

## 6. HFCs, PFCs, and Sulfur Hexafluoride

### U.S. Emissions of HFCs, PFCs, and Sulfur Hexafluoride

In addition to the three principal greenhouse gases (carbon dioxide, methane, and nitrous oxide), three types of engineered gases—hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF<sub>6</sub>)—are also considered greenhouse gases under the United Nations Framework Convention on Climate Change (UNFCCC). HFCs are used as refrigerants, solvents, and propellants and in many other applications. PFCs are emitted as a byproduct of aluminum smelting and are used in semiconductor manufacture. The primary uses of SF<sub>6</sub> are in electrical transmission and distribution equipment and in magnesium production.

U.S. emissions of HFCs, PFCs, and SF<sub>6</sub> in 2003 were estimated to be 143.4 million metric tons carbon dioxide equivalent, down slightly from 143.7 million metric tons in 2002. Collectively, they accounted for 2.1 percent of total U.S. greenhouse gas emissions in 2003.<sup>61</sup> Annual emissions of these gases have increased by 62 percent since 1990, primarily due to increases in emissions of HFCs, which are used as replacements for chlorofluorocarbons (CFCs) in automobile air conditioners (Figure 14). CFCs are being phased out under the Montreal Protocol,<sup>62</sup> because they damage the Earth's stratospheric ozone layer, which absorbs harmful ultraviolet radiation from the sun. Emissions of both PFCs and SF<sub>6</sub> have fallen since 1990.

### Projects Reported

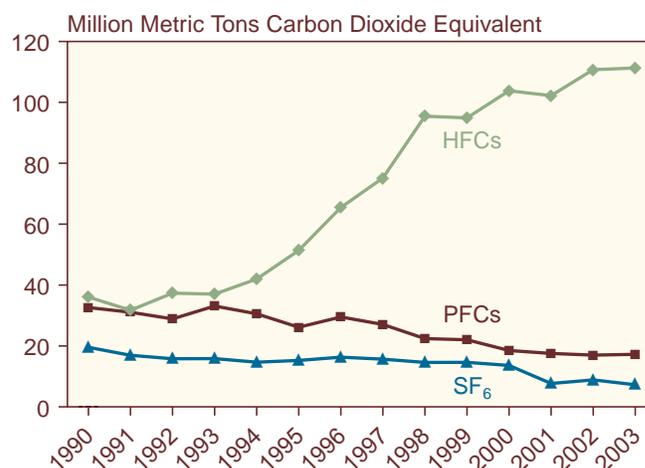
For 2003, 38 entities reported on 66 projects that reduced emissions of HFCs, PFCs, and SF<sub>6</sub>—1 more reporter and 2 more projects than were reported for 2002 (Table 22). Emissions avoidance and recycling of halogenated substances were two of the most frequently reported project types (24 and 18 projects reported, respectively), followed by substitution of other chemicals (7 projects reported) and the destruction of halogenated substances (1 project reported). Reductions in PFC emissions were also reported for 23 post-consumer waste-recycling

projects in which aluminum was one of the materials collected and recycled.

The 38 entities reporting projects to reduce emissions of HFCs, PFCs, and SF<sub>6</sub> for 2003 included: 30 electric utilities; 2 aluminum smelters (Alcan Primary Products Corporation's Sebree Works and Noranda Aluminum, Inc.); a chemical company (Allergan); 1 transportation equipment company (General Motors); a company from the electronic equipment industry (Lucent Technologies, Inc.); a refrigerant reclamation company (Polar Refrigerant Technology); a holding and investment company (CLE Resources); an SF<sub>6</sub> recycling company (Xenon Specialty Gas); and a government organization (Burlington County Board of Chosen Freeholders).

Of the 38 entities that reported projects in this category, 16 were past participants in the U.S. Department of Energy's Climate Challenge Program and Rebuild America. Other voluntary programs with which the projects reported in this category were affiliated include the U.S. Environmental Protection Agency's (EPA's) Voluntary Aluminum Industrial Partnership, EPA's

**Figure 14. Estimated U.S. Emissions of HFCs, PFCs, and Sulfur Hexafluoride, 1990-2003**



Source: Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2003*, DOE/EIA-0573(2003) (Washington, DC, December 2004).

<sup>61</sup>Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2003*, DOE/EIA-0573(2003) (Washington, DC, December 2004), web site [www.eia.doe.gov/oiaf/1605/ggprpt](http://www.eia.doe.gov/oiaf/1605/ggprpt).

<sup>62</sup>The Montreal Protocol on Substances that Deplete the Ozone Layer is an international agreement, signed by most of the industrialized nations, to substantially reduce the use of CFCs. Signed in January 1989, the original document called for a 50-percent reduction in CFC use by 1992 relative to 1986 levels. The subsequent London Agreement called for a complete elimination of CFC use by 2000. The Copenhagen Agreement later accelerated that schedule, calling for a complete phaseout by January 1, 1996.

Waste Wise Program, and EPA's Sulfur Hexafluoride Emissions Reduction Partnership for Electric Power Systems.

## Emission Reductions by Gas

Direct reductions of PFC and SF<sub>6</sub> emissions totaling 6.2 million metric tons carbon dioxide equivalent were reported by 21 entities for 24 projects carried out in 2003 (Table 23). The direct reductions included emissions of PFCs (3.6 million metric tons carbon dioxide equivalent) and SF<sub>6</sub> (2.6 million metric tons carbon dioxide equivalent). Indirect emission reductions totaled 2.5 million metric tons carbon dioxide equivalent, consisting primarily of SF<sub>6</sub> (2.2 million metric tons carbon dioxide

equivalent) and smaller amounts of PFC and HFC emissions.

## Hydrofluorocarbons

HFCs are used primarily as replacements for ozone-depleting substances such as CFCs and hydrochlorofluorocarbons (HCFCs). U.S. emissions of HFCs were estimated at 111 million metric tons carbon dioxide equivalent in 2003, a 209-percent increase over 1990 levels.<sup>63</sup> HFCs are used to replace CFCs as blowing agents, in automobile air conditioners and refrigerators, and in other manufacturing applications, where emissions result from system leaks. In the semiconductor industry, HFCs are also used in plasma etching and chemical vapor deposition processes. HFC-23 is a

**Table 22. Number of Projects Reported on Form EIA-1605 for Hydrofluorocarbon, Perfluorocarbon, and Sulfur Hexafluoride Emissions, Data Years 1994-2003**

| Project Type                                | 1994      | 1995      | 1996      | 1997      | 1998      | 1999      | 2000      | 2001      | 2002      | 2003      |
|---|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| General . . . . .                           | 0         | 1         | 0         | 1         | 0         | 0         | 0         | 0         | 0         | 0         |
| Reclamation: Recycling . . . . .            | 7         | 10        | 10        | 14        | 15        | 15        | 18        | 16        | 18        | 18        |
| Reclamation: Destruction . . . . .          | 0         | 0         | 1         | 1         | 0         | 1         | 1         | 1         | 1         | 1         |
| Substitution . . . . .                      | 1         | 5         | 7         | 7         | 8         | 9         | 9         | 6         | 6         | 7         |
| Emissions Avoidance . . . . .               | 3         | 6         | 8         | 13        | 17        | 16        | 23        | 23        | 24        | 24        |
| Use of Improved Appliances . . . . .        | 0         | 1         | 1         | 1         | 1         | 1         | 1         | 0         | 0         | 0         |
| Other Projects/Activities . . . . .         | 1         | 1         | 0         | 0         | 0         | 0         | 0         | 0         | 0         | 0         |
| PFC Reductions from Materials Recycling . . | 0         | 0         | 0         | 4         | 7         | 10        | 20        | 19        | 21        | 23        |
| <b>Total Number of Projects . . . . .</b>   | <b>13</b> | <b>21</b> | <b>22</b> | <b>33</b> | <b>42</b> | <b>46</b> | <b>63</b> | <b>58</b> | <b>63</b> | <b>66</b> |

Note: Project totals may not equal sum of components because some projects may be counted in more than one category.  
Source: Energy Information Administration, Form EIA-1605.

**Table 23. Reductions of Hydrofluorocarbon, Perfluorocarbon, and Sulfur Hexafluoride Emissions Reported on Form EIA-1605, Data Years 1994-2003**  
(Thousand Metric Tons Carbon Dioxide Equivalent)

| Gas and Reduction Type    | 1994           | 1995           | 1996           | 1997           | 1998           | 1999           | 2000           | 2001           | 2002           | 2003           |
|---------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| <b>HFCs</b>               |                |                |                |                |                |                |                |                |                |                |
| Direct . . . . .          | *              | *              | 15.2           | *              | -1.7           | -1.7           | —              | —              | —              | —              |
| Indirect . . . . .        | —              | —              | —              | —              | —              | —              | —              | —              | **             | 38.7           |
| <b>PFCs</b>               |                |                |                |                |                |                |                |                |                |                |
| Direct . . . . .          | 3,199.6        | 2,962.4        | 3,345.8        | 3,318.6        | 3,504.4        | 3,425.5        | 3,233.6        | 3,606.8        | 3,562.9        | 3,550.5        |
| Indirect . . . . .        | —              | —              | —              | 3.6            | 6.1            | 5.9            | 35.5           | 34.3           | 36.7           | 237.4          |
| <b>SF<sub>6</sub></b>     |                |                |                |                |                |                |                |                |                |                |
| Direct . . . . .          | 83.6           | 186.4          | -70.0          | 516.7          | 624.8          | 595.4          | 1,407.3        | 2,475.1        | 3,043.7        | 2,611.9        |
| Indirect . . . . .        | —              | 7.7            | —              | **             | **             | **             | **             | **             | 0.1            | 2,184.7        |
| <b>Total</b>              |                |                |                |                |                |                |                |                |                |                |
| <b>Direct . . . . .</b>   | <b>3,283.2</b> | <b>3,148.8</b> | <b>3,291.0</b> | <b>3,835.3</b> | <b>4,127.4</b> | <b>4,019.1</b> | <b>4,641.0</b> | <b>6,082.0</b> | <b>6,606.6</b> | <b>6,162.4</b> |
| <b>Indirect . . . . .</b> | <b>—</b>       | <b>7.7</b>     | <b>—</b>       | <b>3.6</b>     | <b>6.1</b>     | <b>5.9</b>     | <b>35.5</b>    | <b>34.3</b>    | <b>36.8</b>    | <b>2,460.8</b> |

\*Less than 0 but greater than -50 metric tons.  
\*\*Greater than 0 but less than 50 metric tons.  
(R) = revised. — = none reported.  
Source: Energy Information Administration, Form EIA-1605.

<sup>63</sup>Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2003*, DOE/EIA-0573(2003) (Washington, DC, December 2004), web site [www.eia.doe.gov/oi/f/1605/ggrpt](http://www.eia.doe.gov/oi/f/1605/ggrpt).

byproduct of HCFC-22 manufacturing. The Tennessee Valley Authority reported on a project that included direct reductions of HFC-134a, but for which no reduction data have been available since 1998.

## Perfluorocarbons

U.S. emissions of PFCs in 2003 totaled 7.3 million metric tons carbon dioxide equivalent.<sup>64</sup> The principal source of PFC emissions is aluminum smelting. PFCs are produced during aluminum production when the alumina content of the electrolytic bath falls below critical levels required by the electrolytic effect. The resulting electrical upset in the reduction cell is manifested as a rapid voltage increase. The gases formed accumulate at the anode of the reduction cell (hence the name “anode effect”). PFCs are also used in some semiconductor manufacturing processes and, consequently, may be emitted from fabrication plants.

For 2003, five companies (Alcan Primary Products Corporation, Burlington County Board of Chosen Freeholders, City Public Service, Los Angeles Department of Water and Light, and Noranda Aluminum, Inc.) reported reductions in direct emissions of PFCs totaling 3.6 million metric tons carbon dioxide equivalent, which accounted for 58 percent of total reported project-level direct reductions in emissions of PFCs, HFCs, and SF<sub>6</sub> in 2003. Alcan and Noranda together accounted for 98 percent of total reported direct reductions of PFC emissions (3.5 million metric tons carbon dioxide equivalent) and 56 percent of total reported direct reductions of HFC, PFC, and SF<sub>6</sub> emissions.

During 2003, efforts by Noranda to reduce PFC emissions were focused on controlling the amount of alumina in solution to avoid anode effects and monitoring the process more closely to stop or correct them expeditiously. According to Noranda’s report, perfluoromethane emissions were reduced by 2.6 million metric tons carbon dioxide equivalent and perfluoroethane emissions by 0.6 million metric tons carbon dioxide equivalent. Alcan reported direct reductions of perfluoromethane emissions totaling 0.3 million metric tons carbon dioxide equivalent. Additionally, City Public Service and Los Angeles Department of Water and Power reported materials recycling projects (see box in Chapter 5, page 52) that included direct reductions of

PFC emissions totaling 22,516 and 1,630 metric tons carbon dioxide equivalent, respectively, during 2003.

The U.S. Environmental Protection Agency sponsors the Voluntary Aluminum Industrial Partnership, which seeks to reduce emissions of PFCs, carbon tetrachloride, and SF<sub>6</sub> during primary aluminum processing. For 2003, both Alcan and Noranda reported participation in the program.

## Sulfur Hexafluoride

U.S. emissions of SF<sub>6</sub> in 2003 totaled 17.3 million metric tons carbon dioxide equivalent.<sup>65</sup> SF<sub>6</sub> is used as an insulator for circuit breakers, switch gear, and other electrical equipment and as a cover gas in magnesium smelting. It is also emitted during the aluminum smelting process. It has a very high GWP—22,200 times the warming effect of carbon dioxide per ton emitted.<sup>66</sup>

For 2003, 17 companies—including Allegheny Energy, Inc., American Electric Power, Inc., Cinergy Corp., City Public Service, City Utilities of Springfield, Consolidated Edison of New York, Inc., Constellation Energy Group, Inc., Duke Energy Corporation, Entergy Services, Inc., FirstEnergy Corporation, FPL Group, Minnesota Power, National Grid USA, NiSource/NIPSCO, Southern California Edison Co., Southern Company, Tucson Electric Power Company, and TXU—claimed direct reductions of SF<sub>6</sub> emissions that totaled 2.6 million metric tons carbon dioxide equivalent, accounting for 42 percent of the total reported project-level direct reductions in emissions of PFCs, HFCs, and SF<sub>6</sub> (Table 23).

For those companies reporting direct reductions of SF<sub>6</sub> emissions for 2003, Consolidated Edison of New York, Inc., reported the largest single reduction (1.5 million metric tons carbon dioxide equivalent), followed by the Southern Company (0.6 million metric tons), TXU (0.3 million metric tons), and Southern California Edison Company (0.1 million metric tons). These four project-level claims of emission reductions combined to account for 99 percent (2.6 million metric tons carbon dioxide equivalent) of total reported project-level direct reductions of SF<sub>6</sub> emissions for 2003 and 42 percent of total project-level direct emission reductions claimed for HFCs, PFCs, and SF<sub>6</sub> combined (Table 24).

<sup>64</sup>Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2003*, DOE/EIA-0573(2003) (Washington, DC, December 2004), web site [www.eia.doe.gov/oiaf/1605/ggrpt](http://www.eia.doe.gov/oiaf/1605/ggrpt).

<sup>65</sup>Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2003*, DOE/EIA-0573(2003) (Washington, DC, December 2004), web site [www.eia.doe.gov/oiaf/1605/ggrpt](http://www.eia.doe.gov/oiaf/1605/ggrpt).

<sup>66</sup>Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2003*, DOE/EIA-0573(2003) (Washington, DC, December 2004), web site [www.eia.doe.gov/oiaf/1605/ggrpt](http://www.eia.doe.gov/oiaf/1605/ggrpt).

**Table 24. Largest Project-Level Direct Reductions of Sulfur Hexafluoride Emissions Reported on Form EIA-1605 by Reporter, Data Year 2003**

| Reporter  | Direct SF <sub>6</sub> Emission Reductions Reported |                                       | Percent of Total Reported Direct Reductions of HFC, PFC, and SF <sub>6</sub> Emissions <sup>a</sup> |
|---|---|---------------------------------------|---|
|   | Metric Tons of Gas                                  | Metric Tons Carbon Dioxide Equivalent |   |
| Consolidated Edison Company of New York, Inc. . | 69.5  | 1,542,047                             | 25.0  |
| Southern Company . . . . .                      | 25.0  | 555,000                               | 9.0   |
| TXU . . . . .                                   | 15.6  | 347,060                               | 5.6   |
| Southern California Edison Co. . . . .          | 6.1   | 134,363                               | 2.2   |
| National Grid USA . . . . .                     | 2.6   | 57,388                                | 0.9   |
| Cinergy Corp. . . . .                           | 2.4   | 52,948                                | 0.9   |
| NiSource/NIPSCO . . . . .                       | 2.0   | 44,710                                | 0.7   |
| Duke Energy Corporation. . . . .                | 1.9   | 42,180                                | 0.7   |
| Tucson Electric Power Company . . . . .         | 1.6   | 35,561                                | 0.6   |
| National Grid USA . . . . .                     | 1.3   | 28,085                                | 0.5   |
| American Electric Power, Inc. . . . .           | 0.4   | 9,476                                 | 0.2   |
| City Public Service . . . . .                   | 0.4   | 8,660                                 | 0.1   |
| Entergy Services, Inc. . . . .                  | 0.2   | 3,524                                 | 0.1   |
| FPL Group . . . . .                             | 0.2   | 3,524                                 | 0.1   |
| <b>Reported Total . . . . .</b>                 | <b>129.0</b>  | <b>2,864,526</b>                      | <b>46.5</b>   |

<sup>a</sup>Based on metric tons carbon dioxide equivalent.

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

Sources: Energy Information Administration, Form EIA-1605. Global warming potentials from Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001), Table 6.7, pp. 388-389.