

Fluorocarbons and Sulfur Hexafluoride Emissions Reduction Strategy in the United States

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1. ABSTRACT

Hydrofluorocarbons (HFCs), perfluorocompounds (PFCs), and sulfur hexafluoride (SF₆), represent possible solutions to the environmental impact caused by chlorofluorocarbons, halons, and other ozone depleting substances; however, most of the PFCs, SF₆, and some HFCs are very potent greenhouse gases. As such, emissions of these gases are under examination by the United States Environmental Protection Agency (USEPA). USEPA is actively tracking emissions of these gases from various sources and has developed programs to control releases of the gases.

2. INTRODUCTION

To protect the earth's ozone layer, substitutes for ozone-depleting chlorofluorocarbons (CFCs) have been developed. At times, these substitute chemicals include gases with extremely high global warming potentials (GWP) and long atmospheric lifetimes. While not posing a major threat to the ozone layer, such substitutes, when emitted, do increase the atmospheric burden of greenhouse gases. Concurrently, emissions of these same high GWP gases may occur aside from applications requiring alternatives to CFCs. Industrial releases may emanate from manufacturing processes or be created as byproducts.

Control of these greenhouse gas emissions is governed internationally by the United Nations Framework Convention on Climate Change (FCCC). The Framework is designed to "achieve ... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". Under the FCCC, parties to the convention are compelled to develop national anthropogenic emissions inventories "of all greenhouse gases not controlled by the Montreal Protocol" by sources and to formulate national programs to mitigate climate change.* The United States is a party to the FCCC.

HFCs, PFCs, and SF₆ are among the most potent greenhouse gases. In comparison to carbon dioxide (CO₂), the predominant, anthropogenically emitted greenhouse gas, several HFCs, PFCs, and SF₆ possess high GWPs and extremely long atmospheric lifetimes. Table 1 illustrates these values.

*United Nations Framework Convention on Climate Change (1992)

Table 1
Global Warming Potentials and Atmospheric Lifetimes for Selected Greenhouse Gases

Greenhouse Gas	Atmospheric Lifetime (year)	Global Warming Potential (100 year time horizon)
Sulfur hexafluoride (SF ₆)	3,200	23,900
Hexafluoroethane (C ₂ F ₆)	10,000	9,200
Tetrafluoromethane (CF ₄)	50,000	6,500
Trifluoromethane (HFC-23)	250	11,700
HFC-134a	14.6	1,300
Methane (CH ₄)	12 ± 3	21
Carbon Dioxide (CO ₂)	250	1

Data from: Climate Change 1995, The Science of Climate Change. Technical Summary. Cambridge University Press. New York, New York. 1996. p. 22.

Concern over emissions of these gases is twofold. First, a discrete emission of a high GWP gas is more potent than the equivalent amount of carbon dioxide. Second, the long atmospheric lifetimes of the gases span to thousands of years. With limited opportunity for removal from the atmosphere by most mechanisms, these gases will persist for a long time. Small emissions have and will continue to contribute to a cumulative atmospheric burden. Environmental effects of these gases will remain for generations of mankind.

3. UNITED STATES STRATEGY TO CONTROL HFC, PFC, AND SF₆ EMISSIONS

In 1993, the United States developed a Climate Change Action Plan (CCAP). Its goal is to "reduce emissions of greenhouse gases to their 1990 levels in 2000".* The plan relies on the cooperation of government and industry to accomplish reductions in greenhouse gas emissions by the year 2000 and is comprehensive in approach including all greenhouse gases as governed by the FCCC. The CCAP includes actions to control emissions of HFCs, PFCs, and SF₆. These actions are classified in two categories: regulatory mechanisms and partnership efforts.

*United States Climate Change Action Plan (1993)

3.1. Regulatory Control of HFC, PFC, and SF₆ Emissions

Regulatory mechanisms restrict the use and emissions of chemicals intended for CFC replacement. Section 612 of the Clean Air Act authorizes the control of uses for high GWP gases if other alternatives to ozone-depleting chemicals exist and pose less risk to human health and the environment. Regulatory actions are developed as part of the USEPA's Significant New Alternatives Policy (SNAP).

SNAP regulation governs new chemicals, new uses of existing chemicals, new product substitutes, and alternative manufacturing processes. Under the SNAP requirements, manufacturers and users of CFC substitutes must submit proposals for use of new alternatives to the USEPA ninety (90) days prior to beginning sales of the product. Manufacturers may not use substitutes deemed unacceptable by USEPA review. USEPA evaluates the ozone depletion potential, GWP, flammability, toxicity, and ecological effects of a substitute in its review. The SNAP has proven effective in reducing the impact on the climate from the phaseout of CFCs by limiting use of high GWP chemicals as alternatives.

3.2. Partnership Efforts

The United States CCAP incorporates partnership programs in the address of greenhouse gas emissions. These efforts are characterized by the development of voluntary programs with emitting industries for reduction of emissions. For HFCs, PFCs, and SF₆, agreements are developed between emitting sources and the USEPA. The agreement, typically called a memorandum of understanding (MOU), specifies that the emitting source track its emissions and agree to implement changes to reduce emissions of the high GWP gases.

Agreements exist between the USEPA and several industrial sources. The first MOU completed controls emissions from aluminum smelting. CF₄ and C₂F₆ are emitted as byproducts. Manufacturers individually have joined with USEPA to make changes in the manufacturing process to reduce the amount of these gases created. By the year 2000, it is expected that 2.7 million metric tons of carbon equivalent (MMTCE) reductions will be achieved.

A second program addresses emissions of the byproduct HFC-23 from HCFC-22 manufacturing. The U.S. producers have committed to reduce their emissions by 5 MMTCE by the year 2000. Opportunities for reduction include process optimization, capture and conversion, and abatement.

The most recent MOU established with U.S. industry covers semiconductor manufacturing. Nitrogen trifluoride (NF₃), CF₄, C₂F₆, SF₆, C₃F₈, and HFC-23 are emitted from the production of microchips. These gases are released due to incomplete use and from reformation following disruption in plasma processes. The U.S. semiconductor industry has implemented a comprehensive research program to identify environmentally protective and cost-effective opportunities for controlling emissions of the PFCs. During 1998, USEPA will work with the current eighteen (18) industry partners to identify actual reduction amounts.

USEPA is continuing to develop voluntary partnerships for the PFC, HFC, and SF₆ reductions. In 1997, programs will be established for the control of SF₆ emissions from electrical power equipment, magnesium production and diecasting, and other uses.

4. CONCLUSION

Opportunities exist for expansion of the voluntary partnerships to countries with similar emitting industries. For instance, the semiconductor industry manufactures microchips worldwide. Individual companies, while formed in one country, operate fabrication facilities in nations around the globe. Extension of voluntary partnerships to the countries of operation would prove beneficial for a global address of PFC control from this industry as well as minimize the barriers that limit a company's ability to compete and implement worldwide climate protection goals.

The U.S. model for controlling of PFC emissions from semiconductor manufacturing has been adopted by Japanese industry and government. In April 1997, the Electronic Industries Association of Japan (EIAJ) announced its agreement with the Japan Ministry of International Trade and Industry (MITI) to implement a program of research and emissions tracking for PFCs in semiconductor manufacturing. The goal of the agreement is to reduce these emissions. It is desirable for such commitments to be made in more countries with significant high technology industry.

Protection of the global climate system is an important activity for government and industry. USEPA and its industry partners are striving to reduce the impact of PFCs, HFCs, and SF₆ on the climate.

REFERENCES

1. United Nations Framework Convention on Climate Change, 1992.
2. Climate Change 1995, The Science of Climate Change. Technical Summary. Cambridge University Press, New York, New York, 1996.
3. United States Climate Change Action Plan, 1993.