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Emissions of Greenhouse Gases in the United States 2007

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Office of Integrated Analysis and Forecasting
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For this report, activity data on coal and natural gas consumption and electricity sales and losses by sector were obtained from the October 2008 *Monthly Energy Review* (*MER*). Petroleum detail is now also available in published tables within the *MER*. Also, while generally in agreement with the *MER*, some data revisions were obtained from the *Electric Power Annual* that are not reflected in the October *MER*.

In keeping with current international practice, this report presents data on greenhouse gas emissions in million metric tons carbon dioxide equivalent. The data can be converted to carbon equivalent units by multiplying by 12/44.

Preface

Title XVI, Section 1605(a) of the Energy Policy Act of 1992 (enacted October 24, 1992) provides:

> *Not later than one year after the date of the enactment of this Act, the Secretary, through the Energy Information Administration, shall develop, based on data available to, and obtained by, the Energy Information Administration, an inventory of the national aggregate emissions of each greenhouse gas for each calendar year of the baseline period of 1987 through 1990. The Administrator of the Energy Information Administration shall annually update and analyze such inventory using available data. This subsection does not provide any new data collection authority.*

This report—the sixteenth annual report—presents the Energy Information Administration's latest estimates of emissions for carbon dioxide, methane, nitrous oxide, and other greenhouse gases. Documentation for these estimates is available on line at www.eia.doe.gov/oiaf/1605/ggrpt.

Contents

Tables

Figures

Greenhouse Gas Emissions Overview

Total Emissions

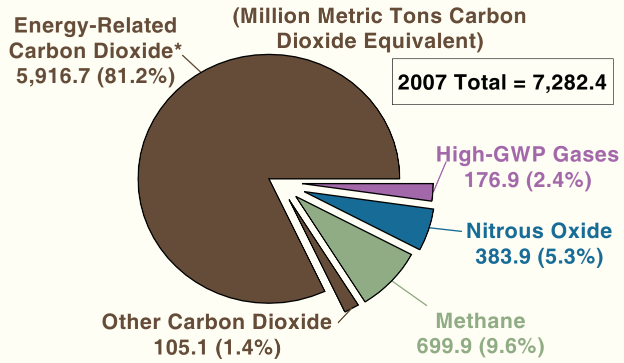
Summary

- Total U.S. greenhouse gas emissions in 2007 were 1.4 percent above the 2006 total.
- Total emissions growth—from 7,179.7 million metric tons carbon dioxide equivalent ($MMTCO_2e$) in 2006 to 7,282.4 $MMTCO_2e$ in 2007—was largely the result of a 75.9-$MMTCO_2e$ increase in carbon dioxide (CO_2) emissions. There were larger percentage increases in emissions of other greenhouse gases, but their absolute contributions to total emissions growth were relatively small: 13.0 $MMTCO_2e$ for methane (CH_4), 8.2 $MMTCO_2e$ for nitrous oxide, and 5.6 $MMTCO_2e$ for the man-made gases with high global warming potentials (high-GWP gases) (Table 1).
- The increase in U.S. carbon dioxide emissions in 2007 resulted primarily from two factors: unfavorable weather conditions, which increased demand for heating and cooling in buildings; and a drop in hydropower availability that led to greater reliance on fossil energy sources (coal and natural gas) for electricity generation, increasing the carbon intensity of the power supply.
- Methane emissions totaled 699.9 $MMTCO_2e$ in 2007 (Figure 1), up by 13.0 $MMTCO_2e$ from 2006, with increases in emissions from energy sources, waste management, and agriculture.
- Emissions of nitrous oxide (N_2O) increased by 8.2 $MMTCO_2e$ from 2006 to a 2007 total of 383.9 $MMTCO_2e$. The increase is attributed primarily to an increase of 6.9 $MMTCO_2e$ in emissions from nitrogen fertilization of agricultural soils.
- U.S. emissions of high-GWP gases, which totaled 176.9 $MMTCO_2e$ in 2007, were 5.6 $MMTCO_2e$ above the 2006 total. The increase resulted mainly from higher emissions levels for hydrofluorocarbons (HFCs, up by 4.1 $MMTCO_2e$) and perfluorocarbons (PFCs, up by 2.0 $MMTCO_2e$). Emissions of sulfur hexafluoride (SF_6) were down by 0.5 $MMTCO_2e$.

U.S. Anthropogenic Greenhouse Gas Emissions, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	6,241.8	7,179.7	7,282.4
Change from 1990 (Million Metric Tons CO_2e)		937.9	1,040.6
(Percent)		*15.0%*	*16.7%*
Average Annual Change from 1990 *(Percent)*		*0.9%*	*0.9%*
Change from 2006 (Million Metric Tons CO_2e)			102.7
(Percent)			*1.4%*

Figure 1. U.S. Greenhouse Gas Emissions by Gas, 2007



Source: EIA estimates. *Adjusted.

Table 1. U.S. Emissions of Greenhouse Gases, Based on Global Warming Potential, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Gas	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Carbon Dioxide	5,021.4	5,348.4	5,892.6	5,806.9	5,880.5	5,938.7	6,023.9	6,032.3	5,945.8	6,021.8
Methane	782.1	752.6	685.7	670.1	674.2	676.5	679.7	679.4	686.9	699.9
Nitrous Oxide	336.0	359.7	344.6	339.3	335.4	334.6	361.5	370.8	375.7	383.9
High-GWP Gases[a]	102.4	114.6	152.1	141.4	153.6	149.0	165.0	174.5	171.3	176.9
Total	**6,241.8**	**6,575.2**	**7,075.0**	**6,957.7**	**7,043.7**	**7,098.8**	**7,230.1**	**7,256.9**	**7,179.7**	**7,282.4**

[a]Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.

Sources: **Emissions:** EIA estimates. **Global Warming Potentials:** Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis* (Cambridge, UK: Cambridge University Press, 2007), web site www.ipcc.ch/ipccreports/ar4-wg1.htm.

Greenhouse Gas Emissions Overview

U.S. Greenhouse Gas Intensity

Summary

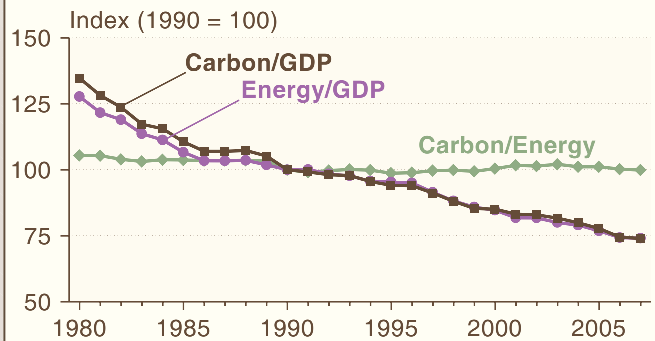
- From 2006 to 2007, the greenhouse gas intensity of the U.S. economy—measured as metric tons carbon dioxide equivalent ($MTCO_2e$) emitted per million dollars of gross domestic product (GDP)—fell by 0.6 percent, the smallest annual decrease since 2002.
- Economic growth of 2.0 percent in 2007, coupled with a 1.4-percent increase in total greenhouse gas emissions, accounted for the relatively slow rate of decrease (improvement) in U.S. greenhouse gas intensity from 2006 to 2007 (Table 2).
- Since 2002, the base year for the Bush Administration's emissions intensity reduction goal of 18 percent in a decade, U.S. greenhouse gas intensity has fallen by an average of 2.1 percent per year, resulting in a total reduction of 9.8 percent from 2002 to 2007.
- The steady decrease in carbon intensity (carbon/GDP) has resulted mainly from reductions in energy use per unit of GDP (energy/GDP) rather than increased use of low-carbon fuels, as indicated by the carbon/energy ratio shown in Figure 2.

U.S. Greenhouse Gas Intensity, 1990, 2006, and 2007

	1990	2006	2007
Estimated Intensity ($MTCO_2e$/GDP*)	877.6	635.7	631.9
Change from 1990 ($MTCO_2e$/GDP*)		-241.9	-245.6
(Percent)		*-27.6%*	*-28.0%*
Average Annual Change from 1990 *(Percent)*		*-2.0%*	*-1.9%*
Change from 2006 ($MTCO_2e$/GDP*)			-3.7
(Percent)			*-0.6%*

*U.S. gross domestic product (million 2000 dollars).

Figure 2. Intensity Ratios: Carbon/Energy, Energy/GDP, and Carbon/GDP, 1980-2007



Source: EIA estimates.

Table 2. U.S. Greenhouse Gas Intensity and Related Factors, 1990, 1995, and 2000-2007

	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Gross Domestic Product (Billion 2000 Dollars)	7,112.5	8,031.7	9,817.0	9,890.7	10,048.8	10,301.0	10,675.8	10,989.5	11,294.8	11,523.9
Greenhouse Gas Emissions ($MMTCO_2e$)	6,241.8	6,575.2	7,074.9	6,957.7	7,043.7	7,098.8	7,230.1	7,257.0	7,179.8	7,282.5
Greenhouse Gas Intensity ($MTCO_2e$ per Million 2000 Dollars)	877.6	818.7	720.7	703.5	701.0	689.1	677.2	660.4	635.7	631.9
Change from Previous Year (Percent)										
Gross Domestic Product	—	2.5	3.7	0.8	1.6	2.5	3.6	2.9	2.8	2.0
Greenhouse Gas Emissions	—	0.8	2.6	-1.7	1.2	0.8	1.8	0.4	-1.1	1.4
Greenhouse Gas Intensity	—	-1.7	-1.0	-2.4	-0.4	-1.7	-1.7	-2.5	-3.7	-0.6
Change from 2002 (Percent)[a]										
Cumulative	—	—	—	—	—	-1.7	-3.4	-5.8	-9.3	-9.8
Annual Average	—	—	—	—	—	-1.7	-1.7	-2.0	-2.4	-2.1

[a]The Bush Administration s emissions intensity goal calls for an 18-percent reduction between 2002 and 2012; achieving that goal would require an average annual reduction of slightly less than 2 percent over the entire period.

P = preliminary data.

Note: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007).

Sources: **Emissions:** EIA estimates. **GDP:** U.S. Department of Commerce, Bureau of Economic Analysis, web site www.bea.gov.

Greenhouse Gas Emissions Overview

Greenhouse Gas Emissions in the U.S. Economy

The diagram on page 4 illustrates the flow of U.S. greenhouse gas emissions in 2007, from their sources to their distribution across the U.S. end-use sectors. The left side shows CO_2 by fuel sources and quantities and other gases by quantities; the right side shows their distribution by sector. The center of the diagram indicates the split between CO_2 emissions from direct fuel combustion and electricity conversion. Adjustments indicated at the top of the diagram for U.S. territories and international bunker fuels correspond to greenhouse gas reporting requirements developed by the United Nations Framework Convention on Climate Change (UNFCCC).

CO_2. CO_2 emission sources include energy-related emissions (primarily from fossil fuel combustion) and emissions from industrial processes. The energy subtotal (5,991 $MMTCO_2e$) includes petroleum, coal, and natural gas consumption and smaller amounts from renewable sources, including municipal solid waste and geothermal power generation. The energy subtotal also includes emissions from nonfuel uses of fossil fuels, mainly as inputs to other products. Industrial process emissions (105 $MMTCO_2e$) include cement manufacture, limestone and dolomite calcination, soda ash manufacture and consumption, carbon dioxide manufacture, and aluminum production. The sum of the energy subtotal and industrial processes equals unadjusted CO_2 emissions (6,096 $MMTCO_2e$). The energy component of unadjusted emissions can be divided into direct fuel use (3,557 $MMTCO_2e$) and fuel converted to electricity (2,433 $MMTCO_2e$).

Non-CO_2 Gases. Methane (700 $MMTCO_2e$) and nitrous oxide (384 $MMTCO_2e$) sources include emissions related to energy, agriculture, waste management, and industrial processes. Other, high-GWP gases (177 $MMTCO_2e$) include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). These gases have a variety of uses in the U.S. economy, including refrigerants, insulators, solvents, and aerosols; as etching, cleaning, and firefighting agents; and as cover gases in various manufacturing processes.

Adjustments. In keeping with the UNFCCC, CO_2 emissions from U.S. Territories (57 $MMTCO_2e$) are added to the U.S. total, and CO_2 emissions from fuels used for international transport (both oceangoing vessels and airplanes) (131 $MMTCO_2e$) are subtracted to derive total U.S. greenhouse gas emissions (7,282 $MMTCO_2e$).

Emissions by End-Use Sector. CO_2 emissions by end-use sectors are based on EIA's estimates of energy consumption (direct fuel use and purchased electricity) by sector and on the attribution of industrial process emissions by sector. CO_2 emissions from purchased electricity are allocated to the end-use sectors based on their shares of total electricity sales. Non-CO_2 gases are allocated by direct emissions in those sectors plus emissions in the electric power sector that can be attributed to the end-use sectors based on electricity sales.

Residential emissions (1,281 $MMTCO_2e$) include energy-related CO_2 emissions (1,261 $MMTCO_2e$); and non-CO_2 emissions (20 $MMTCO_2e$). The non-CO_2 sources include direct methane and nitrous oxide emissions from direct fuel use. Non-CO_2 indirect emissions attributable to purchased electricity, including methane and nitrous oxide emissions from electric power generation and SF_6 emissions related to electricity transmission and distribution, are also included.

Emissions in the **commercial** sector (1,355 $MMTCO_2e$) include both energy-related CO_2 emissions (1,098 $MMTCO_2e$) and non-CO_2 emissions (257 $MMTCO_2e$). The non-CO_2 emissions include direct emissions from landfills, wastewater treatment plants, commercial refrigerants, and stationary combustion emissions of methane and nitrous oxide. Non-CO_2 indirect emissions attributable to purchased electricity, including methane and nitrous oxide emissions from electric power generation and SF_6 emissions related to electricity transmission and distribution, are also included.

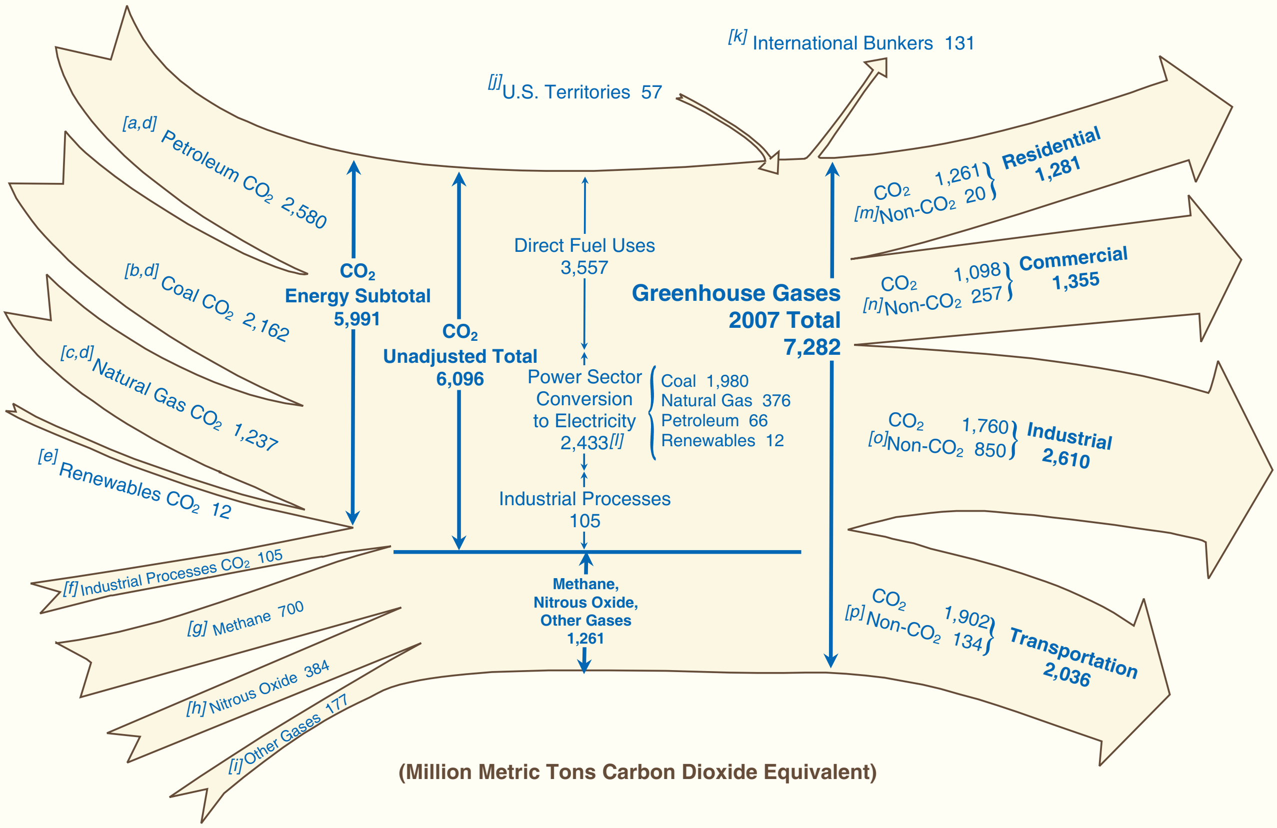
Industrial emissions (2,610 $MMTCO_2e$) include CO_2 emissions (1,760 $MMTCO_2e$)—which can be broken down between combustion (1,655 $MMTCO_2e$) and process emissions (105 $MMTCO_2e$)—and non-CO_2 emissions (850 $MMTCO_2e$). The non-CO_2 direct emissions include emissions from agriculture (methane and nitrous oxide), coal mines (methane), petroleum and natural gas pipelines (methane), industrial process emissions (methane, nitrous oxide, HFCs, PFCs and SF_6), and direct stationary combustion emissions of methane and nitrous oxide. Non-CO_2 indirect emissions attributable to purchased electricity, including methane and nitrous oxide emissions from electric power generation and SF_6 emissions related to electricity transmission and distribution, are also included.

Transportation emissions (2,036 $MMTCO_2e$) include energy-related CO_2 emissions from mobile source combustion (1,902 $MMTCO_2e$); and non-CO_2 emissions (134 $MMTCO_2e$). The non-CO_2 emissions include methane and nitrous oxide emissions from mobile source combustion and HFC emissions from the use of refrigerants for mobile source air-conditioning units.

(continued on page 4)

Greenhouse Gas Emissions Overview

Greenhouse Gas Emissions in the U.S. Economy



(Million Metric Tons Carbon Dioxide Equivalent)

Diagram Notes

[*a*] CO_2 emissions related to petroleum consumption (includes 99.3 $MMTCO_2$ of non-fuel-related emissions).

[*b*] CO_2 emissions related to coal consumption (includes 0.5 $MMTCO_2$ of non-fuel-related emissions).

[*c*] CO_2 emissions related to natural gas consumption (includes 17.8 $MMTCO_2$ of non-fuel-related emissions).

[*d*] Excludes carbon sequestered in nonfuel fossil products.

[*e*] CO_2 emissions from the plastics portion of municipal solid waste (11.5 $MMTCO_2$) combusted for electricity generation and very small amounts (0.4 $MMTCO_2$) of geothermal-related emissions.

[*f*] Includes mainly direct process emissions. Some combustion emissions are included from waste combustion outside the electric power sector and flaring of non-marketed natural gas.

[*g*] Includes methane emissions related to energy, agriculture, waste management, and industrial processes.

[*h*] Includes nitrous oxide emissions related to agriculture, energy, industrial processes, and waste management.

[*i*] Includes hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

[*j*] Includes only energy-related CO_2 emissions from fossil fuels. Emissions are allocated to end-use sectors in proportion to U.S. ratios.

[*k*] Includes vessel bunkers and jet fuel consumed for international travel. Under the UNFCCC, these emissions are not included in country emission inventories. Emissions are subtracted from the transportation sector total.

[*l*] CO_2 emissions from electricity generation in the commercial and industrial sectors are included in those sectors.

[*m*] Non-CO_2: Direct stationary combustion emissions of methane and nitrous oxide plus indirect power sector emissions of methane, nitrous oxide, and other greenhouse gases.

[*n*] Non-CO_2: Direct stationary combustion emissions of methane and nitrous oxide plus indirect power sector emissions of methane, nitrous oxide, and other greenhouse gases. Additional direct emissions include emissions from landfills, wastewater treatment, and commercial refrigerants.

[*o*] Non-CO_2: Direct stationary combustion emissions of methane and nitrous oxide plus indirect power sector emissions of methane, nitrous oxide, and other greenhouse gases. In addition, all agricultural emissions are included in the industrial sector as well as direct process emissions of methane, nitrous oxide, and the other gases.

[*p*] Non-CO_2: Direct mobile combustion emissions of methane and nitrous oxide. Also, emissions related to transportation refrigerants are included.

Source: Estimates presented in this report. CO_2 emissions by end-use sector are based on EIA's estimates of energy consumption by sector and on industrial process emissions. CO_2 emissions from the electric power sector are allocated to the end-use sectors based on electricity sales to the sector. Non-CO_2 emissions by end-use sector are allocated by direct emissions in those sectors plus indirect emissions from the electric power sector allocated by electricity sales. Data are preliminary. Totals may not equal sum of components due to independent rounding.

(continued on page 5)

Greenhouse Gas Emissions Overview

Greenhouse Gas Emissions in the U.S. Economy

Distribution of Total U.S. Greenhouse Gas Emissions by End-Use Sector, 2007

Greenhouse Gas and Source	Sector				
	Residential	Commercial	Industrial	Transportation	Total
	Million Metric Tons Carbon Dioxide Equivalent				
Carbon Dioxide					
Energy-Related (adjusted)	1,261.3	1,097.7	1,655.2	1,902.5	**5,916.7**
Industrial Processes	—	—	105.1	—	**105.1**
Total CO_2	**1,261.3**	**1,097.7**	**1,760.3**	**1,902.5**	**6,021.8**
Methane					
Energy					
Coal Mining	—	—	71.1	—	**71.1**
Natural Gas Systems	—	—	176.6	—	**176.6**
Petroleum Systems	—	—	22.9	—	**22.9**
Stationary Combustion	10.4	0.1	0.6	—	**11.1**
Stationary Combustion: Electricity	0.1	0.1	0.1	—	**0.3**
Mobile Sources	—	—	—	5.1	**5.1**
Waste Management					
Landfills	—	169.0	—	—	**169.0**
Domestic Wastewater Treatment	—	17.4	—	—	**17.4**
Industrial Wastewater Treatment	—	—	9.3	—	**9.3**
Industrial Processes	—	—	2.6	—	**2.6**
Agricultural Sources					
Enteric Fermentation	—	—	138.5	—	**138.5**
Animal Waste	—	—	65.0	—	**65.0**
Rice Cultivation	—	—	9.7	—	**9.7**
Crop Residue Burning	—	—	1.4	—	**1.4**
Total Methane	**10.5**	**186.7**	**497.6**	**5.1**	**699.9**
Nitrous Oxide					
Agriculture					
Nitrogen Fertilization of Soils	—	—	229.6	—	**229.6**
Solid Waste of Animals	—	—	62.2	—	**62.2**
Crop Residue Burning	—	—	0.6	—	**0.6**
Energy Use					
Mobile Combustion	—	—	—	56.2	**56.2**
Stationary Combustion	0.9	0.3	4.4	—	**5.7**
Stationary Combustion: Electricity	3.4	3.3	2.6	—	**9.3**
Industrial Sources	—	—	14.0	—	**14.0**
Waste Management					
Human Sewage in Wastewater	—	6.0	—	—	**6.0**
Waste Combustion	—	—	—	—	**0.0**
Waste Combustion: Electricity	0.1	0.1	0.1	—	**0.4**
Total Nitrous Oxide	**4.5**	**9.8**	**313.5**	**56.2**	**383.9**
Hydrofluorocarbons (HFCs)					
HFC-23	—	—	22.0	—	**22.0**
HFC-32	—	0.5	—	—	**0.5**
HFC-125	—	22.8	—	—	**22.8**
HFC-134a	—	—	—	72.7	**72.7**
HFC-143a	—	23.9	—	—	**23.9**
HFC-236fa	—	3.0	—	—	**3.0**
Total HFCs	**0.0**	**50.2**	**22.0**	**72.7**	**144.9**
Perfluorocarbons (PFCs)					
CF_4	—	—	5.2	—	**5.2**
C_2F_6	—	—	4.2	—	**4.2**
NF_3, C_3F_8, and C_4F_8	—	—	0.7	—	**0.7**
Total PFCs	**0.0**	**0.0**	**10.1**	**0.0**	**10.1**
Other HFCs, PFCs/PFPEs	**—**	**6.1**	**—**	**—**	**6.1**
Sulfur Hexafluoride (SF_6)					
SF_6: Utility	4.6	4.4	3.4	—	**12.3**
SF_6: Other	—	—	3.4	—	**3.4**
Total SF_6	**4.6**	**4.4**	**6.8**	**0.0**	**15.8**
Total Non-CO_2	**19.5**	**257.2**	**849.9**	**133.9**	**1,260.6**
Total Emissions	**1,280.8**	**1,354.7**	**2,610.4**	**2,036.4**	**7,282.4**

Greenhouse Gas Emissions Overview

U.S. Emissions in a Global Perspective

Summary

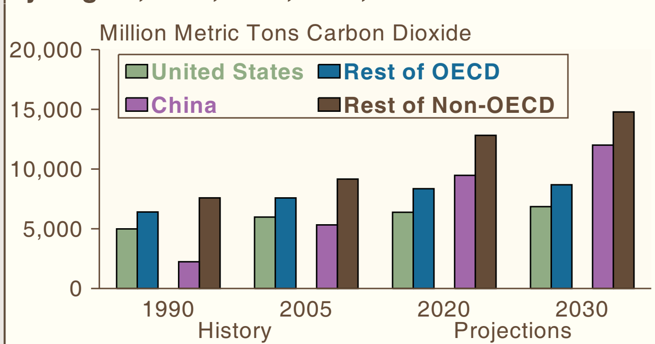
- In EIA's 2006 emissions inventory report, total U.S. energy-related carbon dioxide emissions in 2005 (including nonfuel uses of fossil fuels) were estimated at 5,982 MMT. With the 2005 world total for energy-related carbon dioxide emissions estimated at 28,051 MMT, U.S. emissions were about 21 percent of the world total (see Table 3 on page 7).
- Carbon dioxide emissions related to energy use in the mature economies of countries that are members of the Organization for Economic Cooperation and Development (OECD)—including OECD North America, OECD Europe, Japan, and Australia/New Zealand—are estimated at 13,565 MMT, or 48 percent of the world total. With the remaining 52 percent of worldwide energy-related carbon dioxide emissions (14,486 MMT) estimated as having come from non-OECD countries, 2005 marked the first year in which emissions from the non-OECD economies were significantly greater than those from the OECD economies (Figure 3).
- In EIA's *International Energy Outlook 2008* (*IEO2008*) reference case, projections of energy use and emissions are sensitive to economic growth rates and energy prices. Projections for a range of alternative growth and price scenarios are presented in *IEO2008*.
- U.S. energy-related carbon dioxide emissions are projected to increase at an average annual rate of 0.5 percent from 2005 to 2030 in the *IEO2008* reference case, while emissions from the non-OECD economies are projected to grow by 2.5 percent per year. As a result, the U.S. share of world carbon dioxide emissions is projected to fall to 16 percent in 2030 (6,851 MMT out of a global total of 42,325 MMT) (Figure 4).
- China's share of global energy-related carbon dioxide emissions is projected to grow from 18 percent in 2005 to 28 percent in 2030. As a result, China is expected to be responsible for 47 percent of the projected increase in world emissions over the period. India is expected to account for the second-largest share of the projected increase, 8 percent.

World Energy-Related Carbon Dioxide Emissions, 1990, 2005, and 2030

	1990	2005	2030*
Estimated Emissions (Million Metric Tons)	21,226	28,051	42,325
Change from 1990 (Million Metric Tons)		6,825	21,099
(Percent)		*32.2%*	*99.4%*
Average Annual Change from 1990 *(Percent)*		*1.9%*	*1.7%*
Change from 2005 (Million Metric Tons)			14,274
(Percent)			*50.9%*

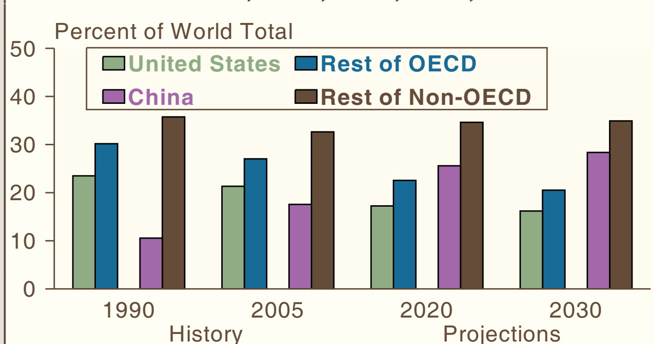
*EIA, *International Energy Outlook 2008.*

Figure 3. World Carbon Dioxide Emissions by Region, 1990, 2005, 2020, and 2030



Source: EIA, *International Energy Outlook 2008.*

Figure 4. Regional Shares of World Carbon Dioxide Emissions, 1990, 2005, 2020, and 2030



Source: EIA, *International Energy Outlook 2008.*

Greenhouse Gas Emissions Overview

U.S. Emissions in a Global Perspective

Table 3. World Energy-Related Carbon Dioxide Emissions by Region, 1990-2030
(Million Metric Tons Carbon Dioxide, Percent Share of World Emissions)

Region/Country	History[a]			Projections[a]					Average Annual Percent Change, 2005-2030[b]
	1990	2004	2005	2010	2015	2020	2025	2030	
OECD									
OECD North America	**5,754**	**6,959**	**7,008**	**7,109**	**7,408**	**7,653**	**7,928**	**8,300**	**0.7**
	(27.1%)	**(25.7%)**	**(25.0%)**	**(22.9%)**	**(21.6%)**	**(20.7%)**	**(20.0%)**	**(19.6%)**	**(9.1%)**
United States[c]	4,989	5,957	5,982	6,011	6,226	6,384	6,571	6,851	0.5
	(23.5%)	(22.0%)	(21.3%)	(19.3%)	(18.1%)	(17.2%)	(16.6%)	(16.2%)	(6.1%)
Canada	465	623	628	669	698	727	756	784	0.9
	(2.2%)	(2.3%)	(2.2%)	(2.2%)	(2.0%)	(2.0%)	(1.9%)	(1.9%)	(1.1%)
Mexico	300	379	398	430	484	542	601	665	2.1
	(1.4%)	(1.4%)	(1.4%)	(1.4%)	(1.4%)	(1.5%)	(1.5%)	(1.6%)	(1.9%)
OECD Europe	**4,101**	**4,373**	**4,383**	**4,512**	**4,678**	**4,760**	**4,800**	**4,834**	**0.4**
	(19.3%)	**(16.2%)**	**(15.6%)**	**(14.5%)**	**(13.6%)**	**(12.9%)**	**(12.1%)**	**(11.4%)**	**(3.2%)**
OECD Asia	**1,541**	**2,148**	**2,174**	**2,208**	**2,287**	**2,322**	**2,357**	**2,403**	**0.4**
	(7.3%)	**(7.9%)**	**(7.8%)**	**(7.1%)**	**(6.7%)**	**(6.3%)**	**(6.0%)**	**(5.7%)**	**(1.6%)**
Japan	1,009	1,242	1,230	1,196	1,201	1,195	1,184	1,170	-0.2
	(4.8%)	(4.6%)	(4.4%)	(3.8%)	(3.5%)	(3.2%)	(3.0%)	(2.8%)	(-0.4%)
South Korea	241	488	500	559	612	632	656	693	1.3
	(1.1%)	(1.8%)	(1.8%)	(1.8%)	(1.8%)	(1.7%)	(1.7%)	(1.6%)	(1.4%)
Australia/New Zealand	291	418	444	454	474	495	517	540	0.8
	(1.4%)	(1.5%)	(1.6%)	(1.5%)	(1.4%)	(1.3%)	(1.3%)	(1.3%)	(0.7%)
Total OECD	**11,396**	**13,480**	**13,565**	**13,829**	**14,373**	**14,736**	**15,085**	**15,538**	**0.5**
	(53.7%)	**(49.8%)**	**(48.4%)**	**(44.5%)**	**(41.9%)**	**(39.8%)**	**(38.1%)**	**(36.7%)**	**(13.8%)**
Non-OECD									
Non-OECD Europe and Eurasia	**4,198**	**2,797**	**2,865**	**3,066**	**3,330**	**3,508**	**3,625**	**3,811**	**1.1**
	(19.8%)	**(10.3%)**	**(10.2%)**	**(9.9%)**	**(9.7%)**	**(9.5%)**	**(9.2%)**	**(9.0%)**	**(6.6%)**
Russia	2,376	1,669	1,696	1,789	1,902	1,984	2,020	2,117	0.9
	(11.2%)	(6.2%)	(6.0%)	(5.8%)	(5.5%)	(5.4%)	(5.1%)	(5.0%)	(2.9%)
Other	1,822	1,128	1,169	1,278	1,428	1,524	1,606	1,694	1.5
	(8.6%)	(4.2%)	(4.2%)	(4.1%)	(4.2%)	(4.1%)	(4.1%)	(4.0%)	(3.7%)
Non-OECD Asia	**3,613**	**7,517**	**8,177**	**10,185**	**12,157**	**13,907**	**15,683**	**17,482**	**3.1**
	(17.0%)	**(27.8%)**	**(29.2%)**	**(32.7%)**	**(35.4%)**	**(37.6%)**	**(39.6%)**	**(41.3%)**	**(65.2%)**
China	2,241	4,753	5,323	6,898	8,214	9,475	10,747	12,007	3.3
	(10.6%)	(17.6%)	(19.0%)	(22.2%)	(23.9%)	(25.6%)	(27.1%)	(28.4%)	(46.8%)
India	565	1,127	1,164	1,349	1,604	1,818	2,019	2,238	2.6
	(2.7%)	(4.2%)	(4.1%)	(4.3%)	(4.7%)	(4.9%)	(5.1%)	(5.3%)	(7.5%)
Other Non-OECD Asia	807	1,637	1,690	1,938	2,338	2,614	2,917	3,237	2.6
	(3.8%)	(6.0%)	(6.0%)	(6.2%)	(6.8%)	(7.1%)	(7.4%)	(7.6%)	(10.8%)
Middle East	**700**	**1,290**	**1,400**	**1,622**	**1,802**	**1,988**	**2,120**	**2,250**	**1.9**
	(3.3%)	**(4.8%)**	**(5.0%)**	**(5.2%)**	**(5.2%)**	**(5.4%)**	**(5.4%)**	**(5.3%)**	**(6.0%)**
Africa	**649**	**943**	**966**	**1,090**	**1,244**	**1,366**	**1,450**	**1,515**	**1.8**
	(3.1%)	**(3.5%)**	**(3.4%)**	**(3.5%)**	**(3.6%)**	**(3.7%)**	**(3.7%)**	**(3.6%)**	**(3.8%)**
Central and South America	**669**	**1,042**	**1,078**	**1,308**	**1,429**	**1,531**	**1,628**	**1,729**	**1.9**
	(3.2%)	**(3.8%)**	**(3.8%)**	**(4.2%)**	**(4.2%)**	**(4.1%)**	**(4.1%)**	**(4.1%)**	**(4.6%)**
Brazil	216	350	356	451	498	541	582	633	2.3
	(1.0%)	(1.3%)	(1.3%)	(1.5%)	(1.5%)	(1.5%)	(1.5%)	(1.5%)	(1.9%)
Other Central/South America	453	692	722	857	931	990	1,046	1,097	1.7
	(2.1%)	(2.6%)	(2.6%)	(2.8%)	(2.7%)	(2.7%)	(2.6%)	(2.6%)	(2.6%)
Total Non-OECD	**9,830**	**13,589**	**14,486**	**17,271**	**19,962**	**22,299**	**24,506**	**26,787**	**2.5**
	(46.3%)	**(50.2%)**	**(51.6%)**	**(55.5%)**	**(58.1%)**	**(60.2%)**	**(61.9%)**	**(63.3%)**	**(86.2%)**
Total World	**21,226**	**27,070**	**28,051**	**31,100**	**34,335**	**37,035**	**39,591**	**42,325**	**1.7**

[a]Values adjusted for nonfuel sequestration.
[b]Values in parentheses indicate percent share of total world absolute change.
[c]Includes the 50 States and the District of Columbia.
Note: The U.S. numbers include carbon dioxide emissions attributable to renewable energy sources.
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2005* (May-July 2007), web site www.eia.doe.gov/iea/; and data presented in this report. **Projections:** EIA, *Annual Energy Outlook 2008*, DOE/EIA-0383(2008) (Washington, DC, June 2008), Table 1, web site www.eia.doe.gov/oiaf/aeo; and *International Energy Outlook 2008*, DOE/EIA-0484(2008) (Washington, DC, September 2008), Table A10.

Greenhouse Gas Emissions Overview

Recent U.S. and International Developments in Global Climate Change

United States

Federal Actions

- The Consolidated Appropriations Act of 2008, which became Public Law 110-161 on December 26, 2007, directed the U.S. Environmental Protection Agency (EPA) to develop a draft mandatory reporting rule for greenhouse gases by the end of September 2008; although the draft rule has not yet been released, the Final Rule is due to be completed by June 2009. The Rule is expected to require mandatory reporting of greenhouse gas emissions "above appropriate thresholds in all sectors of the economy," with thresholds and frequency of reporting to be determined by the EPA.
- In July 2008, the EPA released an Advance Notice of Proposed Rulemaking (ANPR) to implement the ruling of the U.S. Supreme Court case, Massachusetts v. the Environmental Protection Agency. On April 2, 2007, the Court ruled that Section 202(a)(1) of the Clean Air Act (CAA) gives the EPA authority to regulate tailpipe emissions of greenhouse gases. Four key issues for discussion in the ANPR include: descriptions of key provisions and programs in the CAA and advantages and disadvantages of regulating greenhouse gases under those provisions; how a decision to regulate GHG emissions under one section of the CAA could or would lead to regulation of GHG emissions under other sections of the Act, including sections establishing permitting requirements for major stationary sources of air pollutants; issues relevant for Congress to consider for possible future climate legislation and the potential for overlap between future legislation and regulation under the existing CAA; and scientific information relevant to, and the issues raised by, an endangerment analysis.

Congressional Initiatives

- Senate Bill 3036, the Lieberman-Warner Climate Security Act of 2008, came to the floor for debate in the Senate on June 2, 2008. The main purpose of the Act was to establish a Federal program that would substantially reduce U.S. greenhouse gas emissions between 2007 and 2050, in large part through a Federal cap-and-trade program.

Regional and State Efforts

- On September 25, 2008, the Regional Greenhouse Gas Initiative (RGGI) held its first auction. More than 12.6 million tons were sold at a clearing price of $3.07. New York, with 40 percent allowance allocation, did not participate in the first round of auctions; however, all 10 States are expected to participate in the second allowance auction on December 17, 2008, at which 31.5 million allowances will be available with a reserve price set at $1.86. RGGI is a cooperative effort by 10 Northeast and Mid-Atlantic States to limit greenhouse gas emissions from the electric power sector. Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont are signatory States to the RGGI agreement.
- On September 28, 2008, the Western Climate Initiative (WCI) released a detailed scoping plan for its regional market-based cap-and-trade program. The multi-sector program will be the most comprehensive carbon reduction strategy to date, covering nearly 90 percent of the region's emissions, including those from electricity, industry, transportation, and residential and commercial fuel use, and reducing greenhouse gas emissions to 15 percent below 2005 levels by 2020. On September 30, 2008, the WCI released its Second Draft of Reporting Requirements, which addresses the essential requirements for mandatory reporting. Participating U.S. States include Arizona, California, Montana, New Mexico, Oregon, Utah, and Washington. Canadian provinces participating include British Columbia, Manitoba, Ontario, and Quebec.
- Nine Midwestern governors and two Canadian premiers signed on to participate or observe in the Midwestern Greenhouse Gas Reduction Accord as first agreed to in November 2007. Member States have agreed to reduce greenhouse gas emissions, and a working group is to provide recommendations regarding the implementation of the Accord. In September 2008, the Advisory Group released an updated timeline that requires preliminary design recommendations to be released by November 2008, final recommendations by March 2009, and a draft model rule between May and September 2009. Member States include Iowa, Illinois, Kansas, Michigan, Minnesota, and Wisconsin, as well as the Canadian province of Manitoba. Observer States include Indiana, Ohio, and South Dakota, as well as the Canadian province of Ontario.

(continued on page 9)

Greenhouse Gas Emissions Overview

Recent U.S. and International Developments in Global Climate Change

United States (continued)

- On September 30, 2008, Governor Arnold Schwarzenegger of California signed S.B. 375 to integrate greenhouse gas emissions into California's transportation planning decisions. Under the law, the California Air Resources Board will work with California's 18 metropolitan planning organizations to align their regional transportation, housing, and land-use plans and prepare a "sustainable communities strategy" to reduce vehicle-miles traveled in their respective areas and demonstrate the region's ability to meet its greenhouse gas reduction targets.[1]

International: United Nations Framework Convention on Climate Change and the Kyoto Protocol

COP-13 and CMP-3

In December 2007, the Thirteenth Conference of the Parties to the United Nation's Framework Convention on Climate Change (COP-13) and the Third Meeting of the Parties to the Kyoto Protocol (CMP-3) were held in Nusa Dua, Bali. Key areas included:

- Launch of a negotiating process with the expectation of reaching a comprehensive post-2012 agreement in 2009 (COP-13 and CMP-3)
- Agreement by developing countries to consider taking "measurable, reportable, and verifiable" mitigation actions, while receiving technological and financial support from developed countries (COP-13)
- Agreement by developed countries to consider making "commitments or actions, quantified emission limitation and reduction objectives," including making binding targets an option (COP-13)
- Reconstitution of the Expert Group on Technology Transfer for 5 more years, with a new mandate to evaluate technology transfer efforts and develop recommendations for strengthening the efforts in a post-2012 agreement (COP-13)
- Adoption of a decision encouraging countries with tropical forests to undertake demonstration activities, particularly the development of national emission baselines, and provide indicative guidance for such projects (COP-13)
- Setting of parameters for a thorough review of the Kyoto Protocol for CMP-4, including the scope and effectiveness of the flexibility mechanisms, progress by developed countries in implementing their commitments on finance and technology for developing countries, and the possibility of extending to the other flexibility mechanisms the levy now applied to clean development mechanism (CDM) transactions to support the Protocol's Adaptation Fund(CMP-3)
- Resolution of long-standing differences on the governance of the Adaptation Fund, including establishing a 16-member Adaptation Fund Board to manage the fund on behalf of CMP (CMP-3).

COP-14 and CMP-4

Poland will host COP-14 and CMP-4 in Poznań, December 1-12, 2008. Parties are expected to:

- Agree on a plan of action and programs of work for the final year of negotiations after a year of comprehensive and extensive discussions on crucial issues relating to future commitments, actions, and cooperation
- Make significant progress on several issues required to enhance further the implementation of the Convention and the Kyoto Protocol
- Advance understanding and commonality of views on a "shared vision" for a new climate change regime beyond the Kyoto Protocol
- Strengthen momentum and commitment to the process and the agreed timeline
- Discuss capacity-building for developing countries, reducing emissions from deforestation, and technology transfer and adaptation.

[1]State of California, Office of the Governor, "Governor Schwarzenegger Signs Sweeping Legislation To Reduce Greenhouse Gas Emissions Through Land-Use," Press Release GAAS:694:08 (September 30, 2008), web site http://gov.ca.gov/press-release/10697.

Greenhouse Gas Emissions Overview

Units for Measuring Greenhouse Gases

Emissions data are reported here in metric units, as favored by the international scientific community. Metric tons are relatively intuitive for users of U.S. measurement units, because 1 metric ton is only about 10 percent heavier than a short ton.

Throughout this report, emissions of carbon dioxide and other greenhouse gases are given in carbon dioxide equivalents. In the case of carbon dioxide, emissions denominated in the molecular weight of the gas or in carbon dioxide equivalents are the same. Carbon dioxide equivalent data can be converted to carbon equivalents by multiplying by 12/44.

Emissions of other greenhouse gases (such as methane) can also be measured in carbon dioxide equivalent units by multiplying their emissions (in metric tons) by their global warming potentials (GWPs). Carbon dioxide equivalents are the amount of carbon dioxide by weight emitted into the atmosphere that would produce the same estimated radiative forcing as a given weight of another radiatively active gas.

Carbon dioxide equivalents are computed by multiplying the weight of the gas being measured (for example, methane) by its estimated GWP (which is 25 for methane). In 2007, the Intergovernmental Panel on Climate Change (IPCC) Working Group I released its Fourth Assessment Report, *Climate Change 2007: The Physical Science Basis*.[2] Among other things, the Fourth Assessment Report updated a number of the GWP estimates that appeared in the IPCC's Third Assessment Report.[3] The GWPs published in the Fourth Assessment Report were used for the calculation of carbon dioxide equivalent emissions for this report. Table 4 on page 11 summarizes the GWP values from the Second, Third, and Fourth Assessment Reports.

[2]Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis* (Cambridge, UK: Cambridge University Press, 2007), web site www.ipcc.ch/ipccreports/ar4-wg1.htm.

[3]Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001), web site www.ipcc.ch/ipccreports/tar/wg1/index.htm.

Greenhouse Gas Emissions Overview

Units for Measuring Greenhouse Gases

Table 4. Greenhouse Gases and 100-Year Net Global Warming Potentials

Greenhouse Gas	Chemical Formula	Global Warming Potential		
		SAR[a]	TAR[b]	AR4[c]
Carbon Dioxide	CO_2	1	1	1
Methane	CH_4	21	23	25
Nitrous Oxide	N_2O	310	296	298
Hydrofluorocarbons				
HFC-23 (Trifluoromethane)	CHF_3	11,700	12,000	14,800
HFC-32 (Difluoromethane)	CH_2F_2	650	550	675
HFC-41 (Monofluoromethane)	CH_3F	150	97	—
HFC-125 (Pentafluoroethane)	CHF_2CF_3	2,800	3,400	3,500
HFC-134 (1,1,2,2-Tetrafluoroethane)	CHF_2CHF_2	1,000	1,100	—
HFC-134a (1,1,1,2-Tetrafluoroethane)	CH_2FCF_3	1,300	1,300	1,430
HFC-143 (1,1,2-Trifluoroethane)	CHF_2CH_2F	300	330	—
HFC-143a (1,1,1-Trifluoroethane)	CF_3CH_3	3,800	4,300	4,470
HFC-152 (1,2-Difluoroethane)	CH_2FCH_2F	—	43	—
HFC-152a (1,1-Difluoroethane)	CH_3CHF_2	140	120	124
HFC-161 (Ethyl Fluoride)	CH_3CH_2F	—	12	—
HFC-227ea (Heptafluoropropane)	CF_3CHFCF_3	2,900	3,500	3,220
HFC-236cb (1,1,1,2,2,3-Hexafluoropropane)	$CH_2FCF_2CF_3$	—	1,300	—
HFC-236ea (1,1,1,2,3,3-Hexafluoropropane)	CHF_2CHFCF_3	—	1,200	—
HFC-236fa (1,1,1,3,3,3-Hexafluoropropane)	$CF_3CH_2CF_3$	6,300	9,400	9,810
HFC-245ca (1,1,2,2,3-Pentafluoropropane)	$CH_2FCF_2CHF_2$	560	640	—
HFC-245fa (1,1,1,3,3-Pentafluoropropane)	$CHF_2CH_2CF_3$	—	950	1,030
HFC-365mfc (Pentafluorobutane)	$CF_3CH_2CF_2CH_3$	—	890	794
HFC-43-10mee (Decafluoropentane)	$CF_3CHFCHFCF_2CF_3$	1,300	1,500	1,640
Perfluorocarbons				
Perfluoromethane	CF_4	6,500	5,700	7,390
Perfluoroethane	C_2F_6	9,200	11,900	12,200
Perfluoropropane	C_3F_8	7,000	8,600	8,830
Perfluorobutane (FC 3-1-10)	C_4F_{10}	7,000	8,600	8,860
Perfluorocyclobutane	$c\text{-}C_4F_8$	8,700	10,000	10,300
Perfluoropentane	C_5F_{12}	7,500	8,900	9,160
Perfluorohexane (FC 5-1-14)	C_6F_{14}	7,400	9,000	9,300
Sulfur Hexafluoride	SF_6	23,900	22,200	22,800

Sources: [a]Intergovernmental Panel on Climate Change, *Climate Change 1995: The Science of Climate Change* (Cambridge, UK: Cambridge University Press, 1996). [b]Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001), web site www.ipcc.ch/ipccreports/tar/wg1/index.htm. [c]Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis* (Cambridge, UK: Cambridge University Press, 2007), web site www.ipcc.ch/ipccreports/ar4-wg1.htm.

Methodology Updates for This Report

Carbon Dioxide

EIA has begun using a separate carbon coefficient for net imports of metallurgical coke, based on IPCC guidelines. The new coefficient more accurately reflects the carbon content of imported coke. The carbon in coke that is domestically produced, and the carbon dioxide emissions from that coke, are counted in the amount of domestic coking coal consumed. For net coke imports, however, it was decided that the new, higher carbon coefficient should be used. Although the difference between the two coefficients is about 14 percent, the amount of coke imported is relatively small. Thus, the increase in calculated carbon dioxide emissions resulting from the change in coefficients is in the range of 1 to 3 million metric tons for most years over the 1990-2007 period.

Estimates of carbon dioxide emissions from natural gas combustion have been adjusted upward, to reflect increasing concentrations of carbon dioxide in the natural gas produced in the United States in recent years. As a result of the change, the estimates of carbon dioxide emissions from natural gas combustion for recent years are about 1 million metric tons higher than those in last year's report.

Because of a change in methodology, the estimate of carbon dioxide emissions from waste combustion (included in "Other Sources") has been adjusted downward, as most of those emissions are accounted for by grid-connected waste-to-energy plants in the electric power sector, which are captured in EIA's surveys. The result of this change is a reduction of 3 to 4 million metric tons per year from 1990 to 2007.

An error in the calculation code caused emissions from industrial lubricants to be omitted from total emissions in EIA's emissions inventory reports for 2005 and 2006. Although lubricants are a nonfuel use, there are emissions associated with their use. Emissions from this source are again included in total emissions in this year's report. As a result of the correction, the estimates of total U.S. carbon dioxide emissions are higher by about 6 to 7 million metric tons per year from 1990 to 2007 than those in the 2005 and 2006 data reports.

Other changes reflect revisions in the underlying activity data. For example, in the 2006 data report, the amount of natural gas consumed in the United States in 2005 was estimated at 22,241 billion cubic feet, whereas in this year's report the estimate for 2005 is 22,011 billion cubic feet. As a result, the estimate for carbon dioxide emissions from natural gas combustion in 2005 is about 10 million metric tons lower in this year's report than in last year's report.

Methane

In its Fourth Assessment Report (AR4),[4] the IPCC developed revised global warming potential factors (GWPs) for selected gases. The GWP for methane was revised from the previously published value of 23 in the IPCC's Third Assessment Report[5] to 25 in the Fourth Assessment Report. The revised GWP for methane is used in this report. In addition, this report incorporates an increase in the density of methane from 42.28 to 42.37 pounds per thousand cubic feet, in order to provide consistent temperature and pressure values for methane in all EIA data.

Nitrous Oxide

The IPCC also updated the GWP for nitrous oxide in its Fourth Assessment Report, to 298, up from 296 in the IPCC's Third Assessment Report. The revised GWP for nitrous oxide is used in this report.

High-GWP Gases

The IPCC also updated GWPs for most of the high-GWP emissions sources in its Fourth Assessment Report. The revised GWPs are included in Table 4 on page 11, under "Units for Measuring Greenhouse Gases."

Land Use

Forest Land Remaining Forest Land is the major source of change in net carbon dioxide flux resulting from land use. In this report, the addition of newly available forest inventory data, as well as some refinements to previous data, involved the following major changes: incorporating and updating State and sub-State inventory data; and including a portion of Alaskan forest for the first time. In addition, minor refinements to the calculation of flux from harvested wood products included: a shorter half-life for decay in dumps; and separation of decay in dumps from decay in landfills. Overall, these changes, in combination with adjustments in the other sources/sinks within the land-use category, resulted in an average annual increase of 20.1 million metric tons carbon dioxide equivalent (2.5 percent) in net carbon flux to the atmosphere from Land Use, Land-Use Change, and Forestry for the years 1990 through 2005.

[4]S.D. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avervt, M. Tignor, and H.L. Miller (Eds.), *Climate Change 2007: The Physical Science Basis* (Cambridge, UK: Cambridge University Press, 2007), web site www.ipcc.ch/ipccreports/ar4-wg1.htm.

[5]J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, and D. Xiaosu (Eds.), *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001), web site www.ipcc.ch/ipccreports/tar/wg1/index.htm.

Carbon Dioxide Emissions

Total Emissions

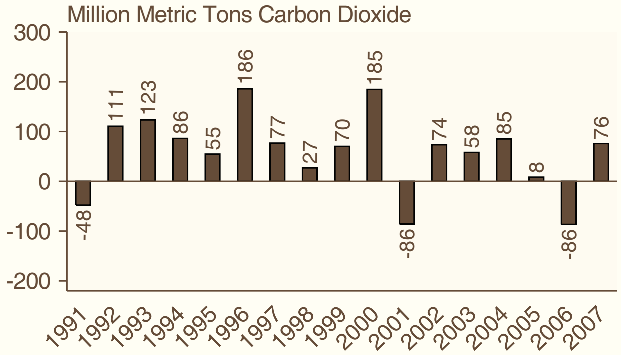
Summary

- Total U.S. carbon dioxide emissions in 2007 increased by 75.9 million metric tons (1.3 percent) compared with 2006 emissions (Figure 5), to 6,022 million metric tons (MMT). The increase offset a 1.4-percent drop in 2006 (to 5,946 MMT), raising the total back close to the 2005 level (6,032 MMT).
- The important factors that contributed to the increase in carbon dioxide emissions in 2007 included: unfavorable weather, with both heating and cooling degree-days above 2006 levels (see box on page 15); and the combination of a 2.5-percent increase in electricity demand and a 14.2-percent decline in hydropower generation that resulted in a 2.9-percent increase in emissions from the electric power sector.
- Energy-related carbon dioxide emissions account for 98 percent of U.S. carbon dioxide emissions (Table 5). The vast majority of carbon dioxide emissions come from fossil fuel combustion, with smaller amounts from the nonfuel use of energy inputs, and the total adjusted for emissions from U.S. Territories and international bunker fuels. Other sources include emissions from industrial processes, such as cement and limestone production.

U.S. Anthropogenic Carbon Dioxide Emissions, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons)	5,021.4	5,945.8	6,021.8
Change from 1990 (Million Metric Tons)		924.5	1,000.4
(Percent)		*18.4%*	*19.9%*
Average Annual Change from 1990 *(Percent)*		*1.1%*	*1.1%*
Change from 2006 (Million Metric Tons)			75.9
(Percent)			*1.3%*

Figure 5. Annual Change in U.S. Carbon Dioxide Emissions, 1990-2007



Source: EIA estimates.

Table 5. U.S. Carbon Dioxide Emissions from Energy and Industry, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide)

Fuel Type or Process	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Energy Consumption										
Petroleum	2,178.8	2,206.1	2,459.0	2,470.2	2,467.7	2,512.4	2,602.8	2,619.9	2,596.2	2,579.9
Coal	1,799.9	1,898.9	2,146.4	2,084.4	2,094.1	2,131.3	2,157.6	2,161.2	2,139.8	2,162.4
Natural Gas	1,033.6	1,193.0	1,239.8	1,189.3	1,245.7	1,212.6	1,194.2	1,182.6	1,158.9	1,237.0
Renewables[a]	6.3	10.5	10.6	11.2	13.1	11.8	11.5	11.6	11.8	11.6
Energy Subtotal	**5,018.7**	**5,308.5**	**5,855.8**	**5,755.1**	**5,820.6**	**5,868.1**	**5,966.2**	**5,975.3**	**5,906.7**	**5,990.9**
Nonfuel Use Emissions[b]	*98.8*	*105.5*	*110.8*	*105.8*	*106.2*	*103.9*	*112.1*	*107.0*	*111.5*	*117.6*
Nonfuel Use Sequestration[c]	*251.2*	*286.5*	*308.2*	*293.8*	*293.9*	*289.6*	*311.9*	*302.3*	*302.0*	*301.5*
Adjustments to Energy	-82.4	-62.4	-60.9	-45.3	-37.8	-28.3	-44.3	-46.5	-66.8	-74.2
Adjusted Energy Subtotal	**4,936.3**	**5,246.0**	**5,794.8**	**5,709.9**	**5,782.8**	**5,839.7**	**5,921.9**	**5,928.9**	**5,839.9**	**5,916.7**
Other Sources	85.1	102.3	97.8	97.0	97.7	98.9	102.0	103.4	105.9	105.1
Total	**5,021.4**	**5,348.4**	**5,892.6**	**5,806.9**	**5,880.5**	**5,938.7**	**6,023.9**	**6,032.3**	**5,945.8**	**6,021.8**

[a]Includes emissions from electricity generation using nonbiogenic municipal solid waste and geothermal energy.
[b]Emissions from nonfuel uses are included in the energy subtotal above.
[c]The Btu value of carbon sequestered by nonfuel uses is subtracted from energy consumption before emissions are calculated.
P = preliminary data.
Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding. Adjusted energy subtotal includes U.S. Territories but excludes international bunker fuels.
Source: EIA estimates.

Carbon Dioxide Emissions

Energy-Related Emissions

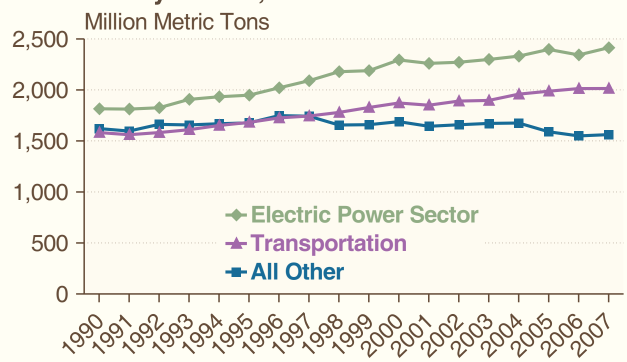
Summary

- Energy-related carbon dioxide emissions account for more than 80 percent of U.S. greenhouse gas emissions. EIA breaks energy use into four end-use sectors (Table 6), and emissions from the electric power sector are attributed to the end-use sectors.
- Growth in energy-related carbon dioxide emissions has resulted largely from increases associated with electric power generation and transportation fuel use. All other energy-related carbon dioxide emissions (from direct fuel use in the residential, commercial, and industrial sectors) have been either flat or declining in recent years (Figure 6).
- Reasons for the growth in electric power and transportation sector emissions include: increased demand for electricity for computers and electronics in homes and offices; strong growth in demand for commercial lighting and cooling; substitution of new electricity-intensive technologies, such as electric arc furnaces for steelmaking, in the industrial sector; and increased demand for transportation services as a result of relatively low fuel prices and robust economic growth in the 1990s and early 2000s.[6]
- Other U.S. energy-related carbon dioxide emissions have remained flat or declined, for reasons that include increased efficiencies in heating technologies, as well as declining activity in older "smokestack" industries and the growing importance of less energy-intensive industries, such as computers and electronics.

U.S. Energy-Related Carbon Dioxide Emissions, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons)	5,018.7	5,906.7	5,990.9
Change from 1990 (Million Metric Tons)		888.0	972.2
(Percent)		*17.7%*	*19.4%*
Average Annual Change from 1990 *(Percent)*		*1.0%*	*1.0%*
Change from 2006 (Million Metric Tons)			84.2
(Percent)			*1.4%*

Figure 6. U.S. Energy-Related Carbon Dioxide Emissions by Sector, 1990-2007



Source: EIA estimates.

Table 6. U.S. Energy-Related Carbon Dioxide Emissions by End-Use Sector, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide)

Sector	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Residential	961.7	1,039.2	1,181.6	1,168.3	1,196.3	1,224.6	1,220.7	1,254.9	1,197.9	1,249.5
Commercial	787.5	848.4	1,015.2	1,020.1	1,017.9	1,027.1	1,042.3	1,060.2	1,043.0	1,087.4
Industrial	1,686.9	1,738.6	1,786.4	1,715.8	1,715.5	1,719.1	1,744.2	1,672.3	1,652.4	1,639.7
Transportation	1,582.6	1,682.2	1,872.6	1,850.9	1,890.9	1,897.2	1,958.9	1,988.0	2,013.4	2,014.4
Total	**5,018.7**	**5,308.5**	**5,855.8**	**5,755.1**	**5,820.6**	**5,868.1**	**5,966.2**	**5,975.3**	**5,906.7**	**5,990.9**
Electricity Generation[a]	1,820.4	1,955.1	2,300.9	2,261.3	2,271.1	2,299.0	2,331.2	2,397.4	2,364.1	2,433.4

[a]Electric power sector emissions are distributed across the end-use sectors. Emissions allocated to sectors are unadjusted. Adjustments are made to total emissions only.

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.

Source: EIA estimates.

[6]This trend leveled off in 2007, and EIA is projecting a 3-percent decline in vehicle-miles traveled for 2008. See web site www.eia.doe.gov/emeu/steo/pub/contents.html.

Carbon Dioxide Emissions

Residential and Commercial Sectors: Weather Effects on Energy-Related Carbon Dioxide Emissions, 2006 and 2007

Annual variations in CO_2 emissions in the residential and commercial sectors over the 2005-2007 period illustrate the impacts that changes in weather can have on emissions in those sectors. Total energy-related CO_2 emissions for all the end-use sectors combined (residential, commercial, industrial, and transportation) were down in 2006 by about 69 million metric tons (MMT), but in 2007 they were up by about 84 MMT, inviting the question: Why are these years so different from each other?

It is difficult to estimate the relative importance of the different factors that affect year-to-year changes in emissions. Since 1990, energy-related emissions have grown on average by about 1.0 percent per year. At current emissions levels that would mean about 60 MMT added per year. With U.S. GDP growing by 2.8 percent in 2006 but by only 2.0 percent in 2007, why was 2006 emissions growth so far below average (-69 MMT) and 2007 growth above average (+84 MMT)?

One of the most important factors causing deviations from average emissions growth is weather. The table below shows emissions from energy use for heating and cooling in the residential and commercial sectors for 2006 and 2007, and weather adjustments for both sectors, based on estimates from EIA's *Annual Energy Outlook 2008*.[7] In 2006, emissions attributable to space heating and space cooling both were lower than in 2005; in 2007, both were higher than in 2006.[8] The annual variations can be estimated more precisely by using changes in heating degree-days (HDD) and cooling degree-days (CDD).[9] In 2006, both HDD and CDD were down relative to 2005, reducing both space heating and cooling requirements; in 2007, both HDD and CDD were up relative to 2006, increasing demand for both heating and cooling.

In the residential sector, CO_2 emissions related to heating and cooling in 2006 were estimated to be about 48 and 13 MMT lower than in 2005, respectively, for a total weather effect of -61 MMT. In the commercial sector, emissions related to heating and cooling in 2006 were 10 and 4 MMT lower than in 2005. Thus, for both sectors, emissions in 2006 were about 76 MMT lower than they would have been without the weather effect. The effect is not insignificant: when 2006 emissions in the two sectors are adjusted for the weather effect, the result shows an increase of 7 MMT from 2005 to 2006. Similarly, for 2007, the weather effect accounts for about two-thirds (56 MMT) of the total increase in residential and commercial sector CO_2 emissions relative to 2006.

With the adjustments for weather, the growth of total energy-related CO_2 emissions in both 2006 and 2007 is below the 1.0-percent average growth rate for the 1990-2007 period. Other important factors in year-to-year changes in CO_2 emissions include total and relative fuel prices, efficiency of electricity generation and the energy-intensive industries, and the availability of hydropower, nuclear power, and other low-carbon energy sources, as well as overall economic growth.

Emissions (MMT CO_2)	2005	2006	2007
Residential Space Heating	358	308	345
Change From Previous Year		-48	37
Residential Space Cooling	158	141	147
Change From Previous Year		-13	6
Residential Weather Adjustment		-61	43
Commercial Space Heating	104	94	101
Change From Previous Year		-10	7
Commercial Space Cooling	105	99	104
Change From Previous Year		-4	5
Commercial Weather Adjustment		-14	12
Total Weather Adjustment, Both Sectors		-76	56
Total Actual Change (All Sectors)		-69	84
Total Weather-Adjusted Change (All Sectors)		7	28

[7] Carbon emissions factors for the appropriate fuels from this report were applied to Btu values from EIA's *Annual Energy Outlook 2008*, Tables A4 and A5, to derive CO_2 emissions related to energy consumed for heating and cooling. Cooling-related emissions were estimated using an average emissions factor for electricity, although it is likely that the emissions came from peaking generation units with emissions factors higher than the average for all generation.

[8] There is also a weather effect on the industrial sector, where about 7 percent of energy consumption is estimated to be weather-related. Inclusion of the industrial sector in this analysis would increase the weather effect for both years.

[9] HDD (or CDD) provide a measure of how cold (or warm) a location is over a period of time relative to a base temperature (most commonly specified as 65ºF) and, in energy analysis, an indicator of space heating (or air conditioning) energy requirements or use.

Carbon Dioxide Emissions

Residential Sector

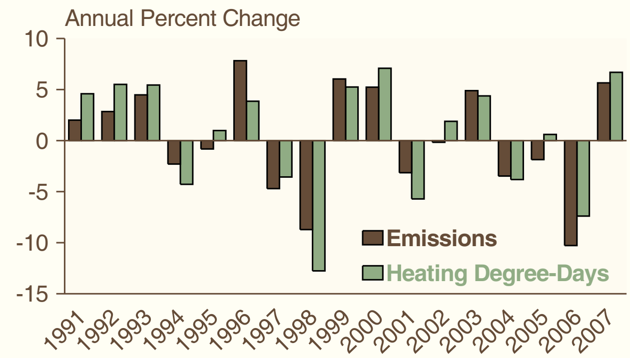
Summary

- Residential sector carbon dioxide emissions originate primarily from:
  - Direct fuel consumption (principally, natural gas) for heating and cooking
  - Electricity for cooling (and some heating), for lighting, and increasingly for televisions, computers, and other household electronic devices (Table 7).
- Energy consumed for heating in homes and businesses has a large influence on the annual fluctuations in energy-related carbon dioxide emissions.
  - The 6.5-percent increase in heating degree-days in 2007 was the second-largest year-to-year increase over the period from 1990 to 2007 (Figure 7).
  - Although annual changes in cooling degree-days have a smaller impact on energy demand, the 2.2-percent increase in 2007 contributed to the upward pressure on electricity demand.
  - Weather was a key factor behind the 4.3-percent increase in carbon dioxide emissions from the residential sector in 2007.
- In the longer run, residential emissions are affected by population growth and income. From 1990 to 2007:
  - Residential sector carbon dioxide emissions grew by an average of 1.6 percent per year.
  - U.S. population grew by an average of 0.9 percent per year.
  - Per-capita income (measured in constant dollars) grew by an average of 1.7 percent per year.

Residential Sector Carbon Dioxide Emissions, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons)	961.7	1,197.9	1,249.5
Change from 1990 (Million Metric Tons)		236.2	287.8
(Percent)		*24.6%*	*29.9%*
Average Annual Change from 1990 *(Percent)*		*1.4%*	*1.6%*
Change from 2006 (Million Metric Tons)			51.6
(Percent)			*4.3%*

Figure 7. Annual Changes in U.S. Heating Degree-Days and Residential Sector CO_2 Emissions from Direct Fuel Combustion, 1990-2007



Source: EIA estimates.

Table 7. U.S. Carbon Dioxide Emissions from Residential Sector Energy Consumption, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide)

Fuel	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Petroleum										
Liquefied Petroleum Gas	22.7	25.2	35.1	33.3	33.8	35.1	33.1	32.2	32.4	32.8
Distillate Fuel	71.6	66.2	66.2	66.4	62.9	66.2	67.6	62.5	52.1	52.6
Kerosene	4.6	5.4	6.8	6.9	4.3	5.1	6.1	6.1	4.8	2.9
Petroleum Subtotal	**98.9**	**96.7**	**108.1**	**106.7**	**101.0**	**106.4**	**106.8**	**100.7**	**89.2**	**88.3**
Coal	2.9	1.7	1.0	1.0	1.1	1.2	1.2	0.9	0.6	0.6
Natural Gas	239.8	264.4	270.6	260.1	265.0	277.5	263.7	263.2	237.5	256.9
Electricity[a]	620.1	676.4	801.9	800.5	829.1	839.5	849.0	890.1	870.6	903.7
Total	**961.7**	**1,039.2**	**1,181.6**	**1,168.3**	**1,196.3**	**1,224.6**	**1,220.7**	**1,254.9**	**1,197.9**	**1,249.5**

[a]Share of total electric power sector carbon dioxide emissions weighted by sales to the residential sector.
P = preliminary data.
Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.
Source: EIA estimates.

Carbon Dioxide Emissions

Commercial Sector

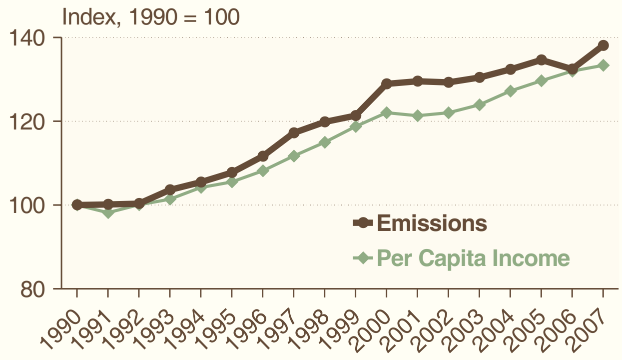
Summary

- Commercial sector emissions (Table 8) are largely the result of energy use for lighting, space heating, and space cooling in commercial structures, such as office buildings, shopping malls, schools, hospitals, and restaurants.
- Lighting accounts for a larger component of energy demand in the commercial sector (approximately 20 percent of total demand in 2006) than in the residential sector (approximately 11 percent of the total).
- Commercial sector emissions are affected less by weather than are residential sector emissions: heating and cooling accounted for approximately 37 percent of energy demand in the residential sector in 2006 but only about 19 percent in the commercial sector.[10]
- Although weather has a smaller effect on emissions in the commercial sector than in the residential sector, it contributed, along with 2-percent economic growth, to the 4.3-percent increase in 2007—well above the average annual increase from 1990 to 2006.
- In the longer run, trends in emissions from the commercial sector parallel economic trends. Commercial sector emissions grew at an average annual rate of 2.0 percent from 1990 to 2007—about the same rate as growth in real per capita income (Figure 8).
- Emissions from direct fuel consumption in the commercial sector declined from 1990 to 2007, while the sector's electricity-related emissions increased by an average of 2.6 percent per year.

Commercial Sector Carbon Dioxide Emissions, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons)	787.5	1,043.0	1,087.4
Change from 1990 (Million Metric Tons)		255.5	299.8
(Percent)		*32.4%*	*38.1%*
Average Annual Change from 1990 *(Percent)*		*1.8%*	*1.9%*
Change from 2006 (Million Metric Tons)			44.4
(Percent)			*4.3%*

Figure 8. U.S. Commercial Sector CO_2 Emissions and Per Capita Income, 1990-2007



Source: EIA estimates.

Table 8. U.S. Carbon Dioxide Emissions from Commercial Sector Energy Consumption, 1990, 1995, and 2000-2007

(Million Metric Tons Carbon Dioxide)

Fuel	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Petroleum										
Motor Gasoline	7.8	1.3	3.2	2.7	3.2	4.2	3.1	3.2	3.2	3.1
Liquefied Petroleum Gas	4.0	4.4	6.2	5.9	6.0	6.2	5.8	5.7	5.7	5.8
Distillate Fuel	39.2	35.0	35.9	37.2	32.5	35.2	34.4	32.7	29.3	29.6
Residual Fuel	18.1	11.1	7.2	5.5	6.3	8.8	9.7	9.1	5.9	6.2
Kerosene	0.9	1.6	2.1	2.3	1.2	1.3	1.5	1.6	1.1	0.7
Petroleum Subtotal	**70.0**	**53.5**	**54.6**	**53.5**	**49.1**	**55.7**	**54.5**	**52.3**	**45.3**	**45.4**
Coal	11.8	11.1	8.2	8.4	8.4	7.9	9.7	9.0	6.3	6.8
Natural Gas	143.1	165.4	172.7	164.9	171.0	174.7	169.5	163.8	154.1	163.4
Electricity[a]	562.6	618.4	779.7	793.3	789.4	788.8	808.6	835.0	837.3	871.7
Total	**787.5**	**848.4**	**1,015.2**	**1,020.1**	**1,017.9**	**1,027.1**	**1,042.3**	**1,060.2**	**1,043.0**	**1,087.4**

[a]Share of total electric power sector carbon dioxide emissions weighted by sales to the commercial sector.

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.

Source: EIA estimates.

[10]Energy Information Administration, *Annual Energy Outlook 2008*, DOE/EIA-0383(2008) (Washington, DC, June 2008), Tables A4 and A5, web site www.eia.doe.gov/oiaf/aeo/excel/aeo_base.xls.

Carbon Dioxide Emissions

Industrial Sector

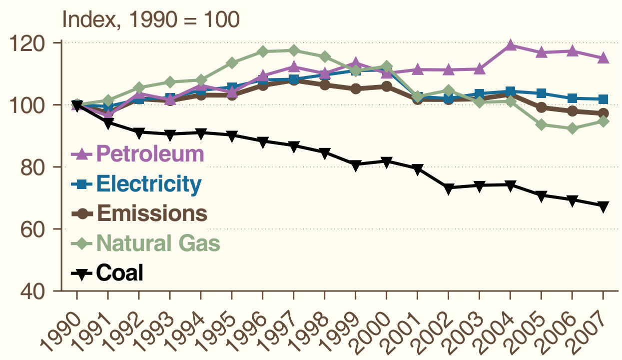
Summary

- Unlike commercial sector emissions, trends in U.S. industrial sector emissions (Table 9) have not followed economic growth trends. In 2007, industrial carbon dioxide emissions fell by 0.8 percent from 2006 and were 2.8 percent below their 1990 level.
- Decreases in industrial sector carbon dioxide emissions have resulted largely from erosion of the older energy-intensive (specifically, coal-intensive) U.S. industrial base.
- Coke plants consumed 22.7 million short tons of coal in 2007, down from 38.9 million short tons in 1990. Other industrial coal consumption declined from 76.3 million short tons in 1990 to 56.5 million short tons in 2007, as reflected by the drop in emissions from coal shown in Figure 9.
- The share of manufacturing activity represented by less energy-intensive industries, such as computer chip and electronic component manufacturing, has increased, while the share represented by the more energy-intensive industries has fallen.
- By fuel, only petroleum and purchased electricity use in 2007 were above 1990 levels for the commercial sector. Coal use has fallen since 1990, and natural gas use, which rose in the 1990s, has fallen since 2000.

Industrial Sector Carbon Dioxide Emissions, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons)	1,686.9	1,652.4	1,639.7
Change from 1990 (Million Metric Tons)		-34.5	-47.2
(Percent)		*-2.0%*	*-2.8%*
Average Annual Change from 1990 *(Percent)*		*-0.1%*	*-0.2%*
Change from 2006 (Million Metric Tons)			-12.8
(Percent)			*-0.8%*

Figure 9. U.S. Industrial Sector CO_2 Emissions and Major Industrial Fuel Use, 1990-2007



Source: EIA estimates.

Table 9. U.S. Carbon Dioxide Emissions from Industrial Sector Energy Consumption, 1990, 1996, and 2000-2007
(Million Metric Tons Carbon Dioxide)

Fuel	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Petroleum										
Motor Gasoline	13.1	14.1	10.6	20.7	21.7	22.6	26.0	24.7	24.9	24.7
Liquefied Petroleum Gas	40.1	46.6	58.2	50.4	56.1	51.7	57.0	53.2	52.6	52.8
Distillate Fuel	83.9	82.4	87.4	94.7	87.7	82.7	88.4	92.0	92.0	90.6
Residual Fuel	30.6	24.5	16.7	13.8	13.2	15.6	17.9	20.4	17.1	17.8
Asphalt and Road Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lubricants	6.9	6.6	7.0	6.5	6.4	5.9	6.0	5.9	5.8	6.0
Kerosene	0.9	1.1	1.1	1.7	1.0	1.7	2.0	2.8	2.2	1.3
Petroleum Coke	63.8	66.9	74.1	77.0	76.2	76.0	82.8	79.1	82.0	71.5
Other Petroleum	125.4	112.5	115.9	130.3	127.6	137.7	140.3	137.5	143.3	141.6
Petroleum Subtotal	**364.8**	**354.7**	**371.1**	**395.0**	**389.9**	**394.0**	**420.3**	**415.7**	**419.9**	**406.4**
Coal	**250.3**	**225.9**	**214.1**	**215.3**	**205.2**	**205.8**	**208.1**	**182.4**	**179.2**	**172.2**
Coal Coke Net Imports	**0.6**	**7.0**	**7.5**	**3.3**	**6.9**	**5.8**	**15.7**	**5.0**	**7.1**	**3.1**
Natural Gas	**436.7**	**494.0**	**478.1**	**438.4**	**464.5**	**447.5**	**431.3**	**401.8**	**394.8**	**404.9**
Electricity[a]	**634.5**	**657.1**	**715.7**	**663.9**	**649.0**	**666.1**	**668.8**	**667.3**	**651.5**	**653.0**
Total[b]	**1,686.9**	**1,738.6**	**1,786.4**	**1,715.8**	**1,715.5**	**1,719.1**	**1,744.2**	**1,672.3**	**1,652.4**	**1,639.7**

[a]Share of total electric power sector carbon dioxide emissions weighted by sales to the industrial sector.
[b]Includes emissions from nonfuel uses of fossil fuels. See Table 12 for details by fuel category.
P = preliminary data.
Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.
Source: EIA estimates.

Carbon Dioxide Emissions

Transportation Sector

Summary

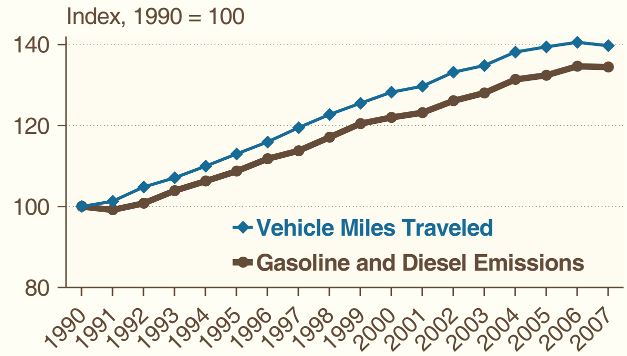
- Transportation sector carbon dioxide emissions in 2007 were 431.8 million metric tons higher than in 1990 (Table 10), an increase that represents 44 percent of the growth in unadjusted energy-related carbon dioxide emissions from all end-use sectors over the period.
- The transportation sector has led all U.S. end-use sectors in emissions of carbon dioxide since 1999; however, with higher fuel prices and slower economic growth in 2007, emissions from the transportation sector were essentially unchanged from their 2006 level.
- Petroleum combustion is the largest source of carbon dioxide emissions in the transportation sector, as opposed to electricity-related emissions in the other end-use sectors.
- Increases in ethanol fuel consumption in recent years have mitigated the growth in transportation sector emissions somewhat (emissions from energy inputs to ethanol production plants are counted in the industrial sector).
- Transportation sector emissions from gasoline and diesel fuel combustion generally parallel total vehicle miles traveled (Figure 10).

Transportation Sector Carbon Dioxide Emissions, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons)	1,582.6	2,013.4	2,014.4
Change from 1990 (Million Metric Tons)		430.8	431.8
(Percent)		*27.2%*	*27.3%*
Average Annual Change from 1990 *(Percent)*		*1.5%*	*1.4%*
Change from 2006 (Million Metric Tons)			1.0
(Percent)			*

*Less than 0.05 percent.

Figure 10. U.S. Vehicle Miles Traveled and CO_2 Emissions from Gasoline and Diesel Transportation Fuel Use, 1990-2007



Source: EIA estimates.

Table 10. U.S. Carbon Dioxide Emissions from Transportation Sector Energy Consumption, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide)

Fuel	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Petroleum										
Motor Gasoline	961.7	1,029.7	1,121.9	1,127.1	1,155.8	1,159.5	1,181.3	1,183.4	1,186.0	1,180.5
Liquefied Petroleum Gas	1.3	1.0	0.7	0.8	0.8	1.0	1.1	1.7	1.7	1.7
Jet Fuel	222.6	222.1	253.8	242.8	236.8	231.5	239.8	246.3	239.5	238.0
Distillate Fuel	267.8	306.9	377.8	387.1	394.5	414.5	433.9	444.4	469.2	472.5
Residual Fuel	80.1	71.7	69.9	46.1	53.3	45.0	58.3	66.0	71.4	73.5
Lubricants[a]	6.5	6.2	6.7	6.1	6.0	5.6	5.6	5.6	5.5	5.6
Aviation Gasoline	3.1	2.7	2.5	2.4	2.3	2.1	2.2	2.4	2.3	2.2
Petroleum Subtotal	**1,543.2**	**1,640.4**	**1,833.3**	**1,812.5**	**1,849.5**	**1,859.1**	**1,922.2**	**1,949.8**	**1,975.5**	**1,974.0**
Coal	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Natural Gas	**36.2**	**38.6**	**35.6**	**34.8**	**37.7**	**33.6**	**32.0**	**33.2**	**33.2**	**35.4**
Electricity[b]	**3.2**	**3.2**	**3.6**	**3.7**	**3.6**	**4.6**	**4.8**	**4.9**	**4.7**	**5.0**
Total	**1,582.6**	**1,682.2**	**1,872.6**	**1,850.9**	**1,890.9**	**1,897.2**	**1,958.9**	**1,988.0**	**2,013.4**	**2,014.4**

[a]Includes emissions from nonfuel uses of fossil fuels. See Table 12 for details by fuel category.
[b]Share of total electric power sector carbon dioxide emissions weighted by sales to the transportation sector.
P = preliminary data.
Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.
Source: EIA estimates.

Carbon Dioxide Emissions

Electric Power Sector

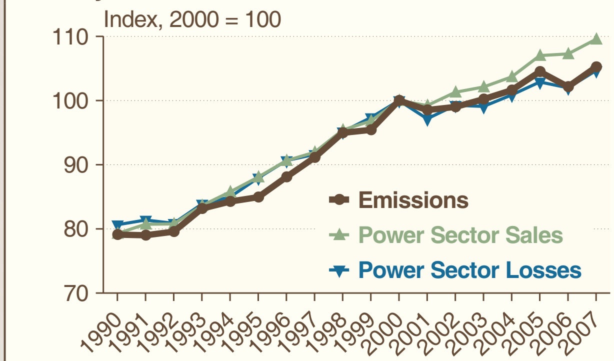
Summary

- The electric power sector transforms primary energy inputs into electricity. The sector consists of companies whose primary business is the generation of electricity.
- Carbon dioxide emissions from electric power generation rose by 2.9 percent in 2007 (Table 11). The increase resulted from growth in total electricity generation (2.5 percent) and an increase in the carbon intensity of the electricity supply (0.4 percent).
- Higher overall carbon intensity of power generation in 2007 was the result of a large drop in generation from hydropower resources (down by 40 billion kilowatthours), which more than offset increases in generation from wind and nuclear power plants (up by 6 and 19 billion kilowatthours, respectively). While nuclear generation rose by 2.4 percent from 2006 to 2007, generation from renewable fuels—including hydropower—fell by 9.6 percent, and generation from fossil fuels increased by 4.1 percent.
- From 2000 to 2007, as the overall efficiency of U.S. electricity generation has increased, there has been a decline in electric power sector energy losses[11] relative to total sales, which has helped to mitigate the sector's carbon dioxide emissions (Figure 11). For example, generation from natural gas rose by 57 percent from 2000 to 2007, but emissions from natural-gas-fired generation rose by only 33 percent over the same period.

Electric Power Sector Carbon Dioxide Emissions, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons)	1,820.4	2,364.1	2,433.4
Change from 1990 (Million Metric Tons)		543.7	613.1
(Percent)		*29.9%*	*33.7%*
Average Annual Change from 1990 *(Percent)*		*1.6%*	*1.7%*
Change from 2006 (Million Metric Tons)			69.4
(Percent)			*2.9%*

Figure 11. U.S. Electric Power Sector Energy Sales and Losses and CO_2 Emissions from Primary Fuel Combustion, 1990-2007



Source: EIA estimates.

Table 11. U.S. Carbon Dioxide Emissions from Electric Power Sector Energy Consumption, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide)

Fuel	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Petroleum										
Residual Fuel Oil	92.0	45.1	69.5	80.1	52.3	69.0	69.8	69.8	34.9	37.1
Distillate Fuel Oil	7.1	7.9	12.8	12.5	9.3	11.7	8.1	8.4	6.2	7.4
Petroleum Coke	2.9	7.8	9.6	10.1	16.6	16.6	21.1	23.2	25.2	21.2
Petroleum Subtotal	**101.9**	**60.7**	**91.8**	**102.6**	**78.2**	**97.2**	**99.0**	**101.3**	**66.4**	**65.7**
Coal	**1,534.4**	**1,653.4**	**1,915.7**	**1,856.3**	**1,872.4**	**1,910.7**	**1,922.9**	**1,963.9**	**1,946.7**	**1,979.7**
Natural Gas	**177.7**	**230.6**	**282.8**	**291.1**	**307.5**	**279.3**	**297.7**	**320.5**	**339.3**	**376.4**
Municipal Solid Waste	**5.9**	**10.1**	**10.2**	**10.9**	**12.7**	**11.4**	**11.2**	**11.2**	**11.4**	**11.2**
Geothermal	**0.4**	**0.4**	**0.4**	**0.3**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**
Total	**1,820.4**	**1,955.1**	**2,300.9**	**2,261.3**	**2,271.1**	**2,299.0**	**2,331.2**	**2,397.4**	**2,364.1**	**2,433.4**

P = preliminary data.
Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Emissions for total fuel consumption are allocated to end-use sectors in proportion to electricity sales. Totals may not equal sum of components due to independent rounding.
Source: EIA estimates.

[11] Electrical system energy losses are calculated as the difference between total primary consumption by the electric power sector and the total energy content of retail electricity sales.

Carbon Dioxide Emissions

Nonfuel Uses of Energy Inputs

Summary

- Nonfuel uses of fossil fuels (for purposes other than their energy value) create carbon dioxide emissions and also sequester carbon in nonfuel products.
- In 2007, carbon dioxide emissions from nonfuel uses of energy inputs totaled 117.6 MMT—more than 5 percent above the 2006 total (Table 12).
- Carbon sequestration from nonfuel uses of energy inputs in 2007 included 301.5 $MMTCO_2e$ that was embedded in plastics and other nonfuel products rather than emitted to the atmosphere (see Table 13 on page 22).
- The 2007 sequestration total was 0.2 percent below the 2006 total.

Carbon Dioxide Emissions from Nonfuel Uses of Energy Inputs, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons)	98.8	111.5	117.6
Change from 1990 (Million Metric Tons)		12.7	18.8
(Percent)		*12.8%*	*19.1%*
Average Annual Change from 1990 *(Percent)*		*0.8%*	*1.0%*
Change from 2006 (Million Metric Tons)			6.2
(Percent)			*5.5%*

Carbon Sequestration from Nonfuel Uses of Energy Inputs, 1990, 2006, and 2007

	1990	2006	2007
Estimated Sequestration (Million Metric Tons CO_2e)	251.2	302.0	301.5
Change from 1990 (Million Metric Tons CO_2e)		50.8	50.3
(Percent)		*20.2%*	*20.0%*
Average Annual Change from 1990 *(Percent)*		*1.2%*	*1.1%*
Change from 2006 (Million Metric Tons CO_2e)			-0.5
(Percent)			*-0.2%*

Table 12. U.S. Carbon Dioxide Emissions from Nonfuel Use of Energy Fuels, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide)

End Use and Type	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Industrial										
Petroleum										
Liquefied Petroleum Gases	14.8	19.6	20.5	19.2	20.0	19.1	19.4	18.3	18.7	19.0
Distillate Fuel Oil	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Residual Fuel Oil	1.9	2.1	2.2	2.2	1.7	1.7	1.7	1.7	1.7	1.7
Asphalt and Road Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lubricants	6.9	6.6	7.0	6.5	6.4	5.9	6.0	5.9	5.8	6.0
Other *(Subtotal)*	*51.6*	*52.0*	*54.2*	*51.9*	*53.1*	*52.9*	*60.3*	*56.6*	*60.8*	*66.6*
Pentanes Plus	1.1	4.1	3.2	2.7	2.3	2.3	2.3	2.0	1.4	1.8
Petrochemical Feed	33.6	36.0	36.8	32.9	33.5	36.5	41.8	38.4	41.0	37.8
Petroleum Coke	9.1	6.8	7.2	10.6	9.8	8.2	12.6	11.7	13.3	21.3
Special Naphtha	7.8	5.2	7.1	5.7	7.5	5.9	3.7	4.6	5.1	5.7
Waxes and Miscellaneous	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum Subtotal	*75.5*	*80.6*	*84.5*	*80.2*	*81.6*	*80.0*	*87.9*	*83.1*	*87.5*	*93.7*
Coal	0.5	0.7	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
Natural Gas	16.3	18.0	19.1	18.9	18.1	17.8	18.1	17.8	18.1	17.8
Industrial Subtotal	**92.3**	**99.2**	**104.2**	**99.7**	**100.2**	**98.3**	**106.5**	**101.4**	**106.0**	**112.0**
Transportation										
Lubricants	6.5	6.2	6.7	6.1	6.0	5.6	5.6	5.6	5.5	5.6
Total	**98.8**	**105.5**	**110.8**	**105.8**	**106.2**	**103.9**	**112.1**	**107.0**	**111.5**	**117.6**

P = preliminary data.

Notes: Emissions from nonfuel use of energy fuels are included in the energy consumption tables in this chapter. Data in this table are revised from unpublished data used to produce the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.

Sources: EIA estimates.

Carbon Dioxide Emissions

Nonfuel Uses of Energy Inputs

Table 13. U.S. Carbon Sequestered by Nonfuel Use of Energy Fuels, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

End Use and Type	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Industrial										
Petroleum										
Liquefied Petroleum Gases	59.3	78.5	82.1	76.7	79.9	76.3	77.7	73.4	74.7	75.8
Distillate Fuel	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Residual Fuel	1.9	2.1	2.2	2.2	1.7	1.7	1.7	1.7	1.7	1.7
Asphalt and Road Oil	88.5	89.1	96.4	95.0	93.7	92.2	98.6	100.0	95.3	90.5
Lubricants	6.9	6.6	7.0	6.5	6.4	5.9	6.0	5.9	5.8	6.0
Other *(Subtotal)*	*72.1*	*83.1*	*88.8*	*84.0*	*86.5*	*88.1*	*101.5*	*94.6*	*97.8*	*100.5*
Pentanes Plus	4.4	16.2	12.7	10.8	9.2	9.0	9.1	8.0	5.7	7.4
Petrochemical Feed	46.0	50.0	57.7	50.7	55.1	59.2	69.2	64.2	66.7	60.3
Petroleum Coke	9.1	6.8	7.2	10.6	9.8	8.2	12.6	11.7	13.3	21.3
Special Naphtha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waxes and Miscellaneous	12.6	10.2	11.2	11.9	12.3	11.6	10.7	10.7	12.0	11.5
Petroleum Subtotal	*228.9*	*259.7*	*277.0*	*264.8*	*268.7*	*264.7*	*286.0*	*276.2*	*275.7*	*274.9*
Coal	1.4	2.1	1.8	1.7	1.5	1.5	1.5	1.5	1.4	1.4
Natural Gas	14.3	18.4	22.6	21.2	17.7	17.9	18.9	19.0	19.4	19.5
Industrial Subtotal	**244.7**	**280.2**	**301.5**	**287.7**	**287.8**	**284.1**	**306.3**	**296.7**	**296.5**	**295.8**
Transportation										
Lubricants	6.5	6.2	6.7	6.1	6.0	5.6	5.6	5.6	5.5	5.6
Total	**251.2**	**286.5**	**308.2**	**293.8**	**293.9**	**289.6**	**311.9**	**302.3**	**302.0**	**301.5**

P = preliminary data.

Notes: Emissions from nonfuel use of energy fuels are included in the energy consumption tables in this chapter. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.

Sources: EIA estimates.

Carbon Dioxide Emissions

Adjustments to Energy Consumption

Summary

- EIA's greenhouse gas emissions inventory includes two "adjustments to energy consumption" (Table 14). First, the energy consumption and carbon dioxide emissions data in this report correspond to EIA's coverage of energy consumption, which includes the 50 States and the District of Columbia, but under the UNFCCC the United States is also responsible for emissions emanating from its Territories; therefore, their emissions are added to the U.S. total. Second, because the IPCC definition of energy consumption excludes international bunker fuels, emissions from international bunker fuels are subtracted from the U.S. total. Similarly, because the IPCC excludes emissions from military bunker fuels from national totals, they are subtracted from the U.S. Total.
- The net adjustment in emissions has been negative in every year from 1990 to 2007, because emissions from bunker fuels have always exceeded emissions from U.S. Territories. The net negative adjustment for 2007 was larger (-74.2 MMT), because emissions from the U.S. Territories fell while emissions from bunker fuels increased.

Carbon Dioxide Emissions from U.S. Territories, 1990, 2006, and 2007*

	1990	2006	2007
Estimated Emissions (Million Metric Tons)	31.1	61.3	56.7
Change from 1990 (Million Metric Tons)		30.2	25.6
(Percent)		*97.0%*	*82.4%*
Average Annual Change from 1990 *(Percent)*		*4.3%*	*3.6%*
Change from 2006 (Million Metric Tons)			-4.6
(Percent)			*-7.4%*

*Added to total U.S. emissions.

Carbon Dioxide Emissions from International Bunker Fuels, 1990, 2006, and 2007*

	1990	2006	2007
Estimated Emissions (Million Metric Tons)	113.5	128.1	131.0
Change from 1990 (Million Metric Tons)		14.6	17.5
(Percent)		*12.9%*	*15.4%*
Average Annual Change from 1990 *(Percent)*		*0.8%*	*0.8%*
Change from 2006 (Million Metric Tons)			2.9
(Percent)			*2.3%*

*Subtracted from total U.S. emissions.

Table 14. U.S. Carbon Dioxide Emissions: Adjustments for U.S. Territories and International Bunker Fuels, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide)

Fuel	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Emissions from U.S. Territories										
Puerto Rico	20.2	24.1	27.6	34.3	34.9	37.2	37.9	39.0	40.4	37.4
U.S. Virgin Islands	7.0	8.5	9.8	14.2	13.7	15.2	18.1	16.1	16.4	15.0
American Samoa	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Guam	1.8	3.6	2.9	3.1	2.1	2.4	2.0	2.2	2.3	2.1
U.S. Pacific Islands	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Wake Island	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4
Subtotal[a]	**31.1**	**38.4**	**42.4**	**53.8**	**52.9**	**57.0**	**60.1**	**59.5**	**61.3**	**56.7**
Emissions from Bunker Fuels										
Marine Bunkers *(Subtotal)*	*62.0*	*46.6*	*37.6*	*35.3*	*24.2*	*19.8*	*29.3*	*29.5*	*49.8*	*51.0*
Distillate Fuel	6.2	5.8	2.9	2.0	1.6	1.4	1.7	2.4	3.1	3.6
Residual Fuel	55.8	40.8	34.6	33.2	22.6	18.3	27.6	27.1	46.7	47.4
Aviation Bunkers *(Subtotal)*	*38.1*	*45.3*	*57.9*	*55.6*	*58.4*	*56.4*	*65.1*	*67.2*	*70.3*	*72.0*
U.S. Carriers	18.5	21.0	25.9	24.8	23.6	23.2	26.5	28.3	28.5	29.4
Foreign Carriers	19.5	24.3	32.0	30.7	34.7	33.2	38.6	38.9	41.8	42.6
Military Bunkers *(Subtotal)*	*13.4*	*8.9*	*7.9*	*8.2*	*8.1*	*9.2*	*10.1*	*9.2*	*8.0*	*8.0*
Subtotal[b]	**113.5**	**100.8**	**103.3**	**99.0**	**90.7**	**85.3**	**104.4**	**106.0**	**128.1**	**131.0**
Net Adjustment	**-82.4**	**-62.4**	**-60.9**	**-45.3**	**-37.8**	**-28.3**	**-44.3**	**-46.5**	**-66.8**	**-74.2**

P = preliminary data.
[a]Added to total U.S. emissions.
[b]Subtracted from total U.S. emissions.
Note: Totals may not equal sum of components due to independent rounding.
Source: EIA estimates.

Carbon Dioxide Emissions

Other Sources

Summary

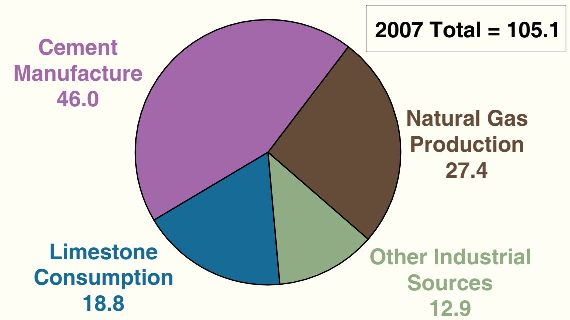
- "Other emissions sources" in total accounted for 1.7 percent (105.1 MMT) of all U.S. carbon dioxide emissions in 2007 (Figure 12).
- The largest source of U.S. carbon dioxide emissions other than fossil fuel consumption is cement manufacture (Table 15), where most emissions result from the production of clinker (consisting of calcium carbonate sintered with silica in a cement kiln to produce calcium silicate).
- Limestone consumption, especially for lime manufacture, is the source of 15 to 20 MMT of carbon dioxide emissions per year.
- In addition, "other sources" include: soda ash manufacture and consumption; carbon dioxide manufacture; aluminum manufacture; flaring of natural gas at the wellhead; carbon dioxide scrubbed from natural gas; and waste combustion in the commercial and industrial sectors.

Carbon Dioxide Emissions from Other Sources, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons)	85.1	105.9	105.1
Change from 1990 (Million Metric Tons)		20.8	20.0
(Percent)		*24.5%*	*23.5%*
Average Annual Change from 1990 *(Percent)*		*1.4%*	*1.3%*
Change from 2006 (Million Metric Tons)			-0.8
(Percent)			*-0.8%*

Figure 12. U.S. Carbon Dioxide Emissions from Other Sources, 2007

(Million Metric Tons)



Source: EIA estimates.

Table 15. U.S. Carbon Dioxide Emissions from Other Sources, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide)

Source	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Cement Manufacture	***33.3***	***36.9***	***41.3***	***41.5***	***43.0***	***43.2***	***45.7***	***46.1***	***46.7***	***46.0***
Clinker Production	32.6	36.1	40.4	40.5	42.0	42.2	44.7	45.1	45.7	45.0
Masonry Cement	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cement Kiln Dust	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9
Limestone Consumption	***15.9***	***17.8***	***18.6***	***18.1***	***17.0***	***18.0***	***18.9***	***18.7***	***19.6***	***18.8***
Lime Manufacture	12.4	14.5	15.4	14.8	14.1	15.1	15.7	15.7	16.5	15.9
Iron Smelting	1.7	1.2	1.1	1.0	0.9	0.9	1.0	0.8	0.9	0.8
Steelmaking	0.3	0.5	0.5	0.6	0.5	0.4	0.4	0.3	0.4	0.3
Copper Refining	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Glass Manufacture	0.1	0.3	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Flue Gas Desulfurization	0.7	0.9	1.2	1.4	1.3	1.3	1.4	1.5	1.5	1.5
Dolomite Manufacture	0.5	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Natural Gas Production	***23.1***	***33.9***	***23.8***	***24.7***	***24.4***	***24.5***	***24.3***	***25.3***	***26.6***	***27.4***
Carbon Dioxide in Natural Gas	14.0	16.7	18.3	18.9	18.4	18.6	18.4	18.1	18.7	19.5
Natural Gas Flaring	9.1	17.2	5.5	5.9	6.0	5.9	5.8	7.2	7.8	7.8
Other	***12.7***	***13.8***	***14.1***	***12.7***	***13.3***	***13.2***	***13.1***	***13.2***	***13.0***	***12.9***
Soda Ash Manufacture	3.4	3.8	3.6	3.6	3.5	3.6	3.8	3.9	3.9	4.0
Soda Ash Consumption	0.5	0.8	0.6	0.5	0.4	0.6	0.6	0.5	0.5	0.6
Carbon Dioxide Manufacture	0.9	1.0	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.7
Aluminum Manufacture	5.9	4.9	5.4	3.9	4.0	4.0	3.7	3.6	3.3	3.8
Shale Oil Production	0.2	*	*	*	*	*	*	*	*	*
Waste Combustion	1.9	3.2	3.2	3.4	4.0	3.6	3.5	3.6	3.6	2.8
Total	**85.1**	**102.3**	**97.8**	**97.0**	**97.7**	**98.9**	**102.0**	**103.4**	**105.9**	**105.1**

P = preliminary data.
*Less than 0.05 million metric tons.
Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.
Source: EIA estimates.

Methane Emissions

Total Emissions

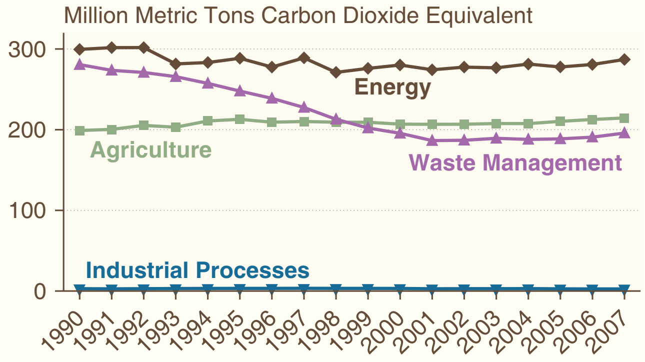
Summary

- The major sources of U.S. methane emissions are energy production, distribution, and use; agriculture; and waste management (Figure 13).
- U.S. methane emissions in 2007 totaled 699.9 million metric tons carbon dioxide equivalent ($MMTCO_2e$), up from the 2006 total of 686.9 $MMTCO_2e$ (Table 16).
- Methane emissions declined steadily from 1990 to 2001, as emissions from coal mining and landfills fell.
- Emissions have risen from 2001 to 2007, with moderate increases in each of the major emission sources.
- The energy sector—including coal mining, natural gas systems, petroleum systems, and stationary and mobile combustion—is the largest source of U.S. methane emissions.
- Agriculture (primarily livestock management) and waste management (primarily landfills) also are large contributors to U.S. methane emissions.

U.S. Anthropogenic Methane Emissions, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	782.1	686.9	699.9
Change from 1990 (Million Metric Tons CO_2e)		-95.2	-82.2
(Percent)		*-12.2%*	*-10.5%*
Average Annual Change from 1990 *(Percent)*		*-0.8%*	*-0.7%*
Change from 2006 (Million Metric Tons CO_2e)			13.0
(Percent)			*1.9%*

Figure 13. U.S. Methane Emissions by Source, 1990-2007



Source: EIA estimates.

Table 16. U.S. Methane Emissions from Anthropogenic Sources, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Source	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Energy Sources	299.5	288.5	280.2	274.2	277.6	276.7	281.3	277.8	280.8	287.0
Agricultural Sources	199.0	212.9	206.8	206.7	206.8	207.6	207.5	210.4	212.7	214.5
Waste Management	280.6	247.9	195.5	186.4	186.9	189.3	188.0	188.6	190.8	195.7
Industrial Processes	2.9	3.3	3.2	2.8	2.9	2.9	3.0	2.7	2.7	2.6
Total	**782.1**	**752.6**	**685.7**	**670.1**	**674.2**	**676.5**	**679.7**	**679.4**	**686.9**	**699.9**

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2006.* Emissions calculations based on Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: IPCC Guidelines for National Greenhouse Gas Inventories* (2007 and revised 1996 guidelines), web site www.ipcc-nggip.iges.or.jp/public/public.htm; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, EPA 430-R-07-002 (Washington, DC, April 2007), web site www.epa.gov/climatechange/emissions/usinventoryreport.html.

Methane Emissions

Energy Use

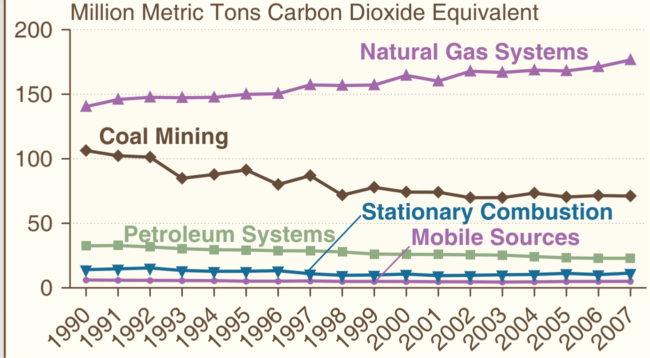
Summary

- Natural gas systems and coal mines are the major sources of methane emissions in the energy sector.
- Methane emissions from natural gas systems grew between 1990 and 2000, in parallel with increases in U.S. natural gas consumption, then leveled off between 2000 and 2005 before resuming growth (Figure 14 and Table 17).
- Emissions from coal mines declined from 1990 to 2002 and have remained low since then, because production increases have been largely from surface mines that produce relatively little methane.
- Methane emissions from petroleum systems have declined as domestic oil production has dropped by more than 30 percent since 1990.
- Residential wood consumption accounts for almost 90 percent of methane emissions from stationary combustion.
- Methane emissions from passenger cars (a major component of mobile sources), which declined from 1990 to 2004 as more efficient catalytic converters were added on newer models, have rebounded with increases in total vehicle miles traveled.

Energy-Related Methane Emissions, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	299.5	280.8	287.0
Change from 1990 (Million Metric Tons CO_2e)		-18.7	-12.5
(Percent)		*-6.2%*	*-4.2%*
Average Annual Change from 1990 *(Percent)*		*-0.4%*	*-0.3%*
Change from 2006 (Million Metric Tons CO_2e)			6.2
(Percent)			*2.2%*

Figure 14. U.S. Methane Emissions from Energy Sources, 1990-2007



Source: EIA estimates.

Table 17. U.S. Methane Emissions from Energy Sources, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Source	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Natural Gas Systems	***140.4***	***149.9***	***164.5***	***160.1***	***167.8***	***166.8***	***168.6***	***168.1***	***171.2***	***176.6***
Production	36.8	39.3	43.5	45.8	46.2	46.7	47.5	48.2	49.8	50.6
Processing	16.2	18.0	17.9	17.4	16.9	15.7	16.2	15.9	15.9	16.5
Transmission and Storage	52.6	53.7	60.4	53.3	60.6	59.6	58.5	58.3	56.2	60.1
Distribution	34.9	38.9	42.8	43.6	44.1	44.8	46.4	45.7	49.3	49.3
Coal Mining	***106.4***	***91.3***	***74.2***	***74.1***	***69.8***	***69.9***	***73.4***	***70.3***	***71.5***	***71.1***
Surface	11.6	12.2	13.5	14.3	14.2	13.8	14.3	14.7	15.5	15.5
Underground	94.8	79.1	60.7	59.7	55.7	56.1	59.1	55.7	56.0	55.6
Petroleum Systems	***32.6***	***29.3***	***25.9***	***25.8***	***25.6***	***25.3***	***24.2***	***23.2***	***22.9***	***22.9***
Refineries	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Exploration and Production	31.6	28.4	25.0	24.9	24.6	24.4	23.3	22.3	21.9	22.0
Crude Oil Transportation	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Stationary Combustion	***14.1***	***12.8***	***10.6***	***9.5***	***9.7***	***10.1***	***10.4***	***11.2***	***10.3***	***11.4***
Mobile Sources	***6.1***	***5.2***	***4.9***	***4.7***	***4.7***	***4.5***	***4.7***	***4.9***	***5.0***	***5.1***
Total	**299.5**	**288.5**	**280.2**	**274.2**	**277.6**	**276.7**	**281.3**	**277.8**	**280.8**	**287.0**

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2006.* Emissions calculations based on Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: IPCC Guidelines for National Greenhouse Gas Inventories* (2007 and revised 1996 guidelines), web site www.ipcc-nggip.iges.or.jp/public/public.htm; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, EPA 430-R-07-002 (Washington, DC, April 2007), web site www.epa.gov/climatechange/emissions/usinventoryreport.html.

Methane Emissions

Agriculture

Summary

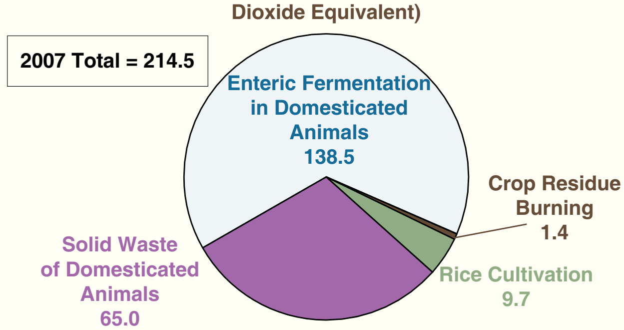
- Livestock management—including emissions from enteric fermentation (two-thirds) and management of animal wastes (one-third)—accounts for most of the U.S. methane emissions from agricultural activities (Table 18).
- Since 1990, there has been a shift in livestock management to larger facilities that are more likely to manage waste in liquid systems, which increase the amounts of methane generated from livestock waste. In addition, increases in the U.S. swine population have contributed to the rise in methane emissions.
- Because 95 percent of all methane emissions from enteric fermentation (digestion in ruminant animals) are attributable to cattle, trends in emissions are correlated with trends in the size of the U.S. cattle population. With little change in the cattle population size since 1990, the level of methane emissions from enteric fermentation has been relatively stable.
- Decreases in U.S. rice production—particularly in California, Louisiana, Oklahoma, and Texas—have reduced the estimated emissions from rice cultivation. In 2007, a rebound in Louisiana's rice cultivation was more than offset by declines in cultivation in Arkansas and Missouri.
- Crop residue burning remains the smallest contributor to methane emissions from agriculture, representing less than 1 percent of total U.S. methane emissions (Figure 15).

Methane Emissions from Agricultural Sources, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	199.0	212.7	214.5
Change from 1990 (Million Metric Tons CO_2e)		13.6	15.5
(Percent)		*6.8%*	*7.8%*
Average Annual Change from 1990 *(Percent)*		*0.4%*	*0.4%*
Change from 2006 (Million Metric Tons CO_2e)			1.8
(Percent)			*0.9%*

Figure 15. U.S. Methane Emissions from Agriculture by Source, 2007

(Million Metric Tons Carbon Dioxide Equivalent)



Source: EIA estimates.

Table 18. U.S. Methane Emissions from Agricultural Sources, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Source	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Enteric Fermentation in Domesticated Animals	140.5	146.4	137.0	135.7	136.1	136.7	134.6	137.1	138.5	138.5
Solid Waste of Domesticated Animals	47.4	54.3	57.5	58.1	58.5	59.1	59.6	60.4	63.0	65.0
Rice Cultivation	10.1	11.1	11.1	11.7	11.1	10.7	11.8	11.5	9.9	9.7
Crop Residue Burning	1.1	1.0	1.2	1.2	1.1	1.3	1.4	1.3	1.3	1.4
Total	**199.0**	**212.9**	**206.8**	**206.7**	**206.8**	**207.6**	**207.5**	**210.4**	**212.7**	**214.5**

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2006*. Emissions calculations based on Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: IPCC Guidelines for National Greenhouse Gas Inventories* (2007 and revised 1996 guidelines), web site www.ipcc-nggip.iges.or.jp/public/public.htm; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, EPA 430-R-07-002 (Washington, DC, April 2007), web site www.epa.gov/climatechange/emissions/usinventoryreport.html.

Methane Emissions

Waste Management

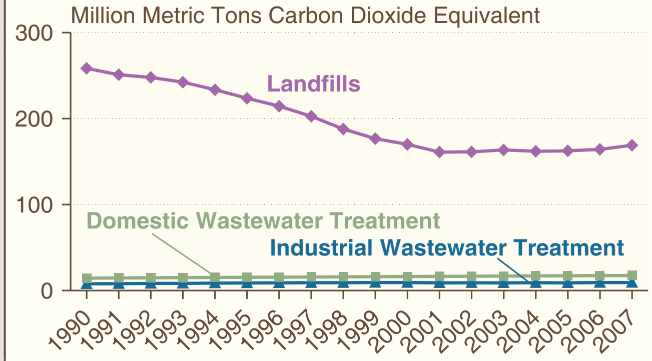
Summary

- Methane emissions from waste management are dominated by the decomposition of solid waste in municipal and industrial landfills (Table 19).
- Emissions from landfills declined substantially from 1990 to 2001 as a result of increases in recycling and in the recovery of landfill methane for energy; since 2001, increases in the total amount of waste deposited in landfills have resulted in increasing methane emissions (Figure 16).
- Rapid growth in methane recovery during the 1990s can be traced in part to the Federal Section 29 tax credit for alternative energy sources, which provided a subsidy of approximately 1 cent per kilowatthour for electricity generated from landfill gas before June 1998.
- The U.S. EPA's New Source Performance Standards and Emission Guidelines, which require large landfills to collect and burn landfill gas, have also played an important role in the growth of methane recovery.
- The Emergency Economic Stabilization Act of 2008 included a 2-year extension (through December 31, 2010) of the production tax credit for waste-to-energy and landfill gas, as well as other renewable energy sources.
- Wastewater treatment, including both domestic wastewater (two-thirds) and industrial wastewater (one-third), is responsible for about 14 percent of methane emissions from waste management.

Methane Emissions from Waste Management, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	280.6	190.8	195.7
Change from 1990 (Million Metric Tons CO_2e)		-89.9	-84.9
(Percent)		*-32.0%*	*-30.2%*
Average Annual Change from 1990 *(Percent)*		*-2.4%*	*-2.1%*
Change from 2006 (Million Metric Tons CO_2e)			5.0
(Percent)			*2.6%*

Figure 16. U.S. Methane Emissions from Waste Management by Source, 1990-2007



Source: EIA estimates.

Table 19. U.S. Methane Emissions from Waste Management, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Source	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Landfills	258.4	223.6	170.0	161.0	161.2	163.5	161.9	162.5	164.2	169.0
Domestic Wastewater Treatment	14.4	15.4	16.3	16.5	16.6	16.8	17.0	17.1	17.3	17.4
Industrial Waste Water Treatment	7.8	8.8	9.2	8.9	9.0	8.9	9.1	9.0	9.3	9.3
Total	**280.6**	**247.9**	**195.5**	**186.4**	**186.9**	**189.2**	**188.0**	**188.6**	**190.8**	**195.7**

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.

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Methane Emissions

Industrial Processes

Summary

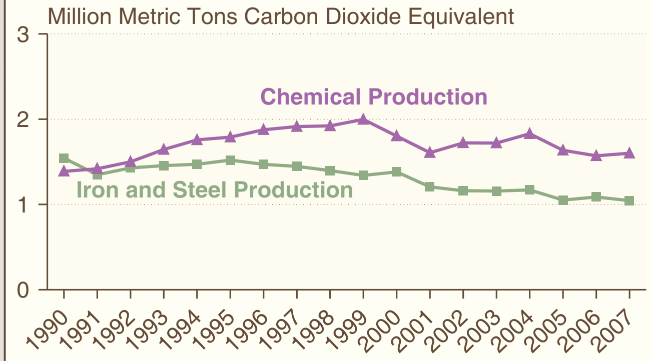
- Methane emissions are generated by industrial processes in the production of iron and steel and in chemical production (Figure 17 and Table 20).
- Methane emissions from industrial processes declined by a net 0.3 $MMTCO_2e$ from 1990 to 2007, as small increases in emissions from chemical production (0.2 $MMTCO_2e$) were more than offset by declines in emissions from iron and steel production (0.5 $MMTCO_2e$).

Methane Emissions from Industrial Processes, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	2.9	2.7	2.6
Change from 1990 (Million Metric Tons CO_2e)		-0.3	-0.3
(Percent)		*-9.4%*	*-9.8%*
Average Annual Change from 1990 *(Percent)*		*-0.6%*	*-0.6%*
Change from 2006 (Million Metric Tons CO_2e)			*
(Percent)			*-0.4%*

*Less than 0.05 million metric tons.

Figure 17. U.S. Methane Emissions from Industrial Processes by Source, 1990-2007



Source: EIA estimates.

Table 20. U.S. Methane Emissions from Industrial Processes, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Source	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Chemical Production										
Ethylene	0.4	0.5	0.6	0.5	0.5	0.5	0.6	0.5	0.6	0.6
Ethylene Dichloride	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Styrene	0.4	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.4	0.5
Methanol	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	*
Carbon Black	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Subtotal	**1.4**	**1.8**	**1.8**	**1.6**	**1.7**	**1.7**	**1.8**	**1.6**	**1.6**	**1.6**
Iron and Steel Production										
Coke[a]	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sinter	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Pig Iron	1.1	1.1	1.1	0.9	0.9	0.9	1.0	0.8	0.9	0.8
Subtotal	**1.5**	**1.5**	**1.4**	**1.2**	**1.2**	**1.2**	**1.2**	**1.1**	**1.1**	**1.0**
Total	**2.9**	**3.3**	**3.2**	**2.8**	**2.9**	**2.9**	**3.0**	**2.7**	**2.7**	**2.6**

[a]Based on total U.S. production of metallurgical coke, including for uses other than iron and steel manufacture.
*Less than 0.05 million metric tons.
P = preliminary data.
Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.
Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2006.* Emissions calculations based on Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: IPCC Guidelines for National Greenhouse Gas Inventories* (2007 and revised 1996 guidelines), web site www.ipcc-nggip.iges.or.jp/public/public.htm; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, EPA 430-R-07-002 (Washington, DC, April 2007), web site www.epa.gov/climatechange/emissions/usinventoryreport.html.

Nitrous Oxide Emissions

Total Emissions

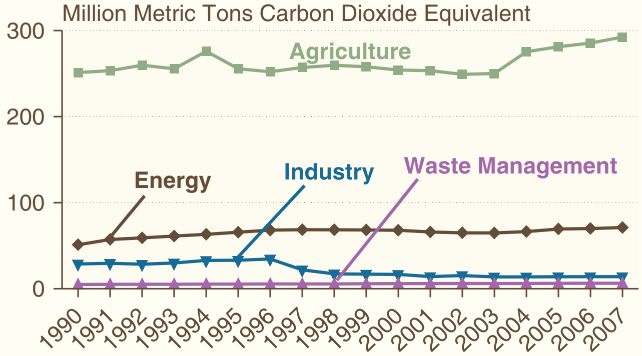
Summary

- U.S. nitrous oxide emissions in 2007 were 2.2 percent (8.2 $MMTCO_2e$) above their 2006 total (Table 21).
- Rising demand for corn-based ethanol in 2007 led to an 18-percent increase in U.S. corn production and a 19-percent drop in soybean production. As a result, the use of synthetic fertilizer (a nitrous oxide emitter), which is required for corn production, rose by 9.6 percent. (Soybeans do not need synthetic fertilizer, because they fix nitrogen in the soil.)
- Sources of U.S. nitrous oxide emissions include agriculture, energy use, industrial processes, and waste management. The largest source is agriculture, and the majority of agricultural emissions result from nitrogen fertilization of agricultural soils and the disposal of animal waste.
- Annual U.S. nitrous oxide emissions rose from 1990 to 1994, then fell from 1994 to 2003 (Figure 18). They began rising sharply from 2003 to 2007, largely as a result of increased use of synthetic fertilizers.

U.S. Anthropogenic Nitrous Oxide Emissions, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	336.0	375.7	383.9
Change from 1990 (Million Metric Tons CO_2e)		39.7	47.9
(Percent)		*11.8%*	*14.2%*
Average Annual Change from 1990 *(Percent)*		*0.7%*	*0.8%*
Change from 2006 (Million Metric Tons CO_2e)			8.2
(Percent)			*2.2%*

Figure 18. U.S. Nitrous Oxide Emissions by Source, 1990-2007



Source: EIA estimates.

Table 21. Estimated U.S. Emissions of Nitrous Oxide, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Source	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Agriculture										
Nitrogen Fertilization of Soils	188.4	188.9	191.1	190.8	186.9	188.3	213.9	218.9	222.7	229.6
Solid Waste of Domesticated Animals	62.3	66.2	62.4	61.9	61.7	61.2	60.9	61.7	62.2	62.2
Crop Residue Burning	0.5	0.5	0.6	0.6	0.5	0.5	0.6	0.6	0.6	0.6
Subtotal	**251.2**	**255.6**	**254.1**	**253.3**	**249.1**	**250.1**	**275.4**	**281.2**	**285.5**	**292.4**
Energy Use										
Mobile Combustion	37.7	51.6	52.7	51.2	50.3	50.0	51.2	54.2	55.2	56.2
Stationary Combustion	13.5	14.0	15.2	14.7	14.6	14.8	15.1	15.2	14.8	14.9
Subtotal	**51.1**	**65.6**	**67.9**	**65.9**	**64.9**	**64.8**	**66.3**	**69.4**	**69.9**	**71.1**
Industrial Sources	**28.8**	**33.1**	**16.7**	**14.1**	**15.3**	**13.7**	**13.7**	**14.0**	**14.0**	**14.0**
Waste Management										
Human Sewage in Wastewater	4.6	5.1	5.6	5.7	5.7	5.7	5.8	5.9	6.0	6.0
Waste Combustion	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4
Subtotal	**4.9**	**5.4**	**5.9**	**6.0**	**6.1**	**6.0**	**6.1**	**6.2**	**6.3**	**6.4**
Total	**336.0**	**359.7**	**344.6**	**339.3**	**335.4**	**334.6**	**361.5**	**370.8**	**375.7**	**383.9**

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.

Sources: Estimates presented in this chapter. Emissions calculations based on Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: IPCC Guidelines for National Greenhouse Gas Inventories* (2007 and revised 1996 guidelines), web site www.ipcc-nggip.iges.or.jp/public/public.htm; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, EPA 430-R-07-002 (Washington, DC, April 2007), web site www.epa.gov/climatechange/emissions/usinventoryreport.html.

Nitrous Oxide Emissions

Agriculture

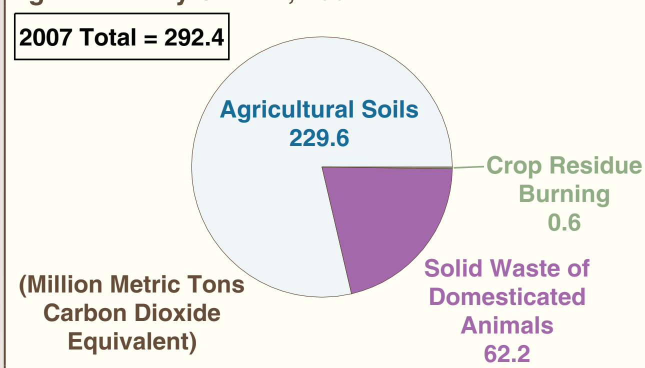
Summary

- Agricultural sources, at 292.4 MMTCO_2e, account for more than three-quarters of all U.S. nitrous oxide emissions. U.S. nitrous oxide emissions from agricultural sources increased by 2.4 percent from 2006 to 2007 (Table 22).
- More than three-quarters (229.6 MMTCO_2e) of U.S. agricultural emissions of nitrous oxide in 2007 is attributable to nitrogen fertilization of soils (Figure 19), including 174.0 MMTCO_2e from direct emissions and 55.7 MMTCO_2e from indirect emissions.
- Microbial denitrification of solid waste from domestic animals in the United States, primarily cattle, emitted 62.2 MMTCO_2e of nitrous oxide in 2007. The amount released is a function of animal size and manure production, the amount of nitrogen in the waste, and the method of managing the waste.

U.S. Anthropogenic Nitrous Oxide Emissions from Agriculture, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	251.2	285.5	292.4
Change from 1990 (Million Metric Tons CO_2e)		34.3	41.2
(Percent)		*13.6%*	*16.4%*
Average Annual Change from 1990 *(Percent)*		*0.8%*	*0.9%*
Change from 2006 (Million Metric Tons CO_2e)			7.0
(Percent)			*2.4%*

Figure 19. U.S. Nitrous Oxide Emissions from Agriculture by Source, 2007



Source: EIA estimates.

Table 22. U.S. Nitrous Oxide Emissions from Agricultural Sources, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Source	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Agricultural Soils										
Direct Emissions										
Biological Fixation in Crops	59.0	62.5	68.3	70.0	65.7	62.9	71.4	71.2	71.7	63.3
Nitrogen Fertilizers	53.4	51.6	45.9	44.7	45.9	48.3	54.7	58.3	60.3	69.5
Crop Residues	28.4	28.3	34.9	34.9	33.1	33.1	38.8	37.6	37.2	36.1
Other	4.5	4.8	4.9	4.9	4.9	5.0	5.0	5.0	5.0	5.0
Total Direct Emissions	***145.4***	***147.2***	***153.9***	***154.5***	***149.7***	***149.2***	***169.9***	***172.0***	***174.2***	***174.0***
Indirect Emissions										
Soil Leaching	36.5	35.4	31.5	30.8	31.6	33.2	37.4	39.8	41.2	47.3
Atmospheric Deposition	6.5	6.3	5.6	5.5	5.6	5.9	6.6	7.1	7.3	8.4
Total Indirect Emissions	***43.0***	***41.7***	***37.2***	***36.3***	***37.2***	***39.1***	***44.0***	***46.8***	***48.5***	***55.7***
Solid Waste of Domesticated Animals										
Cattle	57.9	61.5	57.8	57.3	57.1	56.6	56.2	56.8	57.2	57.1
Swine	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.8
Poultry	0.9	1.2	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4
Horses	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Sheep	1.0	0.9	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Goats	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.4
Total Solid Waste	***62.3***	***66.2***	***62.4***	***61.9***	***61.7***	***61.2***	***60.9***	***61.7***	***62.2***	***62.2***
Crop Residue Burning	***0.5***	***0.5***	***0.6***	***0.6***	***0.5***	***0.5***	***0.6***	***0.6***	***0.6***	***0.6***
Total Agricultural Sources	**251.2**	**255.6**	**254.1**	**253.3**	**249.1**	**250.1**	**275.4**	**281.2**	**285.5**	**292.4**

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.

Source: EIA estimates.

Nitrous Oxide Emissions

Energy Use

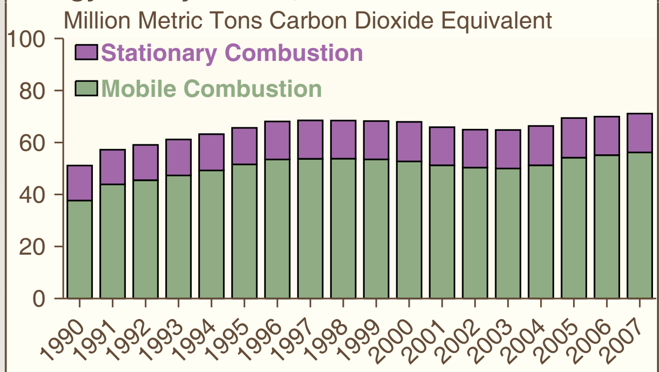
Summary

- Emissions from energy sources made up almost 20 percent of total U.S. nitrous oxide emissions in 2007. Nitrous oxide is a byproduct of fuel combustion in mobile and stationary sources (Figure 20).
- More than three-quarters of U.S. nitrous oxide emissions from energy use can be traced to mobile sources—motor vehicles, primarily passenger cars and light trucks (Table 23). Emissions from mobile sources increased by 1.8 percent from 2006 to 2007, primarily because of a 12.9-percent increase in emissions from off-road vehicles (included in "Other Mobile Sources").
- Nitrous oxide emissions from stationary combustion sources are dominated by coal-fired generation at electric power plants.

U.S. Anthropogenic Nitrous Oxide Emissions from Energy Use, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	51.1	69.9	71.1
Change from 1990 (Million Metric Tons CO_2e)		18.8	20.0
(Percent)		*36.8%*	*39.1%*
Average Annual Change from 1990 *(Percent)*		*2.0%*	*2.0%*
Change from 2006 (Million Metric Tons CO_2e)			1.2
(Percent)			*1.7%*

Figure 20. U.S. Nitrous Oxide Emissions from Energy Use by Source, 1990-2007



Source: EIA estimates.

Table 23. U.S. Nitrous Oxide Emissions from Energy Use, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Item	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Mobile Combustion										
Motor Vehicles	***34.1***	***48.0***	***48.8***	***47.6***	***46.7***	***46.6***	***47.5***	***50.0***	***50.5***	***51.0***
Passenger Cars	21.7	28.7	27.8	26.9	25.7	25.0	24.7	25.8	25.6	25.4
Light-Duty Trucks	10.5	17.0	18.4	18.1	18.3	18.8	19.9	21.3	22.1	22.7
Other Motor Vehicles	1.8	2.2	2.6	2.6	2.7	2.7	2.8	2.8	2.8	2.8
Other Mobile Sources	***3.6***	***3.6***	***3.9***	***3.7***	***3.6***	***3.4***	***3.8***	***4.2***	***4.6***	***5.2***
Total	**37.7**	**51.6**	**52.7**	**51.2**	**50.3**	**50.0**	**51.2**	**54.2**	**55.2**	**56.2**
Stationary Combustion										
Residential and Commercial	1.5	1.4	1.3	1.2	1.2	1.3	1.3	1.3	1.1	1.2
Industrial	4.7	4.9	4.9	4.7	4.6	4.5	4.8	4.6	4.6	4.4
Electric Power	7.3	7.7	9.0	8.8	8.9	9.0	9.1	9.3	9.1	9.3
Total	**13.5**	**14.0**	**15.2**	**14.7**	**14.6**	**14.8**	**15.1**	**15.2**	**14.8**	**14.9**
Total from Energy Use	**51.1**	**65.6**	**67.9**	**65.9**	**64.9**	**64.8**	**66.3**	**69.4**	**69.9**	**71.1**

P = preliminary data.

Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.

Sources: Calculations based on vehicle miles traveled from U.S. Department of Transportation, *Federal Highway Statistics* (various years), Table VM-1, and current year preliminary estimates calculated using growth rates from EIA, *Short-Term Energy Outlook* (various years). Other Mobile Sources calculations based on Oak Ridge National Laboratory, *Transportation Energy Data Book*; EIA, *Fuel Oil and Kerosene Sales*, *State Energy Data Report*, and *Petroleum Supply Annual* (various years). Passenger car and light-duty truck emissions coefficients from U.S. Environmental Protection Agency, Office of Air and Radiation, *Emissions of Nitrous Oxide From Highway Mobile Sources: Comments on the Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-1996*, EPA-420-R-98-009 (Washington DC, August 1998). Emissions coefficients from Intergovernmental Panel on Climate Change, Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: IPCC Guidelines for National Greenhouse Gas Inventories* (2007 and revised 1996 guidelines), web site www.ipcc-nggip.iges.or.jp/public/public.htm.

Nitrous Oxide Emissions

Industrial Sources

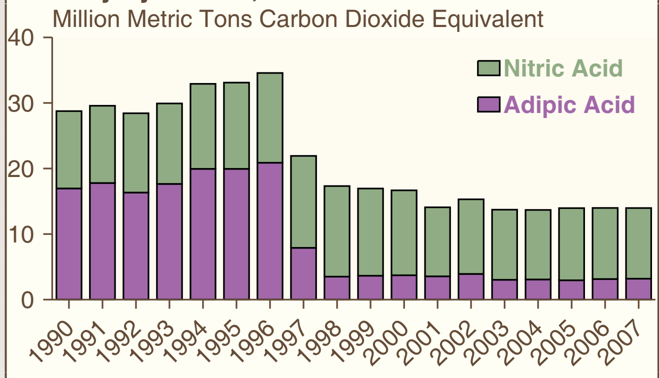
Summary

- U.S. nitrous oxide emissions from industrial sources in 2007, at 14.0 $MMTCO_2e$, were unchanged from 2006 (Table 24).
- The two industrial sources of nitrous oxide emissions are production of adipic acid and production of nitric acid.
- A large decline in nitrous oxide emissions from industrial processes since 1996 (Figure 21) is a result of emissions control technology at three of the four adipic acid plants operating in the United States. Adipic acid is a fine white power used primarily in the manufacture of nylon fibers and plastics. The three companies operating the U.S. plants manufacture adipic acid by oxidizing a ketone-alcohol mixture with nitric acid. The chemical reaction releases nitrous oxide emissions.
- Nitric acid, a primary ingredient in fertilizers, usually is manufactured by oxidizing ammonia with a platinum catalyst. The oxidation process releases nitrous oxide emissions.

U.S. Anthropogenic Nitrous Oxide Emissions from Industrial Sources, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	28.8	14.0	14.0
Change from 1990 (Million Metric Tons CO_2e)		-14.8	-14.8
(Percent)		*-51.4%*	*-51.4%*
Average Annual Change from 1990 *(Percent)*		*-4.4%*	*-4.2%*
Change from 2006 (Million Metric Tons CO_2e)			0.0
(Percent)			*-0.1%*

Figure 21. U.S. Nitrous Oxide Emissions from Industry by Source, 1990-2007



Source: EIA estimates.

Table 24. U.S. Nitrous Oxide Emissions from Industrial Sources, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Source	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Adipic Acid										
Controlled Sources	1.0	1.1	1.6	1.5	1.6	1.6	1.7	1.6	1.7	1.7
Uncontrolled Sources	16.0	18.9	2.1	2.1	2.3	1.4	1.4	1.4	1.5	1.5
Subtotal	**17.0**	**20.0**	**3.7**	**3.6**	**3.9**	**3.0**	**3.1**	**3.0**	**3.2**	**3.2**
Nitric Acid	**11.8**	**13.1**	**12.9**	**10.5**	**11.4**	**10.7**	**10.6**	**11.0**	**10.8**	**10.8**
Total Known Industrial Sources	**28.8**	**33.1**	**16.7**	**14.1**	**15.3**	**13.7**	**13.7**	**14.0**	**14.0**	**14.0**

P = preliminary data.
Note: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.
Source: EIA estimates.

Nitrous Oxide Emissions

Waste Management

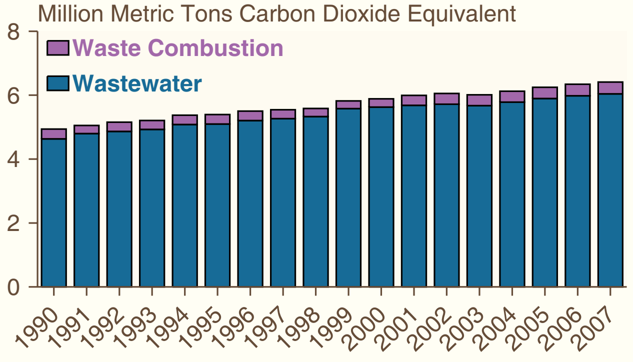
Summary

- Emissions from residential and commercial wastewater account for nearly all U.S. nitrous oxide emissions from waste management. The remainder is associated with the combustion of municipal solid waste (Figure 22 and Table 25).
- Estimates of nitrous oxide emissions from wastewater are scaled to population size and per-capita intake of protein.
- Nitrous oxide is emitted from wastewater that contains nitrogen-based organic materials, such as those found in human or animal waste. Factors that influence the amount of nitrous oxide generated from wastewater include temperature, acidity, biochemical oxygen demand, and nitrogen concentration.

U.S. Anthropogenic Nitrous Oxide Emissions from Waste Management, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	4.9	6.3	6.4
Change from 1990 (Million Metric Tons CO_2e)		1.4	1.5
(Percent)		*28.2%*	*29.5%*
Average Annual Change from 1990 *(Percent)*		*1.6%*	*1.5%*
Change from 2006 (Million Metric Tons CO_2e)			0.1
(Percent)			*1.0%*

Figure 22. U.S. Nitrous Oxide Emissions from Waste Management by Source, 1990-2007



Source: EIA estimates.

Table 25. U.S. Nitrous Oxide Emissions from Waste Management, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Source	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Domestic and Commercial Wastewater	4.6	5.1	5.6	5.7	5.7	5.7	5.8	5.9	6.0	6.0
Waste Combustion	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4
Total	**4.9**	**5.4**	**5.9**	**6.0**	**6.1**	**6.0**	**6.1**	**6.2**	**6.3**	**6.4**

P = preliminary data.
Note: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.
Source: EIA estimates.

High-GWP Gases

Total Emissions

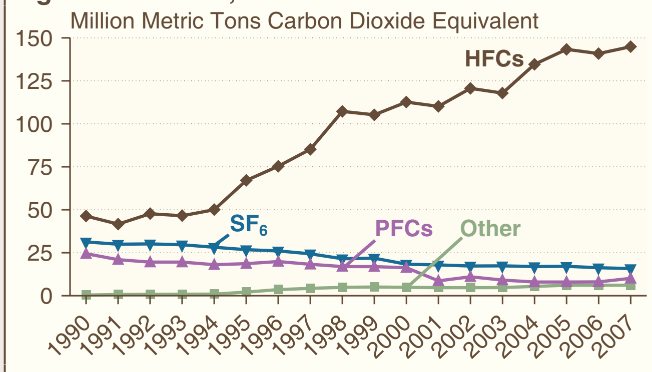
Summary

- Greenhouse gases with high global warming potential (high-GWP gases) are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), which together represented nearly 2.4 percent of U.S. greenhouse gas emissions in 2007.
- Emissions estimates for the high-GWP gases are provided to EIA by the EPA's Office of Air and Radiation. The estimates are derived from the EPA Vintaging Model.
- Emissions of high-GWP gases have increased steadily since 1990 (Figure 23 and Table 26), largely because HFCs are being used to replace chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and other ozone-depleting substances that are being phased out under the terms of the Montreal Protocol, which entered into force on January 1, 1989.
- PFC emissions have declined since 1990 as a result of production declines in the U.S. aluminum industry as well as industry efforts to lower emissions per unit of output.

U.S. Anthropogenic Emissions of High-GWP Gases, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	102.4	171.3	176.9
Change from 1990 (Million Metric Tons CO_2e)		68.9	74.5
(Percent)		*67.3%*	*72.8%*
Average Annual Change from 1990 *(Percent)*		*3.3%*	*3.3%*
Change from 2006 (Million Metric Tons CO_2e)			5.6
(Percent)			*3.3%*

Figure 23. U.S. Anthropogenic Emissions of High-GWP Gases, 1990-2007



Source: U.S. EPA estimates.

Table 26. U.S. Emissions of Hydrofluorocarbons, Perfluorocarbons, and Sulfur Hexafluoride, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Gas	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Hydrofluorocarbons	46.3	67.1	112.6	110.2	120.6	117.9	134.6	143.3	140.8	144.9
Perfluorocarbons	24.4	18.6	16.3	8.6	11.0	9.1	8.0	8.0	8.1	10.1
Other HFCs, PFCs/PFPEs	0.4	2.1	4.9	4.7	4.7	4.7	5.4	6.1	6.1	6.1
Sulfur Hexafluoride	31.3	26.8	18.3	17.9	17.3	17.4	16.9	17.1	16.2	15.8
Total Emissions	**102.4**	**114.6**	**152.1**	**141.4**	**153.6**	**149.0**	**165.0**	**174.5**	**171.3**	**176.9**

P = preliminary data.

Notes: Other HFCs, PFCs/PFPEs include HFC-152a, HFC-227ea, HFC-245fa, HFC-4310mee, and a variety of PFCs and perfluoropolyethers (PFPEs). They are grouped together to protect confidential data. Totals may not equal sum of components due to independent rounding.

Source: U.S. Environmental Protection Agency, Office of Air and Radiation, web site www.epa.gov/globalwarming/ (preliminary estimates, November 2008).

High-GWP Gases

Hydrofluorocarbons

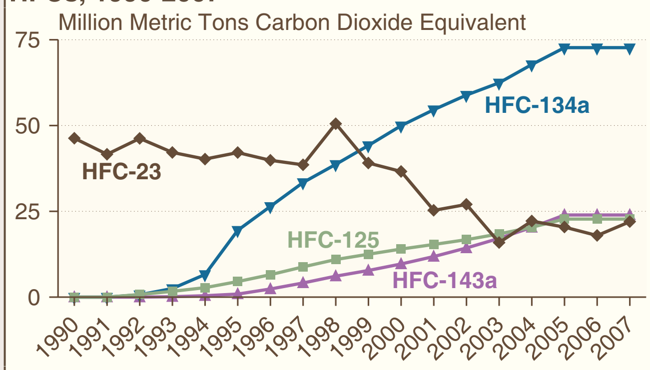
Summary

- HFCs are compounds that contain carbon, hydrogen, and fluorine. Although they do not destroy stratospheric ozone, they are powerful greenhouse gases.
- HFCs are used as solvents, residential and commercial refrigerants, firefighting agents, and propellants for aerosols.
- Emissions of substitutes for ozone-depleting substances, including HFC-32, HFC-125, HFC-134a, and HFC-236fa, have grown from trace amounts in 1990 to nearly 145 $MMTCO_2e$ in 2007 (Table 27).
- Nearly 90 percent of the growth in HFC emissions since 1990 can be attributed to the use of HFCs as replacements for ozone-depleting substances. The market is expanding, with HFCs used in fire protection applications to replace Halon 1301 and Halon 1211.
- Since 2000, HFC-134a—used as a replacement for CFCs in air conditioners for passenger vehicles, trains, and buses—has accounted for the largest share of HFC emissions (Figure 24).
- Under the Clean Air Act, manufacture and import of HCFC-22, except for use as a feedstock and in equipment manufacture before 2010, are scheduled to be phased out by January 1, 2010. Manufacturers of HCFC-22 are using cost-effective methods to make voluntary reductions in the amount of HFC-23 that is created as a byproduct of HCFC-22 manufacture.

U.S. Anthropogenic Emissions of HFCs, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	46.3	140.8	144.9
Change from 1990 (Million Metric Tons CO_2e)		94.6	98.6
(Percent)		*204.2%*	*213.0%*
Average Annual Change from 1990 *(Percent)*		*7.2%*	*6.9%*
Change from 2006 (Million Metric Tons CO_2e)			4.0
(Percent)			*2.9%*

Figure 24. U.S. Anthropogenic Emissions of HFCs, 1990-2007



Source: U.S. EPA estimates.

Table 27. U.S. Emissions of Hydrofluorocarbons, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Gas	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
HFC-23	46.3	42.1	36.6	25.3	27.0	15.9	22.2	20.4	17.9	22.0
HFC-32	0.0	0.0	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5
HFC-125	0.0	4.5	14.0	15.4	16.8	18.4	20.4	22.8	22.8	22.8
HFC-134a	0.0	19.5	49.9	54.6	58.9	62.4	67.8	72.7	72.7	72.7
HFC-143a	0.0	0.9	9.7	11.8	14.3	17.1	20.3	23.9	23.9	23.9
HFC-236fa	0.0	0.0	2.1	2.8	3.3	3.6	3.6	3.0	3.0	3.0
Total HFCs	**46.3**	**67.1**	**112.6**	**110.2**	**120.6**	**117.9**	**134.6**	**143.3**	**140.8**	**144.9**

P = preliminary data.
Note: Totals may not equal sum of components due to independent rounding.
Source: U.S. Environmental Protection Agency, Office of Air and Radiation, web site www.epa.gov/globalwarming/ (preliminary estimates, November 2008).

High-GWP Gases

Perfluorocarbons

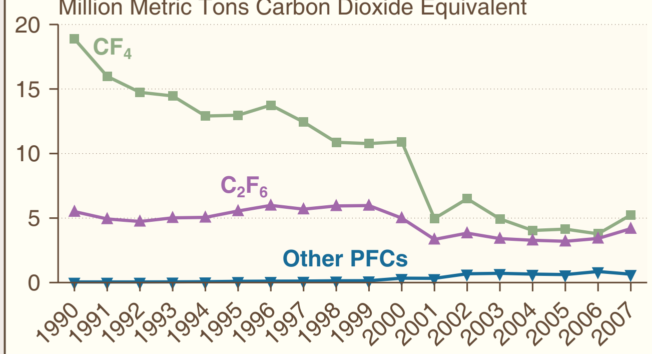
Summary

- The two principal sources of PFC emissions are domestic aluminum production and semiconductor manufacture, which yield perfluoromethane (CF_4) and perfluoroethane (C_2F_6) (Figure 25 and Table 28).
- While PFC emissions from aluminum production have declined markedly since 1990, the decline has been offset in part by increased emissions from semiconductor manufacturing.
- Emissions from process inefficiencies during aluminum production (known as "anode effects") have been greatly reduced; in addition, high costs for alumina and energy have led to production cutbacks.
- Perfluoroethane is used as an etchant and cleaning agent in semiconductor manufacturing. The portion of the gas that does not react with the materials is emitted to the atmosphere.

U.S. Anthropogenic Emissions of PFCs, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	24.4	8.1	10.1
Change from 1990 (Million Metric Tons CO_2e)		-16.4	-14.4
(Percent)		*-67.0%*	*-58.8%*
Average Annual Change from 1990 *(Percent)*		*-6.7%*	*-5.1%*
Change from 2006 (Million Metric Tons CO_2e)			2.0
(Percent)			*25.0%*

Figure 25. U.S. Anthropogenic Emissions of PFCs, 1990-2007



Source: U.S. EPA estimates.

Table 28. U.S. Emissions of Perfluorocarbons, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Gas	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
CF_4	18.9	13.0	10.9	5.0	6.5	4.9	4.0	4.1	3.8	5.2
C_2F_6	5.5	5.6	5.0	3.4	3.8	3.4	3.3	3.2	3.4	4.2
NF_3	*	0.1	0.2	0.2	0.5	0.5	0.5	0.4	0.7	0.5
C_3F_8	*	*	0.2	0.1	0.1	0.1	0.1	*	*	0.1
C_4F_8	*	*	*	*	0.1	0.1	0.1	0.1	0.1	0.1
Total HFCs	**24.4**	**18.6**	**16.3**	**8.6**	**11.0**	**9.1**	**8.0**	**8.0**	**8.1**	**10.1**

*Less than 0.05 million metric tons carbon dioxide equivalent.
P = preliminary data.
Note: Totals may not equal sum of components due to independent rounding.
Source: U.S. Environmental Protection Agency, Office of Air and Radiation, web site www.epa.gov/globalwarming/ (preliminary estimates, November 2008).

High-GWP Gases

Sulfur Hexafluoride

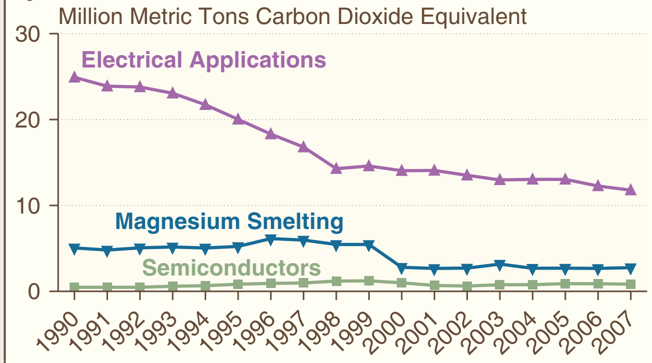
Summary

- SF_6, an excellent dielectric gas for high-voltage applications, is used primarily in electrical applications—as an insulator and arc interrupter for circuit breakers, switch gear, and other equipment in electricity transmission and distribution systems.
- Industry efforts to reduce emissions of SF_6 from electrical power systems have led to a decline in emissions since 1990 (Figure 26 and Table 29).
- SF_6 is also used in magnesium metal casting, as a cover gas during magnesium production, and as an atmospheric tracer for experimental purposes.
- Other, minor applications of SF_6 include leak detection and the manufacture of loudspeakers and lasers.

U.S. Anthropogenic Emissions of SF_6, 1990, 2006, and 2007

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO_2e)	31.3	16.2	15.8
Change from 1990 (Million Metric Tons CO_2e)		-15.0	-15.5
(Percent)		*-48.1%*	*-49.5%*
Average Annual Change from 1990 *(Percent)*		*-4.0%*	*-3.9%*
Change from 2006 (Million Metric Tons CO_2e)			-0.5
(Percent)			*-2.8%*

Figure 26. U.S. Anthropogenic Emissions of SF_6 by Source, 1990-2007



Source: U.S. EPA estimates.

Table 29. U.S. Emissions of Sulfur Hexafluoride by Source, 1990, 1995, and 2000-2007
(Million Metric Tons Carbon Dioxide Equivalent)

Source	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Electrical Applications	25.6	20.6	14.4	14.4	13.9	13.3	13.4	13.4	12.6	12.1
Magnesium Smelting	5.2	5.4	2.9	2.7	2.8	3.3	2.8	2.8	2.7	2.8
Semiconductors	0.5	0.9	1.0	0.7	0.6	0.8	0.8	0.9	0.9	0.9
Total SF_6	**31.3**	**26.8**	**18.3**	**17.9**	**17.3**	**17.4**	**16.9**	**17.1**	**16.2**	**15.8**

P = preliminary data.
Note: Totals may not equal sum of components due to independent rounding.
Source: U.S. Environmental Protection Agency, Office of Air and Radiation, web site www.epa.gov/globalwarming/ (preliminary estimates, November 2008).

Land Use

Overview

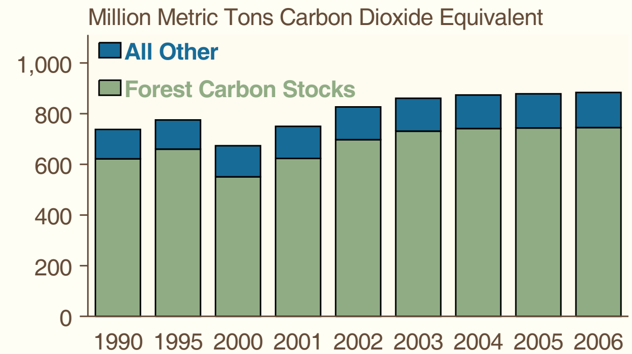
Summary

- Land use, land-use change, and forestry activities in 2006 resulted in net sequestration of 883.7 $MMTCO_2e$ (Table 30), equal to about 12 percent of U.S. greenhouse gas emissions in 2006.
- Net carbon sequestration from land use, land-use change, and forestry activities in 2006 was 20 percent greater than in 1990 (Figure 27). The increase resulted primarily from a higher rate of net carbon accumulation in forest carbon stocks.
- Net carbon accumulation in cropland remaining cropland, land converted to grassland, and settlements remaining settlements increased from 1990 to 2006.
- Net carbon accumulation in landfilled yard trimmings and food scraps decreased from 1990 to 2006. Grassland remaining grassland was a small carbon sink in 1990, but since 1995 it has become an emissions source.
- Emissions from land converted to cropland declined from 1990 to 2006.

U.S. Carbon Sequestration from Land Use, Land-Use Change and Forestry, 1990, 2005, and 2006

	1990	2005	2006
Estimated Sequestration (Million Metric Tons CO_2e)	737.7	878.6	883.7
Change from 1990 (Million Metric Tons CO_2e)		140.9	146.0
(Percent)		*19.1%*	*19.8%*
Average Annual Change from 1990 *(Percent)*		*1.2%*	*1.1%*
Change from 2005 (Million Metric Tons CO_2e)			5.1
(Percent)			*0.6%*

Figure 27. U.S. Carbon Sequestration from Land Use, Land-Use Change, and Forestry, 1990, 1995, and 2000-2006



Source: U.S. EPA estimates.

Table 30. Net U.S. Carbon Dioxide Sequestration from Land Use, Land-Use Change, and Forestry, 1990, 1995, and 2000-2006
(Million Metric Tons Carbon Dioxide Equivalent)

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

[a]Estimates include carbon stock changes in both Forest Land Remaining Forest Land and Land Converted to Forest Land.
[b]Estimates include carbon stock changes in mineral soils and organic soils on Cropland Remaining Cropland and liming emissions from all Cropland, Grassland, and Settlement categories.
[c]Estimates include C stock changes on both Settlements Remaining Settlements, and Land Converted to Settlements.
Note: Totals may not equal sum of components due to independent rounding.
Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, EPA 430-R-08-005 (Washington, DC, April 2008), web site www.epa.gov/climatechange/emissions/usinventoryreport.html.

Land Use

Forest Lands and Harvested Wood Pools

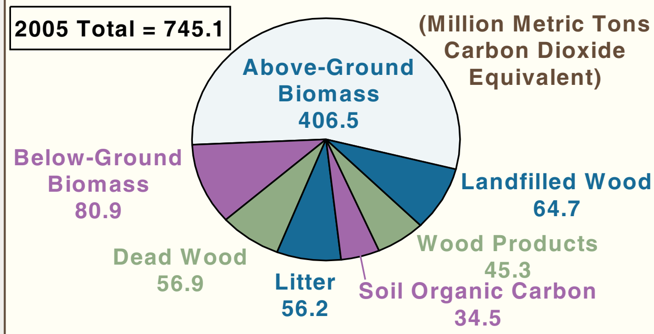
Summary

- Carbon sequestration attributed to forest land remaining forest land in 2006 totaled 745.1 million metric tons carbon dioxide equivalent (Figure 28 and Table 31). This carbon pool has grown by 20 percent since 1990, and it is the primary source of growth in U.S. terrestrial carbon stocks.
- The increase in annual carbon sequestration on forested lands (146 $MMTCO_2e$ higher in 2006 than in 1990) more than equals the decrease in sequestration of carbon in harvested wood over the same period (23 $MMTCO_2e$ lower in 2006 than in 1990).
- The national sequestration estimates shown below[12] are based on individual State surveys, which are performed at different times and irregular frequencies in the different States. For the first time, this year's inventory includes a portion of Alaskan forest.
- Because new data or changes in data for some years and/or States can affect the calculations for intervening years, the annual estimation process generally results in revisions of the national estimates for all years in the series. In this year's inventory, data for 31 of the 48 States were changed from those in the previous year's inventory.

Carbon Sequestration in U.S. Forest Lands and Harvested Wood Pools, 1990, 2005, and 2006

	1990	2005	2006
Estimated Sequestration (Million Metric Tons CO_2e)	621.7	743.6	745.1
Change from 1990 (Million Metric Tons CO_2e)		121.9	123.4
(Percent)		*19.6%*	*19.8%*
Average Annual Change from 1990 *(Percent)*		*1.2%*	*1.1%*
Change from 2005 (Million Metric Tons CO_2e)			1.5
(Percent)			*0.2%*

Figure 28. Carbon Sequestration in U.S. Forest Lands and Harvested Wood Pools, 2006



Source: U.S. EPA estimates.

Table 31. Net Carbon Dioxide Sequestration in U.S. Forests and Harvested Wood Pools, 1990, 1995, and 2000-2006
(Million Metric Tons Carbon Dioxide Equivalent)

Carbon Pool	1990	1995	2000	2001	2002	2003	2004	2005	2006
Forests	**489.1**	**540.5**	**436.8**	**529.0**	**598.0**	**635.1**	**635.1**	**635.1**	**635.1**
Above-Ground Biomass	287.6	318.4	335.4	367.7	384.4	406.5	406.5	406.5	406.5
Below-Ground Biomass	54.2	62.4	67.2	73.7	76.9	80.9	80.9	80.9	80.9
Dead Wood	40.1	57.5	44.9	50.0	53.0	56.9	56.9	56.9	56.9
Litter	63.3	34.9	17.3	36.3	47.7	56.2	56.2	56.2	56.2
Soil Organic Carbon	43.9	67.5	-28.0	1.3	36.0	34.5	34.5	34.5	34.5
Harvested Wood	**132.6**	**119.4**	**113.9**	**94.5**	**99.2**	**95.9**	**106.3**	**108.5**	**110.0**
Wood Products	64.8	55.2	47.0	31.9	35.1	35.4	45.5	47.3	45.3
Landfilled Wood	67.9	64.1	66.9	62.6	64.2	60.4	60.8	61.2	64.7
Total	**621.7**	**659.9**	**550.7**	**623.4**	**697.3**	**730.9**	**741.4**	**743.6**	**745.1**

Notes: The sums of the annual net stock changes in this table (shown in the "Total" row) represent estimates of the actual net flux between the total forest carbon pool and the atmosphere. Forest estimates are based on periodic measurements; harvested wood estimates are based on annual surveys and models. Totals may not equal sum of components due to independent rounding.

Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, EPA 430-R-08-005 (Washington, DC, April 2008), web site www.epa.gov/climatechange/emissions/usinventoryreport.html.

[12]Compiled by the U.S. Department of Agriculture and the U.S. EPA.

Land Use

Croplands and Grasslands

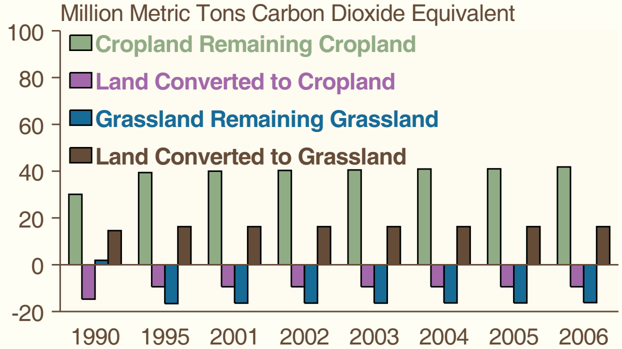
Summary

- For 2006, the aggregate flux of carbon dioxide in the four agricultural categories (cropland remaining cropland, land converted to cropland, grassland remaining grassland, and land converted to grassland) was 32.5 $MMTCO_2e$.
- Cropland remaining cropland and land converted to grassland sequestered 41.8 and 16.3 $MMTCO_2e$, respectively, in 2006. Land converted to cropland and grassland remaining grassland emitted 9.4 and 16.2 $MMTCO_2e$, respectively (Figure 29 and Table 32).
- This year's inventory differs from last year's in the classification of agricultural land use. Last year, if surveys classified a given area of land as, for example, cropland remaining cropland in 2005, that categorization was applied over the entire period from 1990 to 2005. In this year's inventory, the classification of an area is determined separately for each year.

Carbon Sequestration in U.S. Croplands and Grasslands, 1990, 2005, and 2006

	1990	2005	2006
Estimated Sequestration (Million Metric Tons CO_2e)	31.9	31.6	32.5
Change from 1990 (Million Metric Tons CO_2e)		-0.3	0.6
(Percent)		*-0.9%*	*1.9%*
Average Annual Change from 1990 *(Percent)*		*-0.1%*	*0.1%*
Change from 2005 (Million Metric Tons CO_2e)			0.9
(Percent)			*2.8%*

Figure 29. Carbon Sequestration in U.S. Croplands and Grasslands, 1990, 1995, and 2001-2006



Source: U.S. EPA estimates.

Table 32. Net Carbon Dioxide Sequestration in U.S. Croplands and Grasslands, 1990, 1995, and 2000-2006
(Million Metric Tons Carbon Dioxide Equivalent)

Carbon Pool	1990	1995	2000	2001	2002	2003	2004	2005	2006
Cropland Remaining Cropland	**30.1**	**39.4**	**38.4**	**40.0**	**40.3**	**40.5**	**40.9**	**41.0**	**41.8**
Mineral Soils	57.5	67.0	66.1	67.7	68.0	68.1	68.5	68.7	69.5
Organic Soils	-27.4	-27.7	-27.7	-27.7	-27.7	-27.7	-27.7	-27.7	-27.7
Land Converted to Cropland	**-14.7**	**-9.4**	**-9.4**	**-9.4**	**-9.4**	**-9.4**	**-9.4**	**-9.4**	**-9.4**
Mineral Soils	-12.3	-6.7	-6.7	-6.7	-6.7	-6.7	-6.7	-6.7	-6.7
Organic Soils	-2.4	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6
Grassland Remaining Grassland	**1.9**	**-16.6**	**-16.4**	**-16.4**	**-16.4**	**-16.4**	**-16.3**	**-16.3**	**-16.2**
Mineral Soils	5.7	-12.9	-12.8	-12.7	-12.7	-12.7	-12.6	-12.6	-12.5
Organic Soils	-3.9	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7
Land Converted to Grassland	**14.6**	**16.3**	**16.3**	**16.3**	**16.3**	**16.3**	**16.3**	**16.3**	**16.3**
Mineral Soils	15.0	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2
Organic Soils	-0.5	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Total Sequestration	**31.9**	**29.7**	**28.9**	**30.5**	**30.8**	**31.0**	**31.5**	**31.6**	**32.5**
Liming of Soils	-4.7	-4.4	-4.3	-4.4	-5.0	-4.6	-3.9	-4.3	-4.4

Note: Negative values indicate emissions.
Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, EPA 430-R-08-005 (Washington, DC, April 2008), web site www.epa.gov/climatechange/emissions/usinventoryreport.html.

Land Use

Urban Trees, Yard Trimmings, and Food Scraps

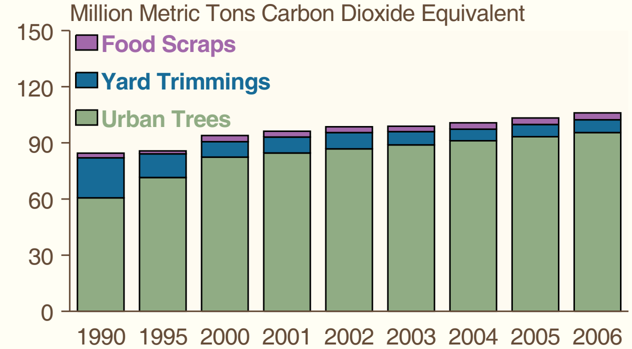
Summary

- Urban trees accounted for nearly all (90 percent) of the carbon sequestration attributed to urban trees, yard trimmings, and food scraps in 2006 (Figure 30 and Table 33).
- The half-lives of branches and food scraps were updated this year to match the values for food scraps and woody materials provided in the IPCC guidelines for analyzing landfill methane.
- The increase in annual carbon sequestration in urban trees (34.9 $MMTCO_2e$ higher in 2006 than in 1990) more than equals the decrease in sequestration of carbon in yard trimmings over the same period (14.6 $MMTCO_2e$ lower in 2006 than in 1990).
- This year's inventory uses new carbon content estimates for leaves and grass, as well as new data on municipal solid waste that eliminate the need for interpolation. As a result of those changes, net flux estimates across the entire time series are 7 percent higher on average, and the estimate for 2005 is 13 percent higher, than in last year's inventory.

Carbon Sequestration in U.S. Urban Trees, Yard Trimmings, and Food Scraps, 1990, 2005, and 2006

	1990	2005	2006
Estimated Sequestration (Million Metric Tons CO_2e)	84.5	103.3	106.0
Change from 1990 (Million Metric Tons CO_2e)		18.8	21.5
(Percent)		*22.2%*	*25.4%*
Average Annual Change from 1990 *(Percent)*		*1.3%*	*1.4%*
Change from 2005 (Million Metric Tons CO_2e)			2.7
(Percent)			*2.6%*

Figure 30. Carbon Sequestration in U.S. Urban Trees, Yard Trimmings, and Food Scraps, 1990, 1995, and 2000-2006



Source: U.S. EPA estimates.

Table 33. Net Carbon Dioxide Sequestration in U.S. Urban Trees, Yard Trimmings, and Food Scraps, 1990, 1995, and 2000-2006
(Million Metric Tons Carbon Dioxide Equivalent)

Carbon Pool	1990	1995	2000	2001	2002	2003	2004	2005	2006
Urban Trees	**60.6**	**71.5**	**82.4**	**84.6**	**86.8**	**88.9**	**91.1**	**93.3**	**95.5**
Yard Trimmings	**21.4**	**12.6**	**8.2**	**8.5**	**8.7**	**7.1**	**6.2**	**6.5**	**6.8**
Grass	1.9	0.8	0.4	0.5	0.6	0.4	0.3	0.4	0.5
Leaves	9.7	6.0	4.0	4.1	4.2	3.5	3.1	3.2	3.3
Branches	9.7	5.8	3.7	3.8	3.9	3.2	2.8	2.9	3.0
Food Scraps	**2.5**	**1.6**	**3.3**	**3.1**	**3.1**	**2.9**	**3.4**	**3.5**	**3.7**
Total Net Flux	**84.5**	**85.7**	**93.9**	**96.2**	**98.6**	**98.9**	**100.7**	**103.3**	**106.0**

Note: Totals may not equal sum of components due to independent rounding.
Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, EPA 430-R-08-005 (Washington, DC, April 2008), web site www.epa.gov/climatechange/emissions/usinventoryreport.html.

Glossary

Acid stabilization: A circumstance where the pH of the waste mixture in an animal manure management system is maintained near 7.0, optimal conditions for methane production.

Aerobic bacteria: Microorganisms living, active, or occurring only in the presence of oxygen.

Aerobic decomposition: The breakdown of a molecule into simpler molecules or atoms by microorganisms under favorable conditions of oxygenation.

Aerosols: Airborne particles.

Afforestation: Planting of new forests on lands that have not been recently forested.

Agglomeration: The clustering of disparate elements.

Airshed: An area or region defined by settlement patterns or geology that results in discrete atmospheric conditions.

Albedo: The fraction of incident light or electromagnetic radiation that is reflected by a surface or body. See *Planetary albedo*.

Anaerobes: Organisms that live and are active only in the absence of oxygen.

Anaerobic bacteria: Microorganisms living, active, or occurring only in the absence of oxygen.

Anaerobic decomposition: The breakdown of molecules into simpler molecules or atoms by microorganisms that can survive in the partial or complete absence of oxygen.

Anaerobic lagoon: A liquid-based manure management system, characterized by waste residing in water to a depth of at least six feet for a period ranging between 30 and 200 days.

Anode: A positive electrode, as in a battery, radio tube, etc.

Anthracite: The highest rank of coal; used primarily for residential and commercial space heating. It is a hard, brittle, and black lustrous coal, often referred to as hard coal, containing a high percentage of fixed carbon and a low percentage of volatile matter. The moisture content of fresh-mined anthracite generally is less than 15 percent. The heat content of anthracite ranges from 22 to 28 million Btu per ton on a moist, mineral-matter-free basis. The heat content of anthracite coal consumed in the United States averages 25 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter). Note: Since the 1980's, anthracite refuse or mine waste has been used for steam electric power generation. This fuel typically has a heat content of 15 million Btu per ton or less.

Anthropogenic: Made or generated by a human or caused by human activity. The term is used in the context of global climate change to refer to gaseous emissions that are the result of human activities, as well as other potentially climate-altering activities, such as deforestation.

API Gravity: American Petroleum Institute measure of specific gravity of crude oil or condensate in degrees. An arbitrary scale expressing the gravity or density of liquid petroleum products. The measuring scale is calibrated in terms of degrees API; it is calculated as follows: Degrees API = (141.5/sp.gr.60 deg.F/60 deg.F) - 131.5.

Asphalt: A dark brown-to-black cement-like material obtained by petroleum processing and containing bitumens as the predominant component; used primarily for road construction. It includes crude asphalt as well as the following finished products: cements, fluxes, the asphalt content of emulsions (exclusive of water), and petroleum distillates blended with asphalt to make cutback asphalts. Note: The conversion factor for asphalt is 5.5 barrels per short ton.

Associated natural gas: See *Associated-dissolved natural gas* and *Natural gas*.

Associated-dissolved natural gas: Natural gas that occurs in crude oil reservoirs either as free gas (associated) or as gas in solution with crude oil (dissolved gas). See *Natural gas*.

Aviation gasoline (finished): A complex mixture of relatively volatile hydrocarbons with or without small quantities of additives, blended to form a fuel suitable for use in aviation reciprocating engines. Fuel specifications are provided in ASTM Specification D 910 and Military Specification MIL-G-5572. Note: Data on blending components are not counted in data on finished aviation gasoline.

Balancing item: Represents differences between the sum of the components of natural gas supply and the sum of the components of natural gas disposition. These differences may be due to quantities lost or to the effects of data reporting problems. Reporting problems include differences due to the net result of conversions of flow data metered at varying temperature and pressure bases and converted to a standard temperature and pressure base; the effect of variations in company accounting and billing practices; differences between billing cycle and calendar period time frames; and imbalances resulting from the merger of data reporting systems that vary in scope, format, definitions, and type of respondents.

Biofuels: Liquid fuels and blending components produced from biomass (plant) feedstocks, used primarily for transportation.

Biogas: The gas produced from the anaerobic decomposition of organic material in a landfill.

Biogenic: Produced by the actions of living organisms.

Biomass: Organic nonfossil material of biological origin constituting a renewable energy source.

Biosphere: The portion of the Earth and its atmosphere that can support life. The part of the global carbon cycle that includes living organisms and biogenic organic matter.

Bituminous coal: A dense coal, usually black, sometimes dark brown, often with well-defined bands of bright and dull material, used primarily as fuel in steam-electric power generation, with substantial quantities also used for heat and power applications in manufacturing and to make coke. Bituminous coal is the most abundant coal in active U.S. mining regions. Its moisture content usually is less than 20 percent. The heat content of bituminous coal ranges from 21 to 30 million Btu per ton on a moist, mineral-matter-free basis. The heat content of bituminous coal consumed in the United States averages 24 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter).

BOD_5: The biochemical oxygen demand of wastewater during decomposition occurring over a 5-day period. A measure of the organic content of wastewater.

Bromofluorocarbons (halons): Inert, nontoxic chemicals that have at least one bromine atom in their chemical makeup. They evaporate without leaving a residue and are used in fire extinguishing systems, especially for large computer installations.

Bunker fuel: Fuel supplied to ships and aircraft, both domestic and foreign, consisting primarily of residual and distillate fuel oil for ships and kerosene-based jet fuel for aircraft. The term "international bunker fuels" is used to denote the consumption of fuel for international transport activities. *Note*: For the purposes of greenhouse gas emissions inventories, data on emissions from combustion of international bunker fuels are subtracted from national emissions totals. Historically, bunker fuels have meant only ship fuel. See *Vessel bunkering*.

Calcination: A process in which a material is heated to a high temperature without fusing, so that hydrates, carbonates, or other compounds are decomposed and the volatile material is expelled.

Calcium sulfate: A white crystalline salt, insoluble in water. Used in Keene's cement, in pigments, as a paper filler, and as a drying agent.

Calcium sulfite: A white powder, soluble in dilute sulfuric acid. Used in the sulfite process for the manufacture of wood pulp.

Capital stock: Property, plant and equipment used in the production, processing and distribution of energy resources.

Carbon black: An amorphous form of carbon, produced commercially by thermal or oxidative decomposition of hydrocarbons and used principally in rubber goods, pigments, and printer's ink.

Carbon budget: Carbon budget: The balance of the exchanges (incomes and losses) of carbon between carbon sinks (e.g., atmosphere and biosphere) in the carbon cycle. See *Carbon cycle* and *Carbon sink*.

Carbon cycle: All carbon sinks and exchanges of carbon from one sink to another by various chemical, physical, geological, and biological processes. See *Carbon sink* and *Carbon budget*.

Carbon dioxide (CO_2): A colorless, odorless, nonpoisonous gas that is a normal part of Earth's atmosphere. Carbon dioxide is a product of fossil-fuel combustion as well as other processes. It is considered a greenhouse gas as it traps heat (infrared energy) radiated by the Earth into the atmosphere and thereby contributes to the potential for global warming. The global warming potential (GWP) of other greenhouse gases is measured in relation to that of carbon dioxide, which by international scientific convention is assigned a value of one (1). See *Global warming potential (GWP)* and *Greenhouse gases*.

Carbon dioxide equivalent: The amount of carbon dioxide by weight emitted into the atmosphere that would produce the same estimated radiative forcing as a given weight of another radiatively active gas. Carbon dioxide equivalents are computed by multiplying the weight of the gas being measured (for example, methane) by its estimated global warming potential (which is 21 for methane). "Carbon equivalent units" are defined as carbon dioxide equivalents multiplied by the carbon content of carbon dioxide (i.e., 12/44).

Carbon flux: See *Carbon budget*.

Carbon intensity: The amount of carbon by weight emitted per unit of energy consumed. A common measure of carbon intensity is weight of carbon per British thermal unit (Btu) of energy. When there is only one fossil fuel under consideration, the carbon intensity and the emissions coefficient are identical. When there are several fuels, carbon intensity is based on their combined emissions coefficients weighted by their energy consumption levels. See *Emissions coefficient* and *Carbon output rate*.

Carbon output rate: The amount of carbon by weight per kilowatthour of electricity produced.

Carbon sequestration: The fixation of atmospheric carbon dioxide in a carbon sink through biological or physical processes.

Carbon sink: A reservoir that absorbs or takes up released carbon from another part of the carbon cycle. The four sinks, which are regions of the Earth within which carbon behaves in a systematic manner, are the atmosphere, terrestrial biosphere (usually including freshwater systems), oceans, and sediments (including fossil fuels).

Catalytic converter: A device containing a catalyst for converting automobile exhaust into mostly harmless products.

Catalytic hydrocracking: A refining process that uses hydrogen and catalysts with relatively low temperatures and high pressures for converting middle boiling or residual material to high octane gasoline, reformer charge stock, jet fuel, and/or high grade fuel oil. The process uses one or more catalysts, depending on product output, and can handle high sulfur feedstocks without prior desulfurization.

Cesspool: An underground reservoir for liquid waste, typically household sewage.

Chlorofluorocarbon (CFC): Any of various compounds consisting of carbon, hydrogen, chlorine, and fluorine used as refrigerants. CFCs are now thought to be harmful to the earth's atmosphere.

Clean Development Mechanism (CDM): A Kyoto Protocol program that enables industrialized countries to finance emissions-avoiding projects in developing countries and receive credit for reductions achieved against their own emissions limitation targets. See *Kyoto Protocol*.

Climate: The average course or condition of the weather over a period of years as exhibited by temperature, humidity, wind velocity, and precipitation.

Climate change: A term used to refer to all forms of climatic inconsistency, but especially to significant change from one prevailing climatic condition to another. In some cases, "climate change" has been used synonymously with the term "global warming"; scientists, however, tend to use the term in a wider sense inclusive of natural changes in climate, including climatic cooling.

Clinker: Powdered cement, produced by heating a properly proportioned mixture of finely ground raw materials (calcium carbonate, silica, alumina, and iron oxide) in a kiln to a temperature of about 2,700ºF.

Cloud condensation nuclei: Aerosol particles that provide a platform for the condensation of water vapor, resulting in clouds with higher droplet concentrations and increased albedo.

Coal coke: See *Coke (coal)*.

Coalbed methane: Methane is generated during coal formation and is contained in the coal microstructure. Typical recovery entails pumping water out of the coal to allow the gas to escape. Methane is the principal component of natural gas. Coalbed methane can be added to natural gas pipelines without any special treatment.

Coke (coal): A solid carbonaceous residue derived from low-ash, low-sulfur bituminous coal from which the volatile constituents are driven off by baking in an oven at temperatures as high as 2,000 degrees Fahrenheit so that the fixed carbon and residual ash are fused together. Coke is used as a fuel and as a reducing agent in smelting iron ore in a blast furnace. Coke from coal is grey, hard, and porous and has a heating value of 24.8 million Btu per ton.

Coke (petroleum): A residue high in carbon content and low in hydrogen that is the final product of thermal decomposition in the condensation process in cracking. This product is reported as marketable coke or catalyst coke. The conversion is 5 barrels (of 42 U.S. gallons each) per short ton. Coke from petroleum has a heating value of 6.024 million Btu per barrel.

Combustion: Chemical oxidation accompanied by the generation of light and heat.

Combustion chamber: An enclosed vessel in which chemical oxidation of fuel occurs.

Conference of the Parties (COP): The collection of nations that have ratified the Framework Convention on Climate Change (FCCC). The primary role of the COP is to keep implementation of the FCCC under review and make the decisions necessary for its effective implementation. See *Framework Convention on Climate Change (FCCC)*.

Cracking: The refining process of breaking down the larger, heavier, and more complex hydrocarbon molecules into simpler and lighter molecules.

Criteria pollutant: A pollutant determined to be hazardous to human health and regulated under EPA's National Ambient Air Quality Standards. The 1970 amendments to the Clean Air Act require EPA to describe the health and welfare impacts of a pollutant as the "criteria" for inclusion in the regulatory regime.

Crop residue: Organic residue remaining after the harvesting and processing of a crop.

Cultivar: A horticulturally or agriculturally derived variety of a plant.

Deforestation: The net removal of trees from forested land.

Degasification system: The methods employed for removing methane from a coal seam that could not otherwise be removed by standard ventilation fans and thus would pose a substantial hazard to coal miners. These systems may be used prior to mining or during mining activities.

Degradable organic carbon: The portion of organic carbon present in such solid waste as paper, food waste, and yard waste that is susceptible to biochemical decomposition.

Desulfurization: The removal of sulfur, as from molten metals, petroleum oil, or flue gases.

Diffusive transport: The process by which particles of liquids or gases move from an area of higher concentration to an area of lower concentration.

Distillate fuel: A general classification for one of the petroleum fractions produced in conventional distillation operations. It includes diesel fuels and fuel oils. Products known as No. 1, No. 2, and No. 4 diesel fuel are used in on-highway diesel engines, such as those in trucks and automobiles, as well as off-highway engines, such as those in railroad locomotives and agricultural machinery. Products known as No. 1, No. 2, and No. 4 fuel oils are used primarily for space heating and electric power generation.

Efflux: An outward flow.

Electrical generating capacity: The full-load continuous power rating of electrical generating facilities, generators, prime movers, or other electric equipment (individually or collectively).

EMCON Methane Generation Model: A model for estimating the production of methane from municipal solid waste landfills.

Emissions: Anthropogenic releases of gases to the atmosphere. In the context of global climate change, they consist of radiatively important greenhouse gases (e.g., the release of carbon dioxide during fuel combustion).

Emissions coefficient: A unique value for scaling emissions to activity data in terms of a standard rate of emissions per unit of activity (e.g., pounds of carbon dioxide emitted per Btu of fossil fuel consumed).

Enteric fermentation: A digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream of an animal.

Eructation: An act or instance of belching.

ETBE (ethyl tertiary butyl ether): $(CH_3)_3COC_2H$: An oxygenate blend stock formed by the catalytic etherification of isobutylene with ethanol.

Ethylene: An olefinic hydrocarbon recovered from refinery processes or petrochemical processes. Ethylene is used as a petrochemical feedstock for numerous chemical applications and the production of consumer goods.

Ethylene dichloride: A colorless, oily liquid used as a solvent and fumigant for organic synthesis, and for ore flotation.

Facultative bacteria: Bacteria that grow equally well under aerobic and anaerobic conditions.

Flange: A rib or a rim for strength, for guiding, or for attachment to another object (e.g., on a pipe).

Flared: Gas disposed of by burning in flares usually at the production sites or at gas processing plants.

Flatus: Gas generated in the intestines or the stomach of an animal.

Flue gas desulfurization: Equipment used to remove sulfur oxides from the combustion gases of a boiler plant before discharge to the atmosphere. Also referred to as scrubbers. Chemicals such as lime are used as scrubbing media.

Fluidized-bed combustion: A method of burning particulate fuel, such as coal, in which the amount of air required for combustion far exceeds that found in conventional burners. The fuel particles are continually fed into a bed of mineral ash in the proportions of 1 part fuel to 200 parts ash, while a flow of air passes up through the bed, causing it to act like a turbulent fluid.

Flux material: A substance used to promote fusion, e.g., of metals or minerals.

Fodder: Coarse food for domestic livestock.

Forestomach: See *Rumen*.

Fossil fuel: An energy source formed in the earths crust from decayed organic material. The common fossil fuels are petroleum, coal, and natural gas.

Framework Convention on Climate Change (FCCC): An agreement opened for signature at the "Earth Summit" in Rio de Janeiro, Brazil, on June 4, 1992, which has the goal of stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent significant anthropogenically forced climate change. See *Climate change*.

Fuel cycle: The entire set of sequential processes or stages involved in the utilization of fuel, including extraction, transformation, transportation, and combustion. Emissions generally occur at each stage of the fuel cycle.

Fugitive emissions: Unintended leaks of gas from the processing, transmission, and/or transportation of fossil fuels.

Gasification: A method for converting coal, petroleum, biomass, wastes, or other carbon-containing materials into a gas that can be burned to generate power or processed into chemicals and fuels.

Gate station: Location where the pressure of natural gas being transferred from the transmission system to the distribution system is lowered for transport through small diameter, low pressure pipelines.

Geothermal: Pertaining to heat within the Earth.

Global climate change: See *Climate change*.

Global warming: An increase in the near surface temperature of the Earth. Global warming has occurred in the distant past as the result of natural influences, but the term is today most often used to refer to the warming that some scientists predict will occur as a result of increased anthropogenic emissions of greenhouse gases. See *Climate change*.

Global warming potential (GWP): An index used to compare the relative radiative forcing of different gases without directly calculating the changes in atmospheric concentrations. GWPs are calculated as the ratio of the radiative forcing that would result from the emission of one kilogram of a greenhouse gas to that from the emission of one kilogram of carbon dioxide over a fixed period of time, such as 100 years.

Greenhouse effect: The result of water vapor, carbon dioxide, and other atmospheric gases trapping radiant (infrared) energy, thereby keeping the earth's surface warmer than it would otherwise be. Greenhouse gases within the lower levels of the atmosphere trap this radiation, which would otherwise escape into space, and subsequent re-radiation of some of this energy back to the Earth maintains higher surface temperatures than would occur if the gases were absent. See *Greenhouse gases*.

Greenhouse gases: Those gases, such as water vapor, carbon dioxide, nitrous oxide, methane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride, that are transparent to solar (short-wave) radiation but opaque to long-wave (infrared) radiation, thus preventing long-wave radiant energy from leaving the Earth's atmosphere. The net effect is a trapping of absorbed radiation and a tendency to warm the planet's surface.

Gross gas withdrawal: The full-volume of compounds extracted at the wellhead, including nonhydrocarbon gases and natural gas plant liquids.

Gypsum: Calcium sulfate dihydrate ($CaSO_4 \cdot 2H_2O$), a sludge constituent from the conventional lime scrubber process, obtained as a byproduct of the dewatering operation and sold for commercial use.

Halogenated substances: A volatile compound containing halogens, such as chlorine, fluorine or bromine.

Halons: See *Bromofluorocarbons*.

Heating degree-days (HDD): A measure of how cold a location is over a period of time relative to a base temperature, most commonly specified as 65 degrees Fahrenheit. The measure is computed for each day by subtracting the average of the day's high and low temperatures from the base temperature (65 degrees), with negative values set equal to zero. Each day's heating degree-days are summed to create a heating degree-day measure for a specified reference period. Heating degree-days are used in energy analysis as an indicator of space heating energy requirements or use.

Herbivore: A plant-eating animal.

Hydrocarbon: An organic chemical compound of hydrogen and carbon in either gaseous, liquid, or solid phase. The molecular structure of hydrocarbon compounds varies from the simple (e.g., methane, a constituent of natural gas) to the very heavy and very complex.

Hydrochlorofluorocarbons (HCFCs): Chemicals composed of one or more carbon atoms and varying numbers of hydrogen, chlorine, and fluorine atoms.

Hydrofluorocarbons (HFCs): A group of man-made chemicals composed of one or two carbon atoms and varying numbers of hydrogen and fluorine atoms. Most HFCs have 100-year Global Warming Potentials in the thousands.

Hydroxyl radical (OH): An important chemical scavenger of many trace gases in the atmosphere that are greenhouse gases. Atmospheric concentrations of OH affect the atmospheric lifetimes of greenhouse gases, their abundance, and, ultimately, the effect they have on climate.

Intergovernmental Panel on Climate Change (IPCC): A panel established jointly in 1988 by the World Meteorological Organization and the United Nations Environment Program to assess the scientific information relating to climate change and to formulate realistic response strategies.

International bunker fuels: See *Bunker fuels*.

Jet fuel: A refined petroleum product used in jet aircraft engines. It includes kerosene-type jet fuel and naphtha-type jet fuel.

Joint Implementation (JI): Agreements made between two or more nations under the auspices of the Framework Convention on Climate Change (FCCC) whereby a developed country can receive "emissions reduction units" when it helps to finance projects that reduce net emissions in another developed country (including countries with economies in transition).

Kerosene: A light petroleum distillate that is used in space heaters, cook stoves, and water heaters and is suitable for use as a light source when burned in wick-fed lamps. Kerosene has a maximum distillation temperature of 400 degrees Fahrenheit at the 10-percent recovery point, a final boiling point of 572 degrees Fahrenheit, and a minimum flash point of 100 degrees Fahrenheit. Included are No. 1-K and No. 2-K, the two grades recognized by ASTM Specification D 3699 as well as all other grades of kerosene called range or stove oil, which have properties similar to those of No. 1 fuel oil. See *Kerosene-type jet fuel*.

Kerosene-type jet fuel: A kerosene-based product having a maximum distillation temperature of 400 degrees Fahrenheit at the 10-percent recovery point and a final maximum boiling point of 572 degrees Fahrenheit and meeting ASTM Specification D 1655 and Military Specifications MIL-T-5624P and MIL-T-83133D (Grades JP-5 and JP-8). It is used for commercial and military turbojet and turboprop aircraft engines.

Kyoto Protocol: The result of negotiations at the third Conference of the Parties (COP-3) in Kyoto, Japan, in December of 1997. The Kyoto Protocol sets binding greenhouse gas emissions targets for countries that sign and ratify the agreement. The gases covered under the Protocol include carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride.

Ketone-alcohol (cyclohexanol): An oily, colorless, hygroscopic liquid with a camphor-like odor. Used in soapmaking, dry cleaning, plasticizers, insecticides, and germicides.

Leachate: The liquid that has percolated through the soil or other medium.

Lignite: The lowest rank of coal, often referred to as brown coal, used almost exclusively as fuel for steam-electric power generation. It is brownish-black and has a high inherent moisture content, sometimes as high as 45 percent The heat content of lignite ranges from 9 to 17 million Btu per ton on a moist, mineral-matter-free basis. The heat content of lignite consumed in the United States averages 13 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter).

Liquefied petroleum gases: A group of hydrocarbon-based gases derived from crude oil refining or natural gas fractionation. They include ethane, ethylene, propane, propylene, normal butane, butylene, isobutane, and isobutylene. For convenience of transportation, these gases are liquefied through pressurization.

Lubricants: Substances used to reduce friction between bearing surfaces, or incorporated into other materials used as processing aids in the manufacture of other products, or used as carriers of other materials. Petroleum lubricants may be produced either from distillates or residues. Lubricants include all grades of lubricating oils, from spindle oil to cylinder oil to those used in greases.

Methane: A colorless, flammable, odorless hydrocarbon gas (CH4) which is the major component of natural gas. It is also an important source of hydrogen in various industrial processes. Methane is a greenhouse gas. See also *Greenhouse gases*.

Methanogens: Bacteria that synthesize methane, requiring completely anaerobic conditions for growth.

Methanol: A light alcohol that can be used for gasoline blending. See oxygenate.

Methanotrophs: Bacteria that use methane as food and oxidize it into carbon dioxide.

Methyl chloroform (trichloroethane): An industrial chemical (CH_3CCl_3) used as a solvent, aerosol propellant, and pesticide and for metal degreasing.

Methyl tertiary butyl ether (MTBE): A colorless, flammable, liquid oxygenated hydrocarbon containing 18.15 percent oxygen.

Methylene chloride: A colorless liquid, nonexplosive and practically nonflammable. Used as a refrigerant in centrifugal compressors, a solvent for organic materials, and a component in nonflammable paint removers.

Mole: The quantity of a compound or element that has a weight in grams numerically equal to its molecular weight. Also referred to as gram molecule or gram molecular weight.

Montreal Protocol: The Montreal Protocol on Substances that Deplete the Ozone Layer (1987). An international agreement, signed by most of the industrialized nations, to substantially reduce the use of chlorofluorocarbons (CFCs). Signed in January 1989, the original document called for a 50-percent reduction in CFC use by 1992 relative to 1986 levels. The subsequent London Agreement called for a complete elimination of CFC use by 2000. The Copenhagen Agreement, which called for a complete phaseout by January 1, 1996, was implemented by the U.S. Environmental Protection Agency.

Motor gasoline (finished): A complex mixture of relatively volatile hydrocarbons with or without small quantities of additives, blended to form a fuel suitable for use in spark-ignition engines. Motor gasoline, as defined in ASTM Specification D 4814 or Federal Specification VV-G-1690C, is characterized as having a boiling range of 122 to 158 degrees Fahrenheit at the 10 percent recovery point to 365 to 374 degrees Fahrenheit at the 90 percent recovery point. "Motor Gasoline" includes conventional gasoline; all types of oxygenated gasoline, including gasohol; and reformulated gasoline, but excludes aviation gasoline. Note: Volumetric data on blending components, such as oxygenates, are not counted in data on finished motor gasoline until the blending components are blended into the gasoline.

Multiple cropping: A system of growing several crops on the same field in one year.

Municipal solid waste: Residential solid waste and some nonhazardous commercial, institutional, and industrial wastes.

Naphtha less than 401 degrees Fahrenheit: A naphtha with a boiling range of less than 401 degrees Fahrenheit that is intended for use as a petrochemical feedstock. Also see *Petrochemical feedstocks*.

Naphtha-type jet fuel: A fuel in the heavy naphtha boiling range having an average gravity of 52.8 degrees API, 20 to 90 percent distillation temperatures of 290 degrees to 470 degrees Fahrenheit, and meeting Military Specification MIL-T-5624L (Grade JP-4). It is used primarily for military turbojet and turboprop aircraft engines because it has a lower freeze point than other aviation fuels and meets engine requirements at high altitudes and speeds.

Natural gas: A mixture of hydrocarbons and small quantities of various nonhydrocarbons in the gaseous phase or in solution with crude oil in natural underground reservoirs.

Natural gas liquids (NGLs): Those hydrocarbons in natural gas that are separated as liquids from the gas. Includes natural gas plant liquids and lease condensate.

Natural gas, pipeline quality: A mixture of hydrocarbon compounds existing in the gaseous phase with sufficient energy content, generally above 900 Btu, and a small enough share of impurities for transport through commercial gas pipelines and sale to end-users.

Nitrogen oxides (NO_x): Compounds of nitrogen and oxygen produced by the burning of fossil fuels.

Nitrous oxide (N_2O): A colorless gas, naturally occurring in the atmosphere.

Nonmethane volatile organic compounds (NMVOCs): Organic compounds, other than methane, that participate in atmospheric photochemical reactions.

Octane: A flammable liquid hydrocarbon found in petroleum. Used as a standard to measure the antiknock properties of motor fuel.

Oil reservoir: An underground pool of liquid consisting of hydrocarbons, sulfur, oxygen, and nitrogen trapped within a geological formation and protected from evaporation by the overlying mineral strata.

Organic content: The share of a substance that is of animal or plant origin.

Organic waste: Waste material of animal or plant origin.

Oxidize: To chemically transform a substance by combining it with oxygen.

Oxygenates: Substances which, when added to gasoline, increase the amount of oxygen in that gasoline blend. Ethanol, Methyl Tertiary Butyl Ether (MTBE), Ethyl Tertiary Butyl Ether (ETBE), and methanol are common oxygenates.

Ozone: A molecule made up of three atoms of oxygen. Occurs naturally in the stratosphere and provides a protective layer shielding the Earth from harmful ultraviolet radiation. In the troposphere, it is a chemical oxidant, a greenhouse gas, and a major component of photochemical smog.

Ozone precursors: Chemical compounds, such as carbon monoxide, methane, nonmethane hydrocarbons, and nitrogen oxides, which in the presence of solar radiation react with other chemical compounds to form ozone.

Paraffinic hydrocarbons: Straight-chain hydrocarbon compounds with the general formula C_nH_{2n+2}.

Perfluorocarbons (PFCs): A group of man-made chemicals composed of one or two carbon atoms and four to six fluorine atoms, containing no chlorine. PFCs have no commercial uses and are emitted as a byproduct of aluminum smelting and semiconductor manufacturing. PFCs have very high 100-year Global Warming Potentials and are very long-lived in the atmosphere.

Perfluoromethane: A compound (CF_4) emitted as a byproduct of aluminum smelting.

Petrochemical feedstocks: Chemical feedstocks derived from petroleum principally for the manufacture of chemicals, synthetic rubber, and a variety of plastics.

Petroleum: A broadly defined class of liquid hydrocarbon mixtures. Included are crude oil, lease condensate, unfinished oils, refined products obtained from the processing of crude oil, and natural gas plant liquids. Note: Volumes of finished petroleum products include nonhydrocarbon compounds, such as additives and detergents, after they have been blended into the products.

Petroleum coke: See *Coke (petroleum)*.

Photosynthesis: The manufacture by plants of carbohydrates and oxygen from carbon dioxide and water in the presence of chlorophyll, with sunlight as the energy source. Carbon is sequestered and oxygen and water vapor are released in the process.

Pig iron: Crude, high-carbon iron produced by reduction of iron ore in a blast furnace.

Pipeline, distribution: A pipeline that conveys gas from a transmission pipeline to its ultimate consumer.

Pipeline, gathering: A pipeline that conveys gas from a production well/field to a gas processing plant or transmission pipeline for eventual delivery to end-use consumers.

Pipeline, transmission: A pipeline that conveys gas from a region where it is produced to a region where it is to be distributed.

Planetary albedo: The fraction of incident solar radiation that is reflected by the Earth-atmosphere system and returned to space, mostly by backscatter from clouds in the atmosphere.

Pneumatic device: A device moved or worked by air pressure.

Polystyrene: A polymer of styrene that is a rigid, transparent thermoplastic with good physical and electrical insulating properties, used in molded products, foams, and sheet materials.

Polyvinyl chloride (PVC): A polymer of vinyl chloride. Tasteless. odorless, insoluble in most organic solvents. A member of the family vinyl resin, used in soft flexible films for food packaging and in molded rigid products, such as pipes, fibers, upholstery, and bristles.

Post-mining emissions: Emissions of methane from coal occurring after the coal has been mined, during transport or pulverization.

Radiative forcing: A change in average net radiation at the top of the troposphere (known as the tropopause) because of a change in either incoming solar or exiting infrared radiation. A positive radiative forcing tends on average to warm the earth's surface; a negative radiative forcing on average tends to cool the earth's surface. Greenhouse gases, when emitted into the atmosphere, trap infrared energy radiated from the earth's surface and therefore tend to produce positive radiative forcing. See *Greenhouse gases*.

Radiatively active gases: Gases that absorb incoming solar radiation or outgoing infrared radiation, affecting the vertical temperature profile of the atmosphere. See *Radiative forcing*.

Ratoon crop: A crop cultivated from the shoots of a perennial plant.

Redox potential: A measurement of the state of oxidation of a system.

Reflectivity: The ratio of the energy carried by a wave after reflection from a surface to its energy before reflection.

Reforestation: Replanting of forests on lands that have recently been harvested or otherwise cleared of trees.

Reformulated gasoline: Finished motor gasoline formulated for use in motor vehicles, the composition and properties of which meet the requirements of the reformulated gasoline regulations promulgated by the U.S. Environmental Protection Agency under Section 211(k) of the Clean Air Act. Note: This category includes oxygenated fuels program reformulated gasoline (OPRG) but excludes reformulated gasoline blendstock for oxygenate blending (RBOB).

Renewable energy resources: Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include: biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action.

Residual fuel oil: A general classification for the heavier oils, known as No. 5 and No. 6 fuel oils, that remain after the distillate fuel oils and lighter hydrocarbons are distilled away in refinery operations. It conforms to ASTM Specifications D 396 and D 975 and Federal Specification VV-F-815C. No. 5, a residual fuel oil of medium viscosity, is also known as Navy Special and is defined in Military Specification MIL-F-859E, including Amendment 2 (NATO Symbol F-770). It is used in steam-powered vessels in government service and inshore powerplants. No. 6 fuel oil includes Bunker C fuel oil and is used for the production of electric power, space heating, vessel bunkering, and various industrial purposes.

Rumen: The large first compartment of the stomach of certain animals in which cellulose is broken down by the action of bacteria.

Sample: A set of measurements or outcomes selected from a given population.

Sequestration: See *Carbon sequestration*.

Septic tank: A tank in which the solid matter of continuously flowing sewage is disintegrated by bacteria.

Sinter: A chemical sedimentary rock deposited by precipitation from mineral waters, especially siliceous sinter and calcareous sinter.

Sodium silicate: A grey-white powder soluble in alkali and water, insoluble in alcohol and acid. Used to fireproof textiles, in petroleum refining and corrugated paperboard manufacture, and as an egg preservative. Also referred to as liquid gas, silicate of soda, sodium metasilicate, soluble glass, and water glass.

Sodium tripolyphosphate: A white powder used for water softening and as a food additive and texturizer.

Stabilization lagoon: A shallow artificial pond used for the treatment of wastewater. Treatment includes removal of solid material through sedimentation, the decomposition of organic material by bacteria, and the removal of nutrients by algae.

Still gas (refinery gas): Any form or mixture of gases produced in refineries by distillation, cracking, reforming, and other processes. The principal constituents are methane, ethane, ethylene, normal butane, butylene, propane, propylene, etc. Still gas is used as a refinery fuel and a petrochemical feedstock. The conversion factor is 6 million Btu per fuel oil equivalent barrel.

Stratosphere: The region of the upper atmosphere extending from the tropopause (8 to 15 kilometers altitude) to about 50 kilometers. Its thermal structure, which is determined by its radiation balance, is generally very stable with low humidity.

Stripper well: An oil or gas well that produces at relatively low rates. For oil, stripper production is usually defined as production rates of between 5 and 15 barrels of oil per day. Stripper gas production would generally be anything less than 60 thousand cubic feet per day.

Styrene: A colorless, toxic liquid with a strong aromatic aroma. Insoluble in water, soluble in alcohol and ether; polymerizes rapidly; can become explosive. Used to make polymers and copolymers, polystyrene plastics, and rubber.

Subbituminous coal: A coal whose properties range from those of lignite to those of bituminous coal and used primarily as fuel for steam-electric power generation. It may be dull, dark brown to black, soft and crumbly, at the lower end of the range, to bright, jet black, hard, and relatively strong, at the upper end. Subbituminous coal contains 20 to 30 percent inherent moisture by weight. The heat content of subbituminous coal ranges from 17 to 24 million Btu per ton on a moist, mineral-matter-free basis. The heat content of subbituminous coal consumed in the United States averages 17 to 18 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter).

Sulfur dioxide (SO_2): A toxic, irritating, colorless gas soluble in water, alcohol, and ether. Used as a chemical intermediate, in paper pulping and ore refining, and as a solvent.

Sulfur hexafluoride (SF_6): A colorless gas soluble in alcohol and ether, and slightly less soluble in water. It is used as a dielectric in electronics.

Sulfur oxides (SO_x): Compounds containing sulfur and oxygen, such as sulfur dioxide (SO_2) and sulfur trioxide (SO_3).

Tertiary amyl methyl ether ($(CH_3)_2(C_2H_5)COCH_3$): An oxygenate blend stock formed by the catalytic etherification of isoamylene with methanol.

Troposphere: The inner layer of the atmosphere below about 15 kilometers, within which there is normally a steady decrease of temperature with increasing altitude. Nearly all clouds form and weather conditions manifest themselves within this region. Its thermal structure is caused primarily by the heating of the earth's surface by solar radiation, followed by heat transfer through turbulent mixing and convection.

Uncertainty: A measure used to quantify the plausible maximum and minimum values for emissions from any source, given the biases inherent in the methods used to calculate a point estimate and known sources of error.

Vapor displacement: The release of vapors that had previously occupied space above liquid fuels stored in tanks. These releases occur when tanks are emptied and filled.

Ventilation system: A method for reducing methane concentrations in coal mines to non-explosive levels by blowing air across the mine face and using large exhaust fans to remove methane while mining operations proceed.

Vessel bunkering: Includes sales for the fueling of commercial or private boats, such as pleasure craft, fishing boats, tugboats, and ocean-going vessels, including vessels operated by oil companies. Excluded are volumes sold to the U.S. Armed Forces.

Volatile organic compounds (VOCs): Organic compounds that participate in atmospheric photochemical reactions.

Volatile solids: A solid material that is readily decomposable at relatively low temperatures.

Waste flow: Quantity of a waste stream generated by an activity.

Wastewater: Water that has been used and contains dissolved or suspended waste materials.

Wastewater, domestic and commercial: Wastewater (sewage) produced by domestic and commercial establishments.

Wastewater, industrial: Wastewater produced by industrial processes.

Water vapor: Water in a vaporous form, especially when below boiling temperature and diffused (e.g., in the atmosphere).

Wax: A solid or semi-solid material derived from petroleum distillates or residues by such treatments as chilling, precipitating with a solvent, or de-oiling. It is a light-colored, more-or-less translucent crystalline mass, slightly greasy to the touch, consisting of a mixture of solid hydrocarbons in which the paraffin series predominates. Includes all marketable wax, whether crude scale or fully refined. The three grades included are microcrystalline, crystalline-fully refined, and crystalline-other. The conversion factor is 280 pounds per 42 U.S. gallons per barrel.

Weanling system: A cattle management system that places calves on feed starting at 165 days of age and continues until the animals have reached slaughter weight.

Wellhead: The point at which the crude (and/or natural gas) exits the ground. Following historical precedent, the volume and price for crude oil production are labeled as "wellhead," even though the cost and volume are now generally measured at the lease boundary. In the context of domestic crude price data, the term "wellhead" is the generic term used to reference the production site or lease property.

Wetlands: Areas regularly saturated by surface or groundwater and subsequently characterized by a prevalence of vegetation adapted for life in saturated-soil conditions.

Wood energy: Wood and wood products used as fuel, including roundwood (cordwood), limbwood, wood chips, bark, sawdust, forest residues, charcoal, pulp waste, and spent pulping liquor..

Yearling system: A cattle management system that includes a stocker period from 165 days of age to 425 days of age followed by a 140-day feedlot period.