

## 5. Reducing Methane Emissions

U.S. anthropogenic (human-caused) methane emissions totaled 28.2 million metric tons in 2000, 3.5 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 7.8 million metric tons in 2000<sup>51</sup> as a result of a rapid increase in methane recovery at landfills in response to the expiring Section 29 tax credit for alternative fuels and the implementation of EPA's New Source Performance Standards and Emission Guidelines.<sup>52</sup> Overall, methane recovery at landfills grew from about 1.0 million metric tons in 1990 to 4.9 million metric tons in 2000.<sup>53</sup> 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 2000 data year, reduction activities were reported for 185 separate landfills, up slightly from 184 in 1999.<sup>54</sup>

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 2.9 million metric tons in 2000.<sup>55</sup> 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 0.8 million metric tons in 2000. The Voluntary Reporting Program received reports on 11 emission reduction projects at coal mines for 2000, down from 17 for 1999 (5 of the 1999 reporters did not report for 2000). Six projects were reported for 2000 from the White Oak Creek and Oak Grove coalbeds in the Warrior basin, which is the Nation's gassiest coal basin. Together, these 11 projects reported direct methane emission reductions of 455,909 metric tons 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 2000 (14.7 percent and 9.3 percent, respectively), some entities reported reductions in emissions from these

sources. Reduced emissions from the natural gas system were reported for 15 projects, and reduced emissions from agricultural activities were reported for 5 projects.

### Overview of Projects Reported

For the 2000 data year, 78 organizations reported a total of 265 projects to reduce methane emissions, a 15-percent increase from the 1999 data year and a 516-percent increase from the first (1994) reporting cycle (Table 16). Fifty-four of the projects were reported for the first time in the 2000 reporting cycle, as compared with 105 projects reported for the first time in 1999. Some projects reported in previous years were not reported in 2000.

Direct emission reductions from all projects reported for the 2000 data year totaled 1,707,413 metric tons of methane (Table 17). Of that total, 99.8 percent was attributable to 133 projects within the waste management, agriculture, and energy production and transport sectors that reported positive direct methane emission reductions. These 133 projects showed an average of 12,813 metric tons direct methane reductions per project. Reductions in direct methane emissions averaging 10,839 metric tons in 2000 were reported for 114 waste management and disposal projects that reported positive direct methane emission reductions. Direct reductions from the 19 natural gas system or coal mining projects that reported positive direct methane emission reductions, including several large coal mine methane recovery projects, were generally much larger, averaging 24,661 metric tons per project reported (Figure 12).

Positive indirect emission reductions were reported for 52 waste management and disposal projects averaging 17,009 metric tons per project, including two very large projects reported by DTE Energy and the Integrated Waste Services Association (IWSA). DTE energy reported 189,471 metric tons in indirect reductions from multiple landfill gas-to-energy systems reported as one

<sup>51</sup>Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2000*, DOE/EIA-0573(2000) (Washington, DC, November 2001), web site <http://www.eia.doe.gov/oiaf/1605/1605a.html>.

<sup>52</sup>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, page 52, in this chapter).

<sup>53</sup>Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2000*, DOE/EIA-0573(2000) (Washington, DC, November 2001), web site <http://www.eia.doe.gov/oiaf/1605/1605a.html>.

<sup>54</sup>The estimate of landfills represented in 1999 dropped from 190 in the previous year's edition of this report due to a systematic effort to identify instances of double reporting.

<sup>55</sup>Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2000*, DOE/EIA-0573(2000) (Washington, DC, November 2001), web site <http://www.eia.doe.gov/oiaf/1605/1605a.html>.

large project, and IWSA reported indirect reductions of 230,122 metric tons from the waste-to-energy facilities of its 65 members. The 41 waste management projects reporting positive reductions on Form EIA-1605EZ averaged 3,242 metric tons for the 2000 data year.<sup>56</sup>

Overall, reported direct and indirect reductions continued to grow in 2000, due to increased program participation. Meanwhile, unspecified reductions (those reported on Form EIA-1605EZ) varied little from those reported for 1998 and 1999. The rapid escalation in reported direct reductions since 1997 is the result of a large influx of reports from landfill gas project developers. After dropping between 1996 and 1997 due to an improvement in the estimation methods by IWSA, indirect reductions have also continued to grow.

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 double counted, because the reductions would be accounted for separately as part of either direct or indirect totals.

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

**Table 16. Projects Reported with Methane Reductions as the Principal Outcome by Project Type, Data Years 1994-2000**

Project Type	1994	1995	1996	1997	1998	1999 <sup>(R)</sup>	2000
<b>Waste Management and Disposal</b> . . . . .	<b>27</b>	<b>39</b>	<b>65</b>	<b>81</b>	<b>129</b>	<b>195</b>	<b>234</b>
Landfill Gas Recovery . . . . .	24	35	60	74	118	181	219
Wastewater Treatment . . . . .	2	2	3	5	6	6	8
Other . . . . .	1	2	2	2	5	8	7
<b>Agriculture</b> . . . . .	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>4</b>	<b>4</b>	<b>5</b>
<b>Energy Production and Consumption</b> . . . . .	<b>13</b>	<b>16</b>	<b>22</b>	<b>19</b>	<b>30</b>	<b>32</b>	<b>26</b>
Coal Mining . . . . .	3	4	6	7	20	17	11
Natural Gas Production, Transmission, and Distribution . .	10	12	16	12	10	14	15
<b>Total</b> . . . . .	<b>43</b>	<b>58</b>	<b>90</b>	<b>103</b>	<b>163</b>	<b>230</b>	<b>265</b>

(R) = revised.

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

**Table 17. Total Reported Methane Emission Reductions, All Project Types, Data Years 1994-2000 (Metric Tons Methane)**

Type of Reduction	1994	1995	1996	1997	1998	1999 <sup>(R)</sup>	2000
Direct . . . . .	25,079	8,450	409,176	378,494	1,379,162	1,564,958	1,707,413
Indirect . . . . .	102,641	1,077,242	1,157,048	505,663	658,811	827,294	897,460
Unspecified <sup>a</sup> . . . . .	24,522	50,554	53,373	79,364	126,905	142,343	135,990

<sup>a</sup>Unspecified reductions represent quantities reported on Form EIA-1605EZ, which does not distinguish between direct and indirect emission reductions.

(R) = revised.

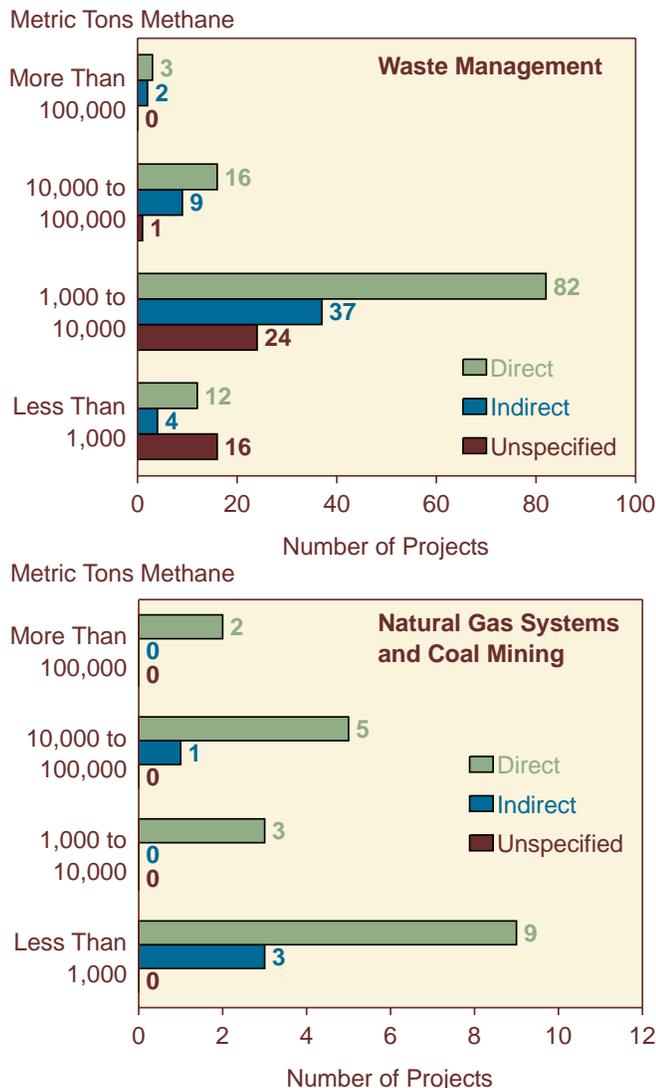
Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

<sup>56</sup>The total number of direct, indirect, and unspecified emission reduction projects does not equal the 265 projects reported for the 2000 data year, because many projects show both direct and indirect reductions, and others report neither direct nor indirect reductions for the 2000 data year.

exceed the reductions actually achieved because the landfill gas developer or energy purchaser will not count flared gas or biogas in energy totals.

For the 2000 data year, EIA implemented a systematic effort to identify instances of double reporting. There were 40 landfills for which more than one entity reported emission reductions, and in several cases one reporter included multiple landfills in a single project report. Thus, there were 56 separate reporters with projects at the 40 identified landfills. In addition, both methane flaring and recovery for energy were reported separately for 18 landfill projects, typically by the same reporter.

**Figure 12. Methane Emission Reduction Projects Reported by Type and Average Size of Reduction, Data Year 2000**



Note: Unspecified reductions represent quantities reported on Form EIA-1605EZ, which does not distinguish between direct and indirect emission reductions.

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

## 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 2000. The number of such projects reported for 2000 (234) was 20 percent higher than the number (195) reported for 1999 and nearly 9 times the number (27) reported for 1994. The principal reported method for reducing methane emissions from waste management 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 234 waste treatment and disposal projects reported for 2000 accounted for 1,235,652 metric tons of direct methane emission reductions and 884,485 metric tons of indirect reductions in 2000 (Table 18), or about 72 percent of all direct methane emission reductions and 99 percent of all indirect methane emission reductions reported. For 226 of the 234 projects reported, methane emission reductions were achieved at landfills, including 7 projects that lowered emissions through diversion of wastes that would have emitted methane during decomposition and 219 that captured methane from landfill gas generated at waste disposal sites.

### 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 219 landfill gas recovery projects reported for 2000, reported direct methane emission reductions totaled 1,198,158 metric tons and indirect reductions totaled 615,208 metric tons of methane. An additional 84,273 metric tons of methane were reported on Form EIA-1605EZ and thus are not specified as direct or indirect. Of the projects reported, 112 recovered landfill methane for energy, 48 simply flared the gas, and 59 included both recovery for energy and flaring.

## 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. Seven such projects were submitted to the Voluntary Reporting Program for 2000 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 seven projects were 256,615 metric tons. 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. Because the project covered 65 waste-to-energy facilities, IWSA reported a very large reduction of 230,122 metric tons of methane in 2000. 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. Eight projects to capture methane generated from wastewater treatment were reported for 2000, with total reported direct reductions of 37,532 metric tons and indirect reductions of 12,662 metric tons methane. Direct reductions were dominated by a Los Angeles County Sanitation District project that captured 37,131 metric tons of methane, and indirect reductions were dominated by a GPU Inc. effort that lowered emissions by 12,393 metric tons methane.

## 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.

**Table 18. Reported Methane Emission Reductions for Waste Treatment and Disposal Projects, Data Years 1994-2000**  
(Metric Tons Methane)

Reduction and Project Type	1994	1995	1996	1997	1998	1999 <sup>(R)</sup>	2000
<b>Direct Reductions</b> . . . . .	*	619	128,449	135,639	484,673	966,785	1,235,652
Landfill Gas Recovery . . . . .	*	619	128,449	135,340	451,445	934,073	1,198,158
Wastewater Treatment . . . . .	—	—	—	298	33,267	32,754	37,532
Waste Combustion . . . . .	—	—	—	—	-39	-42	-38
<b>Indirect Reductions</b> . . . . .	<b>99,431</b>	<b>1,061,691</b>	<b>1,142,877</b>	<b>449,595</b>	<b>644,739</b>	<b>815,344</b>	<b>884,485</b>
Landfill Gas Recovery . . . . .	99,431	111,293	250,480	298,335	470,880	474,618	615,208
Wastewater Treatment . . . . .	—	1	*	—	4,714	10,352	12,662
Waste Combustion . . . . .	0	950,397	892,397	151,259	169,145	330,374	256,615
<b>Unspecified<sup>a</sup></b> . . . . .	<b>24,388</b>	<b>50,324</b>	<b>53,006</b>	<b>78,624</b>	<b>123,958</b>	<b>138,334</b>	<b>132,923</b>
Landfill Gas Recovery . . . . .	24,388	50,324	53,006	58,434	78,447	95,003	84,273
Wastewater Treatment . . . . .	—	—	—	—	—	—	—
Waste Combustion . . . . .	—	—	*	20,190	45,511	43,331	48,650

<sup>a</sup>Unspecified reductions represent quantities reported on Form EIA-1605EZ, which does not distinguish between direct and indirect emission reductions.

\*Less than 0.5 metric ton.

(R) = revised.

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

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 2000, 11 projects to reduce methane emissions from coal mines were reported, with total direct emission reductions of 455,909 metric tons and indirect reductions of 747 metric tons of methane (Table 19). El Paso Production Company reported direct reductions of 140,306 metric tons from its project in White Oak Creek coalbed in Alabama, and U.S. Steel Mining Company reported direct methane reductions of 87,166 metric tons of methane from its two projects.

**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 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. Fifteen such projects were reported for 2000, most with small reductions. Western Resources reported indirect reductions 6,024 metric tons of methane emissions, out of the total 6,038 metric tons of indirect methane reductions reported for natural gas projects on Form EIA-1605. Three projects accounted for most of the reported direct reductions in emissions from

**Recycling and Source Reduction Projects**

The Voluntary Reporting Program has received reports on three types of waste management projects: waste diversion, recycling, and source reduction. Of the 38 recycling and source reduction projects reported for 2000, only 2 involved a combination of recycling and source reduction. Recycling and source reduction projects reported to the Voluntary Reporting Program for 2000 were estimated to have resulted in the avoidance of a total 600,258 metric tons of waste that would otherwise have been placed in landfills, a decline from the 710,012 metric tons reported for the 1999 data year. For 2000, 542,165 metric tons of paper were recycled, with 503,638 metric tons attributable to the Minnesota Resource Recovery Association.

Most emission reductions associated with recycling and source reduction are indirect, because emissions associated with the use of virgin materials in production or management of waste that is instead recycled

are likely to occur outside the reporting entity, at a landfill or manufacturing facility. For 2000, indirect reductions of 370,420 metric tons carbon dioxide equivalent were reported, and direct reductions of 24,757 metric tons carbon equivalent were reported. An additional 75,699 metric tons carbon dioxide equivalent of unspecified reductions were reported on Form EIA-1605EZ. It is likely that most of the unspecified reductions were indirect. Of the reductions classified as indirect, 39,587 metric tons carbon dioxide equivalent consisted of reductions in emissions of perfluorocarbons (PFCs) associated with reduced aluminum production. In addition, indirect reductions of methane emissions were reported, totaling 66,680 metric tons carbon dioxide equivalent, principally as a result of reduced landfilling of paper; and indirect reductions of 264,153 metric tons carbon dioxide were reported in association with lower energy requirements for product manufacturing.

**Reported Emission Reductions from Recycling and Source Reduction Projects by Reduction Type and Greenhouse Gas, Data Year 2000**

(Metric Tons Carbon Dioxide Equivalent)

Type of Reduction	Carbon Dioxide	Methane	Perfluorocarbons	Total
Direct. . . . .	14,233	7,473	3,051	<b>24,757</b>
Indirect . . . . .	264,153	66,680	39,587	<b>370,420</b>
Unspecified <sup>a</sup> . . . . .	5,167	70,531	0	<b>75,699</b>

<sup>a</sup>Unspecified reductions represent quantities reported on Form EIA-1605EZ, which does not distinguish between direct and indirect emission reductions.

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

the natural gas system; CMS Energy's Natural Gas STAR project reduced direct emissions by a reported 4,123 metric tons methane, Consolidated Edison's Natural Gas STAR project lowered direct emissions by a reported 3,529 metric tons methane, and NiSource/NIPSCO reported reducing direct emissions through its Natural Gas STAR project by 2,948 metric tons methane.

## Reducing Emissions from Agriculture

Five projects reported for 2000 focused on reducing methane emissions from agricultural activities. In three cases, methane was recovered from the decomposition of animal waste in anaerobic digesters and used to generate electricity. As the purchaser of the electricity from two projects, GPU, Inc. reported indirect methane reductions of 110 metric tons. PP&L reported indirect reductions of 76 metric tons from a biogas project at Rocky Knolls/Keener Farm. AES reported an indirect reduction of 870 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 utilities have adopted under the Climate Challenge voluntary program. The number of reported methane reduction projects associated with Federal voluntary programs has increased more than sixfold since 1994, with a particularly large increase in the number of projects associated with the LMOP. Of the 234 waste treatment and disposal projects reported to the Voluntary Reporting Program for 2000, 151 were associated with the LMOP (Table 20).

**Table 19. Reported Methane Emission Reductions from Natural Gas Systems and Coal Mining, Data Years 1994-2000**  
(Metric Tons Methane)

Reduction and Project Type	1994	1995	1996	1997	1998	1999 <sup>(R)</sup>	2000
<b>Direct Reductions</b> . . . . .	<b>19,687</b>	<b>7,714</b>	<b>279,766</b>	<b>242,040</b>	<b>893,927</b>	<b>595,311</b>	<b>468,557</b>
Coal Mining . . . . .	13,767	4,191	271,549	232,131	885,807	581,307	455,909
Natural Gas Systems . . . . .	5,920	3,522	8,217	9,909	8,121	14,004	12,648
<b>Indirect Reductions</b> . . . . .	<b>—</b>	<b>3,543</b>	<b>4,039</b>	<b>5,439</b>	<b>7,603</b>	<b>6,565</b>	<b>6,785</b>
Coal Mining . . . . .	—	278	893	2,285	1,568	528	747
Natural Gas Systems . . . . .	—	3,265	3,146	3,150	6,035	6,036	6,038
<b>Unspecified Reductions<sup>a</sup></b> . . . . .	<b>135</b>	<b>230</b>	<b>567</b>	<b>741</b>	<b>2,393</b>	<b>25,910</b>	<b>—</b>
Coal Mining . . . . .	—	—	22	188	2,393	25,910	—
Natural Gas Systems . . . . .	135	230	544	553	—	—	—

<sup>a</sup>Unspecified reductions represent quantities reported on Form EIA-1605EZ, which does not distinguish between direct and indirect emission reductions.

(R) = revised.

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

**Table 20. Number of Methane Reduction Projects Reported to Voluntary Reporting of Greenhouse Gas Program Associated with Other Federal Voluntary Programs, Data Years 1994-2000**

Voluntary Program	1994	1995	1996	1997	1998	1999 <sup>(R)</sup>	2000
Climate Challenge . . . . .	22	27	32	36	34	39	42
Landfill Methane Outreach Program . . . . .	6	8	29	32	90	116	151
Coalbed Methane Outreach Program . . . . .	1	1	2	2	10	11	3
Natural Gas STAR . . . . .	7	9	11	6	5	7	7
Other . . . . .	0	6	2	2	1	3	4
<b>Total</b> . . . . .	<b>30</b>	<b>42</b>	<b>70</b>	<b>67</b>	<b>133</b>	<b>166</b>	<b>198</b>

(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, Forms EIA-1605 and EIA-1605EZ.