

5. Reducing Methane Emissions

Introduction

U.S. anthropogenic methane emissions totaled an estimated 643.2 million MTCO₂e (28.0 million metric tons methane) in 2004, representing 9.0 percent of total U.S. greenhouse gas emissions. Methane emissions in 2004 were 0.8 percent above 2003 levels,⁴² primarily as a result of an increase in methane emissions from landfills and coal mines and, secondarily, increases emissions associated with animal waste and rice cultivation.

U.S. emissions of methane in 2004 were 11 percent below their 1990 level of 722.6 million MTCO₂e. In addition to a reduction of 74.4 million MTCO₂e in methane emissions from landfills since 1990, there has also been a decrease of 29.5 million MTCO₂e in methane emissions from coal mines as a result of a 150-percent increase in methane recovery from coal mines and a shift in production away from gassy mines.

Overview of Projects Reported

For the 2004 data year, participants in the Voluntary Reporting Program reported 443 projects with methane reductions as the principal outcome (Table 17), yielding direct emission reductions of 65.8 million MTCO₂e and indirect emission reductions of 28.8 million MTCO₂e (Table 18). Landfill gas recovery projects accounted for most of the reductions, including 48.8 million MTCO₂e of direct reductions and 18.6 million MTCO₂e of indirect reductions, reflecting the large proportion (88 percent) of reported methane emission reduction projects that focused on landfill gas recovery. The number of reported projects with methane reductions as the principal outcome peaked in 2003 at 471 (with landfill gas recovery projects also peaking at 411), although reported direct emissions reductions reported peaked in 2001.

For 2004, 73 organizations reported on projects with the primary aim of reducing methane emissions—7 fewer than those that reported such projects for 2003. There was a corresponding decline in the total number of projects reported, from 471 to 443, and in the number of direct reduction projects reported (Table 17). After peaking at 81.6 million MTCO₂e in 2001, direct reductions from projects that reduced methane emissions have declined in each subsequent year, to 65.8 million

MTCO₂e in 2004. In contrast, indirect reductions reported for 2004 were the highest since 1994, the first year of the program, at 28.8 million MTCO₂e (Table 18).

More than one-half of the total direct reduction in methane emissions reported on Form EIA-1605 for 2004 (36.1 million MTCO₂e) was reported by Waste Management Incorporated. Waste Management reported more projects for 2004 (229) than it did for 2003 (218) and more direct emission reductions (36.1 million MTCO₂e for 2004, compared with 33.0 million MTCO₂e for 2003). With 51,000 employees and 286 active landfills, the company is the largest waste management services provider in North America. Its report for 2004 covered 196 open and closed landfills, including 57 gas-to-electricity projects that provided more than 260 megawatts of energy and 33 projects that sold landfill gas as fuel to industrial end users in 2004.

The largest contributors of reported indirect reductions were the Integrated Waste Services Association (IWSA) at 9.4 million MTCO₂e and DTE Energy at 5.7 million MTCO₂e. The IWSA includes 50 members that own or operate 65 waste-to-energy plants, which combust a total of 76,000 metric tons of trash daily. IWSA reported avoiding methane emissions from waste that would otherwise have been placed in landfills and decomposed anaerobically, producing methane. DTE Energy reported landfill gas recovery efforts at 18 landfills, where it purchases the electricity generated and bundles the reported reductions into four project reports.

Although the number of reported projects that reduced methane emissions from energy production and consumption (i.e., coal mines and natural gas production, transmission, and distribution) was much smaller than the number that reduced methane emissions from waste management and disposal (mainly landfills), they had a disproportionate effect on methane emissions reductions, because the typical size of reductions reported for energy production and consumption projects is larger than that for waste management and disposal projects. The average direct emission reduction from landfill gas recovery projects (the primary waste management and disposal category) is 123,000 MTCO₂e, as compared with an average of 223,000 MTCO₂e for natural gas system projects and 573,000 MTCO₂e for coal mine projects.

⁴²Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005), web site www.eia.doe.gov/oiaf/1605/ggrpt.

The average of emission reductions reported for coal mine projects was increased by a gobwell degasification project reported by Jim Walter Resources, which recovered 2.9 million MTCO₂e of methane from the Warrior Basin, and a project reported by CDX Gas, which recovered 1.2 million MTCO₂e of methane from the Pinnacle Mine owned by U.S. Steel Mining Company. The largest reductions from natural gas system projects were reported by BP America, which reported a reduction of 1.8 million MTCO₂e resulting from equipment upgrades at natural gas production and processing sites, and NiSource/NIPSCO, which reported a reduction of 1.7 million MTCO₂e resulting from its implementation of Natural Gas STAR⁴³ Best Management Practices at the Columbia Gas Transmission Company.

Only two projects reported for 2004 reduced methane emissions in the agricultural sector. Both used methane generated from the anaerobic digestion of animal waste to produce electricity. Total direct emission reductions from the two projects were 112.5 MTCO₂e, and total indirect reductions were 662.2 MTCO₂e.

Reducing Methane Emissions from Waste Treatment and Disposal

Reducing emissions from waste treatment and disposal sites was the most frequently reported method for lowering methane emissions in 2004. The 403 waste treatment and disposal projects reported for 2004 accounted for 49.8 million MTCO₂e of direct methane emission reductions and 28.7 million MTCO₂e of indirect methane reductions (Table 19). Waste treatment and disposal projects produced 76 percent of the direct methane emission reductions and 99 percent of the indirect methane emission reductions reported for 2004. The principal method reported for reducing methane emissions from waste treatment and disposal was landfill gas recovery (392 of the 403 projects reported). Another 6 projects reduced emissions through the combustion of waste, yielding more than one-third of all indirect methane reductions reported, and the remaining 5 projects

Table 17. Projects Reported on Form EIA-1605 with Methane Reductions as the Principal Outcome by Project Type, Data Years 1994-2004
(Number of Projects)

Project Type	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003 ^(R)	2004
Waste Management and Disposal	17	23	44	53	90	153	350	391	404	426	403
Landfill Gas Recovery	14	19	40	48	80	138	336	380	390	411	392
Wastewater Treatment	2	2	2	3	6	8	8	4	7	8	5
Waste Combustion	1	2	2	2	4	7	6	7	7	7	6
Agriculture	3	3	3	3	4	4	5	3	3	4	2
Cropland	1	1	1	1	1	1	1	1	1	0	0
Livestock	2	2	2	2	3	3	4	2	2	4	2
Energy Production and Consumption	8	11	13	15	28	28	28	35	39	41	38
Coal Mining	2	3	4	5	17	15	14	16	18	13	11
Natural Gas Production, Transmission, and Distribution	6	8	9	10	11	13	14	19	21	28	27
Total	28	37	60	71	122	185	383	429	446	471	443

(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 18. Total Methane Emission Reductions Reported on Form EIA-1605, All Project Types, Data Years 1994-2004
(Million Metric Tons Carbon Dioxide Equivalent)

Type of Reduction	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003 ^(R)	2004
Direct	0.6	0.2	9.4	8.7	31.7	36.0	61.9	81.6	80.1	77.0	65.8
Indirect	2.4	24.8	26.6	11.6	15.2	19.0	20.6	23.2	24.6	23.1	28.8

(R) = revised.

Source: Energy Information Administration, Form EIA-1605.

⁴³Natural Gas STAR is an EPA program designed to promote the implementation of cost-effective technologies and practices to reduce emissions of methane. See web site www.epa.gov/gasstar/.

lowered emissions by capturing methane from wastewater treatment facilities.

Landfill Gas Recovery

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 Btu per cubic foot, or about one-half the heat content 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 electric power 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 also reduced. More recently, higher natural gas prices have resulted in an increasing number of projects that involve piping landfill gas for direct use in medium-Btu boilers, which also displaces fossil fuels.

For the 392 landfill gas recovery projects reported for 2004, direct methane emission reductions totaled 48.8 million MTCO₂e and indirect reductions totaled 18.6 million MTCO₂e. Of the projects reported, 168 recovered landfill methane for energy, 184 simply flared the gas, and 31 included both recovery for energy and flaring.

Waste Combustion

When waste is diverted from a landfill through waste combustion, methane emissions that would have resulted when the waste decomposed at a landfill are avoided. Six waste combustion projects were reported for 2004. Most of the methane emission reductions reported for waste combustion are indirect, because

they typically occur at a landfill where diverted waste would have decomposed to produce methane, rather than at the site of the waste diversion activities. Total indirect reductions for the six projects were 9.9 million MTCO₂e (Table 19). The majority of the reductions were reported by IWSA as part of the waste-to-energy project described above. Other methods of reducing methane emissions from waste include recycling and source reduction (see box on page 46).

Wastewater Treatment

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 can 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. Five projects to capture methane generated from wastewater treatment were reported for 2004, with total reported direct reductions of 0.9 million MTCO₂e and indirect reductions of 0.2 million MTCO₂e. Direct reductions of 0.6 million MTCO₂e were reported for a Los Angeles County Sanitation District project, and Blue Source reported direct reductions of 0.4 million MTCO₂e. Indirect reductions were reported for two projects sponsored by FirstEnergy.

Reducing Emissions from Energy Production and Consumption

Coal Mines

As natural chemical and physical processes form coal from organic material, they also create methane. The

Table 19. Methane Emission Reductions from Waste Treatment and Disposal Projects Reported on Form EIA-1605, Data Years 1994-2004
(Million Metric Tons Carbon Dioxide Equivalent)

Reduction and Project Type	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003 ^(R)	2004
Direct Reductions	*	*	3.0	3.1	11.1	22.2	49.9	48.7	57.8	56.1	49.8
Landfill Gas Recovery . . .	*	*	3.0	3.1	10.4	21.5	49.1	47.8	57.0	54.7	48.8
Wastewater Treatment . .	—	—	—	*	0.8	0.8	0.9	0.9	0.9	1.4	0.9
Waste Combustion	—	—	—	—	*	*	*	*	*	*	*
Indirect Reductions	2.3	24.4	26.3	10.3	14.8	18.8	20.3	23.1	23.1	22.8	28.7
Landfill Gas Recovery . . .	2.3	2.6	5.8	6.9	10.8	10.9	14.1	16.1	14.3	13.0	18.6
Wastewater Treatment . .	—	*	*	*	0.1	0.2	0.3	0.3	0.3	0.2	0.2
Waste Combustion	*	21.9	20.5	3.5	3.9	7.6	6.0	6.7	8.5	9.6	9.9

*Less than 50,000 MTCO₂e. — = none reported.

(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:

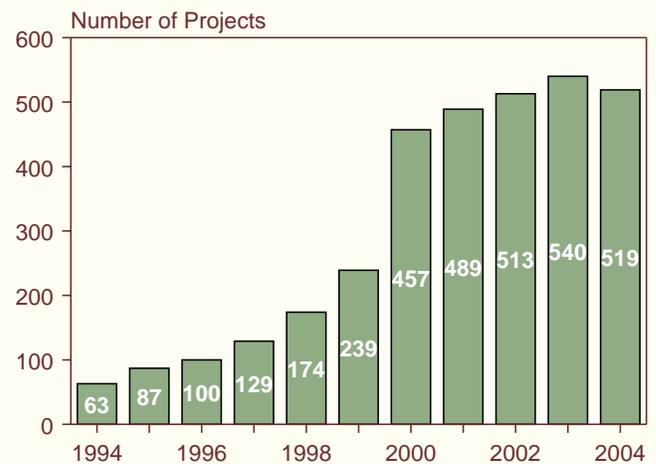
- Use of biomass and waste fuels such as wood and municipal waste, which reduces carbon dioxide emissions by displacing fossil fuels
- Avoidance of methane emissions from the decay of waste materials in landfills, wastewater treatment plants, and other waste management systems through activities such 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 more than sevenfold from 1994 to 2004. A total of 519 projects were reported for 2004 (see figure).

Landfill gas recovery accounted for most (76 percent) of the 519 materials management projects reported for 2004. In addition to 12 other methane emission avoidance projects reported, other materials management projects included coal ash reuse (33), recycling and source reduction of solid waste (28), recycling of halogenated substances (16), and biomass burning (38).

The emission reductions reported for materials management projects are shown in the table below. For 2004, reported net reductions in direct emissions were 47.1 million MTCO₂e, representing 17 percent of the total direct reductions reported. Reported indirect reductions were 59.0 million MTCO₂e, representing 64 percent of the total indirect reductions reported.

Materials Management Projects Reported on Form EIA-1605, Data Years 1994-2004



Source: Energy Information Administration, Form EIA-1605. Note: Data revised for all years (1994-2004).

Reported Emission Reductions from Materials Management Projects by Project Type and Type of Reduction, Data Year 2004

(Metric Tons Carbon Dioxide Equivalent)

Project Type	Number of Projects	Direct Reductions	Indirect Reductions
Biomass and Waste Burning	38	2,584,934	1,662,025
Methane Emission Avoidance			
Landfill Gas Recovery	392	49,166,872	19,748,393
Landfill Avoidance	6	-7,439,069	25,816,225
Wastewater Treatment	5	961,184	263,794
Agricultural Waste	1	113	662
Total	404	42,689,100	45,829,074
Halogenated Substances	16	1,761,239	248,389
Recycling and Source Reduction of Solid Waste . .	28	80,818	5,928,122
Coal Ash Reuse	33	0	5,292,048
Total	519	47,116,091	58,959,658

Source: Energy Information Administration, Form EIA-1605.

methane is stored in the pores (open spaces) of the coal itself and in cracks and fractures in the coalbed. When coal is mined the pressure surrounding the stored methane is decreased, and much of the gas is 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. In some very gassy mines, degasification wells are also used 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 2004, 11 projects to reduce methane emissions from coal mines were reported, with total direct emission reductions of 6.3 million MTCO₂e (Table 20).

Natural Systems

Methane is the principal constituent of natural gas (about 95 percent of the mixture). Methane emissions from natural gas production, processing, transmission, and distribution are generally process related, with normal operations, routine maintenance, and system upsets being the primary contributors. Because emissions are largely a function of operation and maintenance

procedures and equipment conditions, they vary from facility to facility. Replacing leaky system components, improving operations and maintenance, and limiting routine venting procedures can reduce methane emissions. The 27 natural gas system projects reported for 2004 resulted in direct methane emission reductions of 6.2 million MTCO₂e, or about 9.4 percent of all reported direct methane emission reductions.

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 three EPA programs: the Landfill Methane Outreach Program (LMOP), Coalbed Methane Outreach Program (CMOP), and Natural Gas STAR Program. The number of reported methane reduction projects associated with Federal voluntary programs has increased 13-fold since 1994, with a particularly large increase in the number of projects associated with the LMOP. Of the 403 waste treatment and disposal projects reported for 2004, 335 (83 percent) were associated with the LMOP (Table 21).

Table 20. Methane Emission Reductions from Natural Gas Systems and Coal Mining Projects Reported on Form EIA-1605, Data Years 1994-2004
(Million Metric Tons Carbon Dioxide Equivalent)

Reduction and Project Type	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Reductions	0.5	0.2	6.4	5.6	20.6	13.7	11.9	15.1	18.3	20.6	12.5
Coal Mining	0.3	0.1	6.2	5.3	20.4	13.4	11.6	12.4	13.0	9.4	6.3
Natural Gas Systems	0.1	0.1	0.2	0.2	0.2	0.3	0.3	2.8	5.3	11.2	6.2
Indirect Reductions	—	0.1	0.1	0.1	0.2	0.2	0.2	*	*	*	—
Coal Mining	—	*	0.0	0.1	0.0	0.0	0.0	*	*	*	—
Natural Gas Systems	—	0.1	0.1	0.1	0.1	0.1	0.1	—	—	*	—

Source: Energy Information Administration, Form EIA-1605.

Table 21. Number of Reported Methane Reduction Projects Associated with Other Federal Voluntary Programs, Data Years 1994-2004

Voluntary Program	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003 ^(R)	2004
Climate Challenge	22	27	32	36	34	39	42	34	34	37	35
Landfill Methane Outreach Program . . .	6	8	29	32	90	116	309	359	354	365	335
Coalbed Methane Outreach Program . .	1	1	2	2	10	11	6	9	9	6	5
Natural Gas STAR	7	9	11	6	5	7	7	14	17	23	23
Other	0	6	2	2	1	3	4	5	5	5	2
Total	30	42	70	67	133	166	359	413	411	427	404

(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.