	**523.0**	**515.7**
Agricultural Soil Management	224.0	243.6	264.1	264.3	265.8	266.0	263.7
Enteric Fermentation	164.2	168.9	172.7	171.1	168.7	166.3	164.5
Manure Management	51.0	72.8	76.7	78.0	78.7	81.0	78.7
Rice Cultivation	9.2	8.9	9.4	11.1	8.5	9.3	8.3
Field Burning of Agricultural Residues	0.4	0.3	0.4	0.4	0.4	0.4	0.4
Land Use, Land-Use Change, and Forestry	**13.4**	**24.8**	**20.0**	**19.6**	**35.3**	**39.0**	**22.6**
Forest Land Remaining Forest Land	4.3	14.1	10.0	8.2	24.6	26.3	10.0
Cropland Remaining Cropland	7.1	7.9	7.2	8.6	8.0	10.0	9.9
Settlements Remaining Settlements	1.0	1.8	1.7	1.8	1.9	1.9	1.8
Wetlands Remaining Wetlands	1.1	1.1	1.0	1.0	0.9	0.8	0.8
Waste	**206.0**	**189.2**	**181.8**	**145.5**	**144.9**	**138.9**	**138.3**
Landfills	186.2	165.5	158.1	121.8	121.3	115.3	114.6
Wastewater Treatment	19.0	20.2	20.2	20.2	20.1	20.0	20.0
Composting	0.7	3.5	3.6	3.5	3.5	3.7	3.7
Total Emissions	**6,298.8**	**7,367.9**	**6,789.5**	**6,964.7**	**6,843.3**	**6,623.4**	**6,742.2**
Net CO_2 Flux From Land Use, Land-Use Change and Forestry (Sinks)[a]	(774.1)	(912.6)	(871.3)	(872.0)	(881.3)	(880.7)	(882.0)
Net Emissions (Sources and Sinks)	**5,524.7**	**6,455.4**	**5,918.2**	**6,092.7**	**5,962.0**	**5,742.7**	**5,860.2**

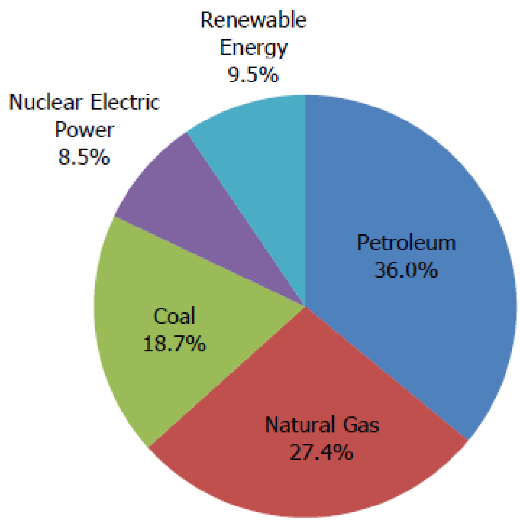
Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.
[a] The net CO_2 flux total includes both emissions and sequestration, and constitutes a sink in the United States. Sinks are only included in net emissions total. Please refer to Table ES-5 for a breakout by source.
Note: Totals may not sum due to independent rounding. 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 2013. In 2013, 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 (43 percent and 12 percent of total U.S. emissions of each gas, respectively). Overall, emission sources in the Energy chapter account for a combined 84.6 percent of total U.S. greenhouse gas emissions in 2013.

Figure ES-12: 2013 U.S. Energy Consumption by Energy Source



Industrial Processes and Product Use

The Industrial Processes and Product Use (IPPU) section includes greenhouse gas emissions occurring from industrial processes and from the use of greenhouse gases in products. This section includes sources of emissions formerly represented in the "Industrial Processes" and "Solvent and Other Product Use" sectors in prior versions of this report.

Greenhouse gas emissions are produced as the by-products of many non-energy-related industrial activities. 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, 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, CO_2 consumption, silicon carbide production and consumption, aluminum production, petrochemical production, nitric acid production, adipic acid production, lead production, zinc production, and N_2O from product uses. Industrial processes also release HFCs, PFCs, SF_6, and NF_3. In addition to their use as ODS substitutes, HFCs, PFCs, SF_6, NF_3, and other fluorinated compounds are employed and emitted by a number of other industrial sources in the United States. These industries include aluminum production, HCFC-22 production, semiconductor manufacture, electric power transmission and distribution, and magnesium metal production and processing. Overall, emission sources in the Industrial Process and Product Use chapter account for 5.3 percent of U.S. greenhouse gas emissions in 2013.

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 25.2 percent and 9.4 percent of total CH_4 emissions from anthropogenic activities, respectively, in 2013. Agricultural soil management activities such as fertilizer application and other cropping practices were the largest source of U.S. N_2O emissions in 2013, accounting for 74.4 percent. In 2013, emission sources accounted for in the Agricultural chapters were responsible for 7.6 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 2013 net CO_2 flux, urban trees accounted for 10 percent, mineral and organic soil carbon stock changes accounted for 0.5 percent, and landfilled yard trimmings and food scraps accounted for 1.5 percent of the total net flux in 2013. 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 2.4 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 2013 resulted in a net C sequestration of 882.0 MMT CO_2 Eq. (Table ES-5). This represents an offset of 15.9 percent of total U.S. CO_2 emissions, or 13.1 percent of total greenhouse gas emissions in 2013. Between 1990 and 2013, total land use, land-use change, and forestry net C flux resulted in a 13.9 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 (MMT CO_2 Eq.)

Sink Category	1990		2005		2009	2010	2011	2012	2013
Forest Land Remaining Forest Land	(639.4)		(807.1)		(764.9)	(765.4)	(773.8)	(773.1)	(775.7)
Cropland Remaining Cropland	(65.2)		(28.0)		(27.5)	(25.9)	(25.8)	(25.0)	(23.4)
Land Converted to Cropland	24.5		19.8		16.2	16.2	16.2	16.1	16.1
Grassland Remaining Grassland	(1.9)		4.2		11.7	11.7	11.7	11.5	12.1
Land Converted to Grassland	(7.4)		(9.0)		(8.9)	(8.9)	(8.9)	(8.8)	(8.8)
Settlements Remaining Settlements	(60.4)		(80.5)		(85.0)	(86.1)	(87.3)	(88.4)	(89.5)
Other (Landfilled Yard Trimmings and Food Scraps)	(24.2)		(12.0)		(12.9)	(13.6)	(13.5)	(13.0)	(12.8)
Total	**(774.1)**		**(912.6)**		**(871.3)**	**(872.0)**	**(881.3)**	**(880.7)**	**(882.0)**

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 2013 resulted in CO_2 emissions of 9.9 MMT CO_2 Eq. (9,936 kt). Lands undergoing peat extraction (i.e., *Peatlands Remaining Peatlands*) resulted in CO_2 emissions of 0.8 MMT CO_2 Eq. (796 kt) and CH_4 and N_2O emissions of less than 0.05 MMT CO_2 Eq. each. The application of synthetic fertilizers to forest soils in 2013 resulted in direct N_2O emissions of 0.3 MMT CO_2 Eq. (1 kt). 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 2013 accounted for 1.8 MMT CO_2 Eq. (6 kt). This represents an increase of 78.3 percent since 1990. Forest fires in 2013 resulted in CH_4 emissions of 5.8 MMT CO_2 Eq. (233 kt), and in N_2O emissions of 3.8 MMT CO_2 Eq. (13 kt).

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

Source Category	1990	2005	2009	2010	2011	2012	2013
CO_2	**8.1**	**9.0**	**8.2**	**9.6**	**8.9**	**10.8**	**10.7**
Cropland Remaining Cropland: Liming of Agricultural Soils	4.7	4.3	3.7	4.8	3.9	5.8	5.9
Cropland Remaining Cropland: Urea Fertilization	2.4	3.5	3.6	3.8	4.1	4.2	4.0
Wetlands Remaining Wetlands: Peatlands Remaining Peatlands	1.0	1.1	1.0	1.0	0.9	0.8	0.8
CH_4	**2.5**	**8.3**	**5.8**	**4.8**	**14.6**	**15.7**	**5.8**
Forest Land Remaining Forest Land: Forest Fires	2.5	8.3	5.8	4.7	14.6	15.7	5.8
Wetlands Remaining Wetlands: Peatlands Remaining Peatlands	+	+	+	+	+	+	+
N_2O	**2.7**	**7.6**	**5.9**	**5.3**	**11.8**	**12.6**	**6.0**
Forest Land Remaining Forest Land: Forest Fires	1.7	5.5	3.8	3.1	9.6	10.3	3.8
Forest Land Remaining Forest Land: Forest Soils	0.1	0.3	0.3	0.3	0.3	0.3	0.3
Settlements Remaining Settlements: Settlement Soils	1.0	1.8	1.7	1.8	1.9	1.9	1.8
Wetlands Remaining Wetlands: Peatlands Remaining Peatlands	+	+	+	+	+	+	+
Total	**13.4**	**24.8**	**20.0**	**19.6**	**35.3**	**39.0**	**22.6**

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values. Totals may not sum due to independent rounding.
+ Less than 0.05 MMT CO_2 Eq.

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 17.5 percent of total U.S. CH_4 emissions.[18] Additionally, wastewater treatment accounts for 14.4 percent of Waste emissions, 2.3 percent of U.S. CH_4 emissions, and 1.4 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 2.0 MMT CO_2 Eq. and 1.8 MMT CO_2 Eq., respectively. Overall, emission sources accounted for in the Waste chapter generated 2.1 percent of total U.S. greenhouse gas emissions in 2013.

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 five sectors (i.e., chapters) defined by the IPCC: Energy; Industrial Processes and Product 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 2013.

[18] 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.

Figure ES-13: Emissions Allocated to Economic Sectors

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.

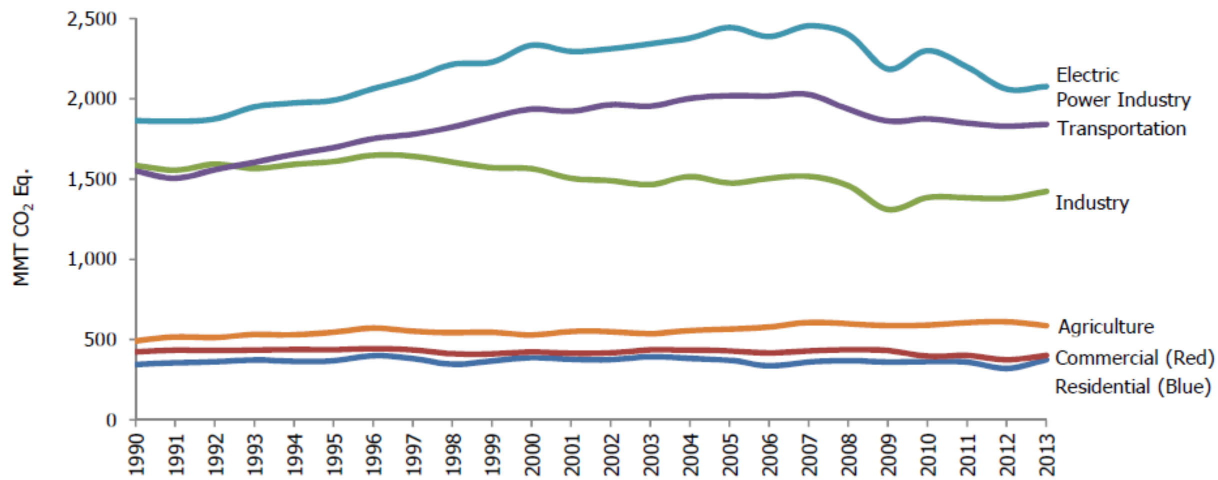


Table ES-7: U.S. Greenhouse Gas Emissions Allocated to Economic Sectors (MMT CO_2 Eq.)

Implied Sectors	1990	2005	2009	2010	2011	2012	2013
Electric Power Industry	1,864.8	2,445.2	2,186.4	2,301.2	2,198.9	2,061.3	2,077.7
Transportation	1,551.3	2,021.0	1,862.0	1,875.7	1,849.2	1,831.0	1,841.8
Industry	1,585.8	1,476.4	1,311.3	1,385.8	1,384.5	1,381.1	1,424.1
Agriculture	492.5	564.9	588.8	590.8	605.6	611.7	586.8
Commercial	424.8	430.0	432.3	396.7	401.0	374.8	401.9
Residential	345.9	372.3	360.7	363.5	360.2	321.2	374.7
U.S. Territories	33.7	58.2	47.9	51.0	43.9	42.5	35.1
Total Emissions	**6,298.8**	**7,367.9**	**6,789.5**	**6,964.7**	**6,843.3**	**6,623.4**	**6,742.2**
Land Use, Land-Use Change, and Forestry (Sinks)	(774.1)	(912.6)	(871.3)	(872.0)	(881.3)	(880.7)	(882.0)
Net Emissions (Sources and Sinks)	**5,524.7**	**6,455.4**	**5,918.2**	**6,092.7**	**5,962.0**	**5,742.7**	**5,860.2**

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.
Note: Totals may not sum due to independent rounding.
See Table 2-11 for more detailed data.

Using this categorization, emissions from electricity generation accounted for the largest portion (31 percent) of U.S. greenhouse gas emissions in 2013. Transportation activities, in aggregate, accounted for the second largest portion (27 percent), while emissions from industry accounted for the third largest portion (21 percent) of U.S. greenhouse gas emissions in 2013. 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 6 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.[19] 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 (29 percent and 27 percent, respectively) in 2013. The residential and commercial sectors contributed the next largest shares of total U.S. greenhouse gas emissions in 2013. 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 2013.

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

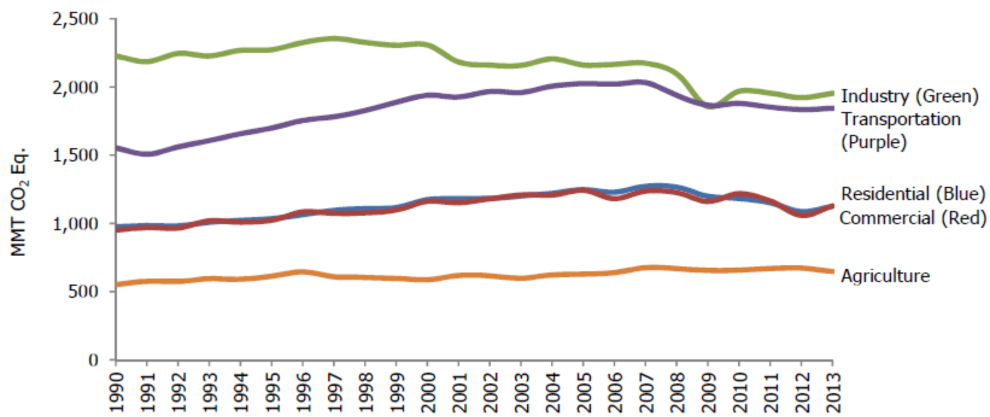
Implied Sectors	1990	2005	2009	2010	2011	2012	2013
Industry	2,227.8	2,162.4	1,856.7	1,970.4	1,955.7	1,923.1	1,954.9
Transportation	1,554.4	2,025.8	1,866.6	1,880.3	1,853.6	1,834.9	1,845.9
Commercial	975.8	1,248.1	1,199.8	1,184.4	1,153.1	1,088.6	1,127.8
Residential	953.3	1,244.4	1,161.8	1,219.5	1,166.0	1,060.5	1,129.1
Agriculture	553.8	629.0	656.7	659.2	671.0	673.9	649.5
U.S. Territories	33.7	58.2	47.9	51.0	43.9	42.5	35.1
Total Emissions	**6,298.8**	**7,367.9**	**6,789.5**	**6,964.7**	**6,843.3**	**6,623.4**	**6,742.2**
Land Use, Land-Use Change, and Forestry (Sinks)	(774.1)	(912.6)	(871.3)	(872.0)	(881.3)	(880.7)	(882.0)
Net Emissions (Sources and Sinks)	**5,524.7**	**6,455.4**	**5,918.2**	**6,092.7**	**5,962.0**	**5,742.7**	**5,860.2**

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.
Note: Emissions from electricity generation are allocated based on aggregate electricity consumption in each end-use sector.
Note: Totals may not sum due to independent rounding. Parentheses indicate negative values or sequestration.
See Table 2-13 for more detailed data.

[19] 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

Note: Emissions values are presented in CO_2 equivalent mass units using IPCC AR4 GWP values.



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 non-utilities combined—was the largest source of U.S. greenhouse gas emissions in 2013; (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 0.3 percent since 1990. 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	2009	2010	2011	2012	2013	Avg. Annual Growth Rate
Greenhouse Gas Emissions[a]	100	117	108	111	109	105	107	0.3%
Energy Consumption[b]	100	119	113	117	116	113	116	0.7%
Fossil Fuel Consumption[b]	100	119	109	113	111	108	111	0.5%
Electricity Consumption[b]	100	134	131	137	137	135	135	1.3%
GDP[c]	100	159	161	165	168	172	175	2.5%
Population[d]	100	118	123	124	125	125	126	1.0%

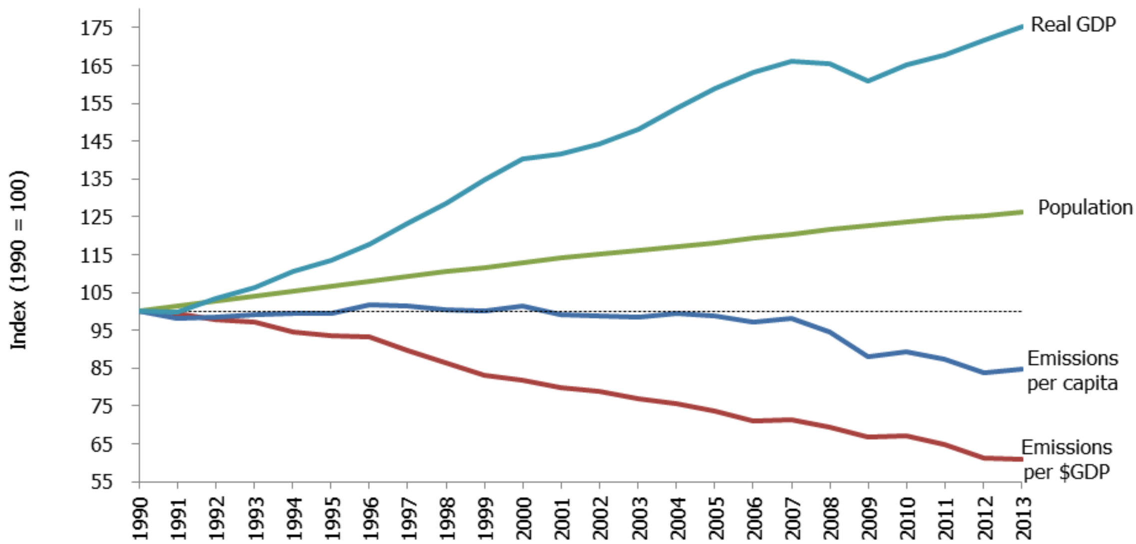
[a] GWP-weighted values

[b] Energy content-weighted values (EIA 2015)

[c] Gross Domestic Product in chained 2009 dollars (BEA 2014)

[d] U.S. Census Bureau (2014)

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



Source: BEA (2014), U.S. Census Bureau (2014), and emission estimates in this report.

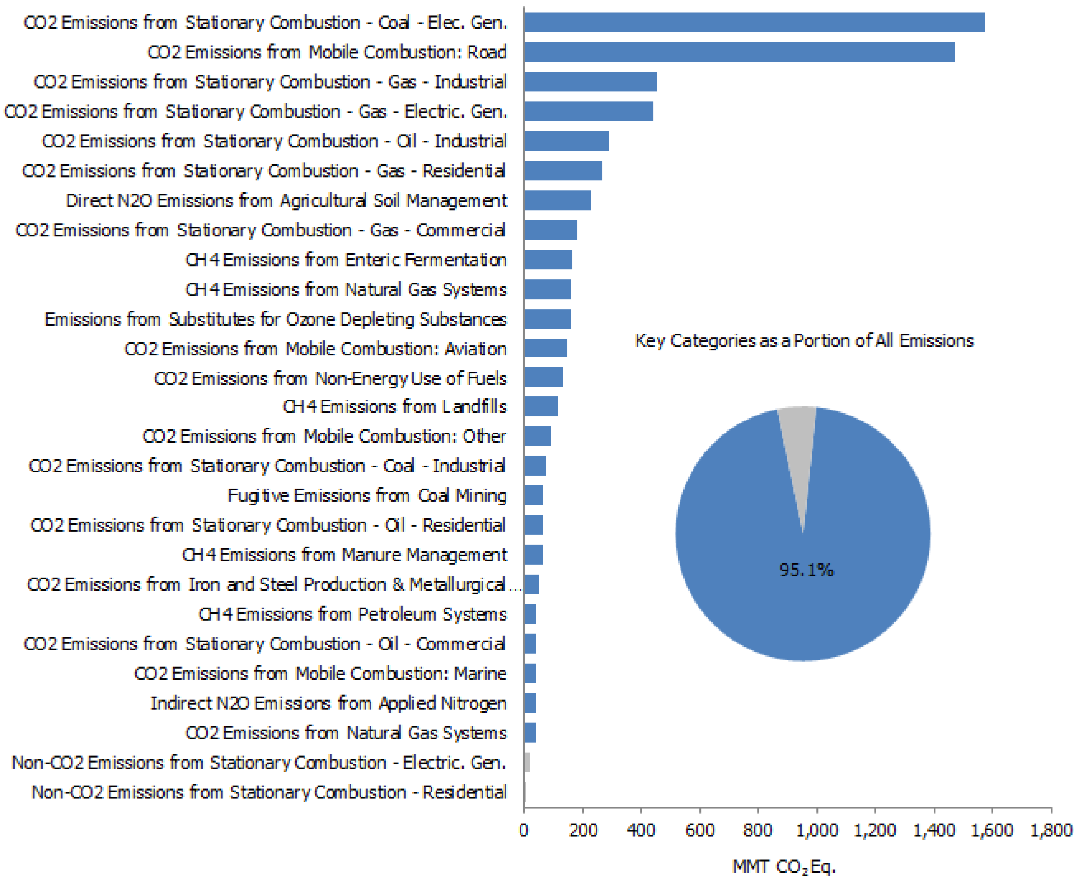
Key Categories

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."[20] 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 2013 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: Key Categories and Annex 1.

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

Figure ES-16: 2013 Key Categories



Note: For a complete discussion of the key category analysis, see Annex 1. Blue bars indicate either a Tier 1, or Tier 1 *and* Tier 2 level assessment key category. Gray bars indicate solely 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 2013) 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.