

2. Carbon Dioxide Emissions

Overview

U.S. Anthropogenic Carbon Dioxide Emissions, 1990-2003		
	Carbon Dioxide	Carbon Equivalent
Estimated 2003 Emissions (Million Metric Tons)	5,870.2	1,601.0
Change Compared to 2002 (Million Metric Tons)	45.5	12.4
Change from 2002 (Percent)	0.8%	0.8%
Change Compared to 1990 (Million Metric Tons)	880.1	240.0
Change from 1990 (Percent)	17.6%	17.6%
Average Annual Increase, 1990-2003 (Percent)	1.3%	1.3%

Total emissions of carbon dioxide in the United States and its territories were 5,870.2 million metric tons in 2003, 45.5 million metric tons (0.8 percent) more than the 2002 total (Table 5). The increase in emissions from 2002 to 2003 can be attributed in large part to an increase in overall U.S. economic growth in 2003, and colder winter weather that increased the demand for heating fuels. The increase in emissions from 2002 to 2003 followed the same percentage increase of 0.8 percent, or 47.8 million metric tons, from 2001 to 2002 (Figure 1). Since 1990, total U.S. carbon dioxide emissions have increased by an average of about 1.3 percent per year.

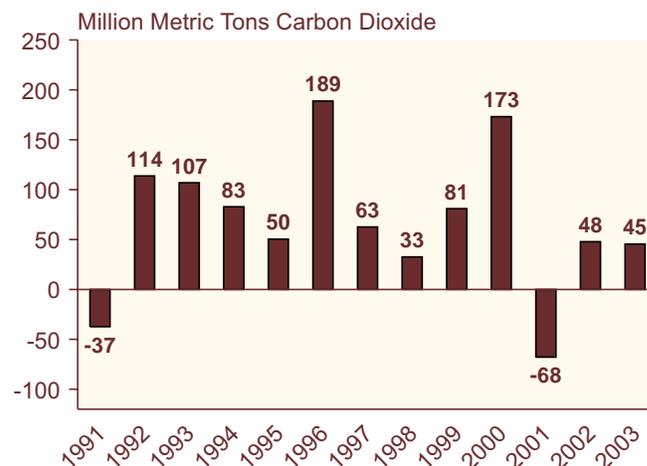
In the United States, most carbon dioxide (98 percent) is emitted as the result of the combustion of fossil fuels; consequently, carbon dioxide emissions and energy use are highly correlated. Historically, economic growth, the weather, the carbon and energy intensity of the economy, and movements in energy prices have caused year-to-year fluctuations in energy consumption and resulting carbon dioxide emissions. Annual economic growth in 2003 (3.0 percent) was higher than in 2002 (1.9 percent). In addition, there was a colder winter in 2003 than in 2002, with heating degree-days up 4 percent. The colder winter led to increased demand for heating fuels, such as natural gas and distillate fuel.

The increased demand for natural gas as a heating fuel can be seen in the residential and commercial sectors (Tables 7 and 8), where energy consumption is dominated by electricity use for air conditioning during the summer and fuel use for heating during the winter. In the residential sector (Table 7), emissions of carbon dioxide increased by 1.7 percent, from 1,193.9 million metric tons of carbon dioxide in 2002 to 1,214.8 million metric tons in 2003. In the commercial sector (Table 8), carbon dioxide emissions increased by 0.6 percent (from 1,019.8 million metric tons in 2002 to 1,025.7 million metric tons in 2003).

Industrial production rose by 0.2 percent in 2003, although industrial emissions of carbon dioxide fell by 0.3 percent, from 1,671.5 million metric tons in 2002 to 1,666.2 million metric tons in 2003 (Table 9). Trends in industrial emissions are driven in part by growth patterns in the six most energy-intensive manufacturing industries, which account for about two-thirds of total industrial emissions of carbon dioxide. In 2003, three of those manufacturing industries (primary metals, food, and chemicals) had declines in output compared with 2002 (2.3 percent, 3.6 percent, and 1.5 percent, respectively). Output from the three other energy-intensive industries increased: paper by 5.1 percent, nonmetallic minerals by 0.9 percent, and petroleum refining by 1.5 percent.

Estimates for 2003 indicate that carbon dioxide emissions in the transportation sector (Table 10) increased by

Figure 1. Annual Change in U.S. Carbon Dioxide Emissions, 1990-2003



Source: Estimates presented in this chapter.

0.5 percent, from 1,866.0 million metric tons in 2002 to 1,874.7 million metric tons in 2003. This is the lowest growth rate in transportation-sector emissions of carbon dioxide during the 1990 to 2003 time period, except for 1991 and 2001 when those emissions actually declined.

Net generation of electricity increased by 0.6 percent from 2002 to 2003, although carbon dioxide emissions from the electric power sector increased by 1.0 percent, from 2,256.4 million metric tons in 2002 to 2,279.3 million metric tons in 2003 (Table 11). Accordingly, the overall carbon intensity of U.S. electricity production rose by 0.4 percent. The rise in carbon intensity was driven by the increased utilization of coal as a fuel to generate electricity, and coal has a higher carbon content than the natural gas fuel it displaced. This displacement of natural gas by coal can be attributed to the increased price of natural gas compared with the price of coal.

In this report, the electric power sector is defined as all utilities, nonutilities, and combined heat and power (CHP) facilities whose primary business is the production of electric power. Carbon dioxide emissions from generators that produce electric power as part of an industrial or commercial operation—that is, businesses that produce electricity primarily for their own use—are not included in the electric power sector total but are assigned to the industrial or commercial sector according to the classification of the business. In addition, the emissions totals reported above for the energy end-use sectors (residential, commercial, industrial, and transportation) include their shares of total electric power sector emissions.

Nonfuel uses of fossil fuels, principally petroleum, resulted in carbon sequestration equal to 298.2 million metric tons carbon dioxide equivalent in 2003, about the same as 2002 (Table 12).⁴⁶ The major fossil fuel products that sequester carbon include liquefied petroleum gas (LPG), feedstocks for plastics and other petrochemicals, and asphalt and road oils. It is estimated that, of the amount of carbon dioxide sequestered in the form of plastic, about 18.8 million metric tons was emitted as carbon dioxide from the burning of the plastic components of municipal solid waste to produce electricity as well as other waste burning in 2002. The 2002 estimate of 18.8 million metric tons is used in this report as an estimate for 2003 emissions of carbon dioxide from the burning of wastes. Emissions of carbon dioxide from other sources—including cement production, industrial processes, waste combustion, carbon dioxide in natural gas, and gas flaring—increased by 0.5 percent, from 109.6 million metric tons in 2002 to 110.2 million metric tons in 2003 (Table 5).

⁴⁶Unlike emissions of carbon that occur in the form of carbon dioxide, carbon is sequestered in combination with other chemicals. Therefore, carbon sequestration is estimated in carbon dioxide equivalent units, rather than simply as carbon dioxide.

Energy Consumption

Energy End-Use Sector Sources of U.S. Carbon Dioxide Emissions, 1990-2003

Sector	Million Metric Tons Carbon Dioxide		Percent Change	
	1990	2003	1990-2003	2002-2003
Residential	948.3	1,214.8	28.1%	1.7%
Commercial	777.2	1,025.7	32.0%	0.6%
Industrial	1,686.9	1,666.2	-1.2%	-0.3%
Transportation	1,569.5	1,874.7	19.4%	0.5%

Note: Electric power sector emissions are distributed across sectors.

The consumption of energy in the form of fossil fuel combustion is the largest single contributor to greenhouse gas emissions in the United States and the world. Of total 2003 U.S. carbon dioxide emissions (adjusting for U.S. Territories and bunker fuels), 98.0 percent, or 5,760.1 million metric tons of carbon dioxide, resulted from the combustion of fossil fuels. This figure represents an increase of 0.8 percent from 2002 levels. In the short term, year-to-year changes in energy consumption and carbon dioxide emissions tend to be dominated by weather, economic fluctuations, and movements in energy prices. Over longer time spans, changes in energy consumption and emissions are influenced by other factors such as population shifts and energy consumers' choice of fuels, appliances, and capital equipment (e.g., vehicles, aircraft, and industrial plant and equipment). The energy-consuming capital stock of the United States—cars and trucks, airplanes, heating and cooling plants in homes and businesses, steel mills, aluminum smelters, cement plants, and petroleum refineries—changes slowly from one year to the next, because capital stock usually is retired only when it begins to break down or becomes obsolete.

EIA divides energy consumption into four general end-use categories: residential, commercial, industrial, and transportation. Emissions from electricity generators, which provide electricity to the end-use sectors, are allocated in proportion to the electricity consumed in, and losses allocated to, each sector (Table 6).

Residential Sector

At 1,214.8 million metric tons, residential carbon dioxide emissions represented 21.0 percent of U.S. energy-related carbon dioxide emissions in 2003. The residential sector's pro-rated share of electric power sector emissions accounts for more than two-thirds of that amount (833.5 million metric tons).⁴⁷ Natural gas accounted for 22.8 percent (276.8 million metric tons) and petroleum (mainly distillate fuel oil) represented 8.5 percent (103.3 million metric tons). Since 1990, residential electricity-related emissions have grown by 2.4 percent annually. In contrast, emissions from the direct combustion of fuels, primarily natural gas, have grown by 0.9 percent annually since 1990.

Total carbon dioxide emissions from the residential sector increased by 1.7 percent in 2003 (Table 7). Year-to-year, residential sector emissions are strongly influenced by weather. For example, in 1996, a relatively cold year, carbon dioxide emissions from the residential sector grew by 5.8 percent relative to 1995. In 1997, emissions declined by 0.8 percent due to warmer winter weather. The colder winter in 2003, relative to 2002, was a contributor to the 2003 increase in residential sector emissions. Additionally, the housing stock in the United States increased by 1.1 percent in 2003, contributing further impetus to the demand for residential fuels and the associated emissions of carbon dioxide.⁴⁸

Since 1990, the growth in carbon dioxide emissions attributable to the residential sector has averaged 1.9 percent per year. Residential sector emissions in 2003 were 266.5 million metric tons higher than in 1990, representing 33.3 percent of the total increase in U.S. energy-related carbon dioxide emissions since 1990. Long-term trends in residential carbon dioxide emissions are strongly influenced by demographic factors, living space attributes, and building shell and appliance efficiency choices. For example, the movement of population into warmer climates tends to increase summer air conditioning consumption and promote the use of electric heat pumps, which increases emissions from electricity use (although the increase could be offset by a reduction in emissions from heating fuel combustion). Growth in the number of households, resulting from

increasing population and immigration, contributes to more residential energy consumption.

Commercial Sector

Commercial sector carbon dioxide emissions, at 1,025.7 million metric tons, accounted for about 17.7 percent of total energy-related carbon dioxide emissions in 2003, of which 77.7 percent (796.7 million metric tons) is the sector's pro-rated share of electricity-related emissions. Natural gas contributes 16.6 percent and petroleum 4.8 percent of the sector's emissions. Commercial sector emissions largely have their origin in the lighting, space heating, and space cooling requirements of commercial structures such as office buildings, shopping malls, schools, hospitals, and restaurants. Lighting is a significantly more important component of energy demand in the commercial sector (approximately 21 percent of total demand in 2002) than it is in the residential sector (approximately 12 percent of total demand in 2002). Heating and cooling demand accounted for approximately 41 percent of energy demand in the residential sector in 2002, and about 21 percent in the commercial sector.⁴⁹ Thus, commercial sector emissions are affected less by the weather than residential sector emissions. In the longer run, because commercial activity is a factor of the larger economy, emissions from the commercial sector are more affected by economic trends and less affected by population growth than are emissions from the residential sector.

Emissions attributable to the commercial sector's pro-rated share of electricity consumption increased by 0.4 percent in 2003, and emissions from the direct combustion of fuels (dominated by natural gas, as in the residential sector) increased by 1.3 percent. Overall, carbon dioxide emissions related to commercial sector activity increased by 0.6 percent—from 1,019.8 to 1,025.7 million metric tons—between 2002 and 2003 (Table 8). Since 1990, commercial emissions growth has averaged 2.2 percent per year, the largest growth of any end-use sector. Commercial sector carbon dioxide emissions have risen by 248.5 million metric tons since 1990, accounting for 31.1 percent of the total increase in U.S. energy-related carbon dioxide emissions.

⁴⁷ Sectoral (residential, commercial, and industrial) energy-related carbon dioxide emissions include the share of total electric power sector carbon dioxide emissions that can be attributed to each end-use sector. The share is based on the percentage of total electricity sales purchased by the sector and losses attributed to the sector. (For values used to calculate sectoral shares, see Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035, Tables 2.2, 2.3, 2.4, and 2.5, web site www.eia.doe.gov/emeu/mer/consump.html.) All carbon dioxide emissions associated with industrial or commercial enterprises whose primary business is not the production of electricity are allocated to the sectors in which they occur.

⁴⁸ Energy Information Administration, *Short-Term Energy Outlook* (Washington, DC, July 2004), Appendix A, Table A2, p. 2, web site www.eia.doe.gov/emeu/steo/pub/pdf/a2tab.pdf.

⁴⁹ Energy Information Administration, *Annual Energy Outlook 2004 with Projections to 2025*, DOE/EIA-0383(2004) (Washington, DC, January 2004), Tables A4 and A5, Figures 50 and 53, web site www.eia.doe.gov/oiaf/aeo/excel/figure50_data.xls, and web site www.eia.doe.gov/oiaf/aeo/excel/figure53_data.xls.

Industrial Sector

Industrial sector emissions, at 1,666.2 million metric tons of carbon dioxide, accounted for 28.8 percent of total U.S. energy-related carbon dioxide emissions in 2003. In terms of fuel shares, electricity consumption was responsible for 38.7 percent of total industrial sector emissions (645.6 million metric tons), petroleum for 24.8 percent (413.2 million metric tons), natural gas for 25.3 percent (421.3 million metric tons), and coal for 10.8 percent (180.3 million metric tons).

Estimated 2003 energy-related carbon dioxide emissions in the industrial sector, at 1,666.2 million metric tons (Table 9), were 0.3 percent lower than the 2002 emissions level of 1,671.5 million metric tons. Carbon dioxide emissions attributable to industrial sector energy consumption have declined by an average of 0.1 percent per year since 1990. As a result, total energy-related industrial emissions in 2003 were 1.2 percent (20.7 million metric tons) lower than in 1990, despite a much larger economy.

A contributing factor to the decline in industrial sector carbon dioxide emissions is the erosion of the older energy-intensive (and specifically coal-intensive) industrial base. For example, coke plants consumed 38.9 million short tons of coal in 1990, as compared with 24.2 million short tons in 2003. Other industrial coal consumption declined from 76.3 million short tons in 1990 to 61.2 million short tons in 2003. Energy-intensive industries have been replaced by others that are less energy-intensive, such as computer chip and electronic component manufacturing.

Transportation Sector

Carbon dioxide emissions from the transportation sector, at 1,874.7 million metric tons, accounted for 32.4 percent of total U.S. energy-related carbon dioxide emissions in 2003. Almost all (97.9 percent) of transportation sector emissions result from the consumption of petroleum products: motor gasoline, at 61.0 percent of total transportation sector emissions; middle distillates (diesel fuel) at 21.6 percent; jet fuel at 12.2 percent of the total; and residual oil (i.e., heavy fuel oil, largely for maritime use) at 2.7 percent of the sector's total emissions. Motor gasoline is used primarily in automobiles and light trucks, and middle distillates are used in heavy trucks, locomotives, and ships.

Emissions attributable to the transportation sector increased by 0.5 percent in 2003, from 1,866.0 to 1,874.7 million metric tons of carbon dioxide (Table 10). The fuel-use patterns and related emissions sources in the transportation sector are different from those in the other end-use sectors. By far the largest single source of emissions, motor gasoline, at 1,143.7 million metric tons

of carbon dioxide, grew by 0.4 percent. Emissions from motor gasoline were mitigated somewhat by a 35-percent increase in the consumption of ethanol. Carbon dioxide emissions from ethanol consumption are considered to be zero because the carbon in the fuel is derived primarily from corn, and it is assumed that an equivalent amount of carbon will be sequestered during the corn growing season.

Since 1990, carbon dioxide emissions related to the transportation sector have increased at an average annual rate of 1.4 percent. The growth since 1990 has meant that transportation emissions have increased by a total of 296.4 million metric tons, representing 37.1 percent of the growth in energy-related carbon dioxide emissions from all sectors. Transportation is the largest contributing end-use sector to total emissions.

Electric Power Sector

Electric Power Sector Carbon Dioxide Emissions by Fuel Input, 1990-2003

Fuel	Million Metric Tons Carbon Dioxide		Percent Change	
	1990	2003	1990-2003	2002-2003
Petroleum	102.1	96.5	-5.5%	25.8%
Natural Gas	175.3	275.3	57.1%	-10.1%
Coal	1,507.1	1,904.3	26.4%	1.8%
Total	1,787.9	2,279.3	27.5%	1.0%

The data in Table 11 represent estimates of carbon dioxide emissions for the electric power sector. These emissions when taken as a whole account for 39.4 percent of total U.S. energy-related carbon dioxide emissions; electric power sector emissions are distributed to the end-use sectors. The electric power sector includes traditional regulated utilities, as well as independent power producers whose primary business is the generation and sale of electricity. The industrial sector and, to a much lesser extent, the commercial sector also include establishments that generate electricity; however, their primary business is not electricity generation, and so their electricity-related emissions are included in the totals for those sectors, not in the electric power sector.

Preliminary estimates indicate that carbon dioxide emissions from the electric power sector increased by 1.0 percent (22.9 million metric tons), from 2,256.4 million metric tons in 2002 to 2,279.3 million metric tons in 2003 (Table 11). Emissions from natural-gas-fired generation decreased by 10.1 percent, emissions from coal-fired

Energy-Related Carbon Dioxide Emissions in Manufacturing

Manufacturing is the single largest source of energy-related carbon dioxide emissions in the U.S. industrial sector, which also includes agriculture, forestry, and fisheries; mining; and construction. The manufacturing subsector accounted for about 83 percent of both energy-related carbon dioxide emissions and energy consumption in the industrial sector in 1998. The table below shows estimates of energy-related carbon dioxide emissions from manufacturing in 1998, based on energy consumption statistics from EIA's Manufacturing Energy Consumption Survey (MECS), which surveys more than 15,000 manufacturing plants every 4 years. The most recent MECS data available are from the 1998 survey. The table on page 24 shows estimates of manufacturing emissions by fuel, based on statistics from the 1991, 1994, and 1998 surveys.

The 1991 MECS reported energy consumption (for fuel and nonfuel purposes) that yielded carbon dioxide emissions from the manufacturing subsector as a whole totaling 1,251.4 million metric tons. The corresponding estimate for 1998 is 1,485.8 million metric tons—an increase of 234.4 million metric tons or 18.7 percent. Over the same interval, the demand for manufacturing products (as measured by the value of shipments) increased by 36.4 percent. Therefore, the overall carbon intensity of U.S. manufacturing, measured as metric tons of carbon dioxide emitted per million 1996 dollars of product shipments, was 408.8 in 1991 but had dropped to 356.0 by 1998, a decrease of 12.9 percent.

The *overall carbon intensity* of the U.S. manufacturing subsector is the ratio of its total carbon dioxide emissions (C) to manufacturing output (Y), as measured by the value of shipments (in constant dollars).

That ratio (C/Y) is calculated as the product of the subsector's aggregate *carbon intensity of energy supply*—carbon dioxide emissions (C) per unit of energy consumed (E)—and its *energy intensity*—energy consumed (E) per unit of product shipped (Y). That is:

$$C/Y = (C/E) \times (E/Y)$$

For the manufacturing subsector as a whole, energy intensity (the ratio E/Y) is a function primarily of the energy intensities of different production groups and their contributions to the total product mix in the subsector. The subsector's carbon intensity of energy supply (the ratio C/E) is determined primarily by the mix of energy fuel inputs and the mix of fuel and nonfuel (sequestering) uses of the inputs. Thus, the overall carbon intensity of manufacturing (C/Y) is a combination of the energy intensity of manufacturing output and the carbon intensity of the energy consumed to meet manufacturing energy demand.^a

The manufacturing C/Y ratio fell by 12.9 percent from 1991 to 1998; however, the reduction was largely the result of a structural shift (i.e., a change in relative market shares in the subsector). The energy intensity for the "all other manufacturing" category declined by 12 percent, and at the same time its share of total manufacturing output grew from 57.2 percent in 1991 to 63.4 percent in 1998, as newer, less energy-intensive industries accounted for an increasing share of manufacturing activity. In 1991 the four most energy-intensive industries (petroleum, chemicals, primary metals, and paper) accounted for 26.3 percent of total manufacturing output, but by 1998 their share had

(continued on page 24)

Carbon Dioxide Emissions from Manufacturing by Industry Group, 1998

Industry Group	SIC ^a Code	Carbon Dioxide Emissions (Million Metric Tons)	Share of Total Manufacturing Emissions (Percent)	Carbon Intensity of Energy Supply (Million Metric Tons per Quadrillion Btu of Energy Consumed)
Petroleum	29	320.4	21.6	45.26
Chemicals	28	319.2	21.5	45.84
Metals	33	251.0	16.9	68.17
Paper	26	118.4	8.0	37.40
Food	20	90.4	6.1	59.05
Glass	32	82.9	5.6	67.76
Other Manufacturing . . .		303.6	20.4	55.20
Total		1,485.8	100.0	50.91

^aStandard Industrial Classification.

Sources: Energy Information Administration, Form EIA-846, "Manufacturing Energy Consumption Survey," and Form EIA-810, "Monthly Refinery Report" (1998).

^aThe ratios presented here are estimated as aggregations of several manufacturing industries. Specifically, 20 manufacturing industries were aggregated into 7 groups for the calculation of industry-specific E/Y and C/Y ratios. Therefore, quantifying influences on the change in overall carbon intensity is valuable to the extent that these groupings represent changes in the U.S. manufacturing sector. It should be noted, however, that these ratios are based on survey data that are subject to sampling errors.

Energy-Related Carbon Dioxide Emissions in Manufacturing (Continued)

Carbon Dioxide Emissions from Manufacturing by Fuel, 1991, 1994, and 1998

Fuel Type	SIC ^a Code						Other Mfg.	Total
	29	28	33	26	20	32		
1991								
CO ₂ Emissions (Million Metric Tons)								
Petroleum	149.9	42.1	3.4	13.6	3.7	6.4	10.4	229.6
Natural Gas	44.2	102.3	37.4	29.1	27.0	20.1	46.4	306.6
Coal	1.4	25.2	83.2	28.3	14.4	27.9	12.8	193.2
Electricity	19.8	83.1	94.3	38.0	31.9	19.8	160.8	447.8
Other	61.0	9.7	3.0	0.2	0.0	0.0	0.5	74.3
Total	276.3	262.4	221.3	109.2	77.0	74.3	230.8	1,251.4
Share of Total Value of Shipments (Percent)	5.5	11.1	4.9	4.9	14.2	2.2	57.2	100.0
Share of Total Energy Use (Percent)	24.8	23.3	13.2	11.9	5.3	4.5	17.0	100.0
Share of Total CO ₂ Emissions (Percent)	22.1	21.0	17.7	8.7	6.2	5.9	18.4	100.0
1994								
CO ₂ Emissions (Million Metric Tons)								
Petroleum	174.8	42.3	4.9	15.7	4.3	7.4	10.1	259.4
Natural Gas	42.8	117.7	42.8	30.4	33.3	22.8	53.1	343.0
Coal	0.0	28.5	96.1	28.6	15.6	26.4	12.9	208.2
Electricity	21.9	94.1	89.2	40.4	35.8	22.3	177.0	480.6
Other	60.6	4.4	3.5	1.1	0.4	0.2	1.6	71.8
Total	300.1	287.1	236.5	116.0	89.4	79.1	254.6	1,363.0
Share of Total Value of Shipments (Percent)	4.9	10.4	5.0	4.7	13.3	2.2	59.6	100.0
Share of Total Energy Use (Percent)	24.4	23.6	12.8	11.5	5.9	4.4	17.4	100.0
Share of Total CO ₂ Emissions (Percent)	22.0	21.1	17.4	8.5	6.6	5.8	18.7	100.0
1998								
CO ₂ Emissions (Million Metric Tons)								
Petroleum	174.8	56.5	3.6	15.1	3.0	6.7	10.4	270.1
Natural Gas	53.2	127.7	47.9	31.1	31.8	23.4	59.7	374.9
Coal	0.0	26.9	94.3	25.8	13.6	27.7	10.0	198.3
Electricity	22.9	103.2	101.8	45.6	41.8	24.4	221.9	561.6
Other	69.5	4.9	3.4	0.8	0.1	0.7	1.5	80.9
Total	320.4	319.2	251.0	118.4	90.4	82.9	303.6	1,485.8
Share of Total Value of Shipments (Percent)	4.3	9.6	4.6	4.0	11.9	2.2	63.4	100.0
Share of Total Energy Use (Percent)	25.2	24.0	12.2	10.8	5.2	4.1	18.4	100.0
Share of Total CO ₂ Emissions (Percent)	21.6	21.5	16.9	8.0	6.1	5.6	20.4	100.0

^aStandard Industrial Classification: 29, petroleum; 28, chemicals; 33, metals; 26, paper; 20, food; 32, glass.

Notes: Totals may not equal sum of components due to independent rounding. To calculate intensity and consumption values, electricity was calculated as primary electricity: 10,436 Btu per kilowatthour for 1991, 10,316 for 1994, and 10,346 for 1998. These conversion factors represent the average energy input to the generation process for fossil-fired utility plants in the United States. See Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(2002/09) (Washington, DC, September 2002), Table A6.

Sources: Energy Information Administration, Form EIA-846, "Manufacturing Energy Consumption Survey," and Form EIA-810, "Monthly Refinery Report" (1991, 1994, and 1998); and U.S. Department of Commerce, Bureau of Economic Analysis, Industry Economics Division.

(continued on page 25)

Energy-Related Carbon Dioxide Emissions in Manufacturing (Continued)

fallen to 22.5 percent. For three of the seven manufacturing categories, energy intensity increased from 1991 to 1998 (petroleum by 15.3 percent, chemicals 7.4 percent, and food 5.7 percent). For paper and allied products, energy intensity remained unchanged. For nonmetallic minerals (stone, clay, and glass products) and for primary metals, energy intensity declined by 15.8 percent and 12.8 percent, respectively.

The mix and quantity of energy fuels consumed by manufacturers (for both fuel and nonfuel uses) affect the subsector's aggregate carbon intensity of energy supply. Overall, manufacturing industries had *C/E* ratios equal to 50.92 million metric tons carbon dioxide equivalent per quadrillion Btu in 1991 and 49.42 million metric tons carbon dioxide equivalent per quadrillion Btu in 1998; however, the carbon dioxide factors of the various industries differed markedly.^b

The petroleum and chemical industries both transform some energy products into products that sequester carbon, such as petrochemical feedstocks, asphalt, and plastics. Because of that use, both the petroleum and chemical industries have lower aggregate *C/E* ratios than the manufacturing average (45.27 and 42.32 million metric tons carbon dioxide equivalent per quadrillion Btu for the petroleum industry and 45.84 and 44.26 for the chemicals industry in 1991 and 1998, respectively).

The paper industry makes extensive use of wood byproducts as an energy source. Carbon dioxide

emissions from wood consumption are considered to be zero, because the carbon that is emitted has been sequestered recently, and the regrowing of trees will again sequester an equivalent amount of carbon dioxide. Consequently, the paper industry has a relatively low *C/E* ratio, at 37.41 and 36.32 million metric tons carbon dioxide equivalent per quadrillion Btu in 1991 and 1998, respectively. In contrast, the primary metals industry, which uses large amounts of coal and other carbon-intensive fuels, has a high *C/E* ratio: 68.18 in 1991 and 68.52 in 1998.

Between 1994 and 1998, manufacturing industries had statistically significant increases in carbon dioxide emissions associated with their use of electricity (81.0 million metric tons or 16.9 percent) and natural gas (31.9 million metric tons or 9.3 percent). Moreover, electricity use continues to account for the largest share of manufacturers' energy-related carbon dioxide emissions: 35.3 percent (480.6 million metric tons) in 1994 and 37.8 percent (561.6 million metric tons) in 1998.

As a result of the above changes in energy intensity, in combination with the structural shift in the subsector, the overall manufacturing energy intensity (*E/Y*) declined by 10.3 percent from 1991 to 1998. When the influence of the structural shift is removed, however, decomposition analysis suggests that the aggregate energy intensity of the manufacturing sector is virtually unchanged.^c

Changes in Key Measures of Carbon Intensity in Manufacturing, 1991-1998

Industry Group	SIC ^a Code	1991			1998			Percent Change, 1991-1998		
		<i>E/Y</i>	<i>C/E</i>	<i>C/Y</i>	<i>E/Y</i>	<i>C/E</i>	<i>C/Y</i>	<i>E/Y</i>	<i>C/E</i>	<i>C/Y</i>
Petroleum	29	36	45.26	1,647.2	42	42.32	1,776.3	15.3	-6.5	7.8
Chemicals	28	17	45.84	771.3	18	44.25	800.0	7.4	-3.5	3.7
Metals	33	22	68.17	1,484.4	19	68.53	1,301.3	-12.8	0.5	-12.3
Paper	26	20	37.40	731.9	20	36.32	709.6	-0.2	-2.9	-3.0
Food	20	3	59.05	176.9	3	57.37	181.6	5.7	-2.9	2.6
Glass	32	16	67.76	1,104.7	14	66.57	913.7	-15.8	-1.8	-17.3
Other Manufacturing	2	2	55.20	131.7	2	54.81	114.7	-12.3	-0.7	-12.9
Total		8	50.91	408.8	7	49.42	356.0	-10.3	-2.9	-12.9
Total Without Structural Shift . .		8	—	—	8	—	—	0.7	—	—

^aStandard Industrial Classification.

Notes: *E/Y* = energy consumed (thousand Btu) per constant 1996 dollar value of shipments. *C/E* = million metric tons CO₂ emitted per quadrillion Btu of energy consumed. *C/Y* = metric tons CO₂ emitted per million chained 1996 dollars value of shipments.

Sources: Energy Information Administration, Form EIA-846, "Manufacturing Energy Consumption Survey," and Form EIA-810, "Monthly Refinery Report" (1998).

^bCarbon dioxide emission factors include indirect emissions from electricity consumed in the manufacturing process. These emission factors are based on a national average for electricity and are assumed for the purposes of this analysis to be uniform across industries.

^cThere are several approaches, based on index number theory, that can be used to decompose aggregate values and trends. The values reported here are based on a discrete approximation of the Divisia integral index. Statistically, the positive change for energy intensity of 0.7 percent is not significantly different from zero.

generation increased by 1.8 percent, and emissions from petroleum-fired generation increased by 25.8 percent. Carbon dioxide emissions from the electric power sector have grown by 27.5 percent since 1990, while total energy-related carbon dioxide emissions have grown by 16.0 percent.

Nonfuel Use of Energy Inputs

In 2003, carbon sequestration through nonfuel uses of fossil fuels totaled 298.2 million metric tons carbon dioxide equivalent (Table 12). The vast majority was sequestered in petroleum-based products (275.0 million metric tons carbon dioxide equivalent), with smaller amounts in natural-gas-based products (21.7 million metric tons) and coal-based products (1.5 million metric tons). The main products that sequester carbon include feedstocks for plastics and other petrochemicals, asphalt and road oil, liquefied petroleum gas, lubricants, and waxes. The amount sequestered in 2003 was about the same as in 2002, when 298.3 million metric tons carbon dioxide equivalent was sequestered. Since 1990, the annual sequestration of carbon in this manner has increased by 47.0 million metric tons or 18.7 percent. This translates to an average annual growth rate of 1.3 percent.

Adjustments to Energy Consumption

Total energy consumption and the carbon dioxide emissions upon which they are based correspond to EIA's coverage of energy consumption, which includes the 50 States and the District of Columbia. Under the United Nations Framework Convention on Climate Change (UNFCCC), however, the United States is also responsible for counting emissions emanating from its territories, and their emissions are added to the U.S. total. Conversely, because the Intergovernmental Panel on Climate Change (IPCC) definition of energy consumption excludes international bunker fuels from the statistics of all countries, emissions from international bunker fuels are subtracted from the U.S. total. Additionally, military bunker fuels are subtracted because they are also excluded by the IPCC from the national total. These sources and subtractions are enumerated and described as "adjustments to energy."

U.S. Territories

Energy-related carbon dioxide emissions for the U.S. territories are added as an adjustment in keeping with IPCC guidelines for national emissions inventories. The territories included are Puerto Rico, the U.S. Virgin

Islands, American Samoa, Guam, the U.S. Pacific Islands, and Wake Island. Most of these emissions are from petroleum products; however, Puerto Rico and the Virgin Islands consume coal in addition to petroleum products. For 2003, total energy-related carbon dioxide emissions from the U.S. Territories are estimated at 61.8 million metric tons (Table 5).

International Bunker Fuels

In keeping with the IPCC guidelines for estimating national greenhouse gas emissions, carbon dioxide emissions from international bunker fuels are subtracted from the estimate of total U.S. energy-related emissions of carbon dioxide. The estimate for bunker fuels is based on purchases of distillate and residual fuels by foreign-bound ships at U.S. seaports, as well as jet fuel purchases by international air carriers at U.S. airports. Additionally, U.S. military operations for which fuel was originally purchased in the United States but consumed in international waters or airspace are subtracted from the total, because they are also considered international bunker fuels under this definition.

For 2002, the carbon dioxide emissions estimate for military bunker fuels was 8.1 million metric tons.⁵⁰ In 2003, approximately 89.2 million metric tons of carbon dioxide was emitted in total from international bunker fuels, including 81.2 million metric tons attributed to civilian consumption of bunker fuels. The total amount is subtracted from the U.S. total in Table 5. Just over half of the carbon dioxide emissions associated with international bunker fuels are from the combustion of jet fuels; residual and distillate fuels account for the other half, with most coming from residual fuel.

Other Carbon Dioxide Emissions

U.S. Carbon Dioxide Emissions from Other Sources, 1990-2003

Estimated 2003 Emissions (Million Metric Tons Carbon Dioxide)	110.2
Change Compared to 2002 (Million Metric Tons Carbon Dioxide)	0.6
Change from 2002 (Percent)	0.5%
Change Compared to 1990 (Million Metric Tons Carbon Dioxide)	19.1
Change from 1990 (Percent)	21.0%

⁵⁰Data for 2003 military bunker fuels were not available at the time of publication. It should also be noted that only bunker fuels purchased in the United States are subject to adjustment.

Energy Production

In addition to emissions resulting from fossil energy consumed, oil and gas production leads to emissions of carbon dioxide from sources other than the combustion of those marketed fossil fuels. The two energy production sources estimated for this report are:

- Flared natural gas (gas burned at the production site), which is flared either because the cost of bringing the gas to market is prohibitive or because the gas is of insufficient quality to sell
- Carbon dioxide scrubbed from natural gas to improve its heat content and quality and subsequently vented to the atmosphere.

Because many States require flaring of natural gas, EIA assumes that all gas reported under the category "Vented and Flared" is actually flared and therefore should be counted as carbon dioxide emissions rather than methane emissions. In 2003, about 6.0 million metric tons of carbon dioxide was emitted in this way (Table 5).

By computing the difference between the estimated carbon dioxide content of raw gas and the carbon dioxide content of pipeline gas, the amount of carbon dioxide that has been removed (scrubbed) in order to improve the heat content and quality of natural gas can be calculated. This amount was about 18.0 million metric tons in 2003 (Table 5). Data on additional energy production sources that are excluded from this report are available in Energy Information Administration, *Documentation for Emissions of Greenhouse Gases in the United States 2002*.⁵¹

Industrial Process Emissions

Industrial emissions of carbon dioxide not caused by the combustion of fossil fuels accounted for only 1.2 percent (70.3 million metric tons) of total U.S. carbon dioxide emissions in 2003 (Table 5). Process-related emissions from industrial sources depend largely on the level of activity in the construction industries and on production at oil and gas wells. These sources include limestone and dolomite calcination, soda ash manufacture and consumption, carbon dioxide manufacture, cement manufacture, and aluminum production.

Estimated industrial process emissions of carbon dioxide in 2003 totaled 70.3 million metric tons, 17.0 percent higher than in 1990 and 0.6 million metric tons (0.9 percent) higher than in 2002 (Table 13). Sixty-two percent of the carbon dioxide emissions from industrial processes are from cement manufacture. When calcium carbonate is heated (calcined) in a kiln, it is converted to lime and carbon dioxide. The lime is combined with other materials to produce clinker (an intermediate product from which cement is made), and the carbon dioxide is released to the atmosphere. In 2003, the United States produced an estimated 91.0 million metric tons of cement, resulting in the direct release of 43.3 million metric tons of carbon dioxide into the atmosphere.⁵² This calculation is independent of the carbon dioxide released by the production of energy consumed in making cement. The estimate for 2003 represents an increase in carbon dioxide emissions of 9.9 million metric tons (29.7 percent) compared with 1990 and an increase of about 0.3 million metric tons (0.6 percent) compared with 2002.

There are numerous other industrial processes in which carbonate minerals are used in ways that release carbon dioxide into the atmosphere, including the use of limestone in the production of lime and in flue gas desulfurization and the manufacture and some uses of soda ash. Carbon dioxide is also released during aluminum smelting, when carbon anodes (with the carbon derived from nonfuel use of fossil fuels) are vaporized in the presence of aluminum oxide. Approximately 27.1 million metric tons of carbon dioxide was released in emissions from these other industrial process sources in 2003.

Municipal solid waste that is combusted contains, on average, a portion that is composed of plastics, synthetic rubber, synthetic fibers, and carbon black. The carbon in these plastics has normally been accounted for as sequestered carbon, as reported in Table 12. However, according to the IPCC, to properly account for that carbon, emissions from the plastics portion of the municipal solid waste must be counted in total national emissions inventories. These emissions produce about 18.8 million metric tons of carbon dioxide, as calculated by the U.S. EPA, with the most recent estimate being for 2002. The 2002 value has been used as an estimate for 2003.

⁵¹Energy Information Administration, *Documentation for Emissions of Greenhouse Gases in the United States 2002*, DOE/EIA-0638(2002) (Washington, DC, January 2004), web site [www.eia.doe.gov/oiaf/1605/ggrpt/documentation/pdf/0638\(2002\).pdf](http://www.eia.doe.gov/oiaf/1605/ggrpt/documentation/pdf/0638(2002).pdf). See also Energy Information Administration, *Documentation for Emissions of Greenhouse Gases in the United States 2003* (to be published).

⁵²U.S. Department of the Interior, U.S. Geological Service, "Cement," *Mineral Commodity Summary*, web site <http://minerals.usgs.gov/minerals/pubs/commodity/cement/cemenmcs04.pdf>.

Table 5. U.S. Carbon Dioxide Emissions from Energy and Industry, 1990 and 1995-2003
(Million Metric Tons Carbon Dioxide)

Fuel Type or Process	1990	1995	1996	1997	1998	1999	2000	2001	2002	P2003
Energy Consumption										
Petroleum	2,180.8	2,194.9	2,278.8	2,296.7	2,348.9	2,416.5	2,438.4	2,475.0	2,456.5	2,498.4
Coal	1,771.6	1,876.5	1,958.8	2,002.6	2,016.1	2,020.0	2,114.8	2,047.2	2,063.8	2,100.4
Natural Gas	1,026.0	1,182.4	1,204.2	1,209.8	1,187.2	1,190.0	1,237.8	1,186.1	1,227.7	1,179.4
Renewables ^a	3.5	3.0	3.0	3.1	3.1	3.1	3.0	3.1	3.2	3.1
Energy Subtotal^b	4,981.9	5,256.8	5,444.8	5,512.2	5,555.3	5,629.6	5,793.9	5,711.4	5,751.2	5,781.4
Adjustments to Energy										
U.S. Territories (+)	30.9	38.0	37.9	39.1	42.3	40.4	42.2	53.6	53.1	61.8
Military Bunker Fuels (-)	13.6	8.9	8.9	9.6	10.0	9.8	7.8	8.2	8.0	8.0
International Bunker Fuels (-)	100.1	91.9	93.3	100.1	104.9	97.4	93.5	89.6	81.2	75.2
Total Energy Adjustments	-82.7	-62.8	-64.3	-70.6	-72.6	-66.8	-59.1	-44.2	-36.1	-21.3
Adjusted Energy Subtotal	4,899.1	5,194.1	5,380.5	5,441.6	5,482.7	5,562.8	5,734.8	5,667.2	5,715.2	5,760.1
Other Sources										
Gas Flaring	9.1	17.2	16.5	15.5	6.2	6.7	5.5	5.9	6.0	5.7
CO ₂ in Natural Gas	14.0	16.7	17.8	18.0	18.0	17.8	18.2	18.6	18.0	18.1
Cement Production	33.3	36.9	37.2	38.4	39.3	40.1	41.3	41.4	43.0	43.3
Other Industrial	26.8	28.4	29.0	29.5	30.0	29.3	29.6	27.7	26.7	27.1
Waste Combustion	7.8	13.5	14.6	15.1	14.4	14.9	15.4	16.1	15.9	16.0
Total Other Sources	91.0	112.6	115.0	116.5	107.9	108.8	110.0	109.7	109.6	110.2
Total	4,990.1	5,306.7	5,495.5	5,558.1	5,590.7	5,671.6	5,844.8	5,777.0	5,824.8	5,870.2

P = preliminary data.

^aIncludes emissions from electricity generation using municipal solid waste and geothermal energy.^bIncludes emissions from nonfuel uses of fossil fuels.Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2002*, DOE/EIA-0573(2002) (Washington, DC, October 2003). Totals may not equal sum of components due to independent rounding. Adjusted energy total includes U.S. Territories.

Sources: EIA estimates presented in this chapter.

Table 6. U.S. Carbon Dioxide Emissions from Energy Consumption by End-Use Sector, 1990 and 1995-2003
(Million Metric Tons Carbon Dioxide)

End-Use Sector	1990	1995	1996	1997	1998	1999	2000	2001	2002	P2003
Residential	948.3	1,026.5	1,086.1	1,077.5	1,083.3	1,107.1	1,170.4	1,163.3	1,193.9	1,214.8
Commercial	777.2	837.3	868.5	911.9	930.3	943.7	1,004.3	1,021.0	1,019.8	1,025.7
Industrial	1,686.9	1,731.6	1,784.8	1,800.1	1,783.8	1,772.9	1,775.0	1,691.4	1,671.5	1,666.2
Transportation	1,569.5	1,661.4	1,705.3	1,722.7	1,757.9	1,806.0	1,844.2	1,835.8	1,866.0	1,874.7
Total^a	4,981.9	5,256.8	5,444.8	5,512.2	5,555.3	5,629.6	5,793.9	5,711.4	5,751.2	5,781.4
Electric Power	1,787.9	1,924.8	1,996.1	2,063.9	2,152.1	2,164.7	2,271.6	2,232.5	2,256.4	2,279.3

P = preliminary data.

^aIncludes emissions from nonfuel uses of fossil fuels.Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2002*, DOE/EIA-0573(2002) (Washington, DC, October 2003). Totals may not equal sum of components due to independent rounding. Electric power sector emissions are distributed across the end-use sectors. Emissions allocated to sectors are unadjusted. Adjustments are made to total emissions only (Table 5).

Sources: EIA estimates presented in this chapter.

Table 7. U.S. Carbon Dioxide Emissions from Residential Sector Energy Consumption, 1990 and 1995-2003
(Million Metric Tons Carbon Dioxide)

Fuel	1990	1995	1996	1997	1998	1999	2000	2001	2002	P2003
Petroleum										
Liquefied Petroleum Gas . . .	22.6	25.1	29.3	28.6	26.9	33.1	34.9	33.2	35.1	33.7
Distillate Fuel	70.8	65.5	67.1	63.3	55.9	59.9	65.5	65.8	62.3	64.5
Kerosene	4.6	5.3	6.4	6.6	7.8	8.0	6.8	6.8	4.1	5.1
Petroleum Subtotal	98.0	95.9	102.7	98.5	90.5	101.0	107.2	105.8	101.4	103.3
Coal	2.4	1.6	1.6	1.5	1.2	1.3	1.1	1.1	1.0	1.1
Natural Gas	238.8	263.0	284.2	270.2	246.5	256.5	270.3	259.7	265.9	276.8
Electricity ^a	609.1	666.0	697.6	707.3	745.1	748.3	791.7	796.7	825.6	833.5
Total	948.3	1,026.5	1,086.1	1,077.5	1,083.3	1,107.1	1,170.4	1,163.3	1,193.9	1,214.8

^aShare 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 2002*, DOE/EIA-0573(2002) (Washington, DC, October 2003). Totals may not equal sum of components due to independent rounding.

Sources: EIA estimates presented in this chapter.

Table 8. U.S. Carbon Dioxide Emissions from Commercial Sector Energy Consumption, 1990 and 1995-2003
(Million Metric Tons Carbon Dioxide)

Fuel	1990	1995	1996	1997	1998	1999	2000	2001	2002	P2003
Petroleum										
Motor Gasoline	7.8	1.3	1.9	3.0	2.7	2.0	3.1	2.6	2.7	2.7
Liquefied Petroleum Gas . . .	4.0	4.4	5.2	5.0	4.7	5.8	6.2	5.9	6.2	5.9
Distillate Fuel	38.8	34.7	35.0	32.1	31.1	31.8	35.6	36.8	32.2	33.3
Residual Fuel	17.9	11.0	10.7	8.7	6.6	5.7	6.6	6.5	6.2	5.9
Kerosene	0.8	1.6	1.5	1.8	2.2	1.9	2.1	2.2	1.3	1.7
Petroleum Subtotal	69.4	53.0	54.2	50.6	47.4	47.2	53.6	54.0	48.6	49.6
Coal	12.1	11.0	11.5	12.2	8.7	9.7	8.6	9.2	8.6	8.9
Natural Gas	142.6	164.3	171.3	174.3	163.5	165.2	172.4	164.5	168.7	170.5
Electricity ^a	553.0	608.9	631.6	674.8	710.7	721.5	769.8	793.3	793.9	796.7
Total	777.2	837.3	868.5	911.9	930.3	943.7	1,004.3	1,021.0	1,019.8	1,025.7

^aShare 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 2002*, DOE/EIA-0573(2002) (Washington, DC, October 2003). Totals may not equal sum of components due to independent rounding.

Sources: EIA estimates presented in this chapter.

Table 9. U.S. Carbon Dioxide Emissions from Industrial Sector Energy Consumption, 1990 and 1995-2003
(Million Metric Tons Carbon Dioxide)

Fuel	1990	1995	1996	1997	1998	1999	2000	2001	2002	P2003
Petroleum										
Motor Gasoline	13.0	14.1	14.0	14.9	14.0	10.6	10.5	20.7	21.3	21.5
Liquefied Petroleum Gas . .	39.9	46.4	47.4	49.3	40.3	49.3	57.9	50.1	54.1	52.5
Distillate Fuel	83.1	81.6	85.6	86.7	87.3	85.5	86.5	93.7	86.8	89.9
Residual Fuel	30.3	24.2	24.1	20.5	15.7	14.0	15.2	16.6	12.6	12.0
Asphalt and Road Oil	*	*	*	*	*	*	*	*	*	*
Lubricants	6.8	6.5	6.3	6.7	7.0	7.1	7.0	6.4	6.3	5.9
Kerosene	0.9	1.1	1.3	1.3	1.6	0.9	1.1	1.7	1.0	1.3
Petroleum Coke	81.2	79.6	84.0	79.5	97.6	109.0	87.6	97.2	94.8	92.0
Other Petroleum	125.1	112.0	130.4	135.9	123.6	127.9	115.5	130.0	127.3	138.1
Petroleum Subtotal	380.4	365.6	393.2	394.9	387.1	404.4	381.4	416.4	404.2	413.2
Coal	249.5	224.3	219.0	215.3	201.2	196.6	200.2	193.5	178.1	180.3
Coal Coke Net Imports	0.5	5.7	3.2	5.3	7.4	6.5	7.2	4.0	5.8	5.8
Natural Gas	433.5	489.4	505.7	506.1	495.0	473.6	479.7	438.7	449.8	421.3
Electricity^a	623.1	646.7	663.7	678.6	693.1	691.7	706.6	638.8	633.5	645.6
Total^b	1,686.9	1,731.6	1,784.8	1,800.1	1,783.8	1,772.9	1,775.0	1,691.4	1,671.5	1,666.2

*Less than 50,000 metric tons carbon dioxide.

^aShare of total electric power sector carbon dioxide emissions weighted by sales to the industrial sector.

^bIncludes emissions from nonfuel uses of fossil fuels.

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 2002*, DOE/EIA-0573(2002) (Washington, DC, October 2003). Totals may not equal sum of components due to independent rounding.

Sources: EIA estimates presented in this chapter.

Table 10. U.S. Carbon Dioxide Emissions from Transportation Sector Energy Consumption, 1990 and 1995-2003
(Million Metric Tons Carbon Dioxide)

Fuel	1990	1995	1996	1997	1998	1999	2000	2001	2002	P2003
Petroleum										
Motor Gasoline	955.2	1,015.5	1,034.0	1,042.5	1,072.9	1,099.9	1,105.9	1,111.2	1,138.7	1,143.7
Liquefied Petroleum Gas . .	1.3	1.0	0.9	0.8	1.0	0.8	0.7	0.8	0.8	0.8
Jet Fuel	220.4	219.9	229.8	232.1	235.6	242.9	251.2	240.4	234.4	228.6
Distillate Fuel	265.1	303.8	323.7	338.4	348.4	362.2	374.0	383.2	390.5	404.5
Residual Fuel	79.3	71.0	66.4	55.5	52.6	51.9	64.2	54.2	52.8	50.4
Lubricants ^a	6.5	6.2	6.0	6.3	6.6	6.7	6.6	6.0	6.0	5.6
Aviation Gasoline	3.1	2.7	2.6	2.7	2.4	2.7	2.5	2.4	2.3	2.2
Petroleum Subtotal	1,530.9	1,620.1	1,663.3	1,678.4	1,719.5	1,767.1	1,805.2	1,798.2	1,825.5	1,835.8
Coal	*									
Natural Gas	35.9	38.2	38.9	41.1	35.1	35.6	35.5	33.9	37.1	35.4
Electricity^b	2.7	3.2	3.2	3.2	3.3	3.2	3.6	3.6	3.4	3.5
Total	1,569.5	1,661.4	1,705.3	1,722.7	1,757.9	1,806.0	1,844.2	1,835.8	1,866.0	1,874.7

*Less than 50,000 metric tons carbon dioxide.

^aIncludes emissions from nonfuel uses of fossil fuels.

^bShare 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 2002*, DOE/EIA-0573(2002) (Washington, DC, October 2003). Totals may not equal sum of components due to independent rounding.

Sources: EIA estimates presented in this chapter.

Table 11. U.S. Carbon Dioxide Emissions from Electric Power Sector Energy Consumption, 1990 and 1995-2003

(Million Metric Tons Carbon Dioxide)

Fuel	1990	1995	1996	1997	1998	1999	2000	2001	2002	P2003
Petroleum										
Heavy Fuel Oil	77.0	44.6	49.6	56.7	82.7	75.7	68.8	78.3	51.4	67.9
Light Fuel Oil.	23.4	7.7	7.8	7.7	9.7	10.0	12.5	12.3	8.2	11.4
Petroleum Coke	1.4	7.8	7.8	9.9	11.8	10.9	9.6	10.0	16.9	16.7
Petroleum Subtotal. . .	102.1	60.3	65.4	74.3	104.4	96.8	91.0	100.7	76.7	96.5
Coal	1,507.1	1,633.9	1,723.5	1,768.3	1,797.6	1,805.8	1,897.7	1,839.4	1,870.2	1,904.3
Natural Gas	175.3	227.5	204.2	218.1	247.1	259.1	279.9	289.4	306.2	275.3
Municipal Solid Waste . .	3.1	2.7	2.6	2.7	2.7	2.7	2.6	2.7	2.9	2.8
Geothermal	0.4	0.3	0.4	0.3						
Total	1,787.9	1,924.8	1,996.1	2,063.9	2,152.1	2,164.7	2,271.6	2,232.5	2,256.4	2,279.3

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 2002*, DOE/EIA-0573(2002) (Washington, DC, October 2003). 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.

Sources: EIA estimates presented in this chapter.

Table 12. U.S. Carbon Sequestered by Nonfuel Use of Energy Fuels, 1990 and 1995-2003

(Million Metric Tons Carbon Dioxide Equivalent)

End Use and Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	P2003
Industrial										
Petroleum										
Liquefied Petroleum Gases. . .	59.3	78.5	81.7	82.7	86.4	89.9	82.1	76.7	79.9	76.3
Distillate Fuel	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Residual Fuel	1.9	2.1	2.1	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Asphalt and Road Oil	88.5	89.1	88.9	92.5	95.5	100.1	96.4	95.0	93.7	92.0
Lubricants	6.9	6.6	6.4	6.8	7.1	7.2	7.0	6.5	6.4	6.0
<i>Other (Subtotal)</i>	<i>72.1</i>	<i>83.1</i>	<i>85.2</i>	<i>90.7</i>	<i>92.7</i>	<i>94.9</i>	<i>88.7</i>	<i>83.9</i>	<i>86.4</i>	<i>92.4</i>
Pentanes Plus.	4.4	16.2	16.9	16.0	10.9	14.0	12.7	10.8	9.2	9.0
Petrochemical Feed	46.0	50.0	50.6	58.4	59.1	55.5	57.7	50.7	55.1	63.0
Petroleum Coke	9.1	6.8	7.6	6.0	10.9	14.5	7.2	10.6	9.8	8.8
Waxes and Miscellaneous . .	12.5	10.1	10.1	10.4	11.8	10.9	11.2	11.8	12.2	11.5
<i>Petroleum Subtotal</i>	<i>228.9</i>	<i>259.6</i>	<i>264.6</i>	<i>275.2</i>	<i>284.3</i>	<i>294.8</i>	<i>277.0</i>	<i>264.7</i>	<i>269.1</i>	<i>269.4</i>
Coal.	1.4	2.1	2.0	1.9	1.8	1.8	1.8	1.7	1.5	1.5
Natural Gas.	14.4	18.4	18.5	19.8	21.9	22.5	22.7	21.3	21.7	21.7
Transportation										
Lubricants	6.5	6.2	6.0	6.4	6.7	6.8	6.7	6.1	6.0	5.6
Total	251.3	286.4	291.2	303.4	314.7	325.8	308.1	293.9	298.3	298.2

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 2002*, DOE/EIA-0573(2002) (Washington, DC, October 2003). Totals may not equal sum of components due to independent rounding.

Sources: EIA estimates presented in this chapter.

Table 13. U.S. Carbon Dioxide Emissions from Industrial Processes, 1990 and 1995-2003
(Million Metric Tons Carbon Dioxide)

Source	1990	1995	1996	1997	1998	1999	2000	2001	2002	P2003
Cement Manufacture										
Clinker Production	32.6	36.1	36.3	37.6	38.4	39.2	40.4	40.5	42.0	42.3
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	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Cement Subtotal	33.3	36.9	37.2	38.4	39.3	40.1	41.3	41.4	43.0	43.3
Other Industrial										
<i>Limestone Consumption</i>										
Lime Manufacture	12.4	14.5	15.1	15.5	15.8	15.5	15.4	14.8	14.1	14.3
Iron Smelting	1.7	1.2	1.1	1.1	1.1	1.0	1.1	1.0	0.9	0.9
Steelmaking	0.3	0.5	0.4	0.3	0.4	0.3	0.5	0.6	0.5	0.5
Copper Refining	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Glass Manufacture	0.1	0.3	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1
Flue Gas Desulfurization	0.7	0.9	0.9	1.0	1.0	1.1	1.2	1.4	1.4	1.4
Dolomite Manufacture	0.5	0.2	0.3	0.3	0.3	0.1	0.3	0.3	0.3	0.3
Limestone Subtotal	15.9	17.8	18.3	18.5	18.9	18.3	18.7	18.4	17.4	17.6
Soda Ash Manufacture	3.4	3.8	3.8	3.9	3.8	3.7	3.6	3.6	3.5	3.6
<i>Soda Ash Consumption</i>										
Glass Manufacture	0.1	0.3	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1
Flue Gas Desulfurization	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1
Sodium Silicate	0.2	0.3	0.2	0.3	0.3	0.2	0.2	0.3	0.2	0.3
Sodium Tripolyphosphate	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Soda Ash Subtotal	0.5	0.8	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5
Carbon Dioxide Manufacture	0.9	1.0	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.5
Aluminum Manufacture	5.9	4.9	5.2	5.3	5.4	5.5	5.4	3.9	4.0	4.0
Shale Oil Production	0.2	*	*	*	*	*	*	*	*	*
Other Industrial Subtotal	26.8	28.4	29.0	29.5	30.0	29.3	29.6	27.7	26.7	27.1
Total	60.1	65.3	66.1	67.9	69.3	69.4	70.9	69.2	69.7	70.3

*Less than 50,000 metric tons carbon equivalent.

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 2002*, DOE/EIA-0573(2002) (Washington, DC, October 2003). Totals may not equal sum of components due to independent rounding.

Sources: EIA estimates presented in this chapter.