# 4. Nitrous Oxide Emissions

## Overview

**U.S. Anthropogenic Nitrous Oxide Emissions, 1990-2004**

| | Nitrous Oxide | Carbon Dioxide Equivalent |
|---|---|---|
| Estimated 2004 Emissions (Thousand Metric Tons) | 1,195 | 353,675 |
| Change Compared to 2003 (Thousand Metric Tons) | 62 | 18,452 |
| Change from 2003 *(Percent)* | *5.5%* | *5.5%* |
| Change Compared to 1990 (Thousand Metric Tons) | 56 | 16,638 |
| Change from 1990 *(Percent)* | *4.9%* | *4.9%* |

Estimated U.S. anthropogenic nitrous oxide emissions totaled 1.2 million metric tons in 2004, or 353.7 million metric tons carbon dioxide equivalent ($MMTCO_2e$), 5.5 percent more than in 2003 and 4.9 percent above 1990 levels (Table 25). The 2004 total for nitrous oxide emissions represents 5.0 percent of all U.S. greenhouse gas emissions for the year. Most of the increase in U.S. nitrous oxide emissions for 2004 can be attributed to emissions from agricultural sources, which increased by 17.4 $MMTCO_2e$ of nitrous oxide or 94 percent of the overall increase in nitrous oxide emissions of 18.5 $MMTCO_2e$.

A downward trend in nitrous oxide emissions that began in 1995, after emissions of nitrous oxide peaked at 374.5 $MMTCO_2e$ in 1994, was ended in 2003. With the increase in 2004, annual U.S. emissions of nitrous oxide were higher than their 1990 level (337.0 $MMTCO_2e$) for the first time since 2000.

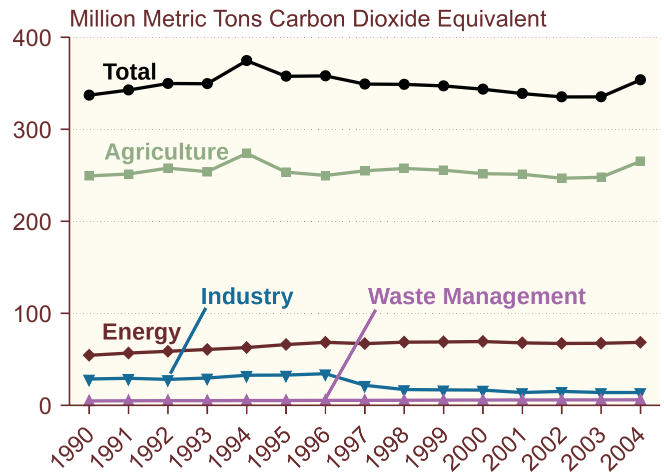
Sources of U.S. nitrous oxide emissions include energy use, agriculture, waste management, and industrial processes. The largest component of U.S. anthropogenic nitrous oxide emissions is emissions from agricultural activities at 265.2 $MMTCO_2e$ or 75 percent of total nitrous oxide emissions. Nitrogen fertilization of agricultural soils represents 77 percent of emissions from agricultural activities. Most of the remainder (23 percent) is from the handling of animal waste in managed systems. Small quantities of nitrous oxide (0.2 percent of nitrous oxide emissions from agricultural activities) are also released from the burning of crop residues. Estimated emissions of nitrous oxide from agricultural sources in 2004 were 7.0 percent above 2003 levels and 6.4 percent above 1990 levels (Figure 3).

The second-largest source of anthropogenic nitrous oxide emissions is energy consumption, which includes mobile source combustion from passenger cars, buses, motorcycles, and trucks; and stationary source combustion from commercial, residential, industrial, and electric power sector energy use. Energy use was responsible for 68.4 $MMTCO_2e$ of nitrous oxide emissions in 2004 (19 percent of total U.S. nitrous oxide

**Sources of U.S. Anthropogenic Nitrous Oxide Emissions, 1990-2004**

| Source | Million Metric Tons $CO_2e$ 1990 | 2004 | *Percent Change* 1990-2004 | 2003-2004 |
|---|---|---|---|---|
| Agriculture | 249.3 | 265.2 | *6.4%* | *7.0%* |
| Energy | 54.4 | 68.4 | *25.9%* | *1.5%* |
| Industrial Processes | 28.6 | 14.0 | *-51.1%* | *-0.3%* |
| Waste Management | 4.8 | 6.0 | *24.8%* | *1.1%* |

**Figure 3. U.S. Emissions of Nitrous Oxide by Source, 1990-2004**




Source: Estimates presented in this chapter.

emissions). Although the 2004 level of emissions from energy sources is 1.5 percent higher than the 2003 level, it is 26 percent higher than in 1990.

Industrial production of adipic and nitric acid, which releases nitrous oxide as a byproduct, accounted for emissions of 14.0 $MMTCO_2e$ in 2004 (3.9 percent of total U.S. nitrous oxide emissions), slightly (0.3 percent) lower than the 2003 level and 51 percent lower than in 1990. The large decline in emissions of nitrous oxide from adipic acid production since 1990 is a result of the continuing utilization of emissions control technology at three of the four adipic acid plants operating in the United States.

Nitrous oxide emissions from activities related to waste management in 2004 totaled 6.0 $MMTCO_2e$, or 1.7 percent of all U.S. anthropogenic nitrous oxide emissions (Table 25). During 2004, emissions from human sewage in wastewater accounted for 96 percent of estimated nitrous oxide emissions from this source, and the remainder was associated with waste combustion.

# Agriculture

**U.S. Nitrous Oxide Emissions from Agriculture, 1990-2004**

| | |
|---|---|
| Estimated 2004 Emissions (Million Metric Tons Carbon Dioxide Equivalent) | 265.2 |
| Change Compared to 2003 (Million Metric Tons Carbon Dioxide Equivalent) | 17.4 |
| Change from 2003 *(Percent)* | *7.0%* |
| Change Compared to 1990 (Million Metric Tons Carbon Dioxide Equivalent) | 16.0 |
| Change from 1990 *(Percent)* | *6.4%* |

Nitrous oxide emissions from agricultural activities increased by 17.4 $MMTCO_2e$ (7.0 percent) in 2004 to a total of 265.2 $MMTCO_2e$, compared with 247.8 $MMTCO_2e$ in 2003. Since 1990, nitrous oxide emissions from agricultural activities have increased by 6.4 percent. Agricultural activities were responsible for 75 percent of U.S. nitrous oxide emissions in 2004, smaller than the 86-percent share that agricultural practices contribute to nitrous oxide emissions globally.[79] Nitrous oxide emissions from agricultural activities represent 3.7 percent of total U.S. greenhouse gas emissions.

Nitrogen fertilization of agricultural soils accounted for 77 percent of U.S. agricultural emissions of nitrous oxide in 2004. Nearly all the remaining agricultural emissions (23 percent) can be traced to the management of the solid waste of domesticated animals. The disposal of crop residues by burning also produces nitrous oxide that is released into the atmosphere; however, the amount is relatively minor, at 0.6 $MMTCO_2e$ (2 thousand metric tons nitrous oxide) or 0.2 percent of total U.S. emissions of nitrous oxide from agricultural sources in 2004.

## Nitrogen Fertilization of Agricultural Soils

EIA estimates that 204.3 $MMTCO_2e$ of nitrous oxide was released into the atmosphere as a result of direct and indirect emissions associated with fertilization practices in 2004 (Table 26). Estimated emissions increased by 9.5 percent compared with 2003 levels and were 9.3 percent higher than in 1990.

Nitrogen uptake and nitrous oxide emissions occur naturally as a result of nitrification and denitrification processes in soil and crops, generally through bacterial action. When nitrogen compounds are added to the soil, bacterial action is stimulated, and emissions generally increase, unless the application precisely matches plant uptake and soil capture.[80] Nitrogen may be added to the soil by synthetic or organic fertilizers, nitrogen-fixing crops, and crop residues. Nitrogen-rich soils, called "histosols," may also stimulate emissions. Direct emissions in 2004 (163.9 $MMTCO_2e$) represented 80 percent of total emissions from nitrogen fertilization, with the primary components including the biological fixation of nitrogen in crops (70.9 $MMTCO_2e$), nitrogen fertilizers (50.0 $MMTCO_2e$), and crop residues (38.5 $MMTCO_2e$).

Indirect emissions from nitrogen fertilization result from adding excess nitrogen to the soil, which in turn enriches ground and surface waters, such as rivers and streams, and results in emissions of nitrous oxide. This source is referred to as "soil leaching." Additional indirect emissions occur from "atmospheric deposition," in which soils emit other nitrogen compounds that react to form nitrous oxide in the atmosphere. Indirect emissions in 2004 (40.4 $MMTCO_2e$) represented 20 percent of total emissions from nitrogen fertilization, with soil leaching accounting for 34.3 $MMTCO_2e$ and atmospheric deposition totaling 6.1 $MMTCO_2e$.

There are significant uncertainties associated with estimating the amount of emissions produced by adding nitrogen to agricultural soils. Models used to estimate the amount are based on limited sources of experimental

[79] U.S. Environmental Protection Agency, web site www.epa.gov/methane/intlanalyses.html.

[80] A.F. Bouwman, "Exchange of Greenhouse Gases Between Terrestrial Ecosystems and the Atmosphere," in A.F. Bouwman (ed.), *Soils and the Greenhouse Effect* (New York, NY: John Wiley and Sons, 1990).

data.[81] The uncertainty increases when moving from emissions associated with animal manure to soil mineralization and atmospheric deposition, where both estimating the amount of emissions and segmenting anthropogenic from biogenic sources become increasingly difficult.

### Solid Waste of Domesticated Animals

Estimated 2004 nitrous oxide emissions from animal waste management were 60.3 MMTCO$_2$e, down by 0.6 percent from 2003 levels and 2.6 percent lower than 1990 levels (Table 27), making animal waste management the second-largest U.S. agricultural source of nitrous oxide emissions, after nitrogen fertilization of soils. Nitrous oxide emissions from animal waste are dominated by emissions from cattle waste, which in 2004 accounted for 93 percent of emissions from the solid waste of domesticated animals (a total of 55.8 MMTCO$_2$e in 2004).

Nitrous oxide is released as part of the microbial denitrification of animal manure. The total volume of nitrous oxide emissions is a function of animal size and manure production, the amount of nitrogen in the animal waste, and the method of managing the animal waste. Waste managed by a solid storage or pasture range method may emit 20 times more nitrous oxide per unit of nitrogen content than does waste managed in anaerobic lagoon and liquid systems. Generally, solid waste from feedlot beef cattle is managed with the solid storage or pasture range method, accounting for the majority of nitrous oxide emissions. Solid waste from swine is generally managed in anaerobic lagoons and other liquid systems. Anaerobic digestion yields methane emissions but only negligible amounts of nitrous oxide. Thus, changes in estimated emissions result primarily from changes in cattle populations. For example, beef cattle populations grew during the first half of the 1990s, leading to higher emissions through 1995, but have since declined slowly, lowering emissions to below 1990 levels.

### Crop Residue Burning

In 2004, estimated emissions of nitrous oxide from crop residue burning were 0.6 MMTCO$_2$e, up by 0.1 MMTCO$_2$e (17 percent) from 2003 levels (Table 25). The large percentage increase is mainly attributable to increased corn and soybean production. Emissions from this source remain very small, at 0.2 percent of all U.S. nitrous oxide emissions. When crop residues are burned, the incomplete combustion of agricultural waste results in the production of nitrous oxide, as well as methane (discussed in Chapter 3).

## Energy Use

**U.S. Nitrous Oxide Emissions from Energy, 1990-2004**

| | |
|---|---|
| Estimated 2004 Emissions (Million Metric Tons Carbon Dioxide Equivalent) | 68.4 |
| Change Compared to 2003 (Million Metric Tons Carbon Dioxide Equivalent) | 1.0 |
| Change from 2003 *(Percent)* | *1.5%* |
| Change Compared to 1990 (Million Metric Tons Carbon Dioxide Equivalent) | 14.1 |
| Change from 1990 *(Percent)* | *25.9%* |

The energy use category includes nitrous oxide emissions from both mobile and stationary sources as byproducts of fuel combustion. Estimated 2004 energy-related emissions were 68.4 MMTCO$_2$e, or 19 percent of total U.S. anthropogenic nitrous oxide emissions (Table 25). Emissions from energy use are dominated by mobile combustion (79 percent of nitrous oxide emissions from energy use in 2004).

### Mobile Combustion

Nitrous oxide emissions from mobile source combustion in 2004 were 53.8 MMTCO$_2$e, an increase of 1.5 percent from the 2003 level of 53.0 MMTCO$_2$e (Table 28). In addition to emissions from passenger cars and light-duty trucks, emissions from air, rail, and marine transportation and from farm and construction equipment are also included in the estimates. Motor vehicles, however, are the predominant source, accounting for 94 percent of nitrous oxide emissions from mobile combustion (Table 27).

Nitrous oxide emissions from motor vehicles are caused primarily by the conversion of nitrogen oxides ($NO_x$) into nitrous oxide ($N_2O$) by vehicle catalytic converters. The normal operating temperature of catalytic converters is high enough to cause the thermal decomposition of nitrous oxide. Consequently, it is probable that nitrous oxide emissions result primarily from "cold starts" of motor vehicles and from catalytic converters that are defective or operating under abnormal conditions. This implies that the primary determinant of the level of emissions is motor vehicle operating conditions;

[81] Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3 (Paris, France, 1997), pp. 4.87-4.100, web site www.ipcc.ch/pub/guide.htm.

however, different types of catalytic converters appear to differ systematically in their emissions, and emissions probably vary with engine size. Thus, emissions also depend on the "mix" of vehicle age and type on the road.

Nitrous oxide emissions from mobile sources grew rapidly between 1990 and 1996 due to increasing motor vehicle use, the shifting composition of the light-duty vehicle fleet toward light trucks that have lower fuel economy and higher per-mile emission factors, and the gradual replacement of low emitting pre-1983 vehicles that did not use catalytic converters with higher emitting post-1983 vehicles that do use catalytic converters. This growth moderated between 1996 and 1999 due to the introduction of more advanced, lower-emitting catalytic converters. After peaking in 1999, emissions declined slowly through 2002, as vehicle turnover led to a fleet dominated by the more advanced catalytic converters.

### Stationary Combustion

In 2004, estimated nitrous oxide emissions from stationary combustion sources were 14.7 $MMTCO_2e$, 1.5 percent (0.2 $MMTCO_2e$) higher than in 2003 and 10 percent (1.4 $MMTCO_2e$) higher than in 1990 (Table 29). The total emissions increase from this source between 1990 and 2004 (1.4 $MMTCO_2e$) can be attributed principally to coal-fired combustion systems. Nitrous oxide emissions from coal-fired combustion systems increased by 17 percent over the period, from 8.0 $MMTCO_2e$ in 1990 to 9.3 $MMTCO_2e$ in 2004.

Coal-fired combustion systems produced 64 percent (9.3 $MMTCO_2e$) of the 2004 emissions of nitrous oxide from stationary combustion. Other fuels—including fuel oil (2.4 $MMTCO_2e$), wood (2.3 $MMTCO_2e$), and natural gas (0.6 $MMTCO_2e$)—accounted for the balance. During combustion, nitrous oxide is produced as a result of chemical interactions between nitrogen oxides (mostly $NO_2$) and other combustion products. With most conventional stationary combustion systems, high temperatures destroy almost all nitrous oxide, limiting the quantity that escapes; therefore, emissions from these systems typically are low.

## Industrial Sources

Emissions of nitrous oxide from industrial sources were 14.0 $MMTCO_2e$ in 2004, a decrease of less than 0.05 $MMTCO_2e$ (0.3 percent) from 2003 and a decrease of 14.6 $MMTCO_2e$ (51 percent) since 1990. Nitrous oxide is emitted as a byproduct of certain chemical production processes. Table 30 provides estimates of emissions from the production of adipic acid and nitric acid, the two principal known sources.

### Nitric Acid Production

The 6.7 million metric tons of nitric acid manufactured in 2004[82] resulted in estimated nitrous oxide emissions of 10.9 $MMTCO_2e$ (Table 30). This estimate was 0.7 percent lower than 2003 levels and 6.8 percent lower than 1990 levels. The emissions factor used to estimate nitrous oxide emissions from the production of nitric acid was based on measurements at a single DuPont plant, which indicated an emissions factor of 2 to 9 grams of nitrous oxide emitted per kilogram of nitric acid manufactured, suggesting a significant range of uncertainty. Nitric acid, a primary ingredient in fertilizers, usually is manufactured by oxidizing ammonia ($NH_3$) with a platinum catalyst. Nitrous oxide emissions are a direct result of the oxidation.

### Adipic Acid Production

Emissions from adipic acid production in 2004 were 3.0 $MMTCO_2e$, 1 percent higher than in 2003. Nitrous oxide emissions from this source in 2004 were 82 percent (13.8 $MMTCO_2e$) lower than in 1990.

Adipic acid is a fine white powder that is used primarily in the manufacture of nylon fibers and plastics, such as carpet yarn, clothing, and tire cord. Other uses of adipic acid include production of plasticizer for polyvinyl chloride and polyurethane resins, lubricants, insecticides, and dyes. In the United States, three companies, which operate four plants, manufacture adipic acid by oxidizing a ketone-alcohol mixture with nitric acid. Nitrous

**U.S. Nitrous Oxide Emissions from Industrial Sources, 1990-2004**

| | |
|---|---|
| Estimated 2004 Emissions (Million Metric Tons Carbon Dioxide Equivalent) | 14.0 |
| Change Compared to 2003 (Million Metric Tons Carbon Dioxide Equivalent) | * |
| Change from 2003 *(Percent)* | *-0.3%* |
| Change Compared to 1990 (Million Metric Tons Carbon Dioxide Equivalent) | -14.6 |
| Change from 1990 *(Percent)* | *-51.1%* |

*Less than 0.05 million metric tons.

[82]U.S. Department of Commerce, Bureau of Census, *Current Industrial Reports: Fertilizer Materials and Related Products, Fourth Quarter 2004*, MQ325B(04)-4 (Washington, DC, April 2005), Table 1.

oxide is an intrinsic byproduct of this chemical reaction. For every metric ton of adipic acid produced, 0.3 metric ton of nitrous oxide is created.[83] Between 1990 and 1996, emissions from adipic acid manufacture grew by 23 percent, reaching 20.7 $MMTCO_2e$ before dropping sharply to 7.8 $MMTCO_2e$ in 1997 (Table 30).

Before 1997, two of the four plants that manufacture adipic acid controlled emissions by thermally decomposing the nitrous oxide. This technique eliminates 98 percent of potential nitrous oxide emissions from the process.[84] During the first quarter of 1997, a third plant installed emissions controls, increasing the share of adipic acid production employing emissions abatement controls from 74 percent in 1996 to 92 percent in 1997. In 1998, with emissions controls in place for the full year, 97 percent of emissions from U.S. adipic acid production were controlled.[85]

Estimated emissions of nitrous oxide from uncontrolled adipic acid production decreased from 19.6 $MMTCO_2e$ in 1996 to 2.0 $MMTCO_2e$ in 1998 and remained fairly stable through 2002, before dropping to 1.4 $MMTCO_2e$ in 2003 and 2004. Emissions of nitrous oxide from controlled plants have remained relatively constant from 1998 through 2004, in a range of 1.4 to 1.6 $MMTCO_2e$. With the share of adipic acid production employing abatement controls now at 98 percent, future changes in nitrous oxide emissions from this source are expected to result primarily from changes in plant production levels in response to market demand.

# Waste Management

Nitrous oxide emissions from waste management in 2004 are estimated at 6.0 $MMTCO_2e$, or 1.7 percent of all U.S. anthropogenic nitrous oxide emissions (Table 25). During 2004, emissions from human sewage in wastewater were responsible for 96 percent of the estimated emissions from this source, and the remainder was associated with waste combustion. Estimated emissions from waste management increased by 1.1 percent between 2003 and 2004 and by 25 percent between 1990 and 2004. Because of the lack of reliable data and an effective estimation method, no estimate of emissions from industrial wastewater was calculated, leaving estimated emissions from waste management lower than they otherwise would be had a viable estimation method been available.

## Human Sewage in Wastewater

In 2004, nitrous oxide emissions from wastewater were 5.8 $MMTCO_2e$, a 1.0-percent increase from 2003 levels and a 26-percent increase from the 1990 level (Table 25). Estimates of nitrous oxide emissions from human waste are scaled to population size and per capita protein intake. U.S. population has grown by 18 percent since 1990. U.S. per capita protein intake rose steadily between 1990 and 1999, before declining between 2000 and 2003. Today, U.S. per capita protein intake is 6.5 percent above 1990 levels. Data on protein intake are taken from the United Nations Food and Agriculture Organization (FAO).[86]

Nitrous oxide is emitted from wastewater that contains nitrogen-based organic materials, such as those found in human or animal waste. Two natural processes—nitrification and denitrification—combine to produce nitrous oxide. Nitrification, an aerobic process, converts ammonia into nitrate; denitrification, an anaerobic process, converts nitrate to nitrous oxide. Factors that influence the amount of nitrous oxide generated from wastewater include temperature, acidity, biochemical oxygen demand (BOD),[87] and nitrogen concentration.

## Waste Combustion

In 2004, estimated nitrous oxide emissions from waste combustion were 0.2 $MMTCO_2e$, up by 4.8 percent from the 2003 level and 6.1 percent above the 1990 level. Data on the amount of waste generated in the United States in

**U.S. Nitrous Oxide Emissions from Waste Management, 1990-2004**

| | |
|---|---|
| Estimated 2004 Emissions (Million Metric Tons Carbon Dioxide Equivalent) | 6.0 |
| Change Compared to 2003 (Million Metric Tons Carbon Dioxide Equivalent) | 0.1 |
| Change from 2003 *(Percent)* | *1.1%* |
| Change Compared to 1990 (Million Metric Tons Carbon Dioxide Equivalent) | 1.2 |
| Change from 1990 *(Percent)* | *24.8%* |

[83] M.H. Thiemens and W.C. Trogler, "Nylon Production: An Unknown Source of Atmospheric Nitrous Oxide," *Science*, Vol. 251, No. 4996 (February 1991).
[84] Radian Corporation, *Nitrous Oxide Emissions From Adipic Acid Manufacturing* (Rochester, NY, January 1992), p. 10.
[85] R.A. Reimer, R.A. Parrett, and C.S. Slaten, "Abatement of $N_2O$ Emissions Produced in Adipic Acid," in *Proceedings of the Fifth International Workshop on Nitrous Oxide Emissions* (Tsukuba, Japan, July 1992).
[86] Food and Agriculture Organization of the United Nations, statistical databases, web site http://apps.fao.org/.
[87] Biochemical oxygen demand (BOD) is a measure of the organic content of wastewater that is subject to decomposition.

2004 were not available in time for this report; therefore, EIA scaled the 2004 estimate for waste combustion to the growth in U.S. gross domestic product. The share of waste burned is estimated to have been unchanged from 2003 to 2004, and the total volume of waste generated is estimated to have increased by 4.8 percent. The total volume of waste generated in the United States increased by 58 percent between 1990 and 2004; however, the share of waste burned in 2004 was just 7.7 percent, compared with 12 percent in 1990.

**Table 25. Estimated U.S. Emissions of Nitrous Oxide, 1990 and 1996-2004**

| Source | 1990 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | P2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Million Metric Tons Carbon Dioxide Equivalent** | | | | | | | | | | |
| **Agriculture** | | | | | | | | | | |
| Nitrogen Fertilization of Soils | 186.9 | 184.2 | 190.5 | 194.0 | 192.7 | 189.4 | 189.1 | 185.1 | 186.6 | 204.3 |
| Solid Waste of Domesticated Animals | 61.9 | 65.1 | 63.8 | 62.9 | 62.4 | 61.8 | 61.4 | 61.2 | 60.7 | 60.3 |
| Crop Residue Burning | 0.5 | 0.5 | 0.6 | 0.6 | 0.5 | 0.6 | 0.6 | 0.5 | 0.5 | 0.6 |
| **Subtotal** | **249.3** | **249.8** | **254.8** | **257.4** | **255.6** | **251.8** | **251.1** | **246.8** | **247.8** | **265.2** |
| **Energy Use** | | | | | | | | | | |
| Mobile Combustion | 41.1 | 53.9 | 52.4 | 54.2 | 54.3 | 54.3 | 53.3 | 53.0 | 53.0 | 53.8 |
| Stationary Combustion | 13.3 | 14.5 | 14.6 | 14.5 | 14.7 | 15.1 | 14.5 | 14.2 | 14.5 | 14.7 |
| **Subtotal** | **54.4** | **68.5** | **67.0** | **68.7** | **68.9** | **69.4** | **67.9** | **67.2** | **67.5** | **68.4** |
| **Industrial Sources** | **28.6** | **34.3** | **21.8** | **17.2** | **16.8** | **16.6** | **14.0** | **15.2** | **14.0** | **14.0** |
| **Waste Management** | | | | | | | | | | |
| Human Sewage in Wastewater | 4.6 | 5.2 | 5.2 | 5.3 | 5.5 | 5.6 | 5.6 | 5.7 | 5.7 | 5.8 |
| Waste Combustion | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| **Subtotal** | **4.8** | **5.4** | **5.4** | **5.5** | **5.7** | **5.8** | **5.9** | **5.9** | **6.0** | **6.0** |
| **Total** | **337.0** | **358.0** | **349.1** | **348.8** | **347.1** | **343.5** | **338.8** | **335.1** | **335.2** | **353.7** |
| **Thousand Metric Tons Nitrous Oxide** | | | | | | | | | | |
| **Agriculture** | | | | | | | | | | |
| Nitrogen Fertilization of Soils | 631 | 622 | 643 | 655 | 651 | 640 | 639 | 625 | 630 | 690 |
| Solid Waste of Domesticated Animals | 209 | 220 | 216 | 212 | 211 | 209 | 208 | 207 | 205 | 204 |
| Crop Residue Burning | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Subtotal** | **842** | **844** | **861** | **870** | **864** | **851** | **848** | **834** | **837** | **896** |
| **Energy Use** | | | | | | | | | | |
| Mobile Combustion | 139 | 182 | 177 | 183 | 183 | 183 | 180 | 179 | 179 | 182 |
| Stationary Combustion | 45 | 49 | 49 | 49 | 50 | 51 | 49 | 48 | 49 | 50 |
| **Subtotal** | **184** | **231** | **227** | **232** | **233** | **234** | **229** | **227** | **228** | **231** |
| **Industrial Sources** | **96** | **116** | **74** | **58** | **57** | **56** | **47** | **51** | **47** | **47** |
| **Waste Management** | | | | | | | | | | |
| Human Sewage in Wastewater | 16 | 17 | 18 | 18 | 19 | 19 | 19 | 19 | 19 | 20 |
| Waste Combustion | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Subtotal** | **16** | **18** | **18** | **19** | **19** | **20** | **20** | **20** | **20** | **20** |
| **Total** | **1,139** | **1,209** | **1,179** | **1,178** | **1,173** | **1,160** | **1,145** | **1,132** | **1,133** | **1,195** |

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 2003*, DOE/EIA-0573(2003) (Washington, DC, December 2004). Totals may not equal sum of components due to independent rounding.

Sources: Estimates presented in this chapter. Emissions calculations based on Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3 (Paris, France, 1997), pp. 4.81-4.94, web site www.ipcc.ch/pub/guide.htm; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003*, EPA 430-R-05-003 (Washington, DC, April 2005), web site http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenter PublicationsGHGEmissionsUSEmissionsInventory2005.html.

**Table 26. U.S. Nitrous Oxide Emissions from Nitrogen Fertilization of Agricultural Soils, 1990 and 1996-2004**

| Source | 1990 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | P2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Million Metric Tons Carbon Dioxide Equivalent** | | | | | | | | | | |
| **Direct Emissions** | | | | | | | | | | |
| Biological Fixation in Crops. . . . | 58.6 | 62.6 | 66.4 | 68.7 | 68.2 | 67.9 | 69.5 | 65.3 | 62.5 | 70.9 |
| Nitrogen Fertilizers . . . . . . . . . . | 53.1 | 47.1 | 47.2 | 47.5 | 47.7 | 45.6 | 44.4 | 45.6 | 48.0 | 50.0 |
| Crop Residues . . . . . . . . . . . . . | 28.2 | 31.9 | 34.2 | 34.8 | 33.8 | 34.6 | 34.7 | 32.9 | 32.8 | 38.5 |
| Soil Mineralization. . . . . . . . . . . | 3.0 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.2 | 3.2 |
| Animal Manure . . . . . . . . . . . . . | 1.2 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| Sewage Sludge. . . . . . . . . . . . . | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 |
| **Total Direct Emissions . . . . .** | **144.1** | **146.0** | **152.2** | **155.5** | **154.1** | **152.4** | **153.0** | **148.2** | **147.7** | **163.9** |
| **Indirect Emissions** | | | | | | | | | | |
| Soil Leaching . . . . . . . . . . . . . . | 36.3 | 32.4 | 32.4 | 32.6 | 32.8 | 31.3 | 30.6 | 31.4 | 33.0 | 34.3 |
| Atmospheric Deposition . . . . . . | 6.5 | 5.8 | 5.8 | 5.8 | 5.8 | 5.6 | 5.5 | 5.6 | 5.9 | 6.1 |
| **Total Indirect Emissions . . .** | **42.8** | **38.2** | **38.2** | **38.5** | **38.6** | **36.9** | **36.0** | **37.0** | **38.8** | **40.4** |
| **Total . . . . . . . . . . . . . . . . . . . . . .** | **186.9** | **184.2** | **190.5** | **194.0** | **192.7** | **184.9** | **189.1** | **185.1** | **186.6** | **204.3** |
| **Thousand Metric Tons Nitrous Oxide** | | | | | | | | | | |
| **Direct Emissions** | | | | | | | | | | |
| Biological Fixation in Crops. . . . | 198 | 212 | 224 | 232 | 230 | 229 | 235 | 221 | 211 | 240 |
| Nitrogen Fertilizers . . . . . . . . . . | 179 | 159 | 159 | 161 | 161 | 154 | 150 | 154 | 162 | 169 |
| Crop Residues . . . . . . . . . . . . . | 95 | 108 | 116 | 118 | 114 | 117 | 117 | 111 | 111 | 130 |
| Soil Mineralization. . . . . . . . . . . | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 |
| Animal Manure . . . . . . . . . . . . . | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Sewage Sludge. . . . . . . . . . . . . | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| **Total Direct Emissions . . . . .** | **487** | **493** | **514** | **525** | **521** | **515** | **517** | **501** | **499** | **554** |
| **Indirect Emissions** | | | | | | | | | | |
| Soil Leaching . . . . . . . . . . . . . . | 123 | 109 | 110 | 110 | 111 | 106 | 103 | 106 | 111 | 116 |
| Atmospheric Deposition . . . . . . | 22 | 20 | 20 | 20 | 20 | 19 | 18 | 19 | 20 | 21 |
| **Total Indirect Emissions . . .** | **144** | **129** | **129** | **130** | **130** | **125** | **122** | **125** | **131** | **136** |
| **Total . . . . . . . . . . . . . . . . . . . . . .** | **631** | **622** | **643** | **655** | **651** | **640** | **639** | **625** | **630** | **690** |

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 2003*, DOE/EIA-0573(2003) (Washington, DC, December 2004). Totals may not equal sum of components due to independent rounding.

Sources: Estimates presented in this chapter. Emissions coefficients from Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3 (Paris, France, 1997), pp. 4.89-4.107, web site www.ipcc.ch/pub/guide.htm. Total nitrogen content of U.S. commercial fertilizer consumption—1988-1994, Tennessee Valley Authority; 1995-2002, Association of American Plant Food Control Officials, *Commercial Fertilizers* (Washington, DC, various years). Manure application based on cattle population data provided by the U.S. Department of Agriculture, National Agricultural Statistics Service, web sites www.usda.gov/nass/pubs/histdata.htm and www.nass.usda.gov/ipedb/. Typical animal sizes from U.S. Environmental Protection Agency, Office of Air and Radiation, *Anthropogenic Methane Emissions in the United States: Estimates for 1990* (Washington, DC, April 1993), p. 6-8. Manure production and waste management systems used from L.M. Safley, M.E. Casada et al., *Global Methane Emissions From Livestock and Poultry Manure* (Washington, DC, February 1992), and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003*, EPA 430-R-05-003 (Washington, DC, April 2005), web site http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2005.html.

**Table 27. U.S. Nitrous Oxide Emissions from Solid Waste of Domesticated Animals, 1990 and 1996-2004**

| Source | 1990 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | P2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Million Metric Tons Carbon Dioxide Equivalent** | | | | | | | | | | |
| Cattle | 57.5 | 60.6 | 59.2 | 58.3 | 57.9 | 57.4 | 56.9 | 56.7 | 56.3 | 55.8 |
| Swine | 1.5 | 1.5 | 1.7 | 1.7 | 1.6 | 1.6 | 1.6 | 1.6 | 1.7 | 1.7 |
| Poultry | 0.9 | 1.2 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.4 |
| Horses | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Sheep | 1.0 | 0.7 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.5 |
| Goats | 0.3 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| **Total** | **61.9** | **65.1** | **63.8** | **62.9** | **62.4** | **61.8** | **61.4** | **61.2** | **60.7** | **60.3** |
| **Thousand Metric Tons Nitrous Oxide** | | | | | | | | | | |
| Cattle | 194 | 205 | 200 | 197 | 195 | 194 | 192 | 192 | 190 | 189 |
| Swine | 5 | 5 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 |
| Poultry | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 |
| Horses | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Sheep | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Goats | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Total** | **209** | **220** | **216** | **212** | **211** | **209** | **208** | **207** | **205** | **204** |

P = preliminary data.

Note: Totals may not equal sum of components due to independent rounding.

Sources: Estimates presented in this chapter. Nitrogen content of waste by species, manure management systems, and emissions coefficients from Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3 (Paris, France, 1997), pp. 4.89-4.107, web site www.ipcc.ch/pub/guide.htm. Population data for horses and goats extrapolated from U.S. Department of Commerce, Bureau of the Census, *Census of Agriculture* (1982, 1987, 1992, and 1997). All other animal populations from U.S. Department of Agriculture, National Agricultural Statistics Service, web sites www.usda.gov/nass/pubs/histdata.htm and www.nass.usda.gov/ipedb/. Typical animal sizes from U.S. Environmental Protection Agency, Office of Air and Radiation, *Anthropogenic Methane Emissions in the United States: Estimates for 1990* (Washington, DC, April 1993), p. 6-8. Cattle sizes adjusted by annual slaughter weight from U.S. Department of Agriculture, National Agricultural Statistics Service.

**Table 28. U.S. Nitrous Oxide Emissions from Mobile Combustion, 1990 and 1996-2004**

| Item | 1990 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | P2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Million Metric Tons Carbon Dioxide Equivalent** | | | | | | | | | | |
| **Motor Vehicles** | | | | | | | | | | |
| Passenger Cars | 25.2 | 30.4 | 29.1 | 30.4 | 30.3 | 30.0 | 29.4 | 28.7 | 28.6 | 28.5 |
| Light-Duty Trucks | 10.4 | 17.5 | 17.3 | 17.7 | 17.7 | 17.8 | 17.7 | 17.9 | 18.3 | 19.2 |
| Other Trucks | 1.7 | 2.2 | 2.3 | 2.3 | 2.4 | 2.4 | 2.5 | 2.6 | 2.6 | 2.6 |
| Buses | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Motorcycles | * | * | * | * | * | * | * | * | * | * |
| **Subtotal** | **37.4** | **50.2** | **48.8** | **50.5** | **50.5** | **50.4** | **49.6** | **49.3** | **49.5** | **50.4** |
| **Other Mobile Sources** | **3.6** | **3.7** | **3.6** | **3.6** | **3.7** | **3.9** | **3.7** | **3.7** | **3.5** | **3.4** |
| **Total** | **41.1** | **53.9** | **52.4** | **54.2** | **54.3** | **54.3** | **53.3** | **53.0** | **53.0** | **53.8** |
| **Thousand Metric Tons Nitrous Oxide** | | | | | | | | | | |
| **Motor Vehicles** | | | | | | | | | | |
| Passenger Cars | 85 | 103 | 98 | 103 | 102 | 101 | 99 | 97 | 97 | 96 |
| Light-Duty Trucks | 35 | 59 | 59 | 60 | 60 | 60 | 60 | 61 | 62 | 65 |
| Other Trucks | 6 | 7 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 |
| Buses | * | * | * | * | * | * | * | * | * | * |
| Motorcycles | * | * | * | * | * | * | * | * | * | * |
| **Subtotal** | **127** | **170** | **165** | **171** | **171** | **170** | **168** | **167** | **167** | **170** |
| **Other Mobile Sources** | **12** | **13** | **12** | **12** | **13** | **13** | **13** | **12** | **12** | **11** |
| **Total** | **139** | **182** | **177** | **183** | **183** | **183** | **180** | **179** | **179** | **182** |

*Less than 500 metric tons nitrous oxide or less than 50,000 metric tons carbon dioxide 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 2003*, DOE/EIA-0573(2003) (Washington, DC, December 2004). Totals may not equal sum of components due to independent rounding.

Sources: Calculations based on vehicle miles traveled from U.S. Department of Transportation, *Federal Highway Statistics* (various years), Table VM-1, and current year preliminary estimates calculated using growth rates from EIA, *Short-Term Energy Outlook* (various years). Other Mobile Sources calculations based on Oak Ridge National Laboratory, *Transportation Energy Data Book*; EIA, *Fuel Oil and Kerosene Sales*, *State Energy Data Report*, and *Petroleum Supply Annual* (various years). Passenger car and light-duty truck emissions coefficients from U.S. Environmental Protection Agency, Office of Air and Radiation, *Emissions of Nitrous Oxide From Highway Mobile Sources: Comments on the Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-1996*, EPA-420-R-98-009 (Washington DC, August 1998). Emissions coefficients from Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3 (Paris, France, 1997), pp. 1.64-1.68, web site www.ipcc.ch/pub/guide.htm.

**Table 29. U.S. Nitrous Oxide Emissions from Stationary Combustion, 1990 and 1996-2004**

| Source | 1990 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | P2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Thousand Metric Tons Carbon Dioxide Equivalent | | | | | | | | | |
| **Residential** | | | | | | | | | | |
| Coal | 13 | 7 | 7 | 5 | 6 | 4 | 5 | 5 | 4 | 5 |
| Fuel Oil[a] | 251 | 266 | 255 | 235 | 263 | 279 | 275 | 261 | 268 | 280 |
| Natural Gas | 128 | 153 | 146 | 133 | 138 | 145 | 139 | 143 | 149 | 143 |
| Wood | 677 | 693 | 504 | 451 | 482 | 504 | 431 | 365 | 418 | 387 |
| **Total** | **1,069** | **1,119** | **912** | **823** | **889** | **933** | **850** | **773** | **840** | **815** |
| **Commercial** | | | | | | | | | | |
| Coal | 52 | 50 | 54 | 42 | 42 | 36 | 38 | 38 | 35 | 36 |
| Fuel Oil[a] | 170 | 134 | 126 | 118 | 118 | 134 | 135 | 122 | 134 | 144 |
| Natural Gas | 77 | 92 | 94 | 88 | 89 | 92 | 89 | 92 | 94 | 88 |
| Wood | 45 | 58 | 57 | 56 | 61 | 62 | 47 | 45 | 47 | 48 |
| **Total** | **344** | **335** | **330** | **304** | **310** | **324** | **308** | **297** | **310** | **315** |
| **Industrial** | | | | | | | | | | |
| Coal | 1,131 | 995 | 977 | 925 | 905 | 918 | 913 | 841 | 851 | 844 |
| Fuel Oil[a] | 1,606 | 1,752 | 1,789 | 1,781 | 1,845 | 1,768 | 1,807 | 1,644 | 1,655 | 1,752 |
| Natural Gas | 242 | 283 | 283 | 279 | 268 | 271 | 248 | 252 | 242 | 250 |
| Wood | 1,680 | 1,962 | 2,017 | 1,867 | 1,887 | 1,906 | 1,681 | 1,626 | 1,588 | 1,687 |
| **Total** | **4,659** | **4,992** | **5,066** | **4,853** | **4,905** | **4,863** | **4,649** | **4,363** | **4,335** | **4,532** |
| **Electric Power** | | | | | | | | | | |
| Coal | 6,770 | 7,680 | 7,878 | 8,008 | 8,034 | 8,426 | 8,205 | 8,244 | 8,411 | 8,446 |
| Fuel Oil[a] | 228 | 146 | 166 | 233 | 216 | 204 | 229 | 216 | 215 | 213 |
| Natural Gas | 94 | 110 | 118 | 133 | 140 | 151 | 153 | 164 | 150 | 156 |
| Wood | 150 | 161 | 160 | 160 | 161 | 156 | 147 | 175 | 195 | 196 |
| **Total** | **7,242** | **8,097** | **8,321** | **8,534** | **8,551** | **8,937** | **8,733** | **8,799** | **8,971** | **9,011** |
| **Total All Sectors** | | | | | | | | | | |
| **Coal** | **7,965** | **8,732** | **8,916** | **8,980** | **8,987** | **9,384** | **9,161** | **9,128** | **9,301** | **9,331** |
| **Fuel Oil[a]** | **2,256** | **2,298** | **2,335** | **2,367** | **2,443** | **2,385** | **2,445** | **2,242** | **2,272** | **2,389** |
| **Natural Gas** | **541** | **638** | **641** | **633** | **634** | **659** | **629** | **651** | **636** | **636** |
| **Wood** | **2,552** | **2,874** | **2,738** | **2,534** | **2,591** | **2,628** | **2,305** | **2,211** | **2,247** | **2,317** |
| **Total** | **13,314** | **14,543** | **14,630** | **14,514** | **14,655** | **15,057** | **14,540** | **14,232** | **14,456** | **14,673** |

[a]Fuel oil use in the residential sector consists of distillate fuel only. In the other sectors it includes both distillate and residual fuel oil.
*Less than 500 metric tons nitrous oxide.
P = preliminary data. See notes and sources at end of table.

**Table 29. U.S. Nitrous Oxide Emissions from Stationary Combustion, 1990 and 1996-2004 (Continued)**

| Source | 1990 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | P2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Thousand Metric Tons Nitrous Oxide | | | | | | | | | |
| **Residential** | | | | | | | | | | |
| Coal | * | * | * | * | * | * | * | * | * | * |
| Fuel Oil[a] | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Natural Gas | * | 1 | * | * | * | * | * | * | 1 | * |
| Wood | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| **Subtotal** | **4** | **4** | **3** | **3** | **3** | **3** | **3** | **3** | **3** | **3** |
| **Commercial** | | | | | | | | | | |
| Coal | * | * | * | * | * | * | * | * | * | * |
| Fuel Oil[a] | 1 | * | * | * | * | 1 | 1 | * | * | * |
| Natural Gas | * | * | * | * | * | * | * | * | * | * |
| Wood | * | * | * | * | * | * | * | * | * | * |
| **Subtotal** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |
| **Industrial** | | | | | | | | | | |
| Coal | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Fuel Oil[a] | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Natural Gas | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Wood | 6 | 7 | 7 | 6 | 6 | 6 | 6 | 5 | 5 | 6 |
| **Subtotal** | **16** | **17** | **17** | **16** | **17** | **16** | **16** | **15** | **15** | **15** |
| **Electric Power** | | | | | | | | | | |
| Coal | 23 | 26 | 27 | 27 | 27 | 28 | 28 | 28 | 28 | 29 |
| Fuel Oil[a] | 1 | * | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Natural Gas | * | * | * | * | * | 1 | 1 | 1 | 1 | 1 |
| Wood | 1 | 1 | 1 | 1 | 1 | 1 | * | 1 | 1 | 1 |
| **Total** | **24** | **27** | **28** | **29** | **29** | **30** | **30** | **30** | **30** | **30** |
| **Total All Sectors** | | | | | | | | | | |
| **Coal** | **27** | **29** | **30** | **30** | **30** | **32** | **31** | **31** | **31** | **32** |
| **Fuel Oil[a]** | **8** | **8** | **8** | **8** | **8** | **8** | **8** | **8** | **8** | **8** |
| **Natural Gas** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** |
| **Wood** | **9** | **10** | **9** | **9** | **9** | **9** | **8** | **7** | **8** | **8** |
| **Total** | **45** | **49** | **49** | **49** | **50** | **51** | **49** | **48** | **49** | **50** |

[a]Fuel oil use in the residential sector consists of distillate fuel only. In the other sectors it includes both distillate and residual fuel oil.

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 2003*, DOE/EIA-0573(2003) (Washington, DC, December 2004). Totals may not equal sum of components due to independent rounding.

Sources: Emissions coefficients from Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3 (Paris, France, 1997), p. 1.50, web site www.ipcc.ch/pub/guide.htm. Non published Energy consumption data from Energy Information Administration, website: http://www.eia.doe.gov/emeu/states/_states.html; and *Monthly Energy Review*, DOE/EIA-0035(2005/08) (Washington, DC, August 2005).

**Table 30. U.S. Nitrous Oxide Emissions from Industrial Sources, 1990 and 1996-2004**

| Source | 1990 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | P2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Million Metric Tons Carbon Dioxide Equivalent** | | | | | | | | | | |
| **Adipic Acid** | | | | | | | | | | |
| Controlled Sources | 1.0 | 1.1 | 1.4 | 1.5 | 1.5 | 1.6 | 1.4 | 1.6 | 1.6 | 1.6 |
| Uncontrolled Sources | 15.9 | 19.6 | 6.4 | 2.0 | 2.1 | 2.1 | 2.1 | 2.3 | 1.4 | 1.4 |
| **Subtotal** | **16.8** | **20.7** | **7.8** | **3.5** | **3.6** | **3.7** | **3.5** | **3.9** | **3.0** | **3.0** |
| **Nitric Acid** | **11.7** | **13.6** | **13.9** | **13.7** | **13.2** | **12.9** | **10.4** | **11.3** | **11.0** | **10.9** |
| **Total Known Industrial Sources** | **28.6** | **34.3** | **21.8** | **17.2** | **16.8** | **16.6** | **14.0** | **15.2** | **14.0** | **14.0** |
| **Thousand Metric Tons Nitrous Oxide** | | | | | | | | | | |
| **Adipic Acid** | | | | | | | | | | |
| Controlled Sources | 3 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 |
| Uncontrolled Sources | 54 | 66 | 22 | 7 | 7 | 7 | 7 | 8 | 5 | 5 |
| **Subtotal** | **57** | **70** | **27** | **12** | **12** | **13** | **12** | **13** | **10** | **10** |
| **Nitric Acid** | **40** | **46** | **47** | **46** | **45** | **43** | **35** | **38** | **37** | **37** |
| **Total Known Industrial Sources** | **96** | **116** | **74** | **58** | **57** | **56** | **47** | **51** | **47** | **47** |

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 2003*, DOE/EIA-0573(2003) (Washington, DC, December 2004). Totals may not equal sum of components due to independent rounding.

Sources: Data sources and methods documented in Energy Information Administration, *Documentation for Emissions of Greenhouse Gases in the United States 2003*, DOE/EIA-0638(2003) (Washington, DC, January 2005), and *Documentation for Emissions of Greenhouse Gases in the United States 2004*, DOE/EIA-0638(2004) (to be published).