

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 (SF₆)—are also considered greenhouse gases under the United Nations Framework Convention on Climate Change (UNFCCC). HFCs are used as solvents, household and commercial refrigerants, firefighting agents, propellants for pharmaceutical and industrial aerosols, foam-blowing agents, in blends for air conditioning refrigerants, and in many other applications. PFCs are emitted as a byproduct of aluminum smelting and are used and emitted in semiconductor manufacture. The primary uses and emission sources of SF₆ are electrical transmission and distribution equipment and magnesium production.

U.S. emissions of HFCs, PFCs, and SF₆ in 2004 were estimated to be 155.9 million MTCO₂e, up by 9.6 percent from 142.4 million MTCO₂e in 2003. Collectively, they accounted for 2.2 percent of total U.S. greenhouse gas emissions in 2004.⁴⁴ Annual emissions of these gases have increased by 77 percent since 1990, primarily due to increases in emissions of HFCs, which are used as replacements for chlorofluorocarbons (CFCs) in a number of refrigerant applications, including automobile air conditioners (Figure 14). CFCs are being phased out under the Montreal Protocol,⁴⁵ because they damage the Earth's stratospheric ozone layer, which absorbs harmful ultraviolet radiation from the sun. U.S. emissions of PFCs and SF₆ have fallen by a combined total of 56 percent since 1990.

Projects Reported

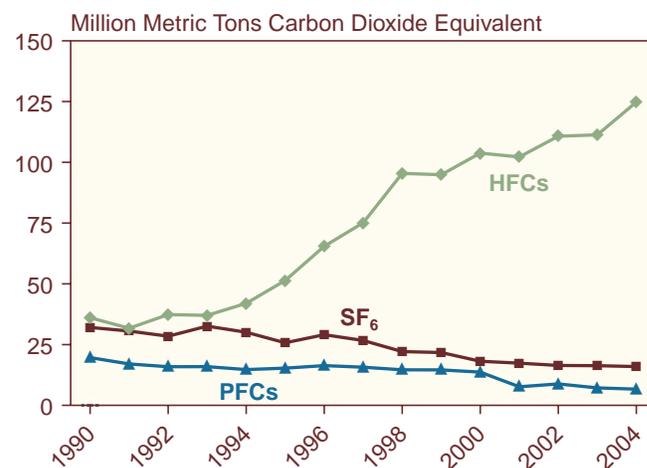
For 2004, 33 entities reported on 59 projects that reduced emissions of HFCs, PFCs, and SF₆—5 more reporters but 7 fewer projects than were reported for 2003 (Table 22). Emissions avoidance and recycling of halogenated substances were two of the most frequently reported project

types (21 and 16 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 19 post-consumer waste-recycling projects in which aluminum was one of the materials collected and recycled.

The 33 entities reporting projects to reduce emissions of HFCs, PFCs, and SF₆ for 2004 included: 26 electric utilities; 2 aluminum smelters (Alcan Primary Products Corporation's Sebree Works and Noranda Aluminum, Inc.); a transportation equipment company (General Motors); a company from the electronic equipment industry (Lucent Technologies, Inc.); a refrigerant reclamation company (Polar Refrigerant Technology); an SF₆ recycling company (Xenon Specialty Gas); and a government organization (Burlington County Board of Chosen Freeholders).

Of the 33 entities that reported projects in this category, 16 were past participants in DOE's Climate Challenge Program and Rebuild America. Other voluntary

Figure 14. Estimated U.S. Emissions of Major HFCs and PFCs and Sulfur Hexafluoride, 1990-2004



Source: Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005).

⁴⁴Energy 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/ggrrpt.

⁴⁵The 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.

programs with which the projects reported in this category were affiliated include the EPA's Voluntary Aluminum Industrial Partnership, Waste Wise Program, and Sulfur Hexafluoride Emissions Reduction Partnership for Electric Power Systems.

Emission Reductions by Gas

For 2004, direct reductions of PFC and SF₆ emissions totaling 7.0 million MTCO₂e were reported by 18 entities for 24 projects (Table 23). The direct reductions included 4.1 million MTCO₂e of PFC emissions and 2.9 million MTCO₂e of SF₆ emissions. Indirect reductions totaled 0.3 million MTCO₂e, consisting primarily of SF₆ (258,600

MTCO₂e) and smaller amounts of PFC and HFC emissions (45,800 MTCO₂e combined).

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 125 million MTCO₂e in 2004, a 246-percent increase over 1990 levels.⁴⁶ 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.

Table 22. Number of Hydrofluorocarbon, Perfluorocarbon, and Sulfur Hexafluoride Emission Reduction Projects Reported on Form EIA-1605 by Type of Project, Data Years 1994-2004

Project Type	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
General	0	1	0	1	0	0	0	0	0	0	0
Reclamation: Recycling	7	10	10	14	15	15	18	16	18	18	16
Reclamation: Destruction	0	0	1	1	0	1	1	1	1	1	1
Substitution	1	5	7	7	8	9	9	6	6	7	7
Emissions Avoidance	3	6	8	13	17	16	23	23	24	24	21
Use of Improved Appliances	0	1	1	1	1	1	1	0	0	0	0
Other Projects/Activities	1	1	0	0	0	0	0	0	0	0	0
PFC Reductions from Materials Recycling . .	0	0	0	4	7	10	20	19	21	23	19
Total Number of Projects	13	21	22	33	42	46	63	58	63	66	59

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 1994-2004
(Thousand Metric Tons Carbon Dioxide Equivalent)

Gas and Reduction Type	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HFCs											
Direct	*	*	15.2	*	-1.7	-1.7	—	—	—	—	—
Indirect	—	—	—	—	—	—	—	—	**	38.7	10.9
PFCs											
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	4,087.7
Indirect	—	—	—	3.6	6.1	5.9	35.5	34.3	36.7	237.4	34.9
SF₆											
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	2,944.1
Indirect	—	7.7	—	**	**	**	**	**	0.1	2,184.7	258.6
Total											
Direct	3,283.2	3,148.8	3,291.0	3,835.3	4,127.4	4,019.1	4,641.0	6,082.0	6,606.6	6,162.4	7,031.8
Indirect	—	7.7	—	3.6	6.1	5.9	35.5	34.3	36.8	2,460.8	304.5

*Less than 0 but greater than -50 MTCO₂e.

**Greater than 0 but less than 50 MTCO₂e.

— = none reported.

Source: Energy Information Administration, Form EIA-1605.

⁴⁶Energy 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/oiarf/1605/ggrpt.

HFC-23 is a byproduct of HCFC-22 manufacturing. The Tennessee Valley Authority reported on a project that included direct reductions of HFC-134a, but no reduction data have been available since 1998. Two entities reported indirect reductions of HFCs emissions totaling 11,000 MTCO₂e for 2004.

Perfluorocarbons

U.S. emissions of PFCs were 6.7 million MTCO₂e in 2004.⁴⁷ 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 semiconductor fabrication plants.

For 2004, five companies (Alcan Primary Products Corporation, American Electric Power, City Public Service, Los Angeles Department of Water and Light, and Noranda Aluminum, Inc.) reported reductions in direct emissions of PFCs totaling 4.1 million MTCO₂e, which accounted for 58 percent of total reported project-level direct reductions in emissions of PFCs, HFCs, and SF₆ in 2004. Alcan and Noranda together accounted for more than 99 percent of total reported direct reductions of PFC emissions.

Noranda reported that it had reduced PFC emissions from aluminum production in 2004 by controlling the amount of alumina in solution in order to avoid anode effects and by monitoring the process more closely to stop or correct anode effects. According to Noranda’s report, direct emissions of perfluoromethane were reduced by 3.0 million MTCO₂e, and direct emissions of perfluoroethane were reduced by 618,800 MTCO₂e. Alcan also reported direct reductions of perfluoromethane emissions (424,000 MTCO₂e) and perfluoroethane (89,000 MTCO₂e). Both Noranda and Alcan were participants in the Voluntary Aluminum Industrial Partnership, which seeks to reduce emissions of PFCs, carbon tetrachloride, and SF₆ during primary aluminum processing.

City Public Service (San Antonio, Texas) and Los Angeles Department of Water and Power reported recycling materials, including aluminum and other metals (see box in Chapter 5, page 46), that resulted in direct reductions of PFC emissions totaling 1,900 and 1,500 MTCO₂e, respectively, during 2004. In addition, 16 other entities reported on 28 aluminum recycling projects for 2004, which collectively reduced indirect emissions of PFCs by 34,900 MTCO₂e.

Sulfur Hexafluoride

U.S. emissions of SF₆ in 2004 totaled 16.0 million MTCO₂e.⁴⁸ SF₆ 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 global warming potential—22,200 times the warming effect of carbon dioxide per ton emitted (see box in Chapter 1, page 7).⁴⁹

For 2004, 15 companies reported direct reductions of SF₆ emissions (2.9 million MTCO₂e), accounting for 42 percent of the total reported project-level direct reductions in emissions of PFCs, HFCs, and SF₆ (Table 23). Consolidated Edison of New York, Inc. reported the largest single reduction (1.7 million MTCO₂e), followed by the Southern Company (0.5 million MTCO₂e), TXU (371,900 MTCO₂e), and Southern California Edison Company (256,500 MTCO₂e). Combined, these four reported project-level SF₆ emission reductions accounted for 97 percent of total reported project-level direct reductions of SF₆ emissions for 2004 and 41 percent of all reported project-level direct emission reductions for HFCs, PFCs, and SF₆ (Table 24).

In addition, three entities reported indirect reductions of SF₆ emissions for 2004: Constellation Energy (81 MTCO₂e), Lower Colorado River Authority (21,100 MTCO₂e), and Xenon Specialty Gas (237,400 MTCO₂e). The reductions were accomplished, respectively, by replacing SF₆ with helium in test procedures, by identifying high-voltage circuit breakers with excessive leakage for removal and replacement, and by reclaiming and recycling gas recovered by electric utility customers.

⁴⁷Energy 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.

⁴⁸Energy 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.

⁴⁹Energy 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.

Table 24. Largest Project-Level Direct Reductions of Sulfur Hexafluoride Emissions Reported on Form EIA-1605 by Reporter, Data Year 2004

Reporter	Direct SF ₆ Emission Reductions Reported		Percent of Total Reported Direct Reductions of HFC, PFC, and SF ₆ Emissions ^a
	Metric Tons of Gas	Metric Tons Carbon Dioxide Equivalent	
Consolidated Edison Company of New York, Inc. .	78.1	1,734,332	24.7
Southern Company	22.8	505,805	7.2
TXU	16.8	371,882	5.3
Southern California Edison Co.	11.6	256,511	3.6
PG&E Corporation	5.2	115,280	1.6
American Electric Power, Inc.	5.0	110,437	1.6
National Grid USA	3.3	72,393	1.0
NiSource/NIPSCO	1.9	41,085	0.6
FPL Group	1.3	28,599	0.4
Cinergy Corp.	1.1	24,591	0.3
City Public Service	0.3	6,556	0.1
Entergy Services, Inc.	0.2	3,524	0.1
South Carolina Electric & Gas Company	0.1	2,316	0.0
Reported Total	147.4	3,273,310	46.6

^aBased 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.