

Emissions of Greenhouse Gases Report

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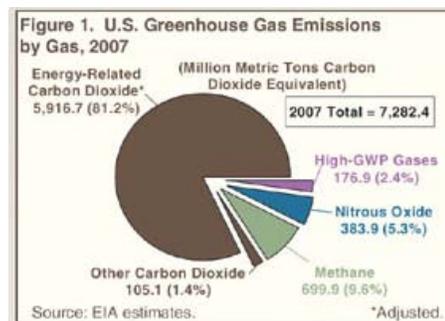
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Total Emissions

- 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 (MMT_{CO₂e}) in 2006 to **7,282.4 MMT_{CO₂e}** in 2007—was largely the result of a **75.9-MMT_{CO₂e}** increase in carbon dioxide (CO₂) 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 MMT_{CO₂e}** for methane (CH₄), **8.2 MMT_{CO₂e}** for nitrous oxide, and **5.6 MMT_{CO₂e}** for the man-made gases with high global warming potentials (high-GWP gases) (Table 1 below).
- 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 MMT_{CO₂e} in 2007 (Figure 1 at right), up by 13.0 MMT_{CO₂e} from 2006, with increases in emissions from energy sources, waste management, and agriculture.
- U.S. emissions of high-GWP gases, which totaled 176.9 MMT_{CO₂e} in 2007, were 5.6 MMT_{CO₂e} above the 2006 total. The increase resulted mainly from higher emissions levels for hydrofluorocarbons (HFCs, up by 4.1 MMT_{CO₂e}) and perfluorocarbons (PFCs, up by 2.0 MMT_{CO₂e}). Emissions of sulfur hexafluoride (SF₆) were down by 0.5 MMT_{CO₂e}.



[figure data](#) 

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

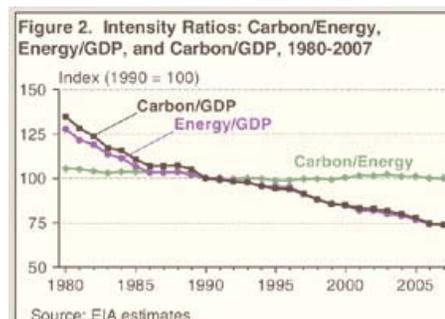
^aHydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆).
P = preliminary data.
Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*. DOE/EIA-0573(2006) (Washington, DC, November 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.

[Data for all years 1990-2007](#) 

	1990	2006	2007
Estimated Emissions (Million Metric Tons CO ₂ e)	6,241.8	7,179.7	7,282.4
Change from 1990 (Million Metric Tons CO ₂ e)		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 ₂ e)			102.7
(Percent)			1.4%

Greenhouse Gas Intensity

- From 2006 to 2007, the greenhouse gas intensity of the U.S. economy—measured as metric tons carbon dioxide equivalent (MTCO₂e) 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 below).
- 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 at right.



	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 (MMT _{CO₂e})	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 ₂ e 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

^aThe 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.

[Data for all years 1990-2007](#) 

	1990	2006	2007
Estimated Intensity (MTCO ₂ e/GDP*)	877.6	635.7	631.9
Change from 1990 (MTCO ₂ e/GDP*)		-241.9	-245.6
(Percent)		-27.6%	-28.0%
Average Annual Change from 1990 (Percent)		-2.0%	-1.9%
Change from 2006 (MTCO ₂ e/GDP*)			-3.7
(Percent)			-0.6%

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

Greenhouse Gas Emissions in the U.S. Economy

The diagram on the right 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 CO₂ 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 CO₂ 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).

CO₂. CO₂ emission sources include energy-related emissions (primarily from fossil fuel combustion) and emissions from industrial processes. The energy subtotal (5,991 MMTCO₂e) 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 MMTCO₂e) 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 CO₂ emissions (6,096 MMTCO₂e). The energy component of unadjusted emissions can be divided into direct fuel use (3,557 MMTCO₂e) and fuel converted to electricity (2,433 MMTCO₂e).

Non-CO₂ Gases. Methane (700 MMTCO₂e) and nitrous oxide (384 MMTCO₂e) sources include emissions related to energy, agriculture, waste management, and industrial processes. Other, high-GWP gases (177 MMTCO₂e) include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆). 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.

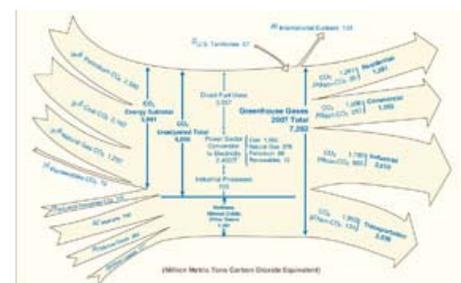
Adjustments. In keeping with the UNFCCC, CO₂ emissions from U.S. Territories (57 MMTCO₂e) are added to the U.S. total, and CO₂ emissions from fuels used for international transport (both oceangoing vessels and airplanes) (131 MMTCO₂e) are subtracted to derive total U.S. greenhouse gas emissions (7,282 MMTCO₂e).

Emissions by End-Use Sector. CO₂ 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. CO₂ emissions from purchased electricity are allocated to the end-use sectors based on their shares of total electricity sales. Non-CO₂ 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 MMTCO₂e) include energy-related CO₂ emissions (1,261 MMTCO₂e); and non-CO₂ emissions (20 MMTCO₂e). The non-CO₂ sources include direct methane and nitrous oxide emissions from direct fuel use. Non-CO₂ indirect emissions attributable to purchased electricity, including methane and nitrous oxide emissions from electric power generation and SF₆ emissions related to electricity transmission and distribution, are also included.

Emissions in the commercial sector (1,355 MMTCO₂e) include both energy-related CO₂ emissions (1,098 MMTCO₂e) and non-CO₂ emissions (257 MMTCO₂e). The non-CO₂ emissions include direct emissions from landfills, wastewater treatment plants, commercial refrigerants, and stationary combustion emissions of methane and nitrous oxide. Non-CO₂ indirect emissions attributable to purchased electricity, including methane and nitrous oxide emissions from electric power generation and SF₆ emissions related to electricity transmission and distribution, are also included.

Industrial emissions (2,610 MMTCO₂e) include CO₂ emissions (1,760 MMTCO₂e)—which can be broken down between combustion (1,655 MMTCO₂e) and process emissions (105 MMTCO₂e)—and non-CO₂ emissions (850 MMTCO₂e). The non-CO₂ direct emissions include emissions from agriculture (methane and nitrous oxide), coal mines (methane), petroleum and natural gas pipelines (methane), industrial process emissions (methane, nitrous



[Click Chart to Enlarge](#)

oxide, HFCs, PFCs and SF₆), and direct stationary combustion emissions of methane and nitrous oxide. Non-CO₂ indirect emissions attributable to purchased electricity, including methane and nitrous oxide emissions from electric power generation and SF₆ emissions related to electricity transmission and distribution, are also included.

Transportation emissions (2,036 MMTCO₂e) include energy-related CO₂ emissions from mobile source combustion (1,902 MMTCO₂e); and non-CO₂ emissions (134 MMTCO₂e). The non-CO₂ 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.

Distribution of Total U.S. Greenhouse Gas Emissions by End-Use Sector, 2007					
Greenhouse Gas and Source	Sector				
	Residential	Commercial	Industrial	Transportation	Total
Carbon Dioxide					
Million Metric Tons Carbon Dioxide Equivalent					
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 CO₂	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 ₂ F ₆	—	—	4.2	—	4.2
NF ₃ , C ₃ F ₈ , and C ₄ F 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 (SF₆)					
SF ₆ : Utility.....	4.6	4.4	3.4	—	12.3
SF ₆ : Other.....	—	—	3.4	—	3.4
Total SF₆	4.6	4.4	6.8	0.0	15.8
Total Non-CO₂	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

U.S. Emissions in a Global Perspective

- 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 below).
- 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 at right).
- 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 at right).
- 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.

	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*.

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 ^b					Average Annual Percent Change, 2005-2030 ^c
	1990	2004	2005	2010	2015	2020	2025	2030	
OECD									
OECD North America	5,754 (27.1%)	6,959 (25.7%)	7,008 (25.0%)	7,109 (22.9%)	7,408 (21.6%)	7,653 (20.7%)	7,928 (20.0%)	8,300 (19.6%)	0.7 (9.1%)
United States ^d	4,989 (23.5%)	5,957 (22.0%)	5,982 (21.3%)	6,011 (19.3%)	6,226 (18.1%)	6,384 (17.2%)	6,571 (16.6%)	6,851 (16.2%)	0.5 (6.1%)
Canada	465 (2.2%)	623 (2.3%)	628 (2.2%)	669 (2.2%)	698 (2.0%)	727 (2.0%)	756 (1.9%)	784 (1.9%)	0.9 (1.1%)
Mexico	300 (1.4%)	379 (1.4%)	398 (1.4%)	430 (1.4%)	484 (1.4%)	542 (1.5%)	601 (1.5%)	665 (1.6%)	2.1 (1.9%)
OECD Europe	4,101 (19.3%)	4,373 (16.2%)	4,383 (15.6%)	4,512 (14.5%)	4,678 (13.6%)	4,760 (12.9%)	4,800 (12.1%)	4,834 (11.4%)	0.4 (3.2%)
OECD Asia	1,541 (7.3%)	2,148 (7.9%)	2,174 (7.8%)	2,208 (7.1%)	2,287 (6.7%)	2,322 (6.3%)	2,357 (6.0%)	2,403 (5.7%)	0.4 (1.6%)
Japan	1,009 (4.8%)	1,242 (4.6%)	1,230 (4.4%)	1,196 (3.8%)	1,201 (3.5%)	1,195 (3.2%)	1,184 (3.0%)	1,170 (2.8%)	-0.2 (-0.4%)
South Korea	241 (1.1%)	488 (1.8%)	500 (1.8%)	559 (1.8%)	612 (1.8%)	632 (1.7%)	656 (1.7%)	693 (1.6%)	1.3 (1.4%)
Australia/New Zealand	291 (1.4%)	418 (1.5%)	444 (1.6%)	454 (1.5%)	474 (1.4%)	495 (1.3%)	517 (1.3%)	540 (1.3%)	0.8 (0.7%)
Total OECD	11,396 (53.7%)	13,480 (49.8%)	13,565 (48.4%)	13,829 (44.5%)	14,373 (41.9%)	14,736 (39.8%)	15,085 (38.1%)	15,538 (36.7%)	0.5 (13.8%)
Non-OECD									
Non-OECD Europe and Eurasia	4,198 (19.8%)	2,797 (10.3%)	2,865 (10.2%)	3,056 (9.9%)	3,330 (9.7%)	3,508 (9.5%)	3,625 (9.2%)	3,811 (9.0%)	1.1 (6.6%)
Russia	2,376 (11.2%)	1,669 (6.2%)	1,696 (6.0%)	1,789 (5.8%)	1,902 (5.5%)	1,984 (5.4%)	2,020 (5.1%)	2,117 (5.0%)	0.9 (2.9%)
Other	1,822 (8.6%)	1,128 (4.2%)	1,169 (4.2%)	1,278 (4.1%)	1,428 (4.2%)	1,524 (4.1%)	1,606 (4.1%)	1,694 (4.0%)	1.5 (3.7%)
Non-OECD Asia	3,613 (17.0%)	7,517 (27.8%)	8,177 (29.2%)	10,185 (32.7%)	12,157 (35.4%)	13,907 (37.6%)	15,683 (39.6%)	17,482 (41.3%)	3.1 (65.2%)
China	2,241 (10.6%)	4,753 (17.6%)	5,323 (19.0%)	6,898 (22.2%)	8,214 (23.9%)	9,475 (25.6%)	10,747 (27.1%)	12,007 (28.4%)	3.3 (46.8%)
India	565 (2.7%)	1,127 (4.2%)	1,164 (4.1%)	1,349 (4.3%)	1,604 (4.7%)	1,818 (4.9%)	2,019 (5.1%)	2,238 (5.3%)	2.6 (7.5%)
Other Non-OECD Asia	807 (3.8%)	1,637 (6.0%)	1,690 (6.0%)	1,938 (6.2%)	2,338 (6.8%)	2,614 (7.1%)	2,917 (7.4%)	3,237 (7.6%)	2.6 (10.8%)
Middle East	700 (3.3%)	1,290 (4.8%)	1,400 (5.0%)	1,622 (5.2%)	1,802 (5.2%)	1,988 (5.4%)	2,120 (5.4%)	2,250 (5.3%)	1.9 (6.0%)
Africa	649 (3.1%)	943 (3.5%)	966 (3.4%)	1,090 (3.5%)	1,244 (3.6%)	1,366 (3.7%)	1,450 (3.7%)	1,515 (3.6%)	1.8 (3.8%)
Central and South America	669 (3.2%)	1,042 (3.8%)	1,078 (3.8%)	1,308 (4.2%)	1,429 (4.2%)	1,531 (4.1%)	1,628 (4.1%)	1,729 (4.1%)	1.9 (4.6%)
Brazil	216 (1.0%)	350 (1.3%)	356 (1.3%)	451 (1.5%)	498 (1.5%)	541 (1.5%)	582 (1.5%)	633 (1.5%)	2.3 (1.9%)
Other Central/South America	453 (2.1%)	692 (2.6%)	722 (2.6%)	857 (2.8%)	931 (2.7%)	990 (2.7%)	1,046 (2.6%)	1,097 (2.6%)	1.7 (2.6%)
Total Non-OECD	9,830 (46.3%)	13,589 (50.2%)	14,486 (51.6%)	17,271 (55.5%)	19,962 (58.1%)	22,299 (60.2%)	24,506 (61.9%)	26,787 (63.3%)	2.5 (86.2%)
Total World	21,226	27,070	28,051	31,100	34,335	37,035	39,591	42,325	1.7

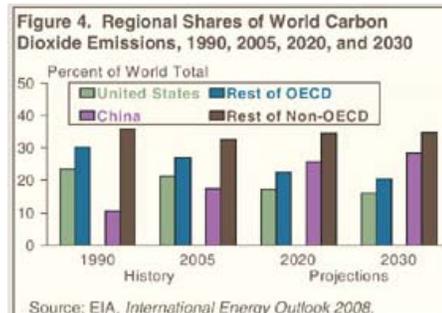
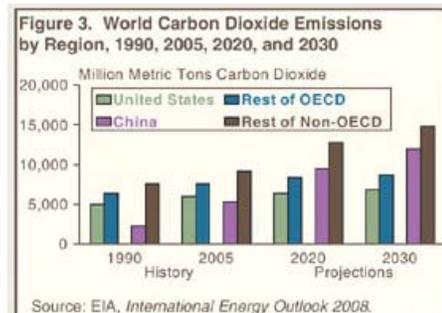
^aValues adjusted for nonfuel sequestration.

^bValues in parentheses indicate percent share of total world absolute change.

^cIncludes 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.



No data for all years

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.
- 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

In December 2007, the Thirteenth Conference of the Parties to the United Nations 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.

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 below summarizes the GWP values from the Second, Third, and fourth Assessment Reports.

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 ₂ O	310	296	298
Hydrofluorocarbons				
HFC-23 (Trifluoromethane)	CHF ₃	11,700	12,000	14,800
HFC-32 (Difluoromethane)	CH ₂ F ₂	650	550	675
HFC-41 (Monofluoromethane)	CH ₃ F	150	97	—
HFC-125 (Pentafluoroethane)	CHF ₂ CF ₃	2,800	3,400	3,500
HFC-134 (1,1,2,2-Tetrafluoroethane)	CHF ₂ CHF ₂	1,000	1,100	—
HFC-134a (1,1,1,2-Tetrafluoroethane)	CH ₂ FCF ₃	1,300	1,300	1,430
HFC-143 (1,1,2-Trifluoroethane)	CHF ₂ CH ₂ F	300	330	—
HFC-143a (1,1,1-Trifluoroethane)	CF ₃ CH ₃	3,800	4,300	4,470
HFC-152 (1,2-Difluoroethane)	CH ₂ FCH ₂ F	—	43	—
HFC-152a (1,1-Difluoroethane)	CH ₃ CHF ₂	140	120	124
HFC-161 (Ethyl Fluoride)	CH ₃ CH ₂ F	—	12	—
HFC-227ea (Heptafluoropropane)	CF ₃ CHFCF ₃	2,900	3,500	3,220
HFC-236cb (1,1,1,2,2,3-Hexafluoropropane)	CH ₂ FCF ₂ CF ₃	—	1,300	—
HFC-236ea (1,1,1,2,3,3-Hexafluoropropane)	CHF ₂ CHFCF ₃	—	1,200	—
HFC-236fa (1,1,1,3,3,3-Hexafluoropropane)	CF ₃ CH ₂ CF ₃	6,300	9,400	9,810
HFC-245ca (1,1,2,2,3-Pentafluoropropane)	CH ₂ FCF ₂ CHF ₂	560	640	—
HFC-245fa (1,1,1,3,3,3-Pentafluoropropane)	CHF ₂ CH ₂ CF ₃	—	950	1,030
HFC-365mc (Pentafluorobutane)	CF ₃ CH ₂ CF ₂ CH ₃	—	890	794
HFC-43-10mee (Decafluoropentane)	CF ₃ CHFCF ₂ CF ₃	1,300	1,500	1,640
Perfluorocarbons				
Perfluoromethane	CF ₄	6,500	5,700	7,390
Perfluoroethane	C ₂ F ₆	9,200	11,900	12,200
Perfluoropropane	C ₃ F ₈	7,000	8,600	8,830
Perfluorobutane (FC 3-1-10)	C ₄ F ₁₀	7,000	8,600	8,860
Perfluorocyclobutane	c-C ₄ F ₈	8,700	10,000	10,300
Perfluoropentane	C ₅ F ₁₂	7,500	8,900	9,160
Perfluorohexane (FC 5-1-14)	C ₆ F ₁₄	7,400	9,000	9,300
Sulfur Hexafluoride	SF ₆	23,900	22,200	22,800

Sources: ^aIntergovernmental Panel on Climate Change, *Climate Change 1995: The Science of Climate Change* (Cambridge, UK: Cambridge University Press, 1996). ^bIntergovernmental 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. ^cIntergovernmental 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 Report⁵ 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.

Notes and Sources

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