

### 3. Methane Emissions

#### Overview

	Methane	Carbon Dioxide Equivalent
Estimated 2005 Emissions (Million Metric Tons)	26.6	611.9
Change Compared to 2004 (Million Metric Tons)	0.2	5.3
Change from 2004 (Percent)	0.9%	0.9%
Change Compared to 1990 (Million Metric Tons)	-3.9	-89.8
Change from 1990 (Percent)	-12.8%	-12.8%

U.S. anthropogenic methane emissions in 2005 totaled 611.9 million metric tons carbon dioxide equivalent (MMT<sub>CO<sub>2</sub>e</sub>),<sup>45</sup> or 26.6 million metric tons of methane, representing 8.6 percent of total U.S. greenhouse gas emissions. U.S. methane emissions in 2005 were 0.9 percent (5.3 MMT<sub>CO<sub>2</sub>e</sub>) higher than their 2004 level of 606.5 MMT<sub>CO<sub>2</sub>e</sub> (Table 15), primarily as a result of an increase in emissions from waste management (landfills and wastewater treatment plants) and smaller increases in emissions associated with agriculture (ruminant animals and animal waste), which together more than offset declines in emissions from energy sources.<sup>46</sup>

U.S. emissions of methane in 2005 were 12.8 percent (89.8 MMT<sub>CO<sub>2</sub>e</sub>) below their 1990 level of 701.7 MMT<sub>CO<sub>2</sub>e</sub> (Figure 2). In addition to a reduction of 81.6 MMT<sub>CO<sub>2</sub>e</sub> (34 percent) in methane emissions from landfills since 1990, there was also a decrease of 32.2 MMT<sub>CO<sub>2</sub>e</sub> (33 percent) in methane emissions from coal mines over the same period. The decline in emissions from coal mining was the result of a 173-percent increase in methane recovery from coal mines and a shift in production away from gassy mines. Methane emissions

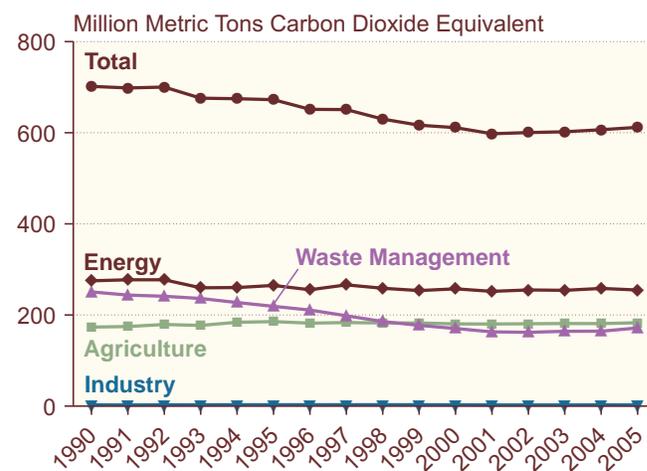
Principal Sources of U.S. Anthropogenic Methane Emissions, 1990-2005

Source	Million Metric Tons CO <sub>2</sub> e		Percent Change	
	1990	2005	1990-2005	2004-2005
Energy	275.0	254.9	-7.3%	-1.3%
Waste Management	250.6	171.5	-31.6%	4.3%
Agriculture	173.4	183.0	5.5%	1.0%
Industrial Processes	2.7	2.5	-8.4%	-7.7%

have decreased on average by 0.9 percent per year since 1990.

Estimates of U.S. methane emissions have been revised to reflect a new methodology for estimating municipal solid waste (MSW) generated and landfilled. As a result, the estimate of total methane emissions in 1990 in this report is 19.4 MMT<sub>CO<sub>2</sub>e</sub> lower than in previous reports. The downward revision grows over the time series, to

Figure 2. U.S. Emissions of Methane by Source, 1990-2005



Source: Estimates presented in this chapter.

<sup>45</sup>Based on an estimated global warming potential factor of 23 for methane. For an expanded discussion of global warming potentials, see Chapter 1, pages 5-6.

<sup>46</sup>Recent research findings suggest that vegetation may emit methane under aerobic conditions. The proper allocation of such emissions to anthropogenic and nonanthropogenic pools remains to be determined. See the text box in Chapter 6, page 73, for discussion.

29.4 MMTCO<sub>2</sub>e in 2003, and is 33.7 MMTCO<sub>2</sub>e in 2004. Methane emission estimates generally are much more uncertain than carbon dioxide emission estimates. Methane emissions usually are accidental or incidental to biological processes and may not be metered in any systematic way.<sup>47</sup> Thus, methane emission estimates often must rely on proxy measurements.

Estimated U.S. anthropogenic methane emissions for 2005 are based on incomplete data for several key sources; thus, the overall estimate is likely to be revised. Because emissions from three of these sources—coal mining, natural gas systems, and landfills—represented more than three-fifths of all U.S. methane emissions, comparisons between 2004 and 2005 numbers are more likely to be valid in terms of their direction than their magnitude. For example, because 2005 data on waste generation are not yet available, waste generation has been estimated from a simple regression equation with economic output as the independent variable. Less critical but still important data are also unavailable for natural gas systems, such as miles of gas transmission and distribution pipeline.

### Energy Sources

U.S. methane emissions from energy sources in 2005 are estimated at 254.9 MMTCO<sub>2</sub>e, equivalent to 42 percent of total methane emissions. The 2005 emission level is 1.3 percent below the 2004 level of 258.3 MMTCO<sub>2</sub>e. Total methane emissions from energy sources in 2005 were 20.1 MMTCO<sub>2</sub>e below their 1990 level of 275.0 MMTCO<sub>2</sub>e.

The drop in methane emissions from energy sources since 1990 can be traced primarily to an overall reduction in emissions from coal mines and secondarily to lower emissions from petroleum systems and stationary combustion. Methane emissions from coal mines dropped by 33 percent (32.2 MMTCO<sub>2</sub>e) between 1990 and 2005. This decline resulted partly from the increased capture and use of methane from coal mine degasification systems and a shift in production away from some of the Nation’s gassiest underground mines in Central Appalachia. Also, between 1990 and 2005, the share of coal production represented by underground mines declined from 41 percent to 33 percent. Methane emissions from underground mines tend to be higher than emissions from surface mines per ton of coal mined,

because coal mined from the surface has been subjected to lower pressures, and methane in the seams of surface mines has had earlier opportunities to migrate to the surface through cracks and fissures.

Methane emissions from petroleum systems dropped from 29.9 MMTCO<sub>2</sub>e in 1990 to 21.1 MMTCO<sub>2</sub>e in 2005. Decreases of 3.2 MMTCO<sub>2</sub>e and 1.1 MMTCO<sub>2</sub>e in estimated methane emissions from stationary and mobile source combustion, respectively, made smaller contributions to the overall drop in emissions from energy sources between 1990 and 2005. Together, the declines in emissions from coal mining, petroleum systems, and stationary and mobile combustion more than compensated for the increase of 25.1 MMTCO<sub>2</sub>e in emissions from natural gas systems, attributed to increasing U.S. consumption of natural gas between 1990 and 2005.

### Coal Mining

	<b>Methane</b>	<b>Carbon Dioxide Equivalent</b>
Estimated 2005 Emissions (Million Metric Tons)	2.8	65.5
Change Compared to 2004 (Million Metric Tons)	-0.1	-1.8
Change from 2004 (Percent)	-2.7%	-2.7%
Change Compared to 1990 (Million Metric Tons)	-1.4	-32.2
Change from 1990 (Percent)	-32.9%	-32.9%

The preliminary estimate of methane emissions from coal mines for 2005 is 65.5 MMTCO<sub>2</sub>e (Table 16), a decrease of 2.7 percent (1.8 MMTCO<sub>2</sub>e) from the 2004 level of 67.3 MMTCO<sub>2</sub>e. Despite a record level of coal production in 2005 to meet escalating demand—attributed to continued economic expansion and warm summer weather<sup>48</sup>—emissions were lower primarily as the result of a decrease in emissions from ventilation and degasification systems in the Nation’s gassiest underground coal mines. Together, emissions from ventilation

<sup>47</sup>Wherever possible, estimates of methane emissions are based on measured data. In some cases, however, measured data are incomplete or unavailable. In the absence of measured data, emissions are indexed to some known activity data, such as coal production or natural gas throughput, and multiplied by an emissions factor derived from a small sample of the relevant emissions source or through laboratory experiments. For a more detailed discussion of where measured data were used and how emissions factors were developed, see Energy Information Administration, *Documentation for Emissions of Greenhouse Gases in the United States 2004*, DOE/EIA-0638(2004) (Washington, DC, November 2006), web site [www.eia.doe.gov/oiaf/1605/ggrpt/documentation/pdf/0638\(2004\).pdf](http://www.eia.doe.gov/oiaf/1605/ggrpt/documentation/pdf/0638(2004).pdf); and Energy Information Administration, *Documentation for Emissions of Greenhouse Gases in the United States 2005* (to be published).

<sup>48</sup>Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(2006/07) (Washington, DC, July 2006), Table 7.3a, “Consumption of Combustible Fuels for Electricity Generation: Total (All Sectors),” web site [www.eia.doe.gov/emeu/mer](http://www.eia.doe.gov/emeu/mer).

and degasification systems in gassy mines totaled 56.0 MMTCO<sub>2</sub>e in 2005, more than 22 MMTCO<sub>2</sub>e lower than in 1990 and lower than in any subsequent year.

Methane emissions from coal mines have dropped by 33 percent, from 97.7 MMTCO<sub>2</sub>e in 1990 to 65.5 MMTCO<sub>2</sub>e in 2005. The decline is attributed to three important trends: (1) methane recovery from active coal mines for use as an energy resource increased from 6.1 MMTCO<sub>2</sub>e in 1990 to about 16.7 MMTCO<sub>2</sub>e in 2005; (2) methane emissions from degasification systems were reduced by nearly 7.3 MMTCO<sub>2</sub>e, from 28.9 MMTCO<sub>2</sub>e in 1990 to 21.6 MMTCO<sub>2</sub>e in 2005; and (3) decreases in coal production from gassy mines, combined with enhanced methane recovery through degasification, caused methane emissions from ventilation systems at gassy mines to drop by about 15.3 MMTCO<sub>2</sub>e, from 48.9 MMTCO<sub>2</sub>e in 1990 to 33.6 MMTCO<sub>2</sub>e in 2005 (Table 16).<sup>49</sup>

Abandoned coal mines represent a significant source of additional emissions that has not been incorporated into the overall estimate of methane emissions in this report because of uncertainties associated with the data. The text box on page 33 provides a discussion of those uncertainties and the potential magnitude of additional emissions.

### Natural Gas Systems

#### U.S. Methane Emissions from Natural Gas Systems, 1990-2005

	Methane	Carbon Dioxide Equivalent
Estimated 2005 Emissions (Million Metric Tons)	6.7	154.0
Change Compared to 2004 (Million Metric Tons)	*	-0.7
Change from 2004 (Percent)	-0.5%	-0.5%
Change Compared to 1990 (Million Metric Tons)	1.1	25.1
Change from 1990 (Percent)	19.5%	19.5%

\*Less than 0.05 million metric tons.

At 154.0 MMTCO<sub>2</sub>e, 2005 estimated methane emissions from natural gas systems were down by 0.5 percent from

the 154.7 MMTCO<sub>2</sub>e emitted in 2004 (Table 17). The 2005 estimate is preliminary, however, because pipeline data for 2005 have not been finalized as of the publication of this report. The estimated 2005 emissions level is 19 percent (25.1 MMTCO<sub>2</sub>e) above the 1990 level (128.9 MMTCO<sub>2</sub>e), with more than three-fifths of the increase attributable to increased mileage of transmission and distribution pipelines and almost two-fifths attributable to increases in natural gas production.<sup>50</sup>

### Petroleum Systems

#### U.S. Methane Emissions from Petroleum Systems, 1990-2005

	Methane	Carbon Dioxide Equivalent
Estimated 2005 Emissions (Million Metric Tons)	0.9	21.1
Change Compared to 2004 (Million Metric Tons)	-0.1	-1.2
Change from 2004 (Percent)	-5.3%	-5.3%
Change Compared to 1990 (Million Metric Tons)	-0.4	-8.8
Change from 1990 (Percent)	-29.5%	-29.5%

Methane emissions from petroleum systems in 2005 are estimated at 21.1 MMTCO<sub>2</sub>e, 5.3 percent below their 2004 level and 29 percent (8.8 MMTCO<sub>2</sub>e) below the 1990 level of 29.9 MMTCO<sub>2</sub>e. The decline in emissions from this source is almost exclusively due to a 30-percent reduction in domestic oil production from 1990 to 2005. Approximately 96 percent (20.2 MMTCO<sub>2</sub>e) of all U.S. emissions from petroleum systems occur during oil exploration and production (Table 18). A much smaller portion of methane emissions from petroleum systems can be traced to refineries (0.6 MMTCO<sub>2</sub>e) and transportation of crude oil (0.2 MMTCO<sub>2</sub>e).

### Stationary Combustion

U.S. methane emissions from stationary combustion in 2005 were 9.7 MMTCO<sub>2</sub>e, up by 1.8 percent from their 2004 level of 9.5 MMTCO<sub>2</sub>e but still 25 percent below

<sup>49</sup>EIA obtains data on methane released and recovered from pre-mining degasification from the U.S. Environmental Protection Agency (EPA).

<sup>50</sup>The EPA estimates that companies participating in the Natural Gas STAR program together avoided emissions of 34.7 MMTCO<sub>2</sub>e of methane from the natural gas system in 2005 (Table 17). Program participants report annually on emissions reductions achieved through such activities as equipment replacement, enhanced inspection and maintenance, and improved operations management. Participating companies may either use their own techniques to estimate reductions achieved or employ default values developed by the EPA and the Gas Technology Institute (formerly the Gas Research Institute).

**U.S. Methane Emissions from Stationary Combustion, 1990-2005**

	Methane	Carbon Dioxide Equivalent
Estimated 2005 Emissions (Million Metric Tons)	0.4	9.7
Change Compared to 2004 (Million Metric Tons)	*	0.2
Change from 2004 (Percent)	1.8%	1.8%
Change Compared to 1990 (Million Metric Tons)	-0.1	-3.2
Change from 1990 (Percent)	-24.9%	-24.9%

\*Less than 0.05 million metric tons.

**U.S. Methane Emissions from Mobile Sources, 1990-2005**

	Methane	Carbon Dioxide Equivalent
Estimated 2005 Emissions (Million Metric Tons)	0.2	4.5
Change Compared to 2004 (Million Metric Tons)	*	0.1
Change from 2004 (Percent)	2.9%	2.9%
Change Compared to 1990 (Million Metric Tons)	*	-1.1
Change from 1990 (Percent)	-19.4%	-19.4%

\*Less than 0.05 million metric tons.

their 1990 level of 12.9 MMTCO<sub>2</sub>e (Table 19). Residential wood consumption typically accounts for about 88 percent of methane emissions from stationary combustion. Methane emissions are the result of incomplete combustion, and residential woodstoves and fireplaces provide much less efficient combustion than industrial or utility boilers. Estimates of emissions from residential wood combustion have fallen by 28 percent, from 11.8 MMTCO<sub>2</sub>e in 1990 to 8.5 MMTCO<sub>2</sub>e in 2005, although these estimates are very uncertain.<sup>51</sup>

The universe of wood consumers is large and heterogeneous, and the Energy Information Administration (EIA) collects data on residential wood consumption only at 4-year intervals in its Residential Energy Consumption Survey (RECS). The most recently published EIA data on residential wood consumption are from the 2001 RECS.<sup>52</sup>

**Mobile Combustion**

Estimated U.S. methane emissions from mobile combustion in 2005 were 4.5 MMTCO<sub>2</sub>e, up by 2.9 percent from the 2004 level but 19 percent lower than the 1990 level of 5.6 MMTCO<sub>2</sub>e (Table 20). Methane emissions from passenger cars have declined since 1990 as older

vehicles with catalytic converters that are less efficient at destroying methane have been taken off the road. Estimates of methane emissions from mobile sources have been revised downward in the last three annual editions of this report, reflecting a change in the source of data for vehicle miles traveled and a related adjustment in the emission factors for light-duty trucks.<sup>53</sup>

**Waste Management**

Methane emissions from waste management, at 171.5 MMTCO<sub>2</sub>e, accounted for 28 percent of U.S. anthropogenic methane emissions in 2005 (Figure 2). Emissions from this source have fallen by 32 percent (79.1 MMTCO<sub>2</sub>e) from their 1990 level of 250.6 MMTCO<sub>2</sub>e. Landfills represent 91 percent (155.7 MMTCO<sub>2</sub>e) of the methane emissions from waste management in 2005, and they are the largest single source of U.S. anthropogenic methane emissions (Table 15). The remainder of emissions from waste management (15.8 MMTCO<sub>2</sub>e) is associated with domestic wastewater treatment. Estimated emissions from waste management would increase if sufficient information were available to develop a reliable estimate of emissions from industrial wastewater treatment.

<sup>51</sup>For further details see Energy Information Administration, *Documentation for Emissions of Greenhouse Gases in the United States 2004*, DOE/EIA-0638(2004) (Washington, DC, November 2006), web site [www.eia.doe.gov/oiaf/1605/ggrpt/documentation/pdf/0638\(2004\).pdf](http://www.eia.doe.gov/oiaf/1605/ggrpt/documentation/pdf/0638(2004).pdf); and Energy Information Administration, *Documentation for Emissions of Greenhouse Gases in the United States 2005* (to be published).

<sup>52</sup>Energy Information Administration, Residential Energy Consumption Survey, web site [www.eia.doe.gov/emeu/recs/recs2001/publicuse2001.html](http://www.eia.doe.gov/emeu/recs/recs2001/publicuse2001.html). Updated data on residential wood consumption for calendar year 2004 will be available from the 2005 RECS in spring 2007.

<sup>53</sup>For a more detailed discussion of the revisions in estimation methods for mobile sources, see Energy Information Administration, *Documentation for Emissions of Greenhouse Gases in the United States 2004*, DOE/EIA-0638(2004) (Washington, DC, November 2006), web site [www.eia.doe.gov/oiaf/1605/ggrpt/documentation/pdf/0638\(2004\).pdf](http://www.eia.doe.gov/oiaf/1605/ggrpt/documentation/pdf/0638(2004).pdf); and Energy Information Administration, *Documentation for Emissions of Greenhouse Gases in the United States 2005* (to be published).

## Methane Emissions from Abandoned Coal Mines

Thousands of coal mines in the United States have been closed and abandoned during the past 100 years. The U.S. Department of Labor's Mine Safety and Health Administration (MSHA) estimates that since 1980 more than 7,500 coal mines have been abandoned, and many continue to emit methane. In an April 2004 report,<sup>a</sup> the U.S. Environmental Protection Agency (EPA) estimated that methane emissions from abandoned coal mines ranged between 3.0 MMTCO<sub>2</sub>e and 4.6 MMTCO<sub>2</sub>e in 1990, and between 4.6 MMTCO<sub>2</sub>e and 6.4 MMTCO<sub>2</sub>e in 2002. More recently, the EPA estimated methane emissions of 7.1 MMTCO<sub>2</sub>e from abandoned underground coal mines in 2004, up from 6.0 MMTCO<sub>2</sub>e in 1990 but down from a peak of 8.7 MMTCO<sub>2</sub>e in 2000 due to a decline in the number of gassy mines being abandoned.<sup>b</sup> Because access to abandoned mines is limited and a systematic measurement program at those sites would be time-intensive and costly, the EPA estimates rely on actual emissions data from when the mines were operating and assume a decline function in emissions based on mine and coal-seam characteristics.

The most important variable in determining the amount of methane emissions from an abandoned mine is its post-mining status—whether the mine has been sealed, flooded, or continues to be vented. Sealed and flooded mines have much lower rates of emissions than vented mines. Another variable deemed important is whether the mine was gassy (emitting more than 100,000 cubic feet per day) when it was operating. Gassy mines are estimated to emit 98 percent of all methane emissions from operating coal mines, and the

EPA assumes that abandoned mines which had been gassy when operating represent a similarly predominant portion of emissions from abandoned mines. The EPA's 2004 study thus focuses on abandoned mines that had been gassy prior to closure. Of the 438 gassy mines abandoned since 1972, the EPA has data on the status (i.e., whether the mines were sealed, flooded, or continue to be vented) of 263 or 60 percent of them. From those data, the EPA calculates percentage shares of emissions by status, then assumes that the same shares apply to mines for which it does not have data.

For abandoned mines that have been vented, the EPA derives an emissions decline curve based on three primary factors: adsorption isotherms by coal basin, coal permeability estimates, and estimates of pressure at abandonment. For mines that are flooded, the EPA assumes a decline curve equation based on measurements taken from eight abandoned mines in two basins. The EPA treats sealed mines similarly to those vented, adjusting the initial emissions rate and length of time for emissions to dissipate, given the slower release rate from sealed vents.

The EPA sought to calibrate its estimation methodology to field measurements, but restricted access precluded measurement at all but seven mines. Although results from those mines suggested the general accuracy of the estimation method, the methodology had not yet been validated when this report was being prepared. EIA expects the new method to be included in the 2006 IPCC *Guidelines for National Greenhouse Gas Inventories* and anticipates the inclusion of estimates for this source in future annual reports.

<sup>a</sup>U.S. Environmental Protection Agency, Coalbed Methane Outreach Program, *Methane Emissions from Abandoned Coal Mines in the United States: Emission Inventory Methodology and 1990-2002 Emissions Estimates* (Washington, DC, April 2004), web site [www.epa.gov/cmop/pdf/amm\\_final\\_report.pdf](http://www.epa.gov/cmop/pdf/amm_final_report.pdf).

<sup>b</sup>U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004*, EPA-430-R-06-002 (Washington, DC, April 2006), web site <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html>.

EIA's estimates of methane emissions from landfills include emissions from both MSW landfills and industrial landfills. Estimated methane emissions from industrial landfills, based on a methodology developed by the EPA, represent 7 percent of emissions from MSW landfills.<sup>54</sup>

In calculating methane emissions from landfills, EIA uses estimates of MSW generated and MSW landfilled, published by *Bicycle* magazine.<sup>55</sup> In its April 2006 issue, *Bicycle* reported estimates of MSW generated in 2002

and 2004 that were more than 20 percent below its previously published estimates. The reason for the revisions is that *Bicycle* now excludes certain non-MSW materials (such as construction and demolition debris and industrial waste) from its MSW generation estimates.

To ensure that EIA's estimates of methane emissions from landfills are consistent over the entire 1990-2005 time frame, waste generation estimates for the years 1989 through 2004 have been adjusted downward, based on the implied downward revision of the *Bicycle*

<sup>54</sup>U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2004*, EPA-430-R-06-002 (Washington, DC, April 2006), web site <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html>.

<sup>55</sup>*Bicycle*, "The State of Garbage in America" (various years).

data most recently reported for 2002 and 2004. EIA assumed a constant ratio of actual MSW generation to reported MSW generation for the period 1989 through 2004 and adjusted the estimates of waste generation—and methane emissions from landfills—for those years downward, to ensure that all the earlier estimates (1990–2004) are consistent with *Biocycle's* new method. The change results in a decrease of roughly 20 percent in the estimated volumes of waste generated and landfilled across all years.

### Landfills

#### U.S. Methane Emissions from Landfills, 1990–2005

	Methane	Carbon Dioxide Equivalent
Estimated 2005 Emissions (Million Metric Tons)	6.8	155.7
Change Compared to 2004 (Million Metric Tons)	0.3	6.9
Change from 2004 (Percent)	4.6%	4.6%
Change Compared to 1990 (Million Metric Tons)	-3.5	-81.6
Change from 1990 (Percent)	-34.4%	-34.4%

Due to increased levels of waste disposed in landfills, estimated methane emissions from landfills rose to 155.7 MMTCO<sub>2</sub>e in 2005, 4.6 percent (6.9 MMTCO<sub>2</sub>e) above the 2004 level of 148.8 MMTCO<sub>2</sub>e but still 34 percent (81.6 MMTCO<sub>2</sub>e) below the 1990 level of 237.3 MMTCO<sub>2</sub>e (Table 21). The decrease in methane emissions (about one-third since 1990) is directly attributable to an increase of 100.8 MMTCO<sub>2</sub>e in methane captured at landfills that otherwise would have been emitted to the atmosphere. Of the 122.5 MMTCO<sub>2</sub>e of methane believed to have been captured from this source in 2005, 64.9 MMTCO<sub>2</sub>e was recovered for energy use, and 57.5 MMTCO<sub>2</sub>e was recovered and flared. In 2005, methane recovery for energy increasingly took the form of direct use of medium-Btu gas in industrial boilers. The acceleration of this practice was driven by higher natural gas prices, which made landfill gas more competitive.<sup>56</sup>

Estimates of methane recovered for energy are drawn from data collected by the U.S. Environmental Protection Agency's (EPA's) Landfill Methane Outreach Program<sup>57</sup> and EIA's Voluntary Reporting of Greenhouse Gas Emissions and Reductions Program. Estimates of methane recovered and flared are based on data collected from flaring equipment vendors, in conjunction with data reported on Form EIA-1605.<sup>58</sup> There is less uncertainty in the estimate of methane recovered and used for energy, which has a market value; however, it is likely that estimates of methane flared are subject to error due to a lack of comprehensive industry data.

The rapid growth in methane recovery has been aided by a combination of regulatory and tax policy. The Federal Section 29 (of the Internal Revenue Code) tax credit for alternative energy sources, added to the tax code as part of the Crude Oil Windfall Profits Act of 1980, provided a subsidy roughly equivalent to 1 cent per kilowatt-hour for electricity generated from landfill gas; however, the tax credit expired on June 30, 1998. As part of the American Jobs Creation Act of 2004, a tax credit for electricity generation using landfill gas was added to Section 45 of the Internal Revenue Code. The credit was augmented under the Energy Policy Act of 2005, which extended the credit period—previously 5 years from the original date of service—to 10 years from the original date of service. To be eligible for the credit, a landfill gas-to-energy project must be placed in service between October 22, 2004, and December 31, 2007. Those facilities that qualify are eligible for a 5-year tax credit valued at 0.9 cent per kilowatt-hour.

Increases in methane recovery have also resulted from the implementation of the EPA's New Source Performance Standards and Emission Guidelines. The regulations require all landfills with more than 2.5 million metric tons of waste in place and annual emissions of nonmethane organic compounds (NMOCs) exceeding 50 metric tons to collect and burn their landfill gas, either by flaring or for use as an energy source.

### Domestic and Commercial Wastewater Treatment

With the U.S. population growing by only about 1 percent per year, methane emissions from domestic and commercial wastewater treatment are estimated to have grown by 1.0 percent between 2004 and 2005 to 15.8 MMTCO<sub>2</sub>e—about 19 percent above the 1990 level of

<sup>56</sup>Personal communication with Brian Guzzone, U.S. Environmental Protection Agency, Landfill Methane Outreach Program.

<sup>57</sup>U.S. Environmental Protection Agency, Landfill Methane Outreach Program, web site [www.epa.gov/lmop](http://www.epa.gov/lmop).

<sup>58</sup>U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2004*, EPA-430-R-06-002 (Washington, DC, April 2006), web site [http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUS\\_EmissionsInventory2006.html](http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUS_EmissionsInventory2006.html); and Energy Information Administration, Voluntary Reporting of Greenhouse Gases database, web site [www.eia.doe.gov/oiaf/1605/database.html](http://www.eia.doe.gov/oiaf/1605/database.html).

**U.S. Methane Emissions from Domestic and Commercial Wastewater Treatment, 1990-2005**

	Methane	Carbon Dioxide Equivalent
Estimated 2005 Emissions (Million Metric Tons)	0.7	15.8
Change Compared to 2004 (Million Metric Tons)	*	0.2
Change from 2004 (Percent)	1.0%	1.0%
Change Compared to 1990 (Million Metric Tons)	0.1	2.5
Change from 1990 (Percent)	19.2%	19.2%

\*Less than 0.05 million metric tons.

13.2 MMTCO<sub>2</sub>e (Table 15). Methane emissions from industrial wastewater treatment are discussed in the text box on page 36.

Methane emissions from domestic and commercial wastewater treatment are a function of the share of organic matter in the wastewater stream and the conditions under which it decomposes. Wastewater may be treated aerobically or anaerobically. Because aerobic decomposition does not yield methane, whereas anaerobic decomposition does, the method of treatment is a critical determinant of emissions; however, there is little information available on wastewater treatment methods. Data on flaring or energy recovery from methane generated by wastewater are also sparse. EIA believes that emissions from this source are relatively small, representing less than 3 percent of all U.S. methane emissions in 2005. Thus, emissions are estimated using a default per-capita emissions factor and U.S. population data.

## Agricultural Sources

Estimated methane emissions from agricultural sources, at 183.0 MMTCO<sub>2</sub>e in 2005, represent 30 percent of total U.S. anthropogenic methane emissions (Table 15). Agricultural methane emissions increased by 1.0 percent (1.9 MMTCO<sub>2</sub>e) from 2004 to 2005, as emissions increases from enteric fermentation and animal waste management more than offset small decreases in emissions from rice cultivation and crop residue burning. Of total estimated methane emissions from agricultural activities, 93 percent (170.9 MMTCO<sub>2</sub>e) results from livestock management, of which 68 percent (115.6

MMTCO<sub>2</sub>e) can be traced to enteric fermentation in ruminant animals and the remainder (55.3 MMTCO<sub>2</sub>e) to anaerobic decomposition of livestock wastes. A small portion of U.S. agricultural methane emissions result from crop residue burning and wetland rice cultivation.

## Enteric Fermentation in Domesticated Animals

### U.S. Methane Emissions from Enteric Fermentation in Domesticated Animals, 1990-2005

	Methane	Carbon Dioxide Equivalent
Estimated 2005 Emissions (Million Metric Tons)	5.0	115.6
Change Compared to 2004 (Million Metric Tons)	0.1	1.4
Change from 2004 (Percent)	1.2%	1.2%
Change Compared to 1990 (Million Metric Tons)	-0.2	-4.1
Change from 1990 (Percent)	-3.4%	-3.4%

In 2005, estimated methane emissions from enteric fermentation in domesticated animals rose by 1.2 percent to 115.6 MMTCO<sub>2</sub>e (Table 22). Because 95 percent (110.0 MMTCO<sub>2</sub>e) of all emissions from enteric fermentation is attributable to cattle, trends in emissions correlate with trends in cattle populations. Between 2004 and 2005, cattle populations grew by 1.1 percent, with small gains in all population categories. Estimated methane emissions from enteric fermentation in 2005 are 3.4 percent below their 1990 level of 119.6 MMTCO<sub>2</sub>e.

## Solid Waste of Domesticated Animals

Estimated methane emissions from the solid waste of domesticated animals increased from 54.7 MMTCO<sub>2</sub>e in 2004 to 55.3 MMTCO<sub>2</sub>e in 2005 (Table 23). The increase reinforced a larger trend over the past decade: in 2005, emissions from the solid waste of domesticated animals were 11.8 MMTCO<sub>2</sub>e above their 1990 level of 43.5 MMTCO<sub>2</sub>e, an increase of 27 percent. Between 1990 and 2005, there was a shift in livestock management to larger facilities, which are believed to be more likely to manage waste using liquid systems that tend to promote methane generation.<sup>59</sup>

<sup>59</sup>U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2004*, EPA-430-R-06-002 (Washington, DC, April 2006), p. 6-7, web site <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html>.

### U.S. Methane Emissions from Solid Waste of Domesticated Animals, 1990-2005

	Methane	Carbon Dioxide Equivalent
Estimated 2005 Emissions (Million Metric Tons)	2.4	55.3
Change Compared to 2004 (Million Metric Tons)	*	0.6
Change from 2004 (Percent)	1.1%	1.1%
Change Compared to 1990 (Million Metric Tons)	0.5	11.8
Change from 1990 (Percent)	27.2%	27.2%

\*Less than 0.05 million metric tons.

### Rice Cultivation

Estimated methane emissions from U.S. rice cultivation in 2005, at 10.9 MMTCO<sub>2</sub>e, were nearly unchanged from their 2004 level (Table 15). The total acreage of rice harvested was 0.9 percent higher in 2005 than in 2004, but the increase was centered in Arkansas and Mississippi—two States where the length of the harvesting season is slightly lower than average.<sup>60</sup> Methane emissions from rice cultivation in 2005 were 17 percent (1.6 MMTCO<sub>2</sub>e) higher than in 1990.

### Burning of Crop Residues

Crop residue burning, the smallest contributor to U.S. methane emissions, represents less than 1 percent of total U.S. methane emissions. Estimated 2005 methane emissions from the burning of crop residues were 1.2 MMTCO<sub>2</sub>e, down by 3.8 percent from 2004 but still 23 percent above their 1990 level of 1.0 MMTCO<sub>2</sub>e (Table 15). The decrease from 2004 to 2005 is attributable to a decline in U.S. crop production.

### Methane Emissions from Industrial Wastewater Treatment

When wastewater containing large amounts of organic material is treated through anaerobic decomposition, methane is emitted. The best estimate of those emissions would be based on a systematic measurement of all point sources; however, the number and diversity of U.S. industrial wastewater sources make such an approach unaffordable and impractical. As an alternative, methane emissions from industrial wastewater treatment are calculated by the following equation:

$$M = P \times O \times COD \times A \times EF$$

where  $M$  = methane emissions,  $P$  = product output,  $O$  = wastewater outflow per unit of product output,  $COD$  = organic loading in outflow,  $A$  = percentage of outflow treated anaerobically, and  $EF$  = emissions factor for anaerobically treated outflow.

The Intergovernmental Panel on Climate Change (IPCC), in its *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*,<sup>a</sup> provides default data for wastewater generation and  $COD$  on an industry-specific basis. The default data, often based on one or two literature sources, are assumed to have an uncertainty range of minus 50 percent to plus 100 percent (although no justification for the range is provided). The IPCC also provides a single default factor of 0.25 kilograms methane per kilogram

of  $COD$ , premised on a general approximation of the theoretical maximum for this emission factor, and identifies an uncertainty of plus or minus 30 percent for this estimate.

There are currently no specific U.S. data that could be used to improve on the IPCC defaults, and the uncertainties make it impossible for the Energy Information Administration (EIA) to provide a reliable estimate of emissions from this source. It can, however, be noted that—depending on the extent to which industrial wastewater from such industries as meat and poultry processing, pulp and paper manufacturing, and vegetable, fruit, and juice processing (which is likely to have a high content of organic material) is treated anaerobically—excluding the resulting methane emissions from the U.S. emissions total will tend to produce an underestimate. The U.S. Environmental Protection Agency estimates that U.S. methane emissions from industrial wastewater treatment could be as high as 16.9 MMTCO<sub>2</sub>e in 2004.<sup>b</sup> EIA anticipates that additional methodological guidance and data will be forthcoming in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories that will support emissions estimates for this source in subsequent annual reports.

<sup>a</sup>Intergovernmental Panel On Climate Change, *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (Montreal, Canada, May 2000), web site [www.ipcc-nggip.iges.or.jp/public/gp/english/](http://www.ipcc-nggip.iges.or.jp/public/gp/english/).

<sup>b</sup>U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004*, EPA-430-R-06-002 (Washington, DC, April 2006), web site <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html>.

<sup>60</sup>U.S. Department of Agriculture, National Agricultural Statistics Service, *Crop Production—Annual Summary* (Washington, DC, various years), web site <http://usda.mannlib.cornell.edu/reports/nassr/field/pcp-bban>.

## Industrial Processes

### Chemical Production

The preliminary estimate of methane emissions from U.S. chemical production in 2005 is 1.5 MMTCO<sub>2</sub>e, down by 6.1 percent from the 2004 level of 1.6 MMTCO<sub>2</sub>e. The decrease from 2004 levels is attributable to declining production of ethylene, ethylene dichloride, methanol, and styrene. Methane emissions from chemical production in 2005 were 18 percent above their 1990 level of 1.3 MMTCO<sub>2</sub>e (Table 24).<sup>61</sup>

### Iron and Steel Production

With production of pig iron reaching a 2-decade low in 2005,<sup>62</sup> methane emissions from iron and steel production dropped to an estimated 1.0 MMTCO<sub>2</sub>e in 2005, a 10-percent decrease from 2004 levels and 32 percent below their 1990 level of 1.4 MMTCO<sub>2</sub>e (Table 24).

#### U.S. Methane Emissions from Industrial Processes, 1990-2005

	Methane	Carbon Dioxide Equivalent
Estimated 2005 Emissions (Million Metric Tons)	0.1	2.5
Change Compared to 2004 (Million Metric Tons)	*	-0.2
Change from 2004 (Percent)	-7.7%	-7.7%
Change Compared to 1990 (Million Metric Tons)	*	-0.2
Change from 1990 (Percent)	-8.4%	-8.4%

\*Less than 0.05 million metric tons.

<sup>61</sup>Personal communication with Kevin Swift, American Chemistry Council (July 2006).

<sup>62</sup>American Iron and Steel Institute, *Annual Statistical Report*, Tables 26, 31, and 32 (Washington, DC, various years).

Table 15. U.S. Methane Emissions from Anthropogenic Sources, 1990, 1995, and 1998-2005

Source	1990	1995	1998	1999	2000	2001	2002	2003	2004	P2005
<b>Million Metric Tons Carbon Dioxide Equivalent</b>										
<b>Energy Sources</b>										
Coal Mining . . . . .	97.7	83.8	75.6	71.5	68.1	68.0	64.1	64.2	67.3	65.5
Natural Gas Systems . . . . .	128.9	137.6	143.9	144.2	151.0	147.0	154.0	153.2	154.7	154.0
Petroleum Systems . . . . .	29.9	26.9	25.5	24.0	23.8	23.7	23.5	23.3	22.3	21.1
Stationary Combustion . . . . .	12.9	11.8	8.9	9.3	10.0	8.7	8.9	9.3	9.5	9.7
Mobile Sources . . . . .	5.6	4.8	4.7	4.6	4.6	4.5	4.4	4.2	4.4	4.5
<b>Total Energy Sources . . . . .</b>	<b>275.0</b>	<b>264.9</b>	<b>258.6</b>	<b>253.7</b>	<b>257.5</b>	<b>251.9</b>	<b>255.0</b>	<b>254.1</b>	<b>258.3</b>	<b>254.9</b>
<b>Waste Management</b>										
Landfills . . . . .	237.3	204.9	170.9	162.4	155.4	147.8	146.7	148.7	148.8	155.7
Wastewater Treatment . . . . .	13.2	14.2	14.7	14.8	15.0	15.2	15.3	15.5	15.6	15.8
<b>Total Waste Management . . . . .</b>	<b>250.6</b>	<b>219.1</b>	<b>185.6</b>	<b>177.2</b>	<b>170.3</b>	<b>162.9</b>	<b>162.0</b>	<b>164.2</b>	<b>164.5</b>	<b>171.5</b>
<b>Agricultural Sources</b>										
Enteric Fermentation . . . . .	119.6	124.4	117.2	117.3	116.3	115.1	115.8	116.1	114.2	115.6
Animal Waste . . . . .	43.5	49.9	53.6	52.7	52.8	53.3	53.7	54.2	54.7	55.3
Rice Cultivation . . . . .	9.3	10.2	10.7	11.5	10.2	10.7	10.2	9.8	10.9	10.9
Crop Residue Burning . . . . .	1.0	1.0	1.1	1.1	1.1	1.1	1.0	1.2	1.3	1.2
<b>Total Agricultural Sources . . . . .</b>	<b>173.4</b>	<b>185.4</b>	<b>182.6</b>	<b>182.5</b>	<b>180.4</b>	<b>180.3</b>	<b>180.7</b>	<b>181.3</b>	<b>181.1</b>	<b>183.0</b>
<b>Industrial Processes . . . . .</b>	<b>2.7</b>	<b>3.0</b>	<b>3.1</b>	<b>3.1</b>	<b>2.9</b>	<b>2.5</b>	<b>2.6</b>	<b>2.6</b>	<b>2.7</b>	<b>2.5</b>
<b>Total . . . . .</b>	<b>701.7</b>	<b>672.5</b>	<b>629.8</b>	<b>616.5</b>	<b>611.2</b>	<b>597.7</b>	<b>600.2</b>	<b>602.2</b>	<b>606.5</b>	<b>611.9</b>
<b>Million Metric Tons Methane</b>										
<b>Energy Sources</b>										
Coal Mining . . . . .	4.25	3.64	3.29	3.11	2.96	2.96	2.79	2.79	2.93	2.85
Natural Gas Systems . . . . .	5.60	5.98	6.26	6.27	6.57	6.39	6.70	6.66	6.73	6.70
Petroleum Systems . . . . .	1.30	1.17	1.11	1.04	1.03	1.03	1.02	1.01	0.97	0.92
Stationary Combustion . . . . .	0.56	0.51	0.39	0.41	0.43	0.38	0.39	0.41	0.41	0.42
Mobile Sources . . . . .	0.24	0.21	0.20	0.20	0.20	0.20	0.19	0.18	0.19	0.20
<b>Total Energy Sources . . . . .</b>	<b>11.96</b>	<b>11.52</b>	<b>11.24</b>	<b>11.03</b>	<b>11.20</b>	<b>10.95</b>	<b>11.09</b>	<b>11.05</b>	<b>11.23</b>	<b>11.08</b>
<b>Waste Management</b>										
Landfills . . . . .	10.32	8.91	7.43	7.06	6.75	6.42	6.38	6.47	6.47	6.77
Wastewater Treatment . . . . .	0.58	0.62	0.64	0.65	0.65	0.66	0.67	0.67	0.68	0.69
<b>Total Waste Management . . . . .</b>	<b>10.89</b>	<b>9.53</b>	<b>8.07</b>	<b>7.70</b>	<b>7.41</b>	<b>7.08</b>	<b>7.04</b>	<b>7.14</b>	<b>7.15</b>	<b>7.46</b>
<b>Agricultural Sources</b>										
Enteric Fermentation . . . . .	5.20	5.41	5.09	5.10	5.06	5.00	5.03	5.05	4.97	5.02
Animal Waste . . . . .	1.89	2.17	2.33	2.29	2.29	2.32	2.33	2.36	2.38	2.41
Rice Cultivation . . . . .	0.40	0.44	0.47	0.50	0.44	0.47	0.45	0.43	0.47	0.47
Crop Residue Burning . . . . .	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05
<b>Total Agricultural Sources . . . . .</b>	<b>7.54</b>	<b>8.06</b>	<b>7.94</b>	<b>7.94</b>	<b>7.85</b>	<b>7.84</b>	<b>7.86</b>	<b>7.88</b>	<b>7.88</b>	<b>7.96</b>
<b>Industrial Processes . . . . .</b>	<b>0.12</b>	<b>0.13</b>	<b>0.13</b>	<b>0.13</b>	<b>0.13</b>	<b>0.11</b>	<b>0.11</b>	<b>0.11</b>	<b>0.12</b>	<b>0.11</b>
<b>Total . . . . .</b>	<b>30.51</b>	<b>29.24</b>	<b>27.38</b>	<b>26.80</b>	<b>26.57</b>	<b>25.99</b>	<b>26.10</b>	<b>26.18</b>	<b>26.37</b>	<b>26.60</b>

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 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005). Totals may not equal sum of components due to independent rounding.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2004*. 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. 4.83-4.84, web site [www.ipcc.ch/pub/guide.htm](http://www.ipcc.ch/pub/guide.htm); and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004*, EPA-430-R-06-002 (Washington, DC, April 2006), web site <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html>.

**Table 16. U.S. Methane Emissions from Coal Mining and Post-Mining Activities, 1990, 1995, and 1998-2005**

Source	1990	1995	1998	1999	2000	2001	2002	2003	2004	P2005
<b>Million Metric Tons Carbon Dioxide Equivalent</b>										
<b>Surface Mining</b>										
Mining . . . . .	9.8	10.3	11.4	11.5	11.4	12.1	12.0	11.7	12.1	12.4
Post-Mining . . . . .	0.9	0.9	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.1
<i>Subtotal</i> . . . . .	<i>10.7</i>	<i>11.2</i>	<i>12.4</i>	<i>12.5</i>	<i>12.4</i>	<i>13.2</i>	<i>13.0</i>	<i>12.7</i>	<i>13.1</i>	<i>13.5</i>
<b>Underground Mining</b>										
Ventilation (Gassy Mines) <sup>a</sup> . . . . .	48.9	43.9	41.5	40.6	38.3	37.2	34.7	33.4	36.3	33.6
Ventilation (Nongassy Mines) . . . . .	0.6	0.8	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8
Degasification Systems . . . . .	28.9	27.8	21.8	17.5	19.8	21.7	22.3	22.1	21.9	21.6
Post-Mining . . . . .	14.7	13.7	14.5	13.6	12.9	13.2	12.4	12.2	12.7	12.8
Methane Recovery for Energy (-) . . . . .	6.1	13.6	15.5	13.6	16.2	18.0	19.0	16.9	17.5	16.7
<i>Subtotal</i> . . . . .	<i>87.0</i>	<i>72.5</i>	<i>63.2</i>	<i>58.9</i>	<i>55.7</i>	<i>54.9</i>	<i>51.1</i>	<i>51.5</i>	<i>54.2</i>	<i>52.1</i>
<b>Net Emissions</b> . . . . .	<b>97.7</b>	<b>83.8</b>	<b>75.6</b>	<b>71.5</b>	<b>68.1</b>	<b>68.0</b>	<b>64.1</b>	<b>64.2</b>	<b>67.3</b>	<b>65.5</b>
<b>Million Metric Tons Methane</b>										
<b>Surface Mining</b>										
Mining . . . . .	0.43	0.45	0.49	0.50	0.49	0.53	0.52	0.51	0.53	0.54
Post-Mining . . . . .	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.04	0.05	0.05
<i>Subtotal</i> . . . . .	<i>0.46</i>	<i>0.49</i>	<i>0.54</i>	<i>0.54</i>	<i>0.54</i>	<i>0.57</i>	<i>0.57</i>	<i>0.55</i>	<i>0.57</i>	<i>0.59</i>
<b>Underground Mining</b>										
Ventilation (Gassy Mines) <sup>a</sup> . . . . .	2.13	1.91	1.80	1.76	1.67	1.62	1.51	1.45	1.58	1.46
Ventilation (Nongassy Mines) . . . . .	0.03	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.04	0.03
Degasification Systems . . . . .	1.26	1.21	0.95	0.76	0.86	0.94	0.97	0.96	0.95	0.94
Post-Mining . . . . .	0.64	0.60	0.63	0.59	0.56	0.57	0.54	0.53	0.55	0.55
Methane Recovery for Energy (-) . . . . .	0.26	0.59	0.67	0.59	0.70	0.78	0.83	0.74	0.76	0.72
<i>Subtotal</i> . . . . .	<i>3.78</i>	<i>3.15</i>	<i>2.75</i>	<i>2.56</i>	<i>2.42</i>	<i>2.38</i>	<i>2.22</i>	<i>2.24</i>	<i>2.36</i>	<i>2.26</i>
<b>Net Emissions</b> . . . . .	<b>4.25</b>	<b>3.64</b>	<b>3.29</b>	<b>3.11</b>	<b>2.96</b>	<b>2.96</b>	<b>2.79</b>	<b>2.79</b>	<b>2.93</b>	<b>2.85</b>

<sup>a</sup>A "gassy" mine is an underground mine with ventilation emissions of 100,000 cubic feet of methane or more per day, as measured by the U.S. Mine Safety and Health Administration.

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 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005). Totals may not equal sum of components due to independent rounding.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2004*. Coal production numbers from Energy Information Administration, *Coal Production*, DOE/EIA-0118 (Washington, DC, various years), and *Coal Industry Annual*, DOE/EIA-0584 (Washington, DC, various years). Methane recovery rates from U.S. Environmental Protection Agency, Office of Air and Radiation, Non-CO<sub>2</sub> Gases and Sequestration Branch, Coalbed Methane Outreach Program. Ventilation data for 1985, 1988, and 1990 provided by G. Finfinger, U.S. Department of the Interior, Bureau of Mines, Pittsburgh Research Center. Ventilation data for all other years provided by U.S. Environmental Protection Agency, Office of Air and Radiation, Non-CO<sub>2</sub> Gases and Sequestration Branch, Coalbed Methane Outreach Program.

**Table 17. U.S. Methane Emissions from Natural Gas Systems, 1990, 1995, and 1998-2005**

Source	1990	1995	1998	1999	2000	2001	2002	2003	2004	P2005
<b>Million Metric Tons Carbon Dioxide Equivalent</b>										
Production . . . . .	33.8	36.1	38.4	37.3	39.9	42.0	42.4	42.9	43.5	43.1
Natural Gas Processing . . . . .	14.9	16.5	16.0	16.1	16.4	16.0	15.5	14.4	14.8	14.5
Transmission and Storage . . . . .	48.3	49.3	51.0	52.8	55.4	49.0	55.6	54.7	53.7	53.8
Distribution . . . . .	32.0	35.7	38.5	38.0	39.3	40.0	40.5	41.2	42.6	42.6
<b>Total . . . . .</b>	<b>128.9</b>	<b>137.6</b>	<b>143.9</b>	<b>144.2</b>	<b>151.0</b>	<b>147.0</b>	<b>154.0</b>	<b>153.2</b>	<b>154.7</b>	<b>154.0</b>
Natural Gas STAR Reductions . . . . .	0.3	5.0	10.4	12.2	14.7	18.2	22.4	24.2	29.2	34.7
<b>Million Metric Tons Methane</b>										
Production . . . . .	1.47	1.57	1.67	1.62	1.73	1.83	1.84	1.87	1.89	1.87
Natural Gas Processing . . . . .	0.65	0.72	0.69	0.70	0.71	0.69	0.67	0.63	0.65	0.63
Transmission and Storage . . . . .	2.10	2.14	2.22	2.30	2.41	2.13	2.42	2.38	2.34	2.34
Distribution . . . . .	1.39	1.55	1.67	1.65	1.71	1.74	1.76	1.79	1.85	1.85
<b>Total . . . . .</b>	<b>5.60</b>	<b>5.98</b>	<b>6.26</b>	<b>6.27</b>	<b>6.57</b>	<b>6.39</b>	<b>6.70</b>	<b>6.66</b>	<b>6.73</b>	<b>6.70</b>
Natural Gas STAR Reductions . . . . .	0.01	0.22	0.45	0.53	0.64	0.79	0.97	1.05	1.27	1.51

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 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005). Totals may not equal sum of components due to independent rounding. Data for Natural Gas STAR reductions are estimates provided by the EPA, based on annual submissions to the EPA by companies participating in the program, which report activities undertaken to avoid methane emissions from natural gas and petroleum systems.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2004*; National Risk Management Research Laboratory, *Methane Emissions From the Natural Gas Industry*, Vol. 2, Technical Report, GRI-94/0257.1 and EPA-600-R-96-08 (Research Triangle Park, NC, June 1996), Appendix A; American Gas Association, *Gas Facts* (various years); Energy Information Administration, *Natural Gas Annual*, DOE/EIA-0131 (various years); Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(2005/07) (Washington, DC, July 2005); and Energy Information Administration, *Petroleum Supply Annual*, DOE/EIA-0340 (Washington, DC, various years).

**Table 18. U.S. Methane Emissions from Petroleum Systems, 1990, 1995, and 1998-2005**

Source	1990	1995	1998	1999	2000	2001	2002	2003	2004	P2005
<b>Million Metric Tons Carbon Dioxide Equivalent</b>										
Refineries . . . . .	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Exploration and Production . . . . .	29.0	26.1	24.7	23.2	22.9	22.9	22.6	22.4	21.4	20.2
Crude Oil Transportation . . . . .	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
<b>Total . . . . .</b>	<b>29.9</b>	<b>26.9</b>	<b>25.5</b>	<b>24.0</b>	<b>23.8</b>	<b>23.7</b>	<b>23.5</b>	<b>23.3</b>	<b>22.3</b>	<b>21.1</b>
<b>Million Metric Tons Methane</b>										
Refineries . . . . .	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Exploration and Production . . . . .	1.26	1.13	1.07	1.01	1.00	0.99	0.98	0.97	0.93	0.88
Crude Oil Transportation . . . . .	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
<b>Total . . . . .</b>	<b>1.30</b>	<b>1.17</b>	<b>1.11</b>	<b>1.04</b>	<b>1.03</b>	<b>1.03</b>	<b>1.02</b>	<b>1.01</b>	<b>0.97</b>	<b>0.92</b>

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 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005). Totals may not equal sum of components due to independent rounding.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2004*; U.S. Environmental Protection Agency, Office of Air and Radiation, *Draft Estimates of Methane Emissions from the U.S. Oil Industry* (Draft Report, Washington, DC); Energy Information Administration, *Petroleum Supply Annual*, DOE/EIA-0340 (Washington, DC, various years); and *Oil and Gas Journal*, Worldwide Refining Issue and Pipeline Economics Issue (various years).

Table 19. U.S. Methane Emissions from Stationary Combustion Sources, 1990, 1995, and 1998-2005

Source	1990	1995	1998	1999	2000	2001	2002	2003	2004	P2005
Thousand Metric Tons Carbon Dioxide Equivalent										
<b>Residential</b>										
Coal . . . . .	*	*	*	*	*	*	*	*	*	*
Fuel Oil <sup>a</sup> . . . . .	113	105	89	96	105	105	99	105	107	108
Natural Gas . . . . .	100	110	103	107	113	108	111	116	111	110
LPG . . . . .	10	11	12	14	15	14	14	14	14	14
Wood . . . . .	11,763	10,546	7,707	8,112	8,721	7,504	7,707	8,112	8,315	8,518
<b>Total . . . . .</b>	<b>11,986</b>	<b>10,772</b>	<b>7,911</b>	<b>8,329</b>	<b>8,953</b>	<b>7,731</b>	<b>7,932</b>	<b>8,347</b>	<b>8,547</b>	<b>8,749</b>
<b>Commercial</b>										
Coal . . . . .	29	27	23	24	20	21	21	19	23	23
Fuel Oil <sup>a</sup> . . . . .	16	12	9	9	10	10	9	11	11	12
Natural Gas . . . . .	71	83	82	83	86	83	86	87	85	83
LPG . . . . .	2	2	2	3	3	3	3	2	3	2
Wood . . . . .	4	5	4	5	5	5	5	5	5	3
<b>Total . . . . .</b>	<b>122</b>	<b>128</b>	<b>121</b>	<b>122</b>	<b>124</b>	<b>120</b>	<b>123</b>	<b>124</b>	<b>127</b>	<b>124</b>
<b>Industrial</b>										
Coal . . . . .	150	136	123	121	125	122	112	113	114	109
Fuel Oil <sup>a</sup> . . . . .	32	27	20	18	21	18	17	19	21	23
Natural Gas . . . . .	263	298	303	291	295	270	274	264	265	242
LPG . . . . .	51	64	65	71	72	65	70	67	69	65
Wood . . . . .	89	102	99	100	101	89	86	84	91	89
<b>Total . . . . .</b>	<b>585</b>	<b>626</b>	<b>610</b>	<b>601</b>	<b>613</b>	<b>564</b>	<b>559</b>	<b>547</b>	<b>560</b>	<b>528</b>
<b>Electric Power</b>										
Coal . . . . .	225	242	267	268	281	273	275	280	282	288
Fuel Oil <sup>a</sup> . . . . .	18	10	16	14	17	17	11	14	14	14
Natural Gas . . . . .	7	10	10	11	12	12	13	12	12	13
Wood . . . . .	1	*	*	*	*	*	*	*	*	*
<b>Total . . . . .</b>	<b>251</b>	<b>262</b>	<b>293</b>	<b>293</b>	<b>309</b>	<b>302</b>	<b>298</b>	<b>306</b>	<b>309</b>	<b>315</b>
<b>Total All Sectors</b>										
Coal . . . . .	405	405	413	412	426	416	408	412	419	420
Fuel Oil <sup>a</sup> . . . . .	179	154	134	137	152	150	137	149	154	157
Natural Gas . . . . .	441	500	499	492	505	473	484	479	474	449
LPG . . . . .	62	77	78	88	90	82	87	83	86	81
Wood . . . . .	11,857	10,652	7,810	8,217	8,826	7,597	7,797	8,201	8,411	8,610
<b>Total . . . . .</b>	<b>12,944</b>	<b>11,788</b>	<b>8,934</b>	<b>9,346</b>	<b>9,999</b>	<b>8,717</b>	<b>8,912</b>	<b>9,324</b>	<b>9,542</b>	<b>9,716</b>

\*Less than 500 metric tons carbon dioxide equivalent.

<sup>a</sup>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.

See notes and sources at end of table.

**Table 19. U.S. Methane Emissions from Stationary Combustion Sources, 1990, 1995, and 1998-2005**  
(Continued)

Source	1990	1995	1998	1999	2000	2001	2002	2003	2004	P2005
Thousand Metric Tons Methane										
<b>Residential</b>										
Coal . . . . .	*	*	*	*	*	*	*	*	*	*
Fuel Oil <sup>a</sup> . . . . .	5	5	4	4	5	5	4	5	5	5
Natural Gas . . . . .	4	5	4	5	5	5	5	5	5	5
LPG . . . . .	*	*	1	1	1	1	1	1	1	1
Wood . . . . .	511	459	335	353	379	326	335	353	362	370
<b>Total . . . . .</b>	<b>521</b>	<b>468</b>	<b>344</b>	<b>362</b>	<b>389</b>	<b>336</b>	<b>345</b>	<b>363</b>	<b>372</b>	<b>380</b>
<b>Commercial</b>										
Coal . . . . .	1	1	1	1	1	1	1	1	1	1
Fuel Oil <sup>a</sup> . . . . .	1	1	*	*	*	*	*	*	*	1
Natural Gas . . . . .	3	4	4	4	4	4	4	4	4	4
LPG . . . . .	*	*	*	*	*	*	*	*	*	*
Wood . . . . .	*	*	*	*	*	*	*	*	*	*
<b>Total . . . . .</b>	<b>5</b>	<b>6</b>								
<b>Industrial</b>										
Coal . . . . .	7	6	5	5	5	5	5	5	5	5
Fuel Oil <sup>a</sup> . . . . .	1	1	1	1	1	1	1	1	1	1
Natural Gas . . . . .	11	13	13	13	13	12	12	11	12	11
LPG . . . . .	2	3	3	3	3	3	3	3	3	3
Wood . . . . .	4	4	4	4	4	4	4	4	4	4
<b>Total . . . . .</b>	<b>25</b>	<b>27</b>	<b>27</b>	<b>26</b>	<b>27</b>	<b>25</b>	<b>24</b>	<b>24</b>	<b>24</b>	<b>23</b>
<b>Electric Power</b>										
Coal . . . . .	10	11	12	12	12	12	12	12	12	13
Fuel Oil <sup>a</sup> . . . . .	1	*	1	1	1	1	*	1	1	1
Natural Gas . . . . .	*	*	*	*	1	1	1	1	1	1
Wood . . . . .	*	*	*	*	*	*	*	*	*	*
<b>Total . . . . .</b>	<b>11</b>	<b>11</b>	<b>13</b>	<b>14</b>						
<b>Total All Sectors</b>										
Coal . . . . .	18	18	18	18	19	18	18	18	18	18
Fuel Oil <sup>a</sup> . . . . .	8	7	6	6	7	7	6	6	7	7
Natural Gas . . . . .	19	22	22	21	22	21	21	21	21	20
LPG . . . . .	3	3	3	4	4	4	4	4	4	4
Wood . . . . .	516	463	340	357	384	330	339	357	366	374
<b>Total . . . . .</b>	<b>563</b>	<b>513</b>	<b>388</b>	<b>406</b>	<b>435</b>	<b>379</b>	<b>387</b>	<b>405</b>	<b>415</b>	<b>422</b>

\*Less than 500 metric tons methane.

<sup>a</sup>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 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005). Totals may not equal sum of components due to independent rounding.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2004*; U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources*, AP 42, Fifth Edition (Washington, DC, January 1995), web site [www.epa.gov/ttn/chief/ap42](http://www.epa.gov/ttn/chief/ap42); Intergovernmental Panel on Climate Change, *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3 (Paris, France, 1997), web site [www.ipcc.ch/pub/guide.htm](http://www.ipcc.ch/pub/guide.htm); Energy Information Administration, *State Energy Data Report*, DOE/EIA-0214 (Washington, DC, various years); Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(2005/07) (Washington, DC, July 2005); and Energy Information Administration, *Annual Energy Review*, DOE/EIA-0384 (Washington, DC, various years).

Table 20. U.S. Methane Emissions from Mobile Sources, 1990, 1995, and 1998-2005

Source	1990	1995	1998	1999	2000	2001	2002	2003	2004	P2005
<b>Thousand Metric Tons Carbon Dioxide Equivalent</b>										
<b>Motor Vehicles</b>										
Passenger Cars .....	3,284	2,234	2,018	1,991	1,955	1,912	1,841	1,708	1,695	1,661
Buses .....	21	24	26	28	28	26	25	25	25	25
Motorcycles.....	92	94	99	102	101	93	92	92	97	97
Light-Duty Trucks .....	1,402	1,630	1,686	1,651	1,625	1,595	1,578	1,541	1,640	1,695
Other Trucks.....	271	330	363	375	380	387	397	403	419	419
<b>Total .....</b>	<b>5,070</b>	<b>4,311</b>	<b>4,192</b>	<b>4,148</b>	<b>4,089</b>	<b>4,013</b>	<b>3,934</b>	<b>3,769</b>	<b>3,875</b>	<b>3,897</b>
Other Transport.....	515	510	460	481	505	476	469	421	500	604
<b>Total Transport .....</b>	<b>5,585</b>	<b>4,820</b>	<b>4,653</b>	<b>4,628</b>	<b>4,594</b>	<b>4,489</b>	<b>4,403</b>	<b>4,190</b>	<b>4,375</b>	<b>4,500</b>
<b>Thousand Metric Tons Methane</b>										
<b>Motor Vehicles</b>										
Passenger Cars .....	143	97	88	87	85	83	80	74	74	72
Buses .....	1	1	1	1	1	1	1	1	1	1
Motorcycles.....	4	4	4	4	4	4	4	4	4	4
Light-Duty Trucks .....	61	71	73	72	71	69	69	67	71	74
Other Trucks.....	12	14	16	16	17	17	17	18	18	18
<b>Total .....</b>	<b>220</b>	<b>187</b>	<b>182</b>	<b>180</b>	<b>178</b>	<b>174</b>	<b>171</b>	<b>164</b>	<b>168</b>	<b>169</b>
Other Transport.....	22	22	20	21	22	21	20	18	22	26
<b>Total Transport .....</b>	<b>243</b>	<b>210</b>	<b>202</b>	<b>201</b>	<b>200</b>	<b>195</b>	<b>191</b>	<b>182</b>	<b>190</b>	<b>196</b>

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 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005). Totals may not equal sum of components due to independent rounding.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2004*. For passenger cars and light-duty trucks, 1990-2000 vehicle miles traveled (VMT) data are based on 2002 data on vehicle stocks provided by R.L. & Polk Co., with VMT modified by Oak Ridge National Laboratory (ORNL), *Transportation Energy Data Book: Edition 23* (Oak Ridge, TN, October 2003), Chapter 7. 1996-2000 data were further adjusted using fleet data and survival curves for the population of aging vehicles. For years after 2000, emissions data are based on fleet data, econometrically modeled VMT, and survival curves for the population of aging vehicles. Calculations for buses, motorcycles, and other trucks are based on VMT from Federal Highway Administration, U.S. Department of Transportation, *Federal Highway Statistics*, Table VM-1 (various years). Vehicle emissions coefficients are 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. 1.65-1.75, web site [www.ipcc.ch/pub/guide.htm](http://www.ipcc.ch/pub/guide.htm). Fuel consumption data for non-highway sources are from Energy Information Administration, *Fuel Oil and Kerosene Sales*, DOE/EIA-0535 (Washington, DC, various years); Energy Information Administration, *Petroleum Supply Annual*, DOE/EIA-0340 (Washington, DC, various years), and ORNL, *Transportation Energy Data Book: Edition 23* (Oak Ridge, TN, October 2003), Chapter 9, web site [www.cta.ornl.gov/data/chapter9.html](http://www.cta.ornl.gov/data/chapter9.html).

**Table 21. U.S. Methane Emissions from Landfills, 1990, 1995, and 1998-2005**

Type	1990	1995	1998	1999	2000	2001	2002	2003	2004	P2005
<b>Million Metric Tons Carbon Dioxide Equivalent</b>										
Gross Emissions from MSW Landfills . . .	172.3	169.8	167.1	166.3	166.2	166.5	169.2	173.6	179.0	185.0
Emissions from Industrial Landfills . . . .	16.9	16.5	16.0	15.8	15.9	16.0	16.3	16.8	17.5	18.2
Methane Recovered for Energy (-) . . . . .	15.6	22.6	37.5	41.7	46.4	51.7	54.5	58.1	61.6	64.9
Methane Assumed Flared (-) . . . . .	6.0	24.6	35.5	36.7	40.6	44.6	47.9	50.6	57.5	57.5
<b>Net Emissions . . . . .</b>	<b>237.3</b>	<b>204.9</b>	<b>170.9</b>	<b>162.4</b>	<b>155.4</b>	<b>147.8</b>	<b>146.7</b>	<b>148.7</b>	<b>148.8</b>	<b>155.7</b>
<b>Million Metric Tons Methane</b>										
Gross Emissions from MSW Landfills . . .	10.52	10.25	9.91	9.78	9.85	9.92	10.12	10.46	10.89	11.30
Emissions from Industrial Landfills . . . .	0.74	0.72	0.69	0.68	0.69	0.69	0.71	0.73	0.76	0.79
Methane Recovered for Energy (-) . . . . .	0.68	0.98	1.63	1.81	2.02	2.25	2.37	2.52	2.68	2.82
Methane Assumed Flared (-) . . . . .	0.26	1.07	1.55	1.60	1.77	1.94	2.08	2.20	2.50	2.50
<b>Net Emissions . . . . .</b>	<b>10.32</b>	<b>8.91</b>	<b>7.43</b>	<b>7.06</b>	<b>6.75</b>	<b>6.42</b>	<b>6.38</b>	<b>6.47</b>	<b>6.47</b>	<b>6.77</b>

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 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005). Totals may not equal sum of components due to independent rounding.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2004*. Municipal solid waste landfilled in 2002 from "Nationwide Survey: The State of Garbage in America," *Biocycle* (January 2004). Municipal solid waste generated and landfilled in previous years from "Nationwide Survey: The State of Garbage in America," *Biocycle* (various years), adjusted on the basis of residential demolitions, to reflect exclusion of construction and demolition waste as in the 2002 data. Municipal waste landfilled in 2003 based on 2002 estimate, scaled to annual economic growth. Emissions calculations based on S.A. Thorneloe et al., "Estimate of Methane Emissions from U.S. Landfills," Prepared for the U.S. Environmental Protection Agency, Office of Research and Development (April 1994), and D. Augenstein, "The Greenhouse Effect and U.S. Landfill Methane," *Global Environment Change* (December 1992), pp. 311-328. Methane recovered and flared from U.S. Environmental Protection Agency, Landfill Methane Outreach Program, web site [www.epa.gov/lmop/](http://www.epa.gov/lmop/). Emissions from industrial landfills estimated at 7 percent of methane emissions from municipal solid waste landfills, based on U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004*, EPA-430-R-06-002 (Washington, DC, April 2006), web site <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html>.

**Table 22. U.S. Methane Emissions from Enteric Fermentation in Domesticated Animals, 1990, 1995, and 1998-2005**

Animal Type	1990	1995	1998	1999	2000	2001	2002	2003	2004	P2005
<b>Million Metric Tons Carbon Dioxide Equivalent</b>										
Cattle . . . . .	113.6	118.7	111.5	111.8	110.9	109.7	110.3	110.8	108.9	110.0
Swine . . . . .	1.6	1.8	1.9	1.9	1.8	1.8	1.9	1.9	1.9	1.9
Sheep . . . . .	2.1	1.6	1.4	1.3	1.3	1.3	1.2	1.1	1.1	1.1
Goats . . . . .	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.3
Horses . . . . .	2.1	2.1	2.2	2.1	2.2	2.2	2.2	2.2	2.2	2.2
<b>Total . . . . .</b>	<b>119.6</b>	<b>124.4</b>	<b>117.2</b>	<b>117.3</b>	<b>116.3</b>	<b>115.1</b>	<b>115.8</b>	<b>116.1</b>	<b>114.2</b>	<b>115.6</b>
<b>Million Metric Tons Methane</b>										
Cattle . . . . .	4.94	5.16	4.85	4.86	4.82	4.77	4.80	4.82	4.73	4.78
Swine . . . . .	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Sheep . . . . .	0.09	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05
Goats . . . . .	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Horses . . . . .	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10
<b>Total . . . . .</b>	<b>5.20</b>	<b>5.41</b>	<b>5.09</b>	<b>5.10</b>	<b>5.06</b>	<b>5.00</b>	<b>5.03</b>	<b>5.05</b>	<b>4.97</b>	<b>5.02</b>

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 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005). Totals may not equal sum of components due to independent rounding.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2004*. Cattle, sheep, and pig population data provided by the U.S. Department of Agriculture, National Agricultural Statistics Service, Livestock, Dairy and Poultry Service. Goat and horse population figures extrapolated from U.S. Department of Commerce, Bureau of the Census, *Census of Agriculture*, 1982, 1987, 1992, and 1997. Emissions calculations based on U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004*, EPA-430-R-06-002 (Washington, DC, April 2006), web site <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html>; and P.J. Crutzen, I. Aselmann, and W.S. Seiler, "Methane Production by Domestic Animals, Wild Ruminants, Other Herbivorous Fauna, and Humans," *Tellus*, Vol. 38B (1986), pp. 271-284.

**Table 23. U.S. Methane Emissions from the Solid Waste of Domesticated Animals, 1990, 1995, and 1998-2005**

Animal Type	1990	1995	1998	1999	2000	2001	2002	2003	2004	P2005
<b>Thousand Metric Tons Carbon Dioxide Equivalent</b>										
<b>Cattle</b>										
Beef Cattle . . . . .	4,037	4,838	4,592	4,547	4,496	4,470	4,454	4,433	4,406	4,455
Dairy Cattle . . . . .	12,717	15,236	16,970	17,092	17,430	17,746	18,014	18,185	18,267	18,544
<b>Swine</b>										
Market Swine . . . . .	19,222	21,368	23,366	22,522	22,368	22,627	22,724	23,165	23,522	23,713
Breeding Swine . . . . .	3,502	3,788	3,739	3,488	3,507	3,470	3,390	3,362	3,340	3,364
<b>Poultry</b>										
Layers . . . . .	1,663	1,814	1,913	1,979	2,016	2,052	2,076	2,082	2,114	2,132
Broilers . . . . .	1,590	2,158	2,298	2,372	2,255	2,284	2,339	2,312	2,379	2,415
<b>Other Animals</b>										
Sheep . . . . .	115	34	29	28	27	27	25	24	24	24
Goats . . . . .	16	15	12	11	11	12	10	10	10	23
Horses . . . . .	624	631	644	636	645	652	652	652	652	652
<b>Total . . . . .</b>	<b>43,486</b>	<b>49,883</b>	<b>53,563</b>	<b>52,676</b>	<b>52,756</b>	<b>53,340</b>	<b>53,684</b>	<b>54,225</b>	<b>54,715</b>	<b>55,320</b>
<b>Thousand Metric Tons Methane</b>										
<b>Cattle</b>										
Beef Cattle . . . . .	176	210	200	198	195	194	194	193	192	194
Dairy Cattle . . . . .	553	662	738	743	758	772	783	791	794	806
<b>Swine</b>										
Market Swine . . . . .	836	929	1,016	979	973	984	988	1,007	1,023	1,031
Breeding Swine . . . . .	152	165	163	152	152	151	147	146	145	146
<b>Poultry</b>										
Layers . . . . .	72	79	83	86	88	89	90	91	92	93
Broilers . . . . .	69	94	100	103	98	99	102	101	103	105
<b>Other Animals</b>										
Sheep . . . . .	5	1	1	1	1	1	1	1	1	1
Goats . . . . .	1	1	1	*	*	1	*	*	*	1
Horses . . . . .	27	27	28	28	28	28	28	28	28	28
<b>Total . . . . .</b>	<b>1,891</b>	<b>2,169</b>	<b>2,329</b>	<b>2,290</b>	<b>2,294</b>	<b>2,319</b>	<b>2,334</b>	<b>2,358</b>	<b>2,379</b>	<b>2,405</b>

\*Less than 500 metric tons methane.

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 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005). Totals may not equal sum of components due to independent rounding.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2004*. 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. Population data for all other animals from U.S. Department of Agriculture, National Agricultural Statistics Service, Livestock, Dairy and Poultry Branch. Typical animal sizes from U.S. Environmental Protection Agency, Office of Air and Radiation, *Anthropogenic Methane Emissions in the United States: Estimates for 1990, Report to Congress* (Washington, DC, April 1993), p. 6-8; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004*, Table M-2, EPA-430-R-06-002 (Washington, DC, April 2006), web site <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html>. Cattle sizes adjusted by annual slaughter weight from U.S. Department of Agriculture, National Agricultural Statistics Service, Livestock, Dairy and Poultry Branch. Maximum methane 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: U.S. Environmental Protection Agency, February 1992), pp. 24-27; U.S. Environmental Protection Agency, *Cost Methodology Report for Beef and Dairy Animal Feeding Operations*, EPA-821-R-01-019 (Washington, DC, January 2001), pp. 1-13-1-14; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2002*, EPA-430-R-04-003 (Washington, DC, April 2004), Table M-2. General methane conversion factors 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. 4.25, web site [www.ipcc.ch/pub/guide.htm](http://www.ipcc.ch/pub/guide.htm). State methane conversion factors for dairy cattle from U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-1998*, EPA-236-R-00-001 (Washington, DC, April 2001); and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2002*, EPA-430-R-04-003 (Washington, DC, April 2004), Table M-4.

Table 24. U.S. Methane Emissions from Industrial Processes, 1990, 1995, and 1998-2005

Source	1990	1995	1998	1999	2000	2001	2002	2003	2004	P2005
<b>Thousand Metric Tons Carbon Dioxide Equivalent</b>										
<b>Chemical Production</b>										
Ethylene . . . . .	380	488	540	578	521	470	493	479	535	500
Ethylene Dichloride . . . . .	58	72	82	91	82	78	78	83	101	94
Styrene . . . . .	335	475	477	499	452	357	415	437	456	427
Methanol . . . . .	174	225	262	254	203	142	137	132	123	97
Carbon Black . . . . .	331	386	407	415	384	363	386	386	386	386
<b>Total . . . . .</b>	<b>1,277</b>	<b>1,646</b>	<b>1,767</b>	<b>1,837</b>	<b>1,643</b>	<b>1,410</b>	<b>1,509</b>	<b>1,518</b>	<b>1,602</b>	<b>1,504</b>
<b>Iron and Steel Production</b>										
Coke <sup>a</sup> . . . . .	251	201	163	148	155	130	132	120	108	100
Sinter . . . . .	141	144	125	127	124	106	104	103	93	96
Pig Iron . . . . .	1,028	1,053	998	958	991	872	833	841	875	770
<b>Total . . . . .</b>	<b>1,420</b>	<b>1,399</b>	<b>1,286</b>	<b>1,233</b>	<b>1,271</b>	<b>1,108</b>	<b>1,068</b>	<b>1,065</b>	<b>1,076</b>	<b>967</b>
<b>Total Industrial Processes . . . .</b>	<b>2,697</b>	<b>3,044</b>	<b>3,053</b>	<b>3,070</b>	<b>2,914</b>	<b>2,518</b>	<b>2,577</b>	<b>2,582</b>	<b>2,678</b>	<b>2,471</b>
<b>Thousand Metric Tons Methane</b>										
<b>Chemical Production</b>										
Ethylene . . . . .	17	21	23	25	23	20	21	21	23	22
Ethylene Dichloride . . . . .	3	3	4	4	4	3	3	4	4	4
Styrene . . . . .	15	21	21	22	20	16	18	19	20	19
Methanol . . . . .	8	10	11	11	9	6	6	6	5	4
Carbon Black . . . . .	14	17	18	18	17	16	17	17	17	17
<b>Total . . . . .</b>	<b>56</b>	<b>72</b>	<b>77</b>	<b>80</b>	<b>71</b>	<b>61</b>	<b>66</b>	<b>66</b>	<b>70</b>	<b>65</b>
<b>Iron and Steel Production</b>										
Coke <sup>a</sup> . . . . .	11	9	7	6	7	6	6	5	5	4
Sinter . . . . .	6	6	5	6	5	5	5	4	4	4
Pig Iron . . . . .	45	46	43	42	43	38	36	37	38	33
<b>Total . . . . .</b>	<b>62</b>	<b>61</b>	<b>56</b>	<b>54</b>	<b>55</b>	<b>48</b>	<b>46</b>	<b>46</b>	<b>47</b>	<b>42</b>
<b>Total Industrial Processes . . . .</b>	<b>117</b>	<b>132</b>	<b>133</b>	<b>133</b>	<b>127</b>	<b>109</b>	<b>112</b>	<b>112</b>	<b>116</b>	<b>107</b>

<sup>a</sup>Based on total U.S. production of metallurgical coke, including non-iron and steel uses.

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 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005). Totals may not equal sum of components due to independent rounding.

Sources: Published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2004*; American Iron and Steel Institute, *Annual Statistical Report* (Washington, DC, various years); American Chemical Council (formerly the Chemical Manufacturers Association), *U.S. Chemical Industry Statistical Handbook* (Washington, DC, various years); and 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. 2.23, web site [www.ipcc/pub/guide.htm](http://www.ipcc/pub/guide.htm).