# $SF_6$ Emissions Reduction Partnership For Electric Power Systems

# 2002 Partnership Report


## U.S. Environmental Protection Agency

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# 1 Introduction

The $SF_6$ Emissions Reduction Partnership for Electric Power Systems is one the United States Environmental Protection Agency's (EPA) many voluntary industrial programs that aim to reduce greenhouse gas emissions. EPA works closely with participants providing technical information and helping them overcome barriers to making process improvements that reduce greenhouse gas emissions. This report documents the partnership's continuing success in reducing $SF_6$ emissions from circuit breakers and other high voltage equipment that is used in the transmission and distribution of electricity.

## 1.1 $SF_6$ Use within the Electric Power Industry

$SF_6$ is used for electrical insulation, arc quenching, and current interruption in high-voltage electrical equipment. $SF_6$ has some other applications but roughly 80 percent of all global $SF_6$ sales go to electric utilities and electrical equipment manufacturers (Smythe, 2002).

### 1.1.1 Primary Uses of $SF_6$

The unique electrical, chemical, and thermal properties of $SF_6$ make it an efficient electrical insulator. $SF_6$ is a synthetic gas that is colorless, non-flammable, and odorless and non-toxic to humans. First manufactured in 1902, this fluorinated compound has an extremely stable molecular structure. Because of its excellent insulation properties along with a high dielectric strength and potent arc quenching abilities, $SF_6$ is considered an invaluable insulator for transmission systems.

### 1.1.2 Climate Impact of $SF_6$

$SF_6$ is a highly potent greenhouse gas. $SF_6$ is 23,900 times more effective at trapping infrared radiation than an equivalent amount of carbon dioxide ($CO_2$) over a 100-year period. In 2001, $SF_6$ emissions from the electric power industry accounted for approximately 10 percent of the total high global warming potential emissions from industrial processes (EPA, 2003). Atmospheric concentrations of the gas are increasing by 7 percent annually (Maiss and Brenninkmeijer, 1998). An atmospheric life of 3,200 years means that $SF_6$ gas released is virtually indestructible and accumulates in the atmosphere for many centuries. Thus, a relatively small amount of $SF_6$ can have a greater impact on global climate change than $CO_2$.

## 1.2 EPA's Electric Power Industry Emission Reduction Partnership

The $SF_6$ Emissions Reduction Partnership for Electric Power Systems is a voluntary industry-government initiative. The partnership's primary objective is to reduce or eliminate $SF_6$ emissions via cost effective and technically feasible means. Partners determine the best abatement strategy for their particular operations. Strategies reported by partners include a commitment to recycle (recover and reuse) $SF_6$, the implementation of leak detection practices to enhance equipment maintenance programs, and the replacement of older leaking equipment with new higher performance equipment.

EPA is responsible for recognizing partners' achievements, serving as a forum for the exchange of technical information, and assisting partners to identify and implement cost effective emission reduction strategies.

### 1.2.1 Brief History of Partnership

Since the launch of the $SF_6$ Emissions Reduction Partnership for Electric Power Systems in 1999, significant progress has been made to identify and implement $SF_6$ emission reduction strategies. Several companies have established emission reduction goals and developed $SF_6$ management protocols that have improved system reliability through the prevention of $SF_6$ leaks.

Over the past four years, The $SF_6$ Emissions Reduction Partnership for Electric Power Systems has welcomed new partners increasing total membership of the partnership to over 60 utilities in 2002. (A list of participating companies is detailed in Appendix A.) Currently, partnership members own and operate approximately 219,750 transmission circuit miles. These miles account for approximately 35 percent of the U.S. high-voltage transmission grid; consequently, the partnership accounts for a large proportion of the banked $SF_6$ within the U.S. electric power system.[1]

### 1.2.2 Climate VISION Strategy and Role of Partnership

Climate VISION (Voluntary Innovative Sector Initiatives: Opportunities Now) is a voluntary public-private partnership administered by the Department of Energy (DOE), which challenges American industries to work to reduce the greenhouse gas intensity of the U.S. economy by 18 percent by the year 2010. Voluntary partnerships are one method for effectively achieving these greenhouse green emissions.

Since nearly 80 percent of all $SF_6$ is purchased by the electric power industry, this partnership offers a flexible mechanism to demonstrate industry's continued commitment to reduce greenhouse gas emissions. Companies involved in the $SF_6$ Emissions Reduction Partnership for Electric Power Systems prove that industry participation in voluntary programs can be a cost-effective means of attaining important environmental, economic, and social goals.

# 2 Partnership Status and Accomplishments

To date, partners have achieved significant emissions reductions through efforts to replace older, leaking equipment with newer, tighter gas-insulated equipment, and through measures to enhance the management and handling of $SF_6$ gas. The following describes how these operational improvements translate into both financial and environmental benefits. Additionally, as part of the partnership's goal to provide a forum to facilitate the sharing of ideas and information on $SF_6$ reduction strategies, EPA sponsored a conference entitled *International Conference on $SF_6$ and the Environment: Emission Reduction Strategies* (November 2002). Details of some of the key sessions are highlighted below.

[1] Since $SF_6$ gas is primarily used in transmission related electrical equipment; transmission miles provide a surrogate measure to estimate the quantity of $SF_6$ utilized by the partnership and the industry as a whole.

## 2.1 Summary of Partner Emissions

### 2.1.1 Partner $SF_6$ Emissions Reductions

Table 1 provides a summary of total nameplate capacity and $SF_6$ emissions for all reporting partners between 1999 and 2002.

**Table 1: Aggregated Statistics for all Reporting Partners**

| | Reporting Year | | | |
|---|---|---|---|---|
| | **1999** | **2000** | **2001** | **2002** |
| **Number of Reporting Partners** | 48 | 50 | 52 | 42 |
| **Total Name-Plate Capacity (lbs.)** | 3,465,872 | 3,858,884 | 3,918,809 | 4,054,135 |
| **Total $SF_6$ Emissions (lbs.)** | 594,902 | 583,523 | 555,867 | 464,379 |
| **Emissions Rate** | 17% | 15% | 14% | 11% |

As Table 1 indicates, through partners' careful management efforts and responsible use of the gas, the emissions rate has decreased by 6 percent since 1999. Table 2 presents a summary of $SF_6$ emissions data in metric tonnes of carbon dioxide equivalent (EPA, 2003). Between 1999 and 2002, cumulative $SF_6$ emissions reductions from the electric utility industry were approximately 3.02 million metric tonnes of carbon dioxide equivalent ($MMTCO_2e$). Partners have reduced emissions of $SF_6$ by approximately 10 percent since 1999.

**Table 2: Summary of Partnership $SF_6$ Emissions Reductions**

| | Reporting Year | | | |
|---|---|---|---|---|
| | **1999[a]** | **2000** | **2001** | **2002** |
| **$SF_6$ Emissions ($MMTCO_2e$)** | 15.77 | 15.18 | 14.92 | 14.20 |
| **Reduction from Baseline ($MMTCO_2e$)** | ----- | 0.59 | 0.86 | 1.57 |
| **Percent Reduction from Baseline** | ----- | 3.74% | 5.39% | 9.95% |

[a]Baseline year.

### 2.1.2 Trends and Implications of $SF_6$ Emissions Reductions

With a cost range for gas of $6.00 to $9.00 per pound, $SF_6$ emissions reduction through 2002 represents a financial benefit ranging between $1.6 to $2.5 million dollars during this time period. The potential environmental value of this emissions reduction is even more impressive. It is equivalent to removing the $CO_2$ pollution of approximately 590,000 cars (FHWA, 2002) or planting close to 10 million trees (American Forests, 2002).

## 2.2 International Conference on $SF_6$ and the Environment

In late November of 2002, the "International Conference on $SF_6$ and the Environment: Emission Reduction Strategies" was held in San Diego, California. Representatives and $SF_6$ stakeholders from the electric utilities and magnesium industry met to share experiences and learn about the advances in the handling and management of $SF_6$ gas. Electric utility sessions were provided on the solid-state current limiters, leak detection methods, $SF_6$ recycling gas cart and cylinder issues, and partners' case studies.

### 2.2.1 RECOGNITION for BPA

During the 2002 International Conference on $SF_6$ and the Environment, EPA recognized Bonneville Power Administration (BPA) for their committed efforts and successful accomplishments in reducing $SF_6$ emissions through implementing effective $SF_6$ inventory tracking and maintenance strategies. BPA was able to reduce $SF_6$ loss from equipment by 2,765 pounds (a 65 percent reduction from the previous year's reported emissions).

**$SF_6$ PARTNER RECOGNITION: Bonneville Power Administration (BPA)**

BPA has been able to save money and simultaneously help address global climate change through their $SF_6$ management strategy. Their $SF_6$ management program is tied directly to their maintenance program by conducting $SF_6$ monitoring as part of a regularly scheduled maintenance and inspection protocol. When operational commitments permit, BPA Substation Maintenance crews will take leaking equipment out of service, evacuate gas, put the vessel under vacuum, and perform leak tests to diagnose and make repairs. In addition to the replacement of existing electrical equipment with models that offer lower tolerances in manufacturer listed leak rates, BPA progressively upgrades their gas handling carts and equipment. These upgrades include moving to self sealing hoses and improving the integrity of gas transfer storage and handling systems.

In 2001, BPA was able to reduce $SF_6$ loss by repair and replacement of leaking equipment by 2,765 lbs. Based on an $SF_6$ gas price of $9 per lb, this calculates to an $SF_6$ gas savings of approximately $25,000 in 2001 alone.


Jerome Blackman, Program Manager for the partnership, presents Louis Church, Bonneville Power Administration, with the Partner Recognition Award.

### 2.2.2 International Activities to Reduce High GWP Emissions

At the 2002 conference, representatives from programs in countries including Australia, the Netherlands, and Norway summarized their progress on programs to target emissions of $SF_6$. L. Eeles of The Australian Greenhouse Office discussed the implementation of a government-industry collaboration, the National Greenhouse Strategy Measure 7.2, that aims to develop environmental management strategies for high global warming gases, such as $SF_6$. Eeles indicated that, currently, more than 95 percent of Australia's electricity transmission and distribuition companies are participating in the trial of a template for reporting $SF_6$ emissions for inclusion into Australia's inventory of greenhouse gases (Eeles, 2002). T. Asphjell of the Norwegian Pollution Control Authority, highlighted a voluntary agreement between government and the electric power industry, whereby industry has committed to reduce emissions of $SF_6$ by 13 percent in 2005 and 30 percent in 2010 from 2000 levels (Asphjell, 2002). R. Flipphi of the Netherlands Minsitry of Housing, Spatial Planning and Environment, discussed the Netherlands commitment to maintain $SF_6$ emissions from electric switchgear at 1995 levels. A voluntary agreement between industry and government is currently being negotiated, but will likely include measures such as, installing mid-range switchgear that do not use $SF_6$; installing seal-for-life mid-range switchgear that can be returned to the manufacturers at the end of their life; and running diagnostics without opening high voltage

switchgear and thus reducing the maintenance frequency (Flipphi, 2002). These initiatives will have a key role in reducing global $SF_6$ emissions.

### 2.2.3 Current and Future Emissions Reduction Options

Emissions reduction opportunties are being explored by the electric power systems industry and organizations that support the industry such as EPRI, a non-profit organization that manages research, technology development, and product implementation for global energy customers. L. van der Zel highlightted EPRI's current research and goals for sustainable $SF_6$ management (van der Zel, 2002). EPRI is involved with $SF_6$ leak research via the collaborative development of the $SF_6$ Camera with Laser Imaging Systems. The camera exploits the strong infrared absorption characteristic of $SF_6$. The camera enables the operator to view leaks as small as 2 pounds per year at distances greater than 100 feet. In collaboration with Powertech Labs, EPRI has also sponsored research into the development of $SF_6$ by-product detection devices. The $SF_6$ Decomposition Products Dectector (DPD) and MicroGC (Gas Chromotograph) are diagonstic tools that enhance safety by identifying toxic by-product concentrations; ensure equipment longevity by determining the purity of $SF_6$; and indentify potential problems, such as sparking, arcing or overheating since these generate specific and known by-products. B. Damsky of EPRI also highlighted recent research efforts to develop a technological alternative to $SF_6$ breakers, a solid state current limiting (SSCL) cicuit breaker. Damsky indicated that SSCL can improve power quality by limiting the current. Consequently, by taking care of most distribution system problems such as voltage swells, sags and power outages, it provides fault isolation and better network protection (Damsky, 2002).

D. Lauzon of Solvay Fluorides, Inc., discussed observations from a case study conducted at American Electric Power. Lauzon detailed specifics of Solvay's ReUse Program, whereby used gas is sampled and then fed back into the production stream. Results from the case study indicate that an $SF_6$ reuse program is a viable method for preventing the use of additional $SF_6$ gas (Lauzon, 2002).

### 2.2.4 Partner Observations and Successes

Partners have experienced significant emissions reductions through leak detection programs and subsequent equipment repair. Starting in 1994, Oncur has undertaken a major effort to overhaul their 345 kV system. T. Johnson of Oncor, described how Oncur targeted specific breakers for replacement or refurbishment (i.e., interrupter and operating mechanisms were upgraded and bushings rebuilt) based on $SF_6$ leak rates, as identified by re-filling records and alarm signals. In addition to this proactive approach to overhauling older equipment, Oncur have implemented strict inventory standards and employee education to support their reduction of $SF_6$ emissions (Johnson, 2002). S. Olsen and S. Thesen from PG&E highlighted the success of their company's $SF_6$ program, which has resulted in a greater than 50 percent reduction in their $SF_6$ emissions since 1999. This success was built on improvements to their $SF_6$ management system and facility-level maintenance procedures. Specifically, Olsen and Thesen highlighted how the use of a full-service $SF_6$ vendor, whose responsibilities included supplying $SF_6$, removing $SF_6$ for recycling from circuit breakers under maintenance, preparing an $SF_6$ cylinder inventory and coordinating the activities of a leak detection subcontractor, enabled them to negotiate a bulk rate for $SF_6$ purchases, a reduction in $SF_6$ inventory demand, as well as the removal of not-in-service cylinders (Olson and Thesen, 2002). M. Alfieri of Con Edison described similar successes

through the implementation of employee training programs, use of an inventory program for $SF_6$ cylinders, and laser imaging systems for detecting equipment leaks. These efforts have resulted in reduced $SF_6$ gas usage and a cost savings that amounts to more than $500,000 dollars annually (Alfieri, 2002).

# 3 Conclusion

Over the next few years, EPA plans to expand the Partnership to over 50 percent of the industry. Ongoing technical research, such as a measurement study to quantify equipment $SF_6$ leak rates and future conferences will add to the growing compendium of research on better $SF_6$ management practices and support the Partnership's goal of reducing $SF_6$ emissions.

By reporting data to EPA, $SF_6$ partners create a lasting record of their accomplishments. Partners also identify themselves as corporate environmental leaders and strategically position themselves as climate change policy continues to unfold.

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# APPENDIX A: EXISTING PARTNERS AS OF AUGUST, 2003

The following lists those companies that are members in the $SF_6$ Emissions Reduction Partnership for Electric Power Systems.

Allegheny Power (Greensburg, PA)
**American Electric Power** (Columbus, OH)
Athens Electric Department (Athens, AL)
**Austin Energy** (Austin, TX)
**Bangor Hydro-Electric Company** (Bangor, ME)
Big Rivers Electric Corporation (Henderson, KY)
**Bonneville Power Administration** (Portland, OR)
**CenterPoint** (formerly Reliant Energy HL&P)
**Central Maine Power Company** (Augusta, ME)
**Central Vermont Public Service Corporation** (Rutland, VT)
**Cinergy Power Generation Services Inc.**, (on behalf of The Cincinnati Gas & Electric Company and PSI Energy, Inc.), (Cincinnati, OH)
City of Monroe (Monroe, NC)
Columbia River People's Utility District (St. Helens, OR)
Commonwealth Edison (Chicago, IL)
Commonwealth Electric (Wareham, MA)
**Connecticut Light and Power Company** (Northeast Utilities) (Berlin, CT)
**Consolidated Edison Company of New York, Inc.** (New York, NY)
Crisp County Power Commission (Cordele, GA)
**Duquesne Light Company** (Pittsburgh, PA)
**Edison International** (Rosemead, CA)
**El Paso Electric Company** (El Paso, TX)
**Eugene Water & Electric Board** (Eugene, OR)
FirstEnergy Corporation (Akron, OH)
**Florida Power & Light Company** (includes recent purchase Seabrook power station from North Atlantic Energy Service Corporation) (Juno Beach, FL)
Fort Pierce Utilities Authority (Fort Pierce, FL)
**GPU Energy** (Reading, PA)
Grand Island Utilities Department (Grand Island, NE)
Hastings Utilities (Hastings, NE)
**Kings River Conservation District** (Fresno, CA)
Lower Colorado River Authority (Austin, TX)
**Maine Public Service Company** (Presque Isle, ME)
Manitowoc Public Utilities (Manitowoc, WI)
Memphis Light, Gas & Water Division (Memphis, TN)
Menasha Electric and Water Utilities (Menasha, WI)
Montana Power Company (Butte, MT)
**Muscatine Power & Water** (Muscatine, IA)
Nashville Electric Service (Nashville, TN)
**Nebraska Public Power District** (Doniphan, NE)
New York Power Authority (New York, NY)

**Niagara Mohawk Power Corp** (Syracuse, NY)
**Northeast Utilities Services Company** (Hartford, CT)
**Northern Indiana Public Service Company (NIPSCO)** (Merriville, IN)
**Oklahoma Gas and Electric Co (OG&E)** (Oklahoma City, OK)
**Oncor (**formerly TXU**)** (Dallas, TX)
**Pacific Gas and Electric Co** (San Francisco, CA)
Paragould City Light & Water (Paragould, AR)
**Public Utility District No. 1 of Douglas County** (East Wenatchee, WA)
**Public Utility District No. 1 of Pend Oreille County** (Newport, WA)
**Public Service Company of New Hampshire** (Northeast Utilities) (Manchester, CT)
Rochester Gas and Electric Corp (Rochester, NY)
**Salt River Project Power District** (Phoenix, AZ)
San Antonio City Public Service Board (San Antonio, TX)
Silicon Valley Power (Santa Clara, CA)
South Carolina Electric & Gas Company (Columbia, SC)
**Southern Company** (Atlanta, GA)
**Southwestern Electric Power Company** (Shreveport, LA)
**Tennessee Valley Authority** (Knoxville, TN)
**Texas Municipal Power Agency** (Bryan, TX)
Village of Prairie du Sac (Prairie du Sac, WI)
**Wallingford Electric Division** (Wallingford, CT)
Wellton-Mohawk Irrigation & Drainage Dist (Wellton, AZ)
**West Texas Utilities Co** (Abilene, TX)
**Western Massachusetts Electric Company** (Northeast Utilities) (West Springfield, MA)
**We Energies (**formerly Wisconsin Electric Power Co**)** (Milwaukee, WI)

[a]The partners identified in bold have established emissions reduction goals.