5. Reducing Methane Emissions

Introduction

U.S. anthropogenic (human-caused) methane emissions totaled 28.0 million metric tons in 2001, 3.7 million metric tons less than in 1990. Estimated emissions from landfills—the largest single anthropogenic source of methane in the United States—dropped from 11.2 million metric tons in 1990 to 8.0 million metric tons in 2001[34] as a result of a rapid increase in methane recovery at landfills in response to the now-expired Section 29 tax credit for alternative fuels and the implementation of EPA's New Source Performance Standards and Emission Guidelines.[35] Overall, methane recovery at landfills grew from about 1.0 million metric tons in 1990 to 4.9 million metric tons in 2001.[36] Although not directly correlated, the increase in activity aimed at capturing methane from landfills is reflected in reports submitted to the Voluntary Reporting Program. For the 2001 data year, reduction activities were reported on Form EIA-1605 for at least 201 separate landfills, up from 185 in 2000.[37]

Another significant component of the overall decline in U.S. methane emissions has been a drop in emissions from coal mining. Methane emissions from coal mines declined from 4.2 million metric tons in 1990 to 2.8 million metric tons in 2001.[38] To some extent, the decline is attributable to an increase in methane recovery at coal mines, from 0.3 million metric tons in 1990 to about 0.7 million metric tons in 2001. The Voluntary Reporting Program received reports on 16 emission reduction projects at coal mines for 2001, up from 14 for 2000. The 16 projects reported total direct methane emission reductions of 538,285 metric tons (12.4 million metric tons carbon dioxide equivalent) in 2001, up from 505,941 metric tons methane (11.6 million metric tons carbon dioxide equivalent) in 2000.

Although U.S. methane emissions from the production, transmission, and distribution of natural gas and from agricultural activities both increased between 1990 and 2001 (9.1 percent and 11.3 percent, respectively), some entities reported reductions in emissions from these sources. Reduced emissions from the natural gas system were reported for 19 projects, and reduced emissions from agricultural activities were reported for 3 projects.

Overview of Projects Reported

For the 2001 data year, 74 organizations reported a total of 246 projects to reduce methane emissions, a 36-percent decrease from the 2000 data year[39] and a sevenfold increase from the first (1994) reporting cycle (Table 16). Twenty-one of the projects were reported for the first time in the 2001 reporting cycle, eiher because they began achieving reductions in 2001 or because they were reported by one of seven new reporters. Some projects reported for previous years were not reported for 2001.

Direct emission reductions from all methane projects reported for 2001 totaled 2,436,799 metric tons methane, down from 2,693,295 metric tons reported for 2000 (Table 17). Of the total for 2001, 41.3 percent was attributable to 208 waste treatment projects that reported an average of 4,843 metric tons direct methane emission reductions per project. Projects to reduce methane emissions from coal mines and natural gas systems generally yielded much larger direct reductions per project (Figure 13), averaging 18,797 metric tons methane. Total direct emission reductions of 538,285 metric tons methane were reported for coal mining projects in 2001, accounting for 22 percent of the direct methane emission reductions reported for 2001. The 19 natural gas system projects reported for 2001 reduced direct emissions by a total of 119,609 metric tons methane, or about 5 percent of all reported direct methane emission reductions.

Indirect methane emission reductions from waste treatment and disposal projects totaled 1,003,287 metric tons, more than 99 percent of all indirect methane emission

[34]Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002), web site www.eia.doe.gov/oiaf/1605/1605a.html.

[35]The EPA's Landfill Methane Outreach Program (LMOP) has also contributed to the increase in methane recovery from landfills, as reflected by the large percentage of landfill gas-to-energy project developers who reported participation in LMOP as part of their submissions to the Voluntary Reporting of Greenhouse Gases Program (see Table 20 in this chapter).

[36]Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2001*, DOE/EIA-0573(2001) (Washington, DC, December 2002), web site www.eia.doe.gov/oiaf/1605/1605a.html.

[37]The counts of landfills represent minimum levels, because not all reporters explicitly identified the landfills on which they were reporting. The counts exclude reports received after the close of the reporting cycles, in order to maintain comparability.

[38]Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2000*, DOE/EIA-0573(2000) (Washington, DC, November 2001), web site www.eia.doe.gov/oiaf/1605/1605a.html.

[39]Excluding late reporters from the 2000 total, the decrease was much smaller (7 percent).

reductions reported on Form EIA-1605. This total included two very large projects reported by DTE Energy and the Integrated Waste Services Association (IWSA). DTE energy reported 192,064 metric tons of indirect reductions from multiple landfill gas-to-energy systems reported as one large project, and IWSA reported indirect reductions of 265,720 metric tons from the waste-to-energy facilities of its members. Overall, reported indirect reductions continued to grow in 2001, due primarily to increases in reported reductions attributed to recovery of biogas at landfills. After dropping between 1996 and 1997 due to an improvement in the estimation methods used by IWSA, indirect reductions have continued to grow as a result of increased reporting of landfill gas capture and use projects.

Methane reduction projects are more prone to double reporting than are most other greenhouse gas reduction projects (with the exception of demand-side management programs), because electricity generated from methane recovery at a landfill, coal mine, or animal waste management facility is often sold to a second party, or recovered gas is piped to a second party for use in a boiler. In such cases, the party that captures the gas may report a direct reduction and the gas or electricity purchaser an indirect reduction. Where double reporting does occur, however, double counting is avoided because electricity producers report methane reductions as indirect unless they have an ownership stake in the landfill or its gas resource, whereas landfill gas developers report methane reductions as direct. Although there may be multiple reports of the same reduction from a single project, the reduction is unlikely to be counted more than once, because the reductions would be accounted for separately as part of either direct or indirect totals. As an example, Pacific Recovery Corporation and Generating Resource Recovery Partners, L.P., reported projects on the same landfill. Pacific Recovery is responsible for recovering methane released from the Otay landfill in California. Generating Resource Recovery Partners buys the recovered methane and uses it to produce electricity. Pacific Recovery reported direct methane emission reductions of 6,582 metric tons for 2001, and Generating Resource Recovery Partners reported indirect reductions of 6,582 metric tons.

Additional instances of double reporting may occur if a project is reported by two or more entities with ownership interests. Again, however, because reporters are instructed to report only the portion of overall reductions equal to their ownership share, double counting should not occur. Finally, in instances where both biogas flaring and biogas recovery for energy occur at the same landfill, the projects may be reported more than once; however, the total reductions reported should not exceed the reductions actually achieved, because the landfill gas developer or energy purchaser will not count flared gas in biogas recovery totals.

There were 30 landfills for which more than one entity reported emission reductions for 2001, or 15 percent of

Table 16. Projects Reported on Form EIA-1605 with Methane Reductions as the Principal Outcome by Project Type, Data Years 1994-2001

Project Type	1994	1995	1996	1997	1998	1999	2000(R)	2001
Waste Management and Disposal	**17**	**23**	**44**	**53**	**90**	**153**	**350**	**208**
Landfill Gas Recovery	14	19	40	48	80	139	337	198
Wastewater Treatment	2	2	2	3	5	6	8	4
Other	1	2	2	2	5	8	5	6
Agriculture	**3**	**3**	**3**	**3**	**4**	**4**	**5**	**3**
Energy Production and Consumption	**8**	**11**	**13**	**15**	**28**	**28**	**28**	**35**
Coal Mining	2	3	4	5	17	15	14	16
Natural Gas Production, Transmission, and Distribution	6	8	9	10	11	13	14	19
Total	**28**	**37**	**60**	**71**	**122**	**185**	**383**	**246**

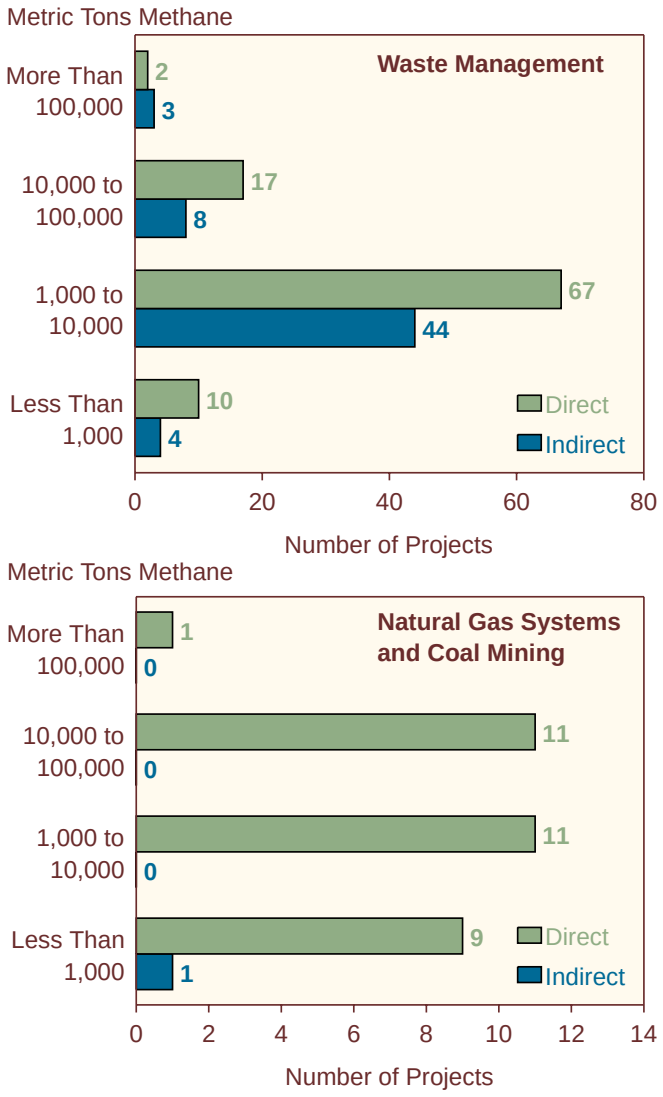
(R) = revised.
Note: Project totals do not equal sum of components, because some projects are counted in more than one category.
Source: Energy Information Administration, Form EIA-1605.

Table 17. Total Methane Emission Reductions Reported on Form EIA-1605, All Project Types, Data Years 1994-2001
(Metric Tons Methane)

Type of Reduction	1994	1995	1996	1997	1998	1999	2000(R)	2001
Direct	25,079	8,450	409,176	378,494	1,379,162	1,564,958	2,693,295	2,436,799
Indirect	102,641	1,077,272	1,157,048	505,663	658,811	827,294	897,465	1,009,400

(R) = revised.
Source: Energy Information Administration, Form EIA-1605.

Figure 13. Methane Emission Reduction Projects Reported on Form EIA-1605 by Type and Size of Reduction, Data Year 2001



Source: Energy Information Administration, Form EIA-1605.

the landfills for which reduction activities were reported on Form EIA-1605. In terms of the number of separate landfills involved in project reports, double reporting can also occur when a single entity reports methane flaring and methane recovery for energy at the same landfill as separate projects. There were two such cases among the Form EIA-1605 reports for 2001.

Reducing Methane Emissions from Waste Treatment and Disposal

Reducing emissions from waste treatment and disposal sites was by far the most frequently reported method for lowering methane emissions in 2001. The number of such projects reported on Form EIA-1605 for 2001 (208) made up 83 percent of all the methane emission reduction projects reported for the year. This was 17 more projects than were reported for 2000 (excluding late reports) and more than 12 times the number (17) reported for 1994. The principal reported method for reducing methane emissions from waste treatment and disposal was the capture of methane generated during the anaerobic decomposition of wastes in a landfill. The methane may be flared, piped to an end-use customer, or used to generate electricity, reducing the need for generation from other, more carbon-intensive fuels. Other methods of lowering emissions from waste treatment and disposal include reducing the volume of waste reaching landfills through combustion or recycling, and capturing methane generated during anaerobic decomposition of organic material in wastewater.

The 208 waste treatment and disposal projects reported for 2001 accounted for 1,007,485 metric tons of direct methane emission reductions and 1,003,287 metric tons of indirect reductions (Table 18). Of the 208 projects reported, 198 achieved methane emission reductions at landfills by capturing methane from landfill gas generated at waste disposal sites, 6 lowered emissions through diversion of wastes that would have emitted methane during decomposition, and 4 captured methane from wastewater treatment facilities.

Recovery of Landfill Gas

As waste decomposes in a landfill it produces a biogas that is approximately 50 percent carbon dioxide and 50 percent methane. As a result, landfill gas is a potentially valuable source of energy, with a heat content of about 500 British thermal units (Btu) per cubic foot, or about half that of commercially marketed natural gas. Because of its relatively low Btu content and the presence of several impurities, the typical method for using landfill gas is to burn it for electricity generation rather than upgrading it for sale to a pipeline. The electricity generated is then used on site or sold to the grid. The process lowers methane emissions and reduces consumption of other fuels for electricity generation. When the electricity generated displaces oil- or coal-fired generation, carbon dioxide emissions are reduced. More recently, an increasing number of projects have involved piping landfill gas for direct use in medium-Btu boilers, which also displaces fossil fuels.

For the 198 landfill gas recovery projects reported for 2001, reported direct methane emission reductions totaled 969,932 metric tons and indirect reductions totaled 701,901 metric tons methane. Of the projects reported, 100 recovered landfill methane for energy, 14 simply flared the gas, 77 included both recovery for energy and flaring, and 7 reported other activities.

Waste Diversion

When waste is diverted from a landfill through recycling, source reduction, or waste combustion, methane

emissions that would have resulted when the waste decomposed at a landfill are avoided. Six such projects were submitted to the Voluntary Reporting Programon Form EIA-1605 for 2001 under the category of waste treatment and disposal. The preponderance of the methane emission reductions reported for waste diversion are indirect, because they typically occur at a landfill where diverted waste would have decomposed to produce methane. Total indirect reductions for the six projects were 288,325 metric tons methane. The majority of the reductions were reported by IWSA, which reported reductions associated with the combustion of waste at facilities owned by its members across the United States. IWSA's total reported reduction of methane emissions in 2001 was 265,719 metric tons. There were also many recycling projects reported under project types other than waste treatment and disposal that showed reductions in methane emissions (see box on page 51).

Reducing Methane Emissions from Wastewater Treatment Plants

When wastewater is treated under anaerobic conditions, the decomposition of its organic portion yields methane. Like methane generated from waste at landfills, the methane generated from wastewater treatment may be captured and either flared or used as an energy resource. Because captured methane has value as an energy resource, operators may use an anaerobic digester to treat the wastewater and maximize methane generation. Four projects to capture methane generated from wastewater treatment were reported for 2001, with total reported direct reductions of 37,591 metric tons methane and indirect reductions of 13,060 metric tons methane. All the direct reductions were reported by a Los Angeles County Sanitation District project, and all the indirect reductions were reported for two projects sponsored by FirstEnergy.

Reducing Emissions from Energy Production and Consumption

Reducing Emissions from Coal Mines

As coal is formed from organic material by natural chemical and physical processes, methane is also created. The methane is stored in the pores (open spaces) of the coal itself and in cracks and fractures in the coalbed. As coal is mined, the pressure surrounding the stored methane decreases, allowing much of it to be released into the operating coal mine. Because methane in concentrations of 5 to 15 percent is explosive, mine operators use large fans to provide a steady airflow across the mine face and ventilate the mine shaft. Some very gassy mines must also employ degasification wells to remove methane before or after mining so that it does not enter the mine. Because methane is a valuable energy source, most of the mines with degasification systems now inject the methane into gas pipelines or use it to generate electricity or heat.

For 2001, 16 projects to reduce methane emissions from coal mines were reported on Form EIA-1605, with total direct emission reductions of 538,285 metric tons and indirect reductions of 96 metric tons methane (Table 19). U.S. Steel Mining Company reported direct methane reductions of 106,771 metric tons methane from its two projects, and El Paso Production Company reported direct reductions of 79,914 metric tons from its project in White Oak Creek coalbed in Alabama.

Reducing Emissions from Natural Gas Production, Transmission, and Distribution

Methane is the principal constituent of natural gas (about 95 percent of the mixture). Methane emissions

Table 18. Methane Emission Reductions from Waste Treatment and Disposal Projects Reported on Form EIA-1605, Data Years 1994-2001
(Metric Tons Methane)

Reduction and Project Type	1994	1995	1996	1997	1998	1999	2000(R)	2001
Direct Reductions	*	619	128,449	135,639	484,673	966,785	2,171,501	1,007,485
Landfill Gas Recovery	*	619	128,449	135,340	451,445	921,666	2,134,007	969,932
Wastewater Treatment	—	—	—	298	33,267	40,763	37,532	37,591
Waste Combustion	—	—	—	—	-39	4,356	-38	-38
Indirect Reductions	99,431	1,061,691	1,142,877	449,595	644,739	815,344	884,484	1,003,287
Landfill Gas Recovery	99,431	111,293	250,480	298,335	470,880	575,484	612,862	710,345
Wastewater Treatment	—	1	*	—	4,714	19,648	12,662	13,060
Waste Combustion	0	950,397	892,397	151,259	169,145	220,212	258,960	279,882

*Less than 0.5 metric ton.
(R) = revised.
Source: Energy Information Administration, Form EIA-1605.

Materials Management Projects

"Materials management" is a crosscutting category that can encompass a variety of greenhouse gas and emission sources, and may include any of the following activities:

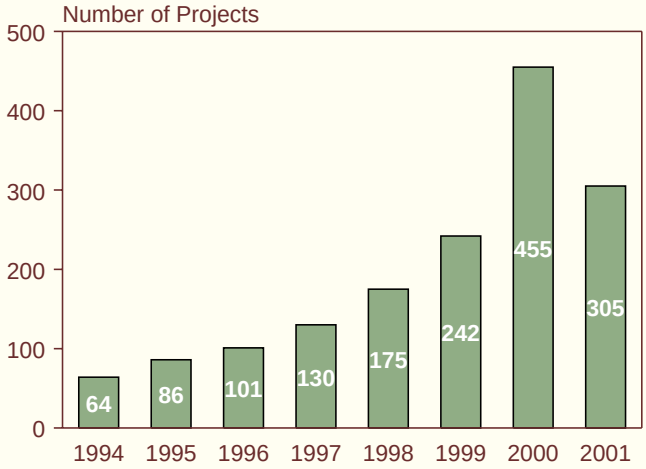
- Use of biomass fuels, such as wood waste, which reduces carbon dioxide emissions by displacing fossil fuels
- Avoidance of methane emissions from the decay of waste materials in landfills, wastewater treatment plants, and other waste management systems through activities such as recovery of methane from landfills or from anaerobic digesters treating municipal sewage, agricultural wastes, or animal manure, and diversion of municipal solid waste from landfills to waste-to-energy systems
- Recycling of halogenated substances, such as sulfur hexafluoride, hydrofluorocarbons, chlorofluorocarbons, and hydrochlorofluorocarbons
- Recycling and source reduction of solid waste, which reduce methane emissions from municipal landfills and reduce emissions of carbon dioxide and other gases associated with the production of virgin materials displaced by the materials recycled
- Reuse of coal ash as a substitute for Portland cement in concrete, which reduces carbon dioxide emissions from the manufacture of the cement.

Reporting of materials management activities on Form EIA-1605 increased sevenfold from 1994 to 2000. Only 305 projects were reported for 2001, 33 percent fewer than were reported for 2000 (see figure); however, Waste Management, Inc., submitted a late report for 2000 that added a large number of projects, and late reports will raise the project total for 2001.

Landfill gas recovery accounted for most (65 percent) of the 305 materials management projects reported for 2001. In addition to 12 other methane emission avoidance projects reported, other materials management projects included coal ash reuse (37), recycling and source reduction of solid waste (31), recycling of halogenated substances (16), and biomass burning (11).

The emission reductions reported for materials management projects are shown in the table below. For 2001, reported net reductions in direct emissions were 15.4 million metric tons carbon dioxide equivalent, representing 7 percent of the total direct reductions reported. Reported indirect reductions were 47.2 million metric tons carbon dioxide equivalent, representing 66 percent of the total indirect reductions reported.

Materials Management Projects Reported on Form EIA-1605, Data Years 1994-2001



Source: Energy Information Administration, Form EIA-1605.

Reported Emission Reductions from Materials Management Projects by Project Type and Type of Reduction, Data Year 2001
(Metric Tons Carbon Dioxide Equivalent)

Project Type	Number of Projects	Direct Reductions	Indirect Reductions
Biomass Burning	11	462,901	107,633
Methane Emission Avoidance			
Landfill Gas Recovery	198	22,062,248	16,979,711
Municipal Waste Combustion	7	-9,454,425	23,632,655
Wastewater Treatment	4	859,918	293,604
Agricultural Waste	1	148	1,433
Total	*210*	*13,467,889*	*40,907,404*
Halogenated Substances	16	1,123,904	81
Recycling and Source Reduction of Solid Waste	31	362,733	789,941
Coal Ash Reuse	37	0	5,370,767
Total	**305**	**15,417,426**	**47,175,827**

Source: Energy Information Administration, Form EIA-1605.

from natural gas production, processing, transmission, and distribution are generally process related, with normal operations, routine maintenance, and system upsets being the primary contributors. Emissions vary greatly from facility to facility and are largely a function of operation and maintenance procedures and equipment conditions. Thus, methane emissions can be reduced by replacing leaky system components, improving operations and maintenance, and limiting routine venting procedures. Nineteen such projects were reported for 2001, with total direct emission reductions of 119,609 metric tons methane. No indirect reductions were reported. Two of NIPSCO's Natural Gas STAR projects were responsible for 91,657 metric tons of direct methane emission reductions, or 77 percent of the total for natural gas projects.

Reducing Emissions from Agriculture

Three projects reported for 2001 focused on reducing methane emissions from agricultural activities, but only two of them reported emission reductions. As the purchaser of the electricity from one project, FirstEnergy reported indirect methane emission reductions of 71 metric tons from Mason Dixon Farms. AES reported an indirect reduction of 915 metric tons methane from improving feed supplements for cattle in India and reducing emissions from enteric fermentation. The remaining project was a study on reducing emissions from rice cultivation, financed by Reliant Energy (formerly Houston Lighting and Power Company), for which reductions were not estimated.

Federal Voluntary Programs To Reduce Methane Emissions

The U.S. Government sponsors a number of voluntary programs specifically targeted to reduce methane emissions. Most frequently cited by reporters to the Voluntary Reporting Program are the Landfill Methane Outreach Program (LMOP), the Coalbed Methane Outreach Program (CMOP), and the Natural Gas STAR Program. In addition, reducing methane is an effective method for meeting the reduction targets adopted by utilities under the Climate Challenge voluntary program. The number of reported methane reduction projects associated with Federal voluntary programs has increased nearly eightfold since 1994, with a particularly large increase in the number of projects associated with the LMOP. Of the 208 waste treatment and disposal projects reported to the Voluntary Reporting Program for 2001, 176 (85 percent) were associated with the LMOP (Table 20).

Table 19. Methane Emission Reductions from Natural Gas Systems and Coal Mining Reported on Form EIA-1605, Data Years 1994-2001
(Metric Tons Methane)

Reduction and Project Type	1994	1995	1996	1997	1998	1999	2000(R)	2001
Direct Reductions	**19,687**	**7,714**	**279,766**	**242,040**	**893,927**	**595,311**	**518,590**	**657,894**
Coal Mining	13,767	4,191	271,549	232,131	885,807	581,307	505,941	538,285
Natural Gas Systems	5,920	3,522	8,217	9,909	8,121	14,004	12,648	119,609
Indirect Reductions	**—**	**3,543**	**4,039**	**5,439**	**7,603**	**6,565**	**6,785**	**96**
Coal Mining	—	278	893	2,285	1,568	528	747	96
Natural Gas Systems	—	3,265	3,146	3,154	6,035	6,036	6,038	0

(R) = revised.
Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

Table 20. Number of Reported Methane Reduction Projects Associated with Other Federal Voluntary Programs, Data Years 1994-2001

Voluntary Program	1994	1995	1996	1997	1998	1999	2000(R)	2001
Climate Challenge	22	27	32	36	34	39	42	34
Landfill Methane Outreach Program	6	8	29	32	90	116	309	176
Coalbed Methane Outreach Program	1	1	2	2	10	11	6	9
Natural Gas STAR	7	9	11	6	5	7	7	14
Other	0	6	2	2	1	3	4	5
Total	**30**	**42**	**64**	**65**	**132**	**164**	**354**	**224**

(R) = revised.
Note: Totals may not equal sum of components, because some projects are associated with more than one voluntary program.
Source: Energy Information Administration, Form EIA-1605.