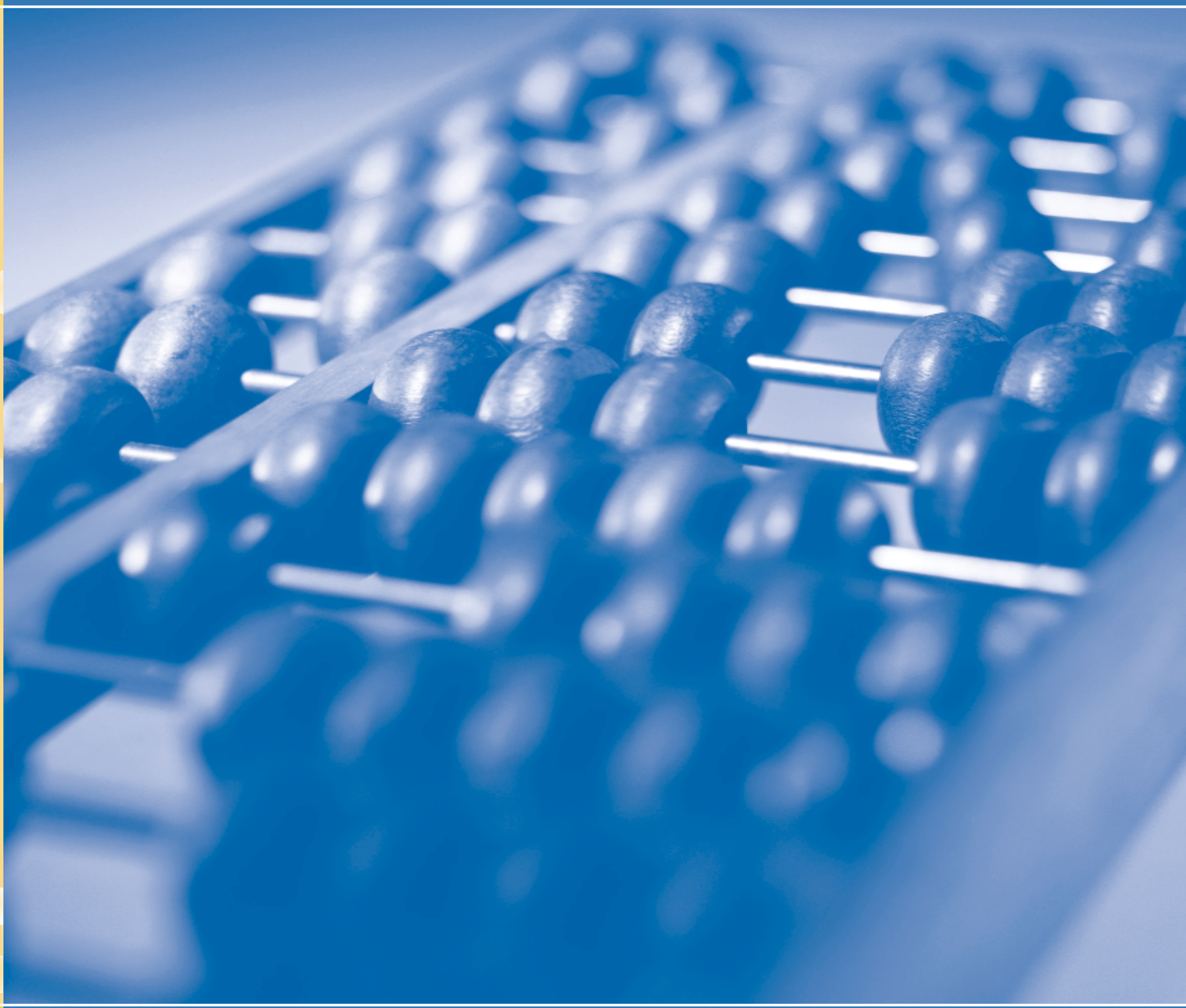
EPA
United States
Environmental Protection
Agency

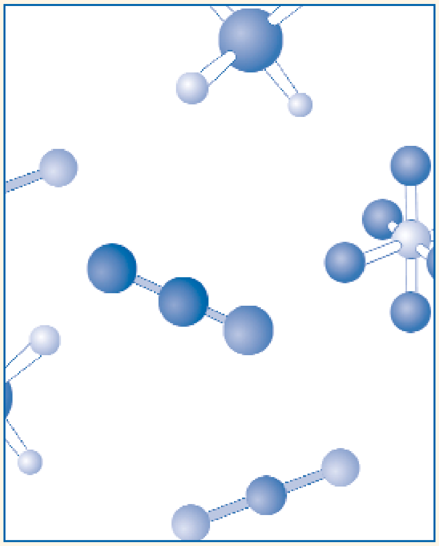
In Brief



The U.S. Greenhouse Gas Inventory

International Reporting

In 1992, under the United Nations Framework Convention on Climate Change (UNFCCC), the United States, along with 185 other countries, agreed to develop and submit a national inventory of anthropogenic greenhouse gas emissions and sinks. To fulfill this obligation, each year the U.S. Environmental Protection Agency (EPA) prepares the official *Inventory of U.S. Greenhouse Gas Emissions and Sinks* in cooperation with the U.S. Department of State and other U.S. government agencies.



Under the direction of the Intergovernmental Panel on Climate Change (IPCC), hundreds of scientists and national experts collaborated in developing a set of methodologies and guidelines to help countries create inventories that are comparable across international borders. The information presented in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* is in full compliance with these IPCC guidelines.

The U.S. Greenhouse Gas Inventory Program

The U.S. Environmental Protection Agency's Clean Air Markets Division (CAMD) in the Office of Atmospheric Programs is responsible for developing the annual *Inventory of U.S. Greenhouse Gas Emissions and Sinks*. EPA's Greenhouse Gas Inventory Program has developed extensive technical expertise, internationally recognized analytical methodologies, and one of the most rigorous management systems in the world for the estimation, documentation, and evaluation of greenhouse gas emissions and sinks for all source categories. To accomplish its work, the Inventory Program collaborates with hundreds of experts representing more than a dozen federal agencies, many academic institutions, industry associations, consultants, and environmental organizations. The Program also works directly with industries and other government agencies to develop high quality emissions data and is supported by CAMD's experience with the U.S. emissions trading programs and its network of continuous emission monitors for CO_2 on most electric power plants in the United States.

What is the Significance of Emission Inventories?

Greenhouse gas emission inventories are developed for a variety of reasons. Scientists use inventories of natural and anthropogenic emissions as tools when developing atmospheric models. Policy makers use inventories to develop strategies and policies for emissions reductions and to track the progress of those policies. And, regulatory agencies and corporations rely on inventories to establish compliance records with allowable emission rates. Businesses, the public, and other interest groups use inventories to better understand the sources and trends in emissions.

A well constructed inventory is consistently prepared, accurate, and thoroughly documented. Inventories typically include the following information:

- Chemical and physical identity of the pollutants
- Types of activities that cause emissions
- Time period over which the emissions were estimated
- Geographic area covered
- Clear description of estimation methodologies used and data collected

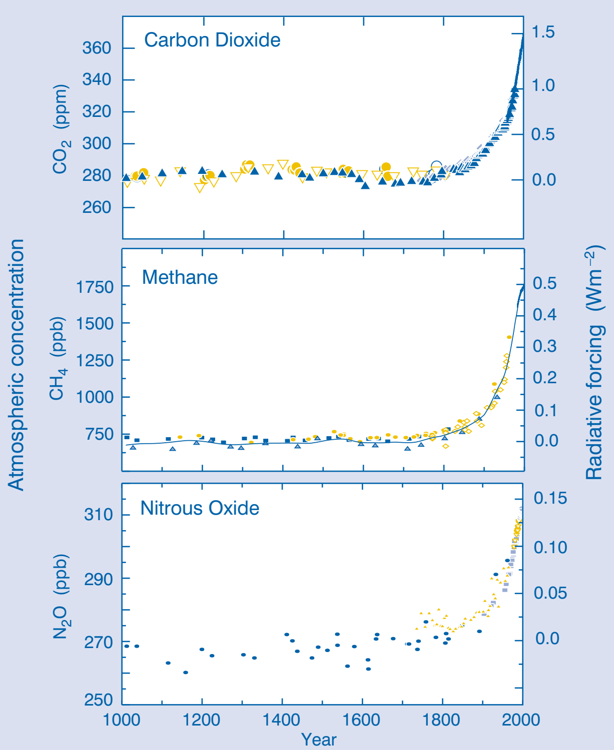
The *Inventory of U.S. Greenhouse Gas Emissions and Sinks* provides important information about greenhouse gases, quantifies how much of each gas was emitted into the atmosphere, and describes some of the effects of these emissions on the environment.

What are Greenhouse Gases?

Many chemical compounds found in the earth's atmosphere act as greenhouse gases, trapping outgoing terrestrial radiation and warming the earth's atmosphere. Some emissions of greenhouse gases occur naturally, while others result from human activities. Carbon dioxide, methane, nitrous oxide, and ozone are greenhouse gases that have both natural and human-related emission sources. In addition, humans have created other greenhouse gases, such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

The global warming potential (GWP) of a greenhouse gas is the ratio of global warming, or radiative forcing, from the emission of one unit mass of a greenhouse gas to that of one unit mass of carbon dioxide over a specified time horizon. Calculation of GWPs is based on the lifetime of the gas and how efficiently it traps heat in the atmosphere. *See the Inventory Fast Facts data card for a table of GWP values.*

Changes in Atmospheric Concentration of CO_2, CH_4, and N_2O

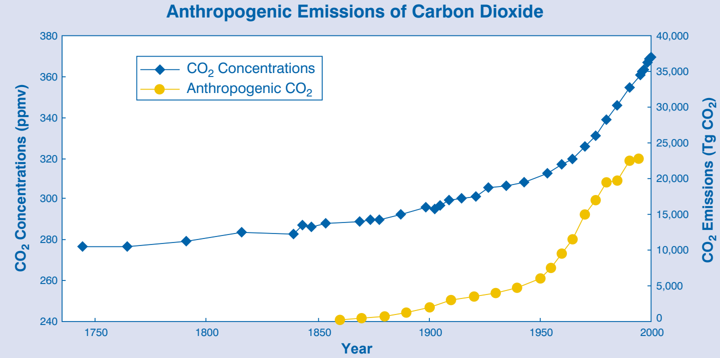


Source: IPCC Third Assessment Report (2001)

What is the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*?

The *Inventory of U.S. Greenhouse Gas Emissions and Sinks* is a catalog of anthropogenic, or human-generated, greenhouse gas emissions in the United States. Carbon dioxide can also be sequestered (i.e., stored) in "sinks" that result from forestry and other land-use practices. Excluding all naturally occurring greenhouse gas emissions and sinks, the Inventory provides a detailed record of all emissions and sinks directly attributable to human activities. It does not address naturally occurring emissions or sinks.

Trends in Atmospheric Concentrations and Anthropogenic Emissions of Carbon Dioxide



Source: Oak Ridge National Laboratory (2001)

The gases covered in the U.S. Inventory include:

Carbon Dioxide (CO_2)

In nature, carbon is cycled between various atmospheric, oceanic, biotic, and mineral reservoirs. In the atmosphere, carbon mainly exists in its oxidized form as CO_2. Carbon dioxide is released into the atmosphere primarily as a result of the burning of fossil fuels (oil, natural gas, and coal) for power generation and in transportation. It is also emitted through various industrial processes, forest clearing, natural gas flaring, and biomass burning. And, some carbon is sequestered in forest and agricultural soils.

Methane (CH_4)

Methane is produced primarily through anaerobic decomposition of organic matter in biological systems. Specifically, methane is emitted as a result of the decomposition of organic wastes in municipal solid waste landfills and from agricultural and biological processes related to wetland rice cultivation, livestock digestion, and waste production. Methane emissions also occur during the production and distribution of fossil fuels such as coal, natural gas, and petroleum. Methane's overall contribution to global warming is significant because it is estimated to be more than 20 times as effective at trapping heat in the atmosphere than CO_2.

Nitrous Oxide (N_2O)

The microbial processes of nitrification and denitrification naturally produce nitrous oxide in soils. Anthropogenic additions of nitrogen to soils during agricultural soil management activities increase the amount of N_2O emitted to the atmosphere. Nitrous oxide is also emitted during industrial production activities, solid waste combustion, and fossil fuel combustion. Nitrous oxide is approximately 300 times more powerful than CO_2 at trapping heat in the atmosphere.

HFCs, PFCs, and SF_6

Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) are powerful greenhouse gases. HFCs are primarily used as replacements for ozone-depleting substances, but also are emitted as a by-product of the HCFC-22 manufacturing process. PFCs and SF_6 are emitted by a variety of industrial processes including aluminum smelting, electric power transmission and distribution, magnesium processing, and semiconductor manufacturing. Currently, HFCs, PFCs, and SF_6 have a relatively small aggregate radiative forcing impact; however, because some of them have long atmospheric lifetimes, their concentrations can irreversibly accumulate in the atmosphere.

Emissions by Sector

Emissions of greenhouse gases result from many of the industrial, transportation, agricultural, and other activities that take place in the United States. The following is a description of the various sectors that emit greenhouse gases.

Energy

Historically, energy-related activities have accounted for more than three-quarters of GWP-weighted greenhouse gas emissions. Most of these are carbon dioxide emissions; however, some emissions of methane and nitrous oxide also result from stationary and mobile combustion. Almost all emissions from the energy sector result from fossil fuel combustion, which includes the burning of coal, natural gas, and petroleum. Fossil fuel combustion from stationary sources, such as electricity generation, represents more than half of energy-related emissions, while combustion of fossil fuels by mobile sources, such as automobiles, represents approximately one-third. In addition to fossil fuel combustion-related activities, carbon dioxide is also emitted as a result of natural gas flaring and biomass burning, and methane is emitted through coal mining as well as the production, processing, transmission, and distribution of natural gas and petroleum.

Industrial Processes

Industrial processes emit greenhouse gases as a by-product of various non-energy related industrial activities. Manufacture of cement, lime, soda ash, iron, steel, aluminum, ammonia, titanium dioxide, and ferroalloys produces carbon dioxide as a by-product. The consumption of limestone, dolomite, and carbon dioxide as raw materials in industrial applications also releases carbon dioxide emissions. The production of petrochemicals and silicon carbide result in small amounts of methane emissions, while producing nitric and adipic acid generates nitrous oxide emissions. Emissions of HFCs, PFCs, and SF_6 are particularly important as substitutes for ozone-depleting substances such as chlorofluorocarbons (CFCs). These gases may also be emitted as a result of aluminum and HCFC-22 production, semiconductor manufacturing, electrical transmission and distribution, and magnesium production and processing.

Agriculture

Agricultural activities contribute directly to emissions of methane and nitrous oxide. The majority of nitrous oxide emissions occur because cropping and fertilizer practices increase the quantity of reactive nitrogen in the soils. This occurs through application of commercial fertilizers, livestock manure, and sewage sludge; production of nitrogen-fixing crops and forages; retention of crop residues on the field; and the cultivation of soils high in organic matter. These activities make more nitrogen available for the generation of nitrous oxide through microbial activity. The normal digestive processes in ruminant livestock (known as enteric fermentation) account for the largest portion of methane emissions. The agriculture sector also emits methane and nitrous oxide from managed and unmanaged manure, rice cultivation, and the burning of agricultural residues.

Land-Use Change and Forestry

The natural carbon fluxes between biomass, soils, and the atmosphere change when humans alter the terrestrial biosphere through land-use, changes in land-use, and forest management practices. Various forest, agricultural soil, and land management practices can result in the uptake (i.e., sequestration) or emission of carbon dioxide. If these activities result in a net removal of carbon dioxide (versus net emission), they can offset a portion of total greenhouse gas emissions each year. Forestlands contribute the most to the net uptake of carbon dioxide, followed by agricultural soils.

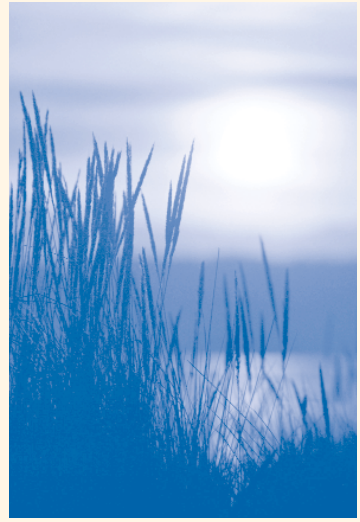
Waste

Waste management and treatment activities are another source of greenhouse gas emissions in the United States. Landfills are the nation's largest source of anthropogenic methane emissions. Wastewater treatment systems, including human sewage treatment, are sources of methane and nitrous oxide emissions.

To download a free copy of the current edition of the Inventory, to download emissions data, or for more information, visit our Web site at
www.epa.gov/globalwarming/publications/emissions
or contact:

U.S. Greenhouse Gas Inventory Program
ghginventory@epa.gov

To order a free copy of the current edition of the Inventory, order online at **http://yosemite.epa.gov/ncepihom/nsCatalog.nsf/SearchPubs** or call (800) 490-9198.



Other Useful Links

U.S. EPA's Global Warming site
www.epa.gov/globalwarming

Intergovernmental Panel on Climate Change Web site
www.ipcc.ch

United Nations Framework Convention on Climate Change Web site
www.unfccc.de

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The U.S. Inventory of Greenhouse Gas Emissions and Sinks: Fast Facts

U.S. Greenhouse Gas Emissions and Sinks (Tg CO_2 Equivalents)

Change from 1990 to 2000

													Percent
CO_2	**4,998.5**	**4,943.2**	**5,045.9**	**5,157.3**	**5,261.0**	**5,305.9**	**5,483.7**	**5,568.0**	**5,575.1**	**5,665.5**	**5,840.0**	841.5	16.8%
Fossil Fuel Combustion	4,779.8	4,733.0	4,836.0	4,950.9	5,047.2	5,085.0	5,266.6	5,339.6	5,356.2	5,448.6	5,623.3	843.4	17.6%
Iron and Steel Production	85.4	76.2	75.0	69.9	73.6	74.4	68.3	76.1	67.4	64.4	65.7	(19.7)	-23.1%
Cement Manufacture	33.3	32.5	32.8	34.6	36.1	36.8	37.1	38.3	39.2	40.0	41.1	7.8	23.4%
Indirect CO_2 Emissions	30.9	30.7	30.5	29.5	29.3	29.5	28.9	28.4	28.2	27.0	26.3	(4.6)	-14.9%
Waste Combustion	14.1	15.8	16.3	17.2	17.9	18.6	19.6	21.3	20.3	21.8	22.5	8.4	59.5%
Ammonia Manufacture	18.5	18.7	19.5	18.7	19.5	18.9	19.5	19.5	20.1	18.9	18.0	(0.5)	-2.7%
Lime Manufacture	11.2	11.0	11.4	11.6	12.1	12.8	13.5	13.7	13.9	13.5	13.3	2.1	18.5%
Limestone and Dolomite Use	5.2	5.0	4.5	4.1	5.2	7.0	7.4	8.4	8.2	9.1	9.2	4.0	77.5%
Natural Gas Flaring	5.5	5.6	5.1	6.5	6.6	8.7	8.2	7.6	6.3	6.7	6.1	0.5	9.9%
Aluminum Production	6.3	6.4	6.3	5.8	5.1	5.3	5.6	5.6	5.8	5.9	5.4	(0.9)	-14.3%
Soda Ash Manufacture and Consumption	4.1	4.0	4.1	4.0	4.0	4.3	4.2	4.4	4.3	4.2	4.2	0.0	0.9%
Titanium Dioxide Production	1.3	1.3	1.5	1.6	1.7	1.7	1.7	1.8	1.8	1.9	2.0	0.7	50.1%
Ferroalloys	2.0	2.0	2.0	2.0	1.8	1.9	2.0	2.0	2.0	2.0	1.7	(0.3)	-13.1%
Carbon Dioxide Consumption	0.8	0.8	0.9	0.9	0.9	1.0	1.1	1.3	1.4	1.6	1.4	0.6	70.2%
Land-Use Change and Forestry (Sink)[a]	(1,097.7)	(1,085.6)	(1,091.1)	(1,113.8)	(1,117.8)	(1,110.0)	(1,108.1)	(887.5)	(885.9)	(896.4)	(902.5)	195.3	-17.8%
International Bunker Fuels[b]	113.9	119.9	109.9	99.8	98.0	101.0	102.3	109.9	112.9	105.3	100.2	(13.6)	-12.0%
CH_4	**651.3**	**651.0**	**656.7**	**648.9**	**653.3**	**657.6**	**643.7**	**633.3**	**627.1**	**620.5**	**614.5**	**(36.8)**	**-5.6%**
Landfills	213.4	213.2	215.8	217.8	217.8	216.6	211.5	206.4	201.0	203.1	203.5	(9.9)	-4.7%
Enteric Fermentation	127.9	127.2	130.2	128.5	130.1	133.2	129.6	126.8	124.9	124.5	123.9	(4.0)	-3.1%
Natural Gas Systems	121.2	122.7	124.5	129.0	127.3	125.7	126.6	122.7	122.2	118.6	116.4	(4.9)	-4.0%
Coal Mining	87.1	83.7	81.4	69.7	70.3	73.5	68.4	68.1	67.9	63.7	61.0	(26.2)	-30.0%
Manure Management	29.2	31.1	30.7	31.6	33.8	34.8	34.2	35.8	38.0	37.6	37.5	8.3	28.3%
Wastewater Treatment	24.3	24.6	25.2	25.6	26.2	26.8	27.0	27.5	27.8	28.3	28.7	4.5	18.4%
Petroleum Systems	26.4	26.8	25.9	25.0	24.6	24.2	24.0	24.0	23.4	22.3	21.9	(4.6)	-17.3%
Stationary Sources	7.9	8.0	8.3	7.8	7.8	8.2	8.4	7.5	7.0	7.3	7.5	(0.4)	-5.0%
Rice Cultivation	7.1	7.0	7.9	7.0	8.2	7.6	7.0	7.5	7.9	8.3	7.5	0.4	5.3%
Mobile Sources	4.9	4.9	4.9	4.9	4.8	4.8	4.7	4.6	4.5	4.4	4.4	(0.5)	-10.9%
Petrochemical Production	1.2	1.2	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.7	1.7	0.5	42.1%
Agricultural Residue Burning	0.7	0.6	0.8	0.6	0.8	0.7	0.7	0.8	0.8	0.8	0.8	0.1	14.8%
Silicon Carbide Production	+	+	+	+	+	+	+	+	+	+	+	(0.0)	-57.1%
International Bunker Fuels[b]	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	(0.0)	-26.4%
N_2O	**387.3**	**392.8**	**402.7**	**402.0**	**428.7**	**419.8**	**430.5**	**429.8**	**426.3**	**423.5**	**425.3**	**38.0**	**9.8%**
Agricultural Soil Management	267.1	270.1	278.0	273.0	295.1	283.4	292.6	297.5	298.4	296.3	297.6	30.5	11.4%
Mobile Sources	50.9	53.2	56.4	58.5	60.0	60.4	60.1	59.7	59.1	58.7	58.3	7.4	14.4%
Nitric Acid	17.8	17.8	18.3	18.6	19.6	19.9	20.7	21.2	20.9	20.1	19.8	1.9	10.9%
Manure Management	16.0	16.5	16.3	16.7	16.7	16.4	16.8	17.1	17.1	17.1	17.5	1.5	9.3%
Stationary Sources	12.8	12.7	12.9	13.1	13.4	13.5	14.1	14.2	14.3	14.6	14.9	2.1	16.5%
Human Sewage	7.0	7.2	7.3	7.5	7.7	7.7	7.8	7.9	8.1	8.4	8.5	1.4	20.1%
Adipic Acid	14.9	14.7	12.6	13.9	15.4	17.9	17.8	11.5	7.7	7.7	8.1	(6.8)	-45.6%
Agricultural Residue Burning	0.4	0.4	0.4	0.3	0.5	0.4	0.4	0.4	0.5	0.4	0.5	0.1	24.1%
Waste Combustion	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	(0.1)	-20.7%
International Bunker Fuels[b]	1.0	1.0	0.9	0.9	0.9	0.9	0.9	1.0	1.0	0.9	0.9	(0.1)	-8.1%
HFCs, PFCs, and SF_6	**93.6**	**88.1**	**89.4**	**94.0**	**92.8**	**98.5**	**111.9**	**116.9**	**127.7**	**120.0**	**121.3**	**27.7**	**29.6%**
Substitution of Ozone Depleting Subs	0.9	0.8	1.5	5.2	8.4	21.8	30.6	38.0	44.9	51.3	57.8	56.8	6025.4%
HCFC-22 Production	35.0	30.8	34.9	31.8	31.6	27.0	31.1	30.0	40.2	30.4	29.8	(5.2)	-14.8%
Electrical Transmission and Distribution	31.2	32.5	30.2	34.1	31.4	26.5	26.8	24.5	20.1	15.5	14.4	(16.8)	-53.7%
Aluminum Production	18.1	15.7	14.5	13.9	12.2	11.8	12.5	11.0	9.0	8.9	7.9	(10.2)	-56.1%
Semiconductor Manufacture	2.9	2.9	2.9	3.6	3.9	5.9	5.4	6.5	7.3	7.7	7.4	4.5	157.5%
Magnesium Production and Processing	5.5	5.5	5.5	5.4	5.2	5.5	5.5	6.9	6.2	6.1	4.0	(1.5)	-27.3%
Total	**6,130.7**	**6,075.2**	**6,194.8**	**6,302.2**	**6,435.7**	**6,481.8**	**6,669.8**	**6,748.1**	**6,756.2**	**6,829.5**	**7,001.2**	**870.5**	**14.2%**
Net Emission (Sources and Sinks)	**5,033.0**	**4,989.6**	**5,103.6**	**5,188.4**	**5,317.9**	**5,371.8**	**5,561.7**	**5,860.5**	**5,870.3**	**5,933.1**	**6,098.7**	**1,065.8**	**21.2%**

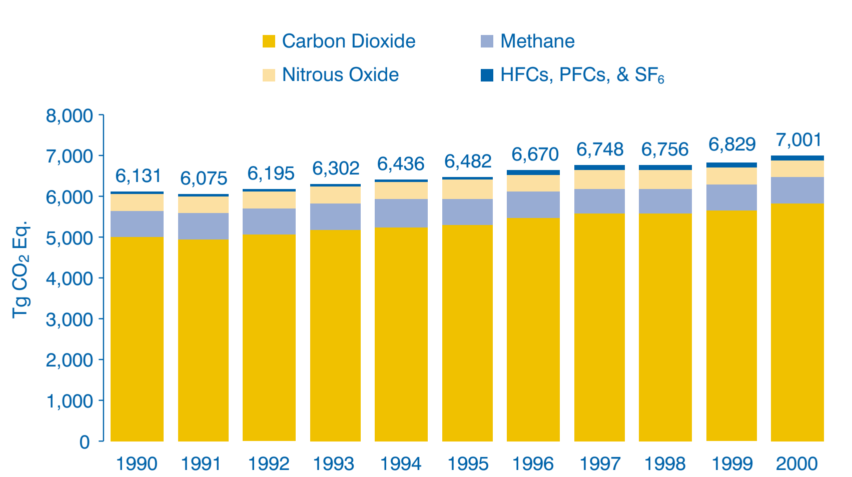
+ Does not exceed 0.05 Tg CO_2 Eq.
[a] Sinks are only included in net emissions total.
[b] Emissions from International Bunker Fuels are not included in totals.

Notes: Totals may not sum due to independent rounding. Emissions weighted using GWP values from *IPCC Second Assessment Report* (1996) in keeping with UNFCCC reporting guidelines.

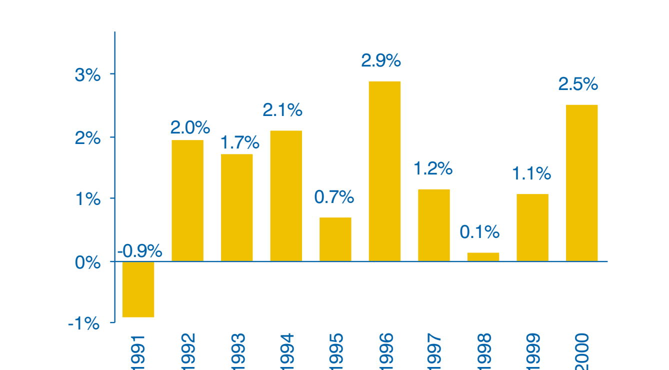
1990-2000 Trends

- Total GHG emissions rose 14.2 percent since 1990 (2.5 percent since 1999)
- Dominant gas emitted was CO_2, mostly from fossil fuel combustion
- Methane emissions decreased by 5.6 percent
- Nitrous oxide emissions increased by 9.8 percent
- HFC, PFC, and SF_6 emissions have grown by over 29.6 percent

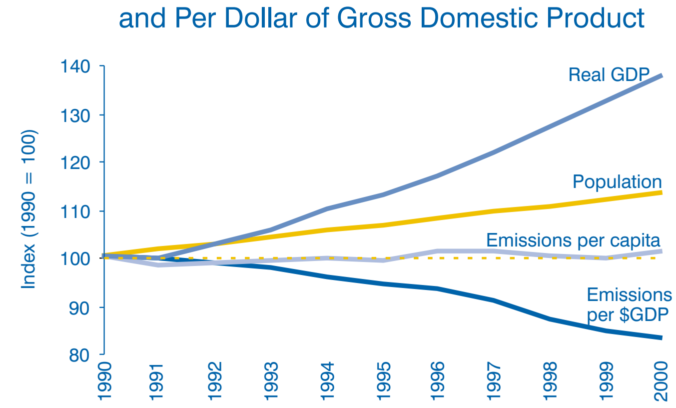
U.S. GHG Emissions by Gas



Annual Percent Change in U.S. GHG Emissions



U.S. Greenhouse Gas Emissions Per Capita and Per Dollar of Gross Domestic Product



The U.S. Inventory of Greenhouse Gas Emissions and Sinks:

Reference Tables and Conversions

Global Warming Potentials (100 Year Time Horizon)

Gas	GWP SAR[a]	GWP TAR[b]
Carbon dioxide (CO_2)	1	1
Methane (CH_4)*	21	23
Nitrous oxide (N_2O)	310	296
HFC-23	11,700	12,000
HFC-125	2,800	3,400
HFC-134a	1,300	1,300
HFC-143a	3,800	4,300
HFC-152a	140	120
HFC-227ea	2,900	3,500
HFC-236fa	6,300	9,400
HFC-4310mee	1,300	1,500
CF_4	6,500	5,700
C_2F_6	9,200	11,900
C_4F_{10}	7,000	8,600
C_6F_{14}	7,400	9,000
SF_6	23,900	22,200

[a] *IPCC Second Assessment Report* (1996)
[b] *IPCC Third Assessment Report* (2001)

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

Note: GWP values from the *IPCC Second Assessment Report* are used in accordance with UNFCCC guidelines

Global Warming Potential (GWP) is defined as the cumulative radiative forcing effects of a gas over a specified time horizon resulting from the emission of a unit mass of gas relative to a reference gas. The GWP-weighted emissions of direct greenhouse gases in the U.S. Inventory are presented in terms of equivalent emissions of carbon dioxide (CO_2), using units of teragrams of carbon dioxide equivalents (Tg CO_2 Eq.).

Conversion:

$$\text{Tg} = 10^9 \text{ kg} = 10^6 \text{ metric tons} = 1 \text{ million metric tons}$$

The molecular weight of carbon is 12, and the molecular weight of oxygen is 16; therefore, the molecular weight of CO_2 is 44 (i.e., 12+[16×2]), as compared to 12 for carbon alone. Thus, carbon comprises 12/44ths of carbon dioxide by weight.

Conversion from gigagrams of gas to teragrams of carbon dioxide equivalents:

$$\text{Tg } CO_2 \text{ Eq.} = \left(\frac{\text{Gg}}{\text{of gas}}\right) \times (\text{GWP}) \times \left(\frac{\text{Tg}}{1{,}000 \text{ Gg}}\right)$$

Guide to Metric Unit Prefixes

	Factor	
Atto (a)	10^{-18}	.000000000000000001
Femto (f)	10^{-15}	.000000000000001
Pico (p)	10^{-12}	.000000000001
Nano (n)	10^{-9}	.000000001
Micro (μ)	10^{-6}	.000001
Milli (m)	10^{-3}	.001
Centi (c)	10^{-2}	.01
Deci (d)	10^{-1}	.1
		1
Deca (da)	10	10
Hecto (h)	10^{2}	100
Kilo (k)	10^{3}	1,000
Mega (M)	10^{6}	1,000,000
Giga (G)	10^{9}	1,000,000,000
Tera (T)	10^{12}	1,000,000,000,000
Peta (P)	10^{15}	1,000,000,000,000,000
Exa (E)	10^{18}	1,000,000,000,000,000,000

Unit Conversions

1 pound	= 0.454 kilograms	= 16 ounces	
1 kilogram	= 2.205 pounds	= 35.27 ounces	
1 short ton	= 0.9072 metric tons	= 2,000 pounds	
1 metric ton	= 1.1023 short tons	= 1,000 kilograms	
1 cubic foot	= 0.02832 cubic meters	= 28.3168 liters	
1 cubic meter	= 35.315 cubic feet	= 1,000 liters	
1 U.S. gallon	= 3.78541 liters	= 0.03175 barrels	= 0.02381 barrels petroleum
1 liter	= 0.2642 U.S. gallons	= 0.0084 barrels	= 0.0063 barrels petroleum
1 barrel	= 31.5 U.S. gallons	= 119 liters	= 0.75 barrels petroleum
1 barrel petroleum	= 42 U.S. gallons	= 159 liters	
1 foot	= 0.3048 meters	= 12 inches	
1 meter	= 3.28 feet	= 39.37 inches	
1 mile	= 1.609 kilometers	= 5,280 feet	
1 kilometer	= 0.6214 miles	= 3,280.84 feet	
1 square mile	= 2.590 square kilometers	= 640 acres	
1 square kilometer	= 0.386 square miles	= 100 hectares	
1 acre	= 43,560 square feet	= 0.4047 hectares	= 4,047 square meters

Energy Conversions

The common energy unit used in international reports of greenhouse gas emissions is the joule. A joule is the energy required to move an object one meter with the force of one Newton. A terajoule (TJ) is one trillion (10^{12}) joules. A British thermal unit (Btu, the customary U.S. energy unit) is the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit at or near 39.2 Fahrenheit.

1 TJ =
- 2.388×10^{11} calories
- 23.88 metric tons of crude oil equivalent
- 9.478×10^{8} Btu
- 277,800 kilowatt-hours

Energy Units

Btu	British thermal unit	1 Btu
MBtu	Thousand Btu	1×10^{3} Btu
MMBtu	Million Btu	1×10^{6} Btu
BBtu	Billion Btu	1×10^{9} Btu
TBtu	Trillion Btu	1×10^{12} Btu
QBtu	Quadrillion Btu	1×10^{15} Btu

Source for all data: *U.S. Inventory of Greenhouse Gas Emissions and Sinks 1990-2000* (EPA 2002)

CO_2 Emissions from Fossil Fuel Combustion = Fuel Combusted × Carbon Content Coefficient × Fraction Oxidized × (44/12)

May include adjustments for carbon stored in fossil fuel-based products, emissions from international bunker fuels, or emissions from territories

Carbon Intensity of Different Fuel Types

The amount of carbon in fossil fuels per unit of energy content varies significantly by fuel type. For example, coal contains the highest amount of carbon per unit of energy, while petroleum has about 25 percent less carbon than coal, and natural gas about 45 percent less.

Converting Various Physical Units to Energy Units

The values in the following table provide conversion factors from physical units to energy equivalent units and from energy units to carbon contents. These factors can be used as default factors, if local data are not available.

Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types

Fuel Type	Heat Content	Carbon Content Coefficients (Tg Carbon/EJ)	Fraction Oxidized
Solid Fuels	**(TJ/Gg)**		
Anthracite Coal	24.94	25.46	0.99
Bituminous Coal	26.39	24.51	0.99
Sub-bituminous Coal	18.94	24.89	0.99
Lignite	14.21	26.22	0.99
Coke	27.40	24.23	0.99
Unspecified	27.62	24.40	0.99
Gas Fuels	**(MJ/Cubic Meter)**		
Natural Gas (dry)	36.37	13.71	0.995
Liquid Fuels	**(MJ/Liter)**		
Crude Oil	34.64	19.14	0.99
Nat Gas Liquids and LRGs	22.56	16.10	0.99
Other Liquids	34.79	19.14	0.99
Motor Gasoline	31.37	18.35	0.99
Aviation Gasoline	30.15	17.89	0.99
Kerosene	33.86	18.69	0.99
Jet Fuel	33.86	18.32	0.99
Distillate Fuel	34.79	18.91	0.99
Residual Oil	37.55	20.37	0.99
Naptha for Petrofeed	31.34	17.19	0.99
Petroleum Coke	35.98	26.40	0.99
Other Oil for Petrofeed	34.79	18.91	0.99
Special Napthas	31.34	18.82	0.99
Lubricants	36.22	19.18	0.99
Waxes	33.07	18.78	0.99
Asphalt/Road Oil	39.63	19.54	0.99
Still Gas	35.83	16.60	0.99
Misc. Products	34.61	19.14	0.99

Notes: For fuels with annually variable heat contents and carbon content coefficients, 1999 U.S. average values are presented. U.S. fossil fuel energy statistics are generally presented using gross calorific values (GCV) (i.e., higher heating values). However, this data has been adjusted to correspond to international standards, which are to report energy statistics in terms of net calorific values (NCV) (i.e., lower heating values). To convert between gross and net calorific values while accounting for heat associated with the water content of the fuels, the heat content of solid and liquid fuels was multiplied by 0.95, and the heat content of gaseous fuels was multiplied by 0.90. Dividing by these values will convert from NCV back to GCV.

Density Conversions

Methane (Natural Gas)	1 cubic meter	=	35.32 cubic feet	=	0.676 kilograms
Carbon dioxide	1 cubic meter	=	35.32 cubic feet	=	1.854 kilograms
Natural gas liquids	1 metric ton	=	11.60 barrels	=	1,844.20 liters
Unfinished oils	1 metric ton	=	7.46 barrels	=	1,186.04 liters
Alcohol	1 metric ton	=	7.94 barrels	=	1,262.36 liters
Liquefied petroleum gas	1 metric ton	=	11.60 barrels	=	1,844.20 liters
Aviation gasoline	1 metric ton	=	8.90 barrels	=	1,415.00 liters
Naphtha jet fuel	1 metric ton	=	8.27 barrels	=	1,314.82 liters
Kerosene jet fuel	1 metric ton	=	7.93 barrels	=	1,260.72 liters
Motor gasoline	1 metric ton	=	8.53 barrels	=	1,356.16 liters
Kerosene	1 metric ton	=	7.73 barrels	=	1,228.97 liters
Naphtha	1 metric ton	=	8.22 barrels	=	1,306.87 liters
Distillate	1 metric ton	=	7.46 barrels	=	1,186.04 liters
Residual oil	1 metric ton	=	6.66 barrels	=	1,058.85 liters
Lubricants	1 metric ton	=	7.06 barrels	=	1,122.45 liters
Bitumen	1 metric ton	=	6.06 barrels	=	963.46 liters
Waxes	1 metric ton	=	7.87 barrels	=	1,251.23 liters
Petroleum coke	1 metric ton	=	5.51 barrels	=	876.02 liters
Petrochemical feedstocks	1 metric ton	=	7.46 barrels	=	1,186.04 liters
Special naphtha	1 metric ton	=	8.53 barrels	=	1,356.16 liters
Miscellaneous products	1 metric ton	=	8.00 barrels	=	1,271.90 liters

Note: Gas densities are at room temperature and pressure.

For more information on calculating CO_2 emissions per kWh, download E-GRID at: **http://www.epa.gov/airmarkets/egrid/**

For other related information, see: **http://www.epa.gov/globalwarming**
http://www.unfcc.de

Download the Inventory at: http://www.epa.gov/globalwarming/publications/emissions