

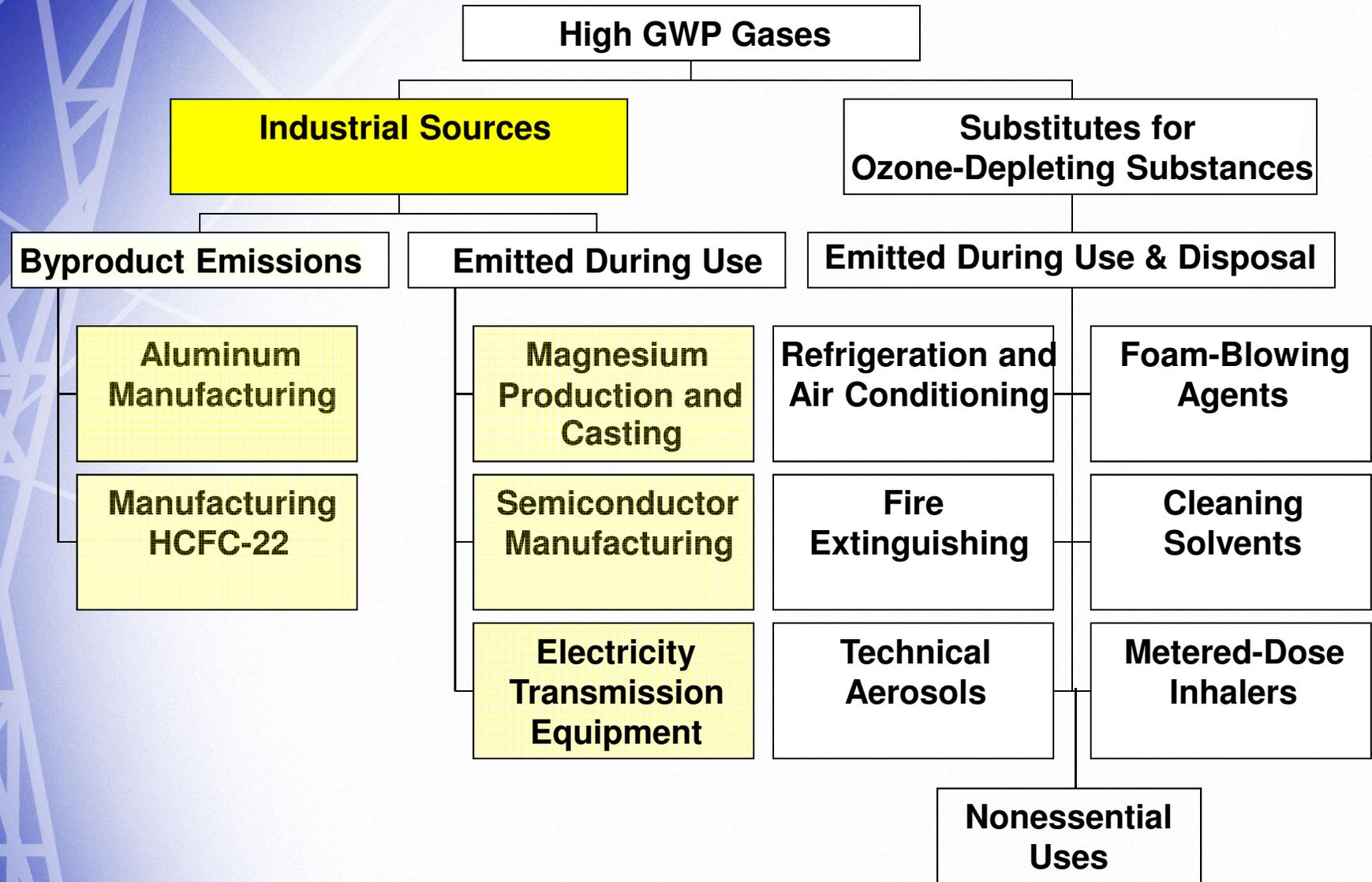
EPA's SF₆ Emission Reduction Partnership for Electric Power Systems

June 4, 2012

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Fluorinated Gases Emissions



How Do FGHGs Compare to Other Greenhouse Gases?

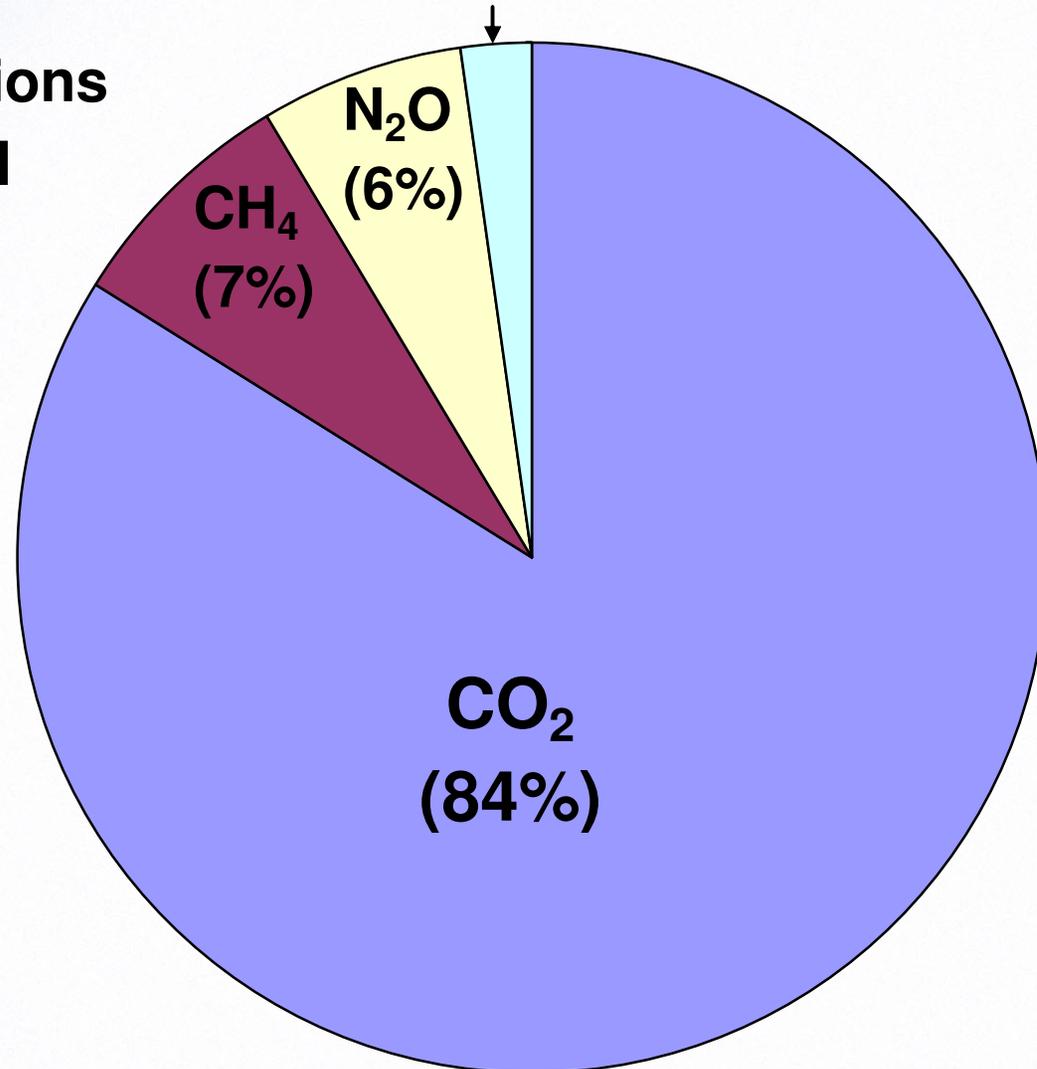
Compound	Atmospheric Life (Years)	Global Warming Potential (100-year time horizon)
CO ₂	—	1
CH ₄	12	21
HFC-134a	14.6	1,300
CF ₄	50,000	6,500
HFC-23	264	11,700
SF₆	3,200	23,900

Source: Second Assessment Report values as reported in IPCC, 2007.

U.S. GHG Emissions (2010)

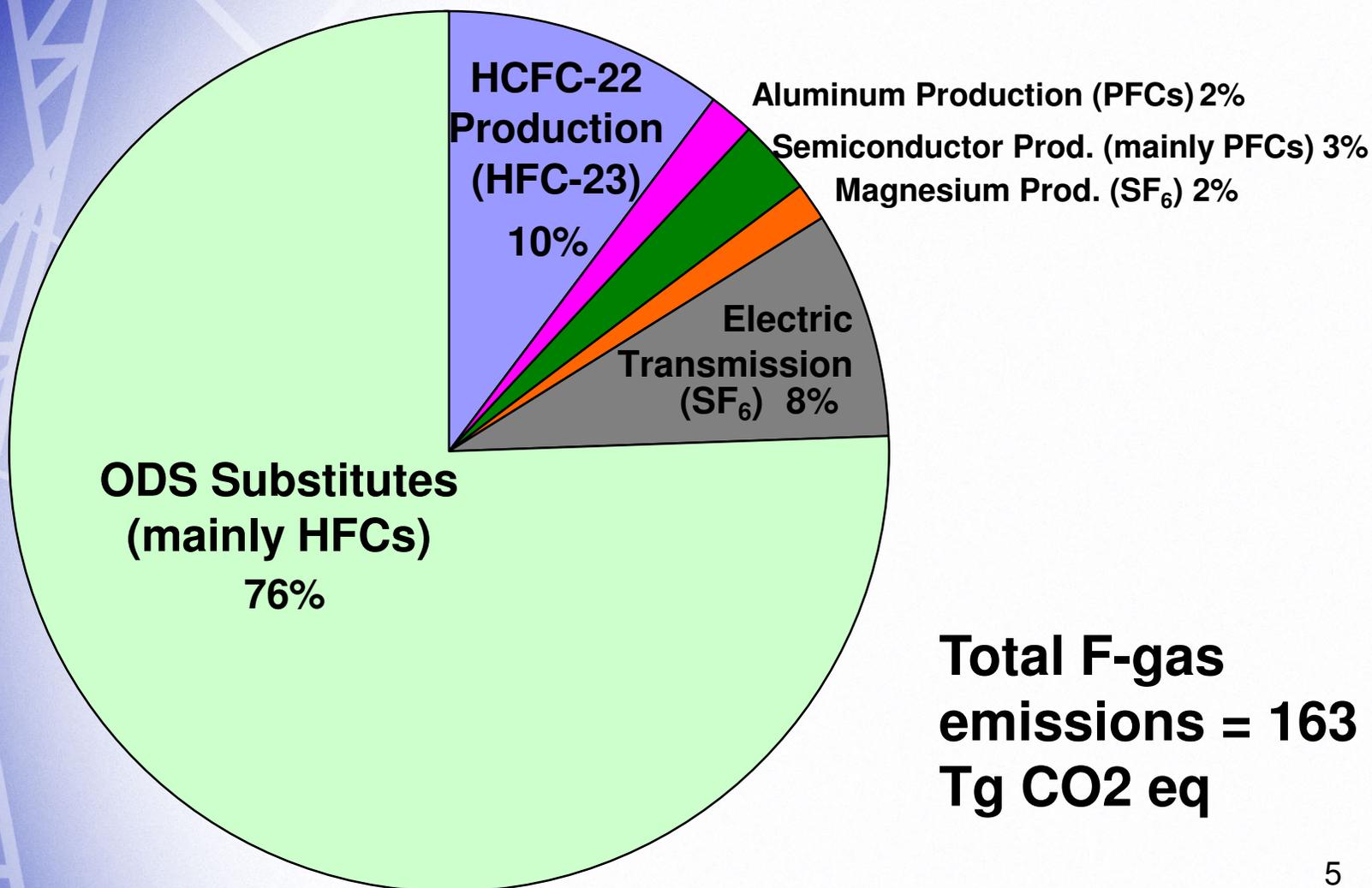
HFCs, PFCs, and SF₆ (2%)

Total U.S. Emissions
= 7260 Tg CO₂-eq



1 Tg = 1 million
metric tons

U.S. Emissions of FGHGs



Trends: Summary

- Emissions of HFCs, PFCs, and SF₆ from “industrial sources” (HCFC-22, aluminum, magnesium, electric power systems, semiconductors)
 - Have fallen by over 55% since 2000
 - Primarily due to reductions in emission rates
- Low FGHG emission rates technically feasible in these “industrial sources”

EPA Voluntary Emission Reduction Partnerships For PFCs, SF₆ and HFC-23

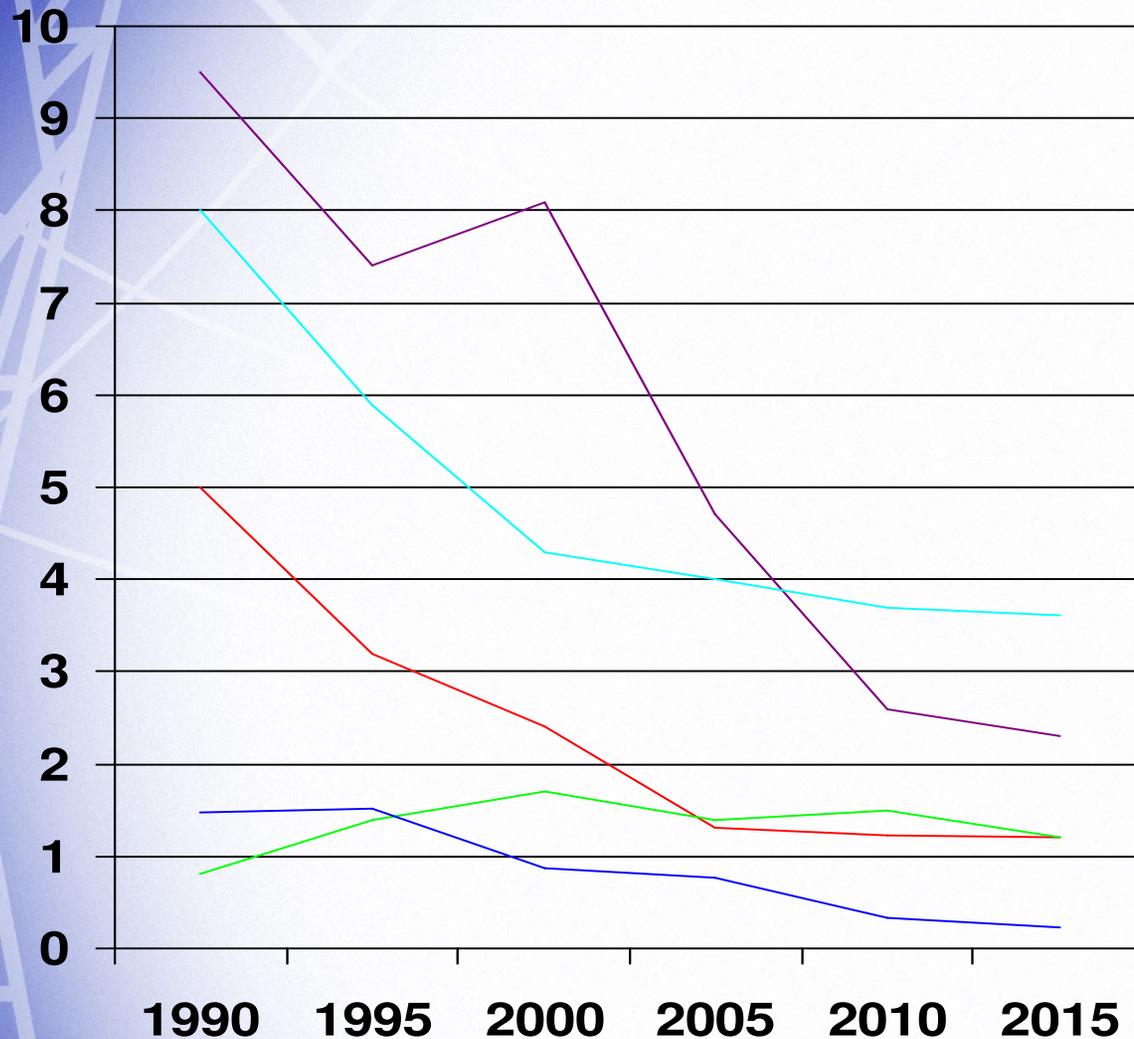
- Collaborative, voluntary agreements between EPA and companies
- Designed to cost-effectively reduce emissions
- Partners are encouraged to implement practices that are economically and technically feasible
- Each partnership has resulted in:
 - Well defined inventory methods
 - Advancing emission reduction knowledge and methods
 - Overall cost savings - improved efficiency and sector-wide collaboration
 - Motivation for climate protection

Emission Reduction Pathways

Very low emissions technically feasible in all sectors

- PFCs from Primary Aluminum
 - Process optimization, automation of AE termination
- HFC-23 from HCFC-22
 - Process optimization, thermal abatement
- SF₆ from Magnesium
 - Substitutes: SO₂, HFC-134a, Novec™
- SF₆ from Electric Power Equipment
 - Best practices, replace old equipment
- FGHGs from Electronics – SC, FPD, thin-film PV
 - Abatement, process optimization, more efficient chemicals

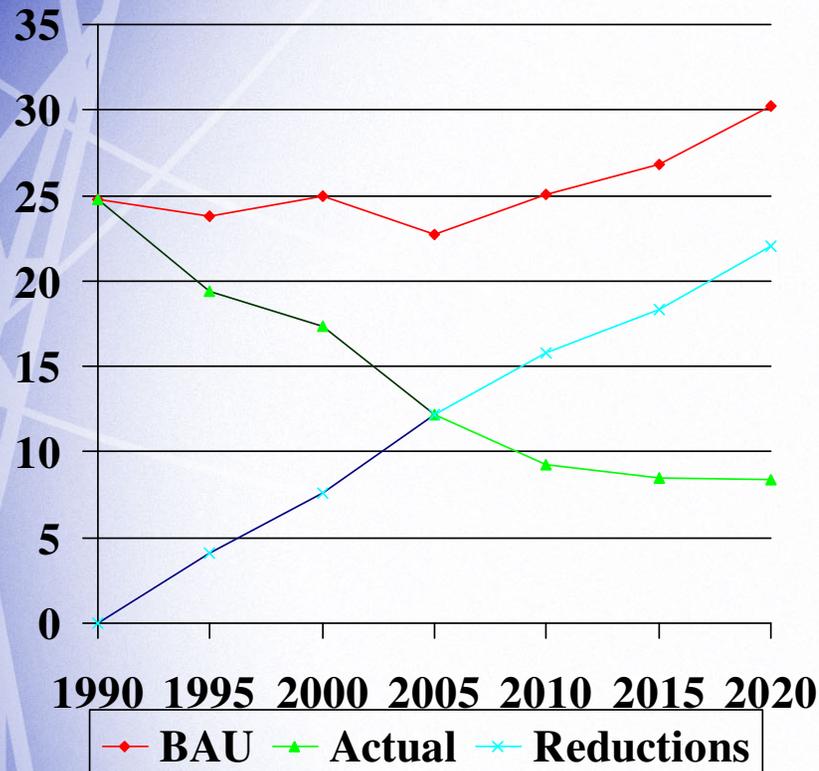
Sector Trends: Emissions (MtCeq)



- Aluminum
- HCFC-22
- Semiconductors
- Electric Power
- Magnesium

Source: EPA
2010

U.S. High GWP Partnerships (MtCO₂eq)



Avoid BAU growth

- Significant progress
- Global leadership
- Established methods for MRV
- Reductions in absence of regulatory

Voluntary Inventory Methods

- Industry participants in EPA emission reduction partnerships (“partners”) monitor and submit annual emissions estimates
- Estimates based on EPA/IPCC methods.
 - EPA very active in IPCC inventory method development
- EPA checks partner estimates and use them to estimate total U.S. emissions
 - Don’t require 3rd party verification

Partners Develop Estimates

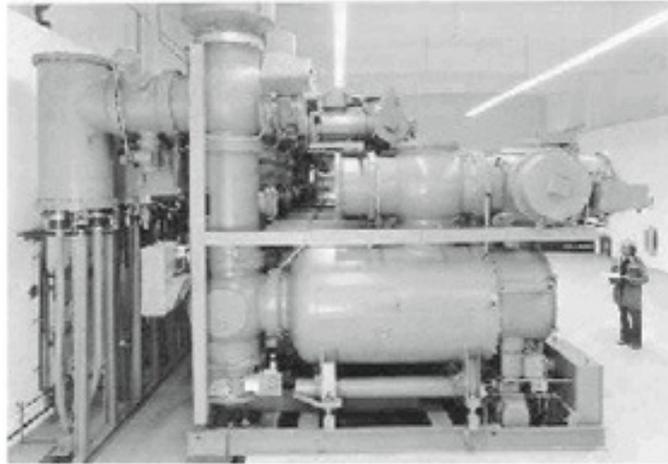
Industry	Method (IPCC GPG Tier)
Aluminum	Al production x anode effect minutes x slope (Tier 2/3)
HCFC-22	Direct measurement of HFC-23 in process stream (Tier 2)
Semiconductors	PFCs fed into process x emission factors (Tier 2)
Magnesium	Track SF ₆ used (Tier 2)
Electrical Equipment	Track SF ₆ used; amount not otherwise accounted for is assumed to be emitted (Tier 3)

QA/QC

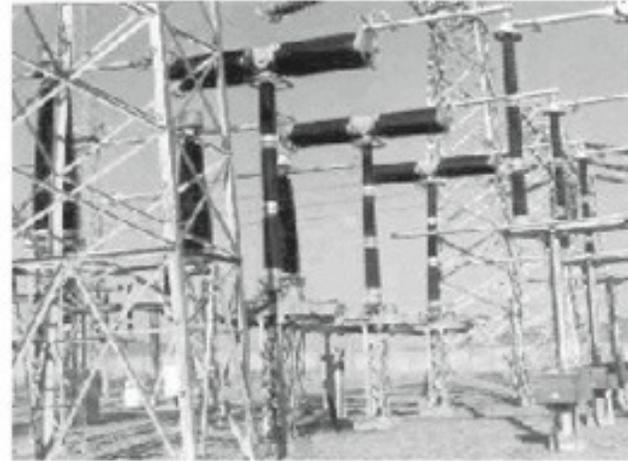
- Reports checked for math, consistency over time and across firms (as appropriate), documentation.
- Reports kept by third parties (HCFC-22, semiconductor, magnesium production) are periodically audited by EPA
 - Reports by semiconductor manufacturers audited annually.
 - 1995 and 2007 HCFC-22 audits involved site visits and plant-specific assessments of measurement accuracy, precision, and QA/QC, verification of emission estimates, and estimates of uncertainty.
- EPA sponsors measurement studies to validate methods and verify emission factors

Sulfur Hexafluoride (SF₆)

- A gaseous dielectric used in high voltage electrical equipment as an insulator and/or arc quenching medium
- Emissions from electric power systems caused primarily by:
 1. Leakage from gas handling practices
 2. Leakage from SF₆-containing equipment including installation, use and decommissioning



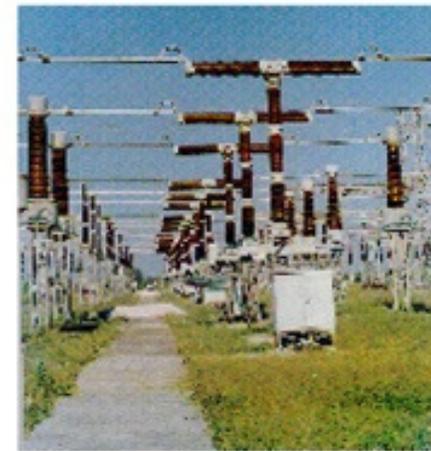
33 kV Indoor Type (GIS)



Outdoor Type (AIS)



Dead tank breaker (courtesy ABB)



Live bank breaker (Courtesy BHEL)

Why Care About SF₆?

- 1. SF₆ is the most potent greenhouse gas**
 - Global warming potential (GWP) of 23,900
(1 pound of SF₆ = 23,900 pounds (11 metric tons) of CO₂)
- 2. SF₆ is a very persistent greenhouse gas**
 - Atmospheric lifetime of 3,200 years
 - Accumulates in the earth's atmosphere for centuries
- 3. Lost SF₆ gas = Increased operating expense**
 - Cost of SF₆ gas ranges from US\$6 to \$9/lb
 - Leakage means diminished transmission efficiency and increased maintenance expenses

SF₆ Emission Reduction Partnership for Electric Power Systems

- **Voluntary** agreement between EPA and the electric power industry designed to **cost-effectively** reduce SF₆ emissions from electrical transmission operations
- Began in 1999 with 49 Charter Partners
- Has grown to 82 U.S. Partner Utilities
- Approximately 48% of total U.S. grid (estimated)



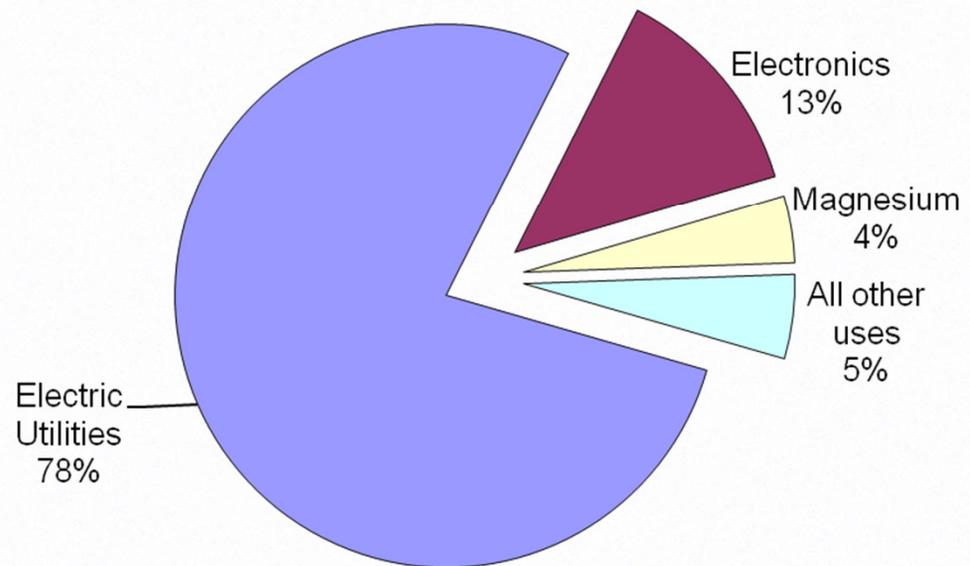
Electric Utility's Partner Responsibilities

- Sign the Memorandum of Understanding
 - Establish senior management commitment
- Develop and distribute an SF₆ handling strategy
 - Identify expected activities and scope of implementation
- Establish an SF₆ Emissions Rate/Reduction Goal
 - Goals may be changed and annually updated to reflect ongoing performance
- Report annual SF₆ emissions and reductions
 - Document emission reduction activities undertaken
 - Use standardized mass-balance reporting method

Sulfur Hexafluoride (SF₆)

In U.S. electric power industry is the primary user of SF₆

Breakdown of Total SF₆ Sales by Industry: 2008



Total 2008 Sales: 6,438 metric tons

Carbon Price – an illustration

	100-year GWP	Atmospheric life (years)	Additional Cost of 1 lb at CO ₂ Price			
			\$5	\$10	\$25	\$50
CO ₂	1	~120	5	\$10	\$25	\$50
SF ₆	23,900	3,200	\$54	\$108	\$271	\$542

Opportunities to Reduce SF₆ Emissions

- Track SF₆ Inventory
- Detect Leaks with Laser Leak Detection Equipment
- Repair and Replace Leaking Equipment
- Train Employees
- Recycle SF₆

SF₆ Emissions Reporting Protocol

Change in Inventory (SF ₆ contained in cylinders, <u>not</u> electrical equipment)	Inventory (in cylinders, <u>not</u> equipment)
	1. Beginning of Year
	2. End of Year
A. Change in Inventory (1 - 2)	
Purchases/ Acquisitions of SF ₆	3. SF ₆ purchased from producers or distributors in cylinders
	4. SF ₆ provided by equipment manufacturers with/inside equipment
	5. SF ₆ returned to the site after off-site recycling
	B. Total Purchases/Acquisitions (3+4+5)
Sales/ Disbursements of SF ₆	6. Sales of SF ₆ to other entities, including gas left in equipment that is sold
	7. Returns of SF ₆ to supplier
	8. SF ₆ sent to destruction facilities
	9. SF ₆ sent off-site for recycling
	C. Total Sales/ Disbursements (6+7+8+9)
Change in Nameplate Capacity	10. Total nameplate capacity (proper full charge) of <u>new</u> equipment
	11. Total nameplate capacity (proper full charge) of <u>retired</u> or <u>sold</u> equipment
	D. Change in Capacity (10 - 11)

- Mass-balance
- User-friendly, automated process
- Simplified approach to submitting emissions data to EPA
- Accessible from the Partnership website
- Labor intensive
- Accuracy?

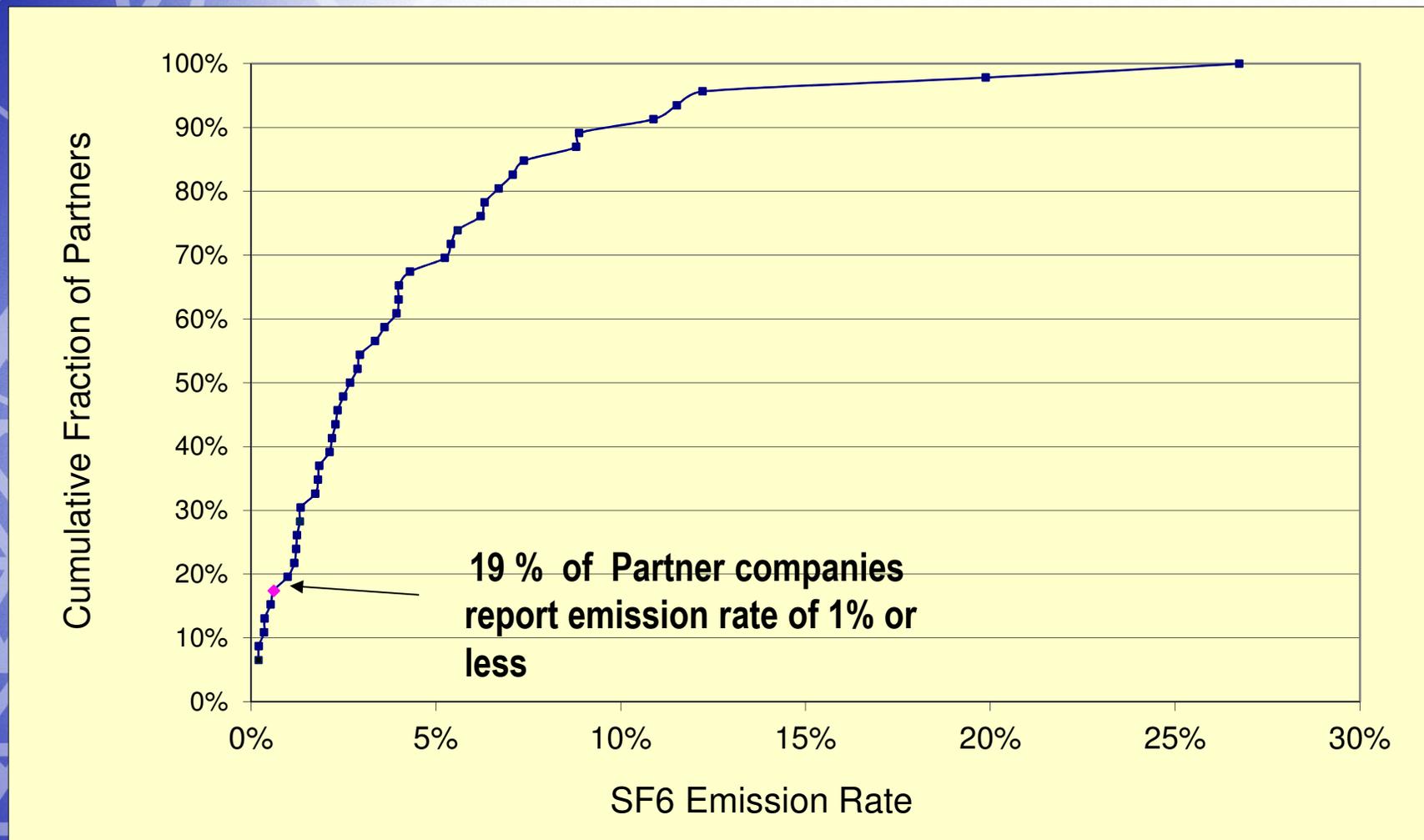
Electric Power Systems

- Reporting facilities (partners) represent over 80% of emissions since 1999.
- Partners track SF₆ use; all assumed to be emitted (Tier 2).
- Missing partner data is interpolated or extrapolated.
 - Extrapolated activity held constant; extrapolated emission rates assumed to follow partnership trends.
- Emissions of non-partners are estimated using net transmission miles and emission factors based on historical partner rates or expert judgment.

Partnership Benefits: Resources from EPA

- Bi-annual Conferences
 - April 2012 Atlanta, GA
- Technology Session Webcasts
 - Topics include: Estimating emissions, tracking inventory, monitoring equipment, detection and repair methods
- Benchmark Reports
 - Track progress and compare performance
- Research and Resources
 - Service Directory
 - Conference Proceedings
 - Technical studies (e.g., Leak Study)
 - Annual Reports
 - Partner Case Studies

2010 SF6 Emission Rates



What All Countries Should Do

- Develop an inventory of SF₆ use and emissions with direct reporting
 - SF₆ Partnership methodology – Tier 2 or higher
- Train personnel on proper handling and benefits of reducing SF₆ emissions
 - Saves money!
- Develop strategy to reduce emissions
 - Avoid irreversible climate impact



F-GHG Reductions Contribute to Early Climate Protection

- Compelling need to act
 - High grow sectors
 - Irreversible impacts on climate
- Opportunity to act
 - Technically feasible, cost-effective reductions available now
- Evaluate compliance assistance
 - Complementary policies and measures can accelerate reductions



Thank you

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