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INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990 – 2007

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greenhouse gas to trap heat in the atmosphere relative to another gas.

The GWP of a greenhouse gas is defined as the ratio of the time-integrated radiative forcing from the instantaneous release of 1 kilogram (kg) of a trace substance relative to that of 1 kg of a reference gas (IPCC 2001). Direct radiative effects occur when the gas itself is a greenhouse gas. The reference gas used is CO_2, and therefore GWP-weighted emissions are measured in teragrams (or million metric tons) of CO_2 equivalent (Tg CO_2 Eq.).[7,8] All gases in this Executive Summary are presented in units of Tg CO_2 Eq.

The UNFCCC reporting guidelines for national inventories were updated in 2006,[9] but continue to require the use of GWPs from the IPCC Second Assessment Report (SAR) (IPCC 1996). This requirement ensures that current estimates of aggregate greenhouse gas emissions for 1990 to 2007 are consistent with estimates developed prior to the publication of the IPCC Third Assessment Report (TAR) and the IPCC Fourth Assessment Report (AR4). Therefore, to comply with international reporting standards under the UNFCCC, official emission estimates are reported by the United States using SAR GWP values. All estimates are provided throughout the report in both CO_2 equivalents and unweighted units. A comparison of emission values using the SAR GWPs versus the TAR and AR4 GWPs can be found in Chapter 1 and, in more detail, in Annex 6.1 of this report. The GWP values used in this report are listed below in Table ES-1.

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

Gas	GWP
CO_2	1
CH_4*	21
N_2O	310
HFC-23	11,700
HFC-32	650
HFC-125	2,800
HFC-134a	1,300
HFC-143a	3,800
HFC-152a	140
HFC-227ea	2,900
HFC-236fa	6,300
HFC-4310mee	1,300
CF_4	6,500
C_2F_6	9,200
C_4F_{10}	7,000
C_6F_{14}	7,400
SF_6	23,900

Source: IPCC (1996)
* The CH_4 GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO_2 is not included.

Global warming potentials are not provided for CO, NO_x, NMVOCs, SO_2, and aerosols because there is no agreed-upon method to estimate the contribution of gases that are short-lived in the atmosphere, spatially variable, or have only indirect effects on radiative forcing (IPCC 1996).

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

In 2007, total U.S. greenhouse gas emissions were 7,150.1 Tg CO_2 Eq. Overall, total U.S. emissions have risen by 17 percent from 1990 to 2007. Emissions rose from 2006 to 2007, increasing by 1.4 percent (99.0 Tg CO_2 Eq.). The following factors were primary contributors to this increase: (1) cooler winter and warmer summer conditions in 2007 than in 2006 increased the demand for heating fuels and contributed to the increase in the demand for electricity, (2) increased consumption of fossil fuels to generate electricity and (3) a significant decrease (14.2

[7] Carbon comprises 12/44^{ths} of carbon dioxide by weight.
[8] One teragram is equal to 10^{12} grams or one million metric tons.
[9] See <http://unfccc.int/resource/docs/2006/sbsta/eng/09.pdf>.

land to agricultural or urban use) or can act as a sink for CO_2 (e.g., through net additions to forest biomass).

Figure ES- 5: 2007 Sources of CO_2 Emissions

As the largest source of U.S. greenhouse gas emissions, CO_2 from fossil fuel combustion has accounted for approximately 79 percent of GWP-weighted emissions since 1990, growing slowly from 77 percent of total GWP-weighted emissions in 1990 to 80 percent in 2007. Emissions of CO_2 from fossil fuel combustion increased at an average annual rate of 1.3 percent from 1990 to 2007. The fundamental factors influencing this trend include (1) a generally growing domestic economy over the last 17 years, and (2) significant overall growth in emissions from electricity generation and transportation activities. Between 1990 and 2007, CO_2 emissions from fossil fuel combustion increased from 4,708.9 Tg CO_2 Eq. to 5,735.8 Tg CO_2 Eq. —a 21.8 percent total increase over the eighteen-year period. From 2006 to 2007, these emissions increased by 100.4 Tg CO_2 Eq. (1.8 percent).

Historically, changes in emissions from fossil fuel combustion have been the dominant factor affecting U.S. emission trends. Changes in CO_2 emissions from fossil fuel combustion are influenced by many long-term and short-term factors, including population and economic growth, energy price fluctuations, technological changes, and seasonal temperatures. On an annual basis, the overall consumption of fossil fuels in the United States generally fluctuates in response to changes in general economic conditions, energy prices, weather, and the availability of non-fossil alternatives. For example, in a year with increased consumption of goods and services, low fuel prices, severe summer and winter weather conditions, nuclear plant closures, and lower precipitation feeding hydroelectric dams, there would likely be proportionally greater fossil fuel consumption than a year with poor economic performance, high fuel prices, mild temperatures, and increased output from nuclear and hydroelectric plants.

Figure ES- 6: 2007 CO_2 Emissions from Fossil Fuel Combustion by Sector and Fuel Type

Figure ES- 7: 2007 End-Use Sector Emissions of CO_2, CH_4, and N_2O from Fossil Fuel Combustion

The five major fuel consuming sectors contributing to CO_2 emissions from fossil fuel combustion are electricity generation, transportation, industrial, residential, and commercial. CO_2 emissions are produced by the electricity generation sector as they consume fossil fuel to provide electricity to one of the other four sectors, or "end-use" sectors. For the discussion below, electricity generation emissions have been distributed to each end-use sector on the basis of each sector's share of aggregate electricity consumption. This method of distributing emissions assumes that each end-use sector consumes electricity that is generated from the national average mix of fuels according to their carbon intensity. Emissions from electricity generation are also addressed separately after the end-use sectors have been discussed.

Note that emissions from U.S. territories are calculated separately due to a lack of specific consumption data for the individual end-use sectors.

Figure ES- 6, Figure ES- 7, and Table ES-3 summarize CO_2 emissions from fossil fuel combustion by end-use sector.

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

End-Use Sector	1990	1995	2000	2005	2006	2007
Transportation	**1,487.5**	**1,601.7**	**1,803.7**	**1,886.2**	**1,885.4**	**1,892.2**
Combustion	1,484.5	1,598.7	1,800.3	1,881.5	1,880.9	1,887.4
Electricity	3.0	3.0	3.4	4.7	4.5	4.8
Industrial	**1,516.8**	**1,575.5**	**1,629.6**	**1,558.5**	**1,550.7**	**1,553.4**
Combustion	834.2	862.6	844.6	828.0	844.5	845.4
Electricity	682.6	712.9	785.0	730.5	706.2	708.0
Residential	**927.1**	**993.3**	**1,128.2**	**1,207.2**	**1,145.9**	**1,198.0**
Combustion	337.7	354.4	370.4	358.0	321.9	340.6

per kilogram of HCFC-22 manufactured) and the use of thermal oxidation at some plants to reduce HFC-23 emissions.

- SF_6 emissions from electric power transmission and distribution systems decreased by 53 percent (14.1 Tg CO_2 Eq.) from 1990 to 2007, primarily because of higher purchase prices for SF_6 and efforts by industry to reduce emissions.
- PFC emissions from aluminum production decreased by 79 percent (14.7 Tg CO_2 Eq.) from 1990 to 2007, due to both industry emission reduction efforts and lower domestic aluminum production.

Overview of Sector Emissions and Trends

In accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC/UNEP/OECD/IEA 1997), and the 2003 UNFCCC Guidelines on Reporting and Review (UNFCCC 2003), Figure ES-11 and Table ES-4 aggregate emissions and sinks by these chapters. Emissions of all gases can be summed from each source category from Intergovernmental Panel on Climate Change (IPCC) guidance. Over the eighteen-year period of 1990 to 2007, total emissions in the Energy, Industrial Processes, and Agriculture sectors climbed by 976.7 Tg CO_2 Eq. (19 percent), 28.5 Tg CO_2 Eq. (9 percent), and 28.9 Tg CO_2 Eq. (8 percent), respectively. Emissions decreased in the Waste and Solvent and Other Product Use sectors by 11.5 Tg CO_2 Eq. (6 percent) and less than 0.1 Tg CO_2 Eq. (0.4 percent), respectively. Over the same period, estimates of net C sequestration in the Land Use, Land-Use Change, and Forestry sector increased by 192.5 Tg CO_2 Eq. (23 percent).

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

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

Chapter/IPCC Sector	**1990**	**1995**	**2000**	**2005**	**2006**	**2007**
Energy	5,193.6	5,520.1	6,059.9	6,169.2	6,084.4	6,170.3
Industrial Processes	325.2	345.8	356.3	337.6	343.9	353.8
Solvent and Other Product Use	4.4	4.6	4.9	4.4	4.4	4.4
Agriculture	384.2	402.0	399.4	410.8	410.3	413.1
Land Use, Land-Use Change, and Forestry (Emissions)	14.2	16.2	33.0	26.4	45.1	42.9
Waste	177.1	174.7	154.6	160.2	163.0	165.6
Total Emissions	**6,098.7**	**6,463.3**	**7,008.2**	**7,108.6**	**7,051.1**	**7,150.1**
Net CO_2 Flux from Land Use, Land-Use Change, and Forestry (Sinks)*	(841.4)	(851.0)	(717.5)	(1,122.7)	(1,050.5)	(1,062.6)
Net Emissions (Sources and Sinks)	**5,257.3**	**5,612.3**	**6,290.7**	**5,985.9**	**6,000.6**	**6,087.5**

* The net CO_2 flux total includes both emissions and sequestration, and constitutes a sink in the United States. Sinks are only included in net emissions total.
Note: Totals may not sum due to independent rounding. Parentheses indicate negative values or sequestration.

Energy

The Energy chapter contains emissions of all greenhouse gases resulting from stationary and mobile energy activities including fuel combustion and fugitive fuel emissions. Energy-related activities, primarily fossil fuel combustion, accounted for the vast majority of U.S. CO_2 emissions for the period of 1990 through 2007. In 2007, approximately 85 percent of the energy consumed in the United States (on a Btu basis) was produced through the combustion of fossil fuels. The remaining 15 percent came from other energy sources such as hydropower, biomass, nuclear, wind, and solar energy (see Figure ES-12). Energy-related activities are also responsible for CH_4 and N_2O emissions (35 percent and 14 percent of total U.S. emissions of each gas, respectively). Overall, emission sources in the Energy chapter account for a combined 86.3 percent of total U.S. greenhouse gas emissions in 2007.

Figure ES-12: 2007 U.S. Energy Consumption by Energy Source