Update on GHGRP: Electrical Transmission and Distribution

Stephanie Bogle

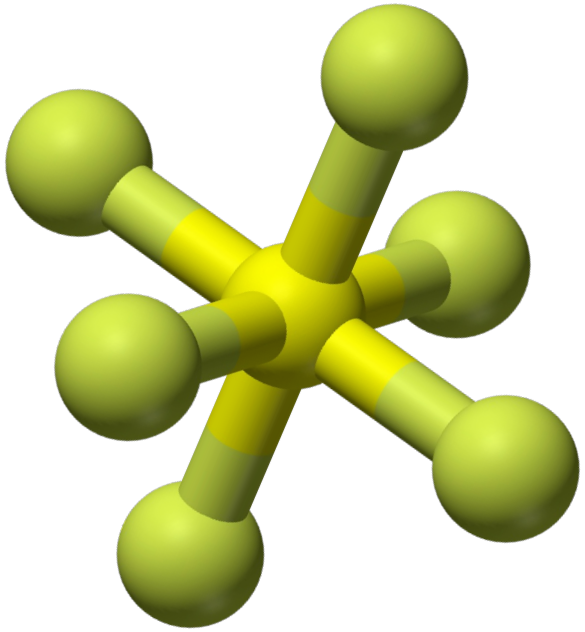
U.S. Environmental Protection Agency

Topics of Discussion

- Basics about SF_6
- Emissions trends from Greenhouse Gas Reporting Program
- Proposed revisions to Subparts DD and SS

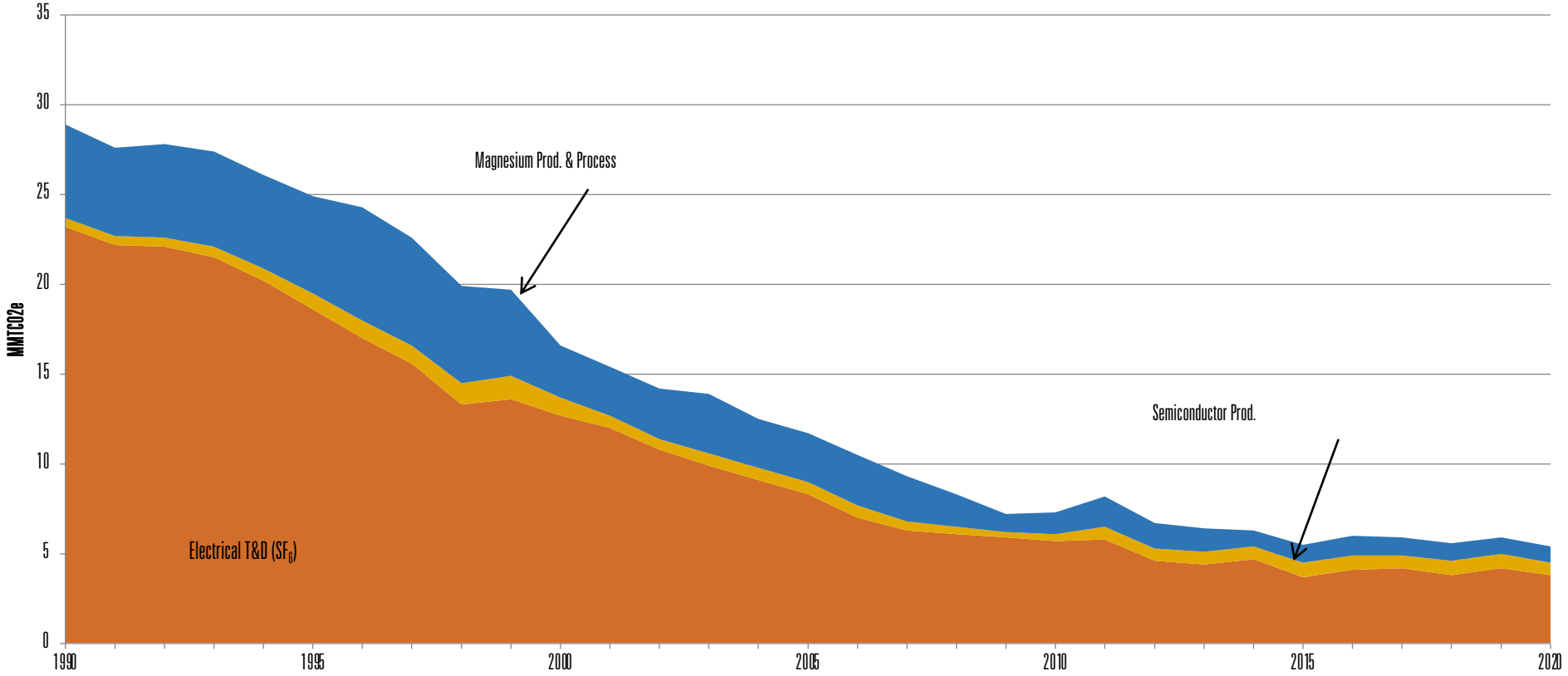
Sulfur Hexafluoride (SF_6)

- SF_6 is a human-made gas emitted primarily from:
  - electrical transmission and distribution equipment
  - manufacture of electronics / semiconductors
  - production of magnesium
- SF_6 lasts ~3,200 years in the atmosphere
- SF_6 has a high global warming potential compared to CO_2 over 100-year time scale:
  - SF_6 GWP = 22,800 times CO_2[(a)]



[(a)] IPCC (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

US Emissions of SF6 by Source Since 1990



Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990—2020. U.S. Environmental Protection Agency. April 2022.

Scope of GHGRP and Partnership Data

Percentage of GHG Emissions Accounted for by Facilities Covered by GHGRP By Source Category

Source	Estimated Percentage of Partnership Emissions Coverage (1999-2009/2010)	Estimated Percentage of GHGRP GHG Emissions Coverage[a] (2010/2011+)
Users / Emitters		
Electronics Manufacturing	~69-81%	96-97%
Magnesium Production and Processing	88-95%	67-92%
Use of Electric Transmission and Distribution (ET&D) Equipment	60-65%	66-78%
Manufacture of Electric Transmission and Distribution (ET&D) Equipment	N/A	~50%
Suppliers		
Importers / Exporters	N/A	>95%
Production of Fluorinated Gases	N/A	100%

[a] Coverage estimates include both F-GHGs and other GHGs emitted from these sources and show the range in coverage from 2011-2019.

The Greenhouse Gas Reporting Program

- Annual Reporting Program
  - For reporting year (RY) 2021, over **8,000** facilities and suppliers reported to the greenhouse gas reporting program.
  - Reported direct emissions in RY21 totaled **2.71** billion metric tons carbon dioxide equivalent (CO_2e), about half of total U.S. greenhouse gas emissions.
- Reporting threshold of 25,000 metric tons CO_2 equivalent (CO_2e) or more per year for most sources
- Reports are submitted to EPA electronically via the electronic greenhouse gas reporting tool (e-GGRT)
- Reports go through EPA verification

GHGRP: Electrical Transmission & Distribution Equipment - DD

- Both subparts DD and SS use a mass-balance equation to calculate emissions

- **Subpart DD – Eq. DD-1**

User Emissions = (Decrease in Storage Inventory) + (Acquisitions) – (Disbursements) – (Net increase in Total Nameplate Capacity of Equipment Operated)

  - Inventory refers to gas inside containers or non-energized equipment. Under the annual mass-balance approach, the beginning of year inventory for a given year must equal the end of year inventory from the prior year in order for emissions to be estimated properly.

  - Gas or nameplate associated with hermetically sealed-pressure equipment *must be included* in all of the inputs of the mass-balance formula.

GHGRP: Electrical Transmission & Distribution Equipment Manufacturers- SS

- **Subpart SS – Eq. SS-1**

User Emissions = (Decrease in Storage Inventory) + (Acquisitions) – (Disbursements)

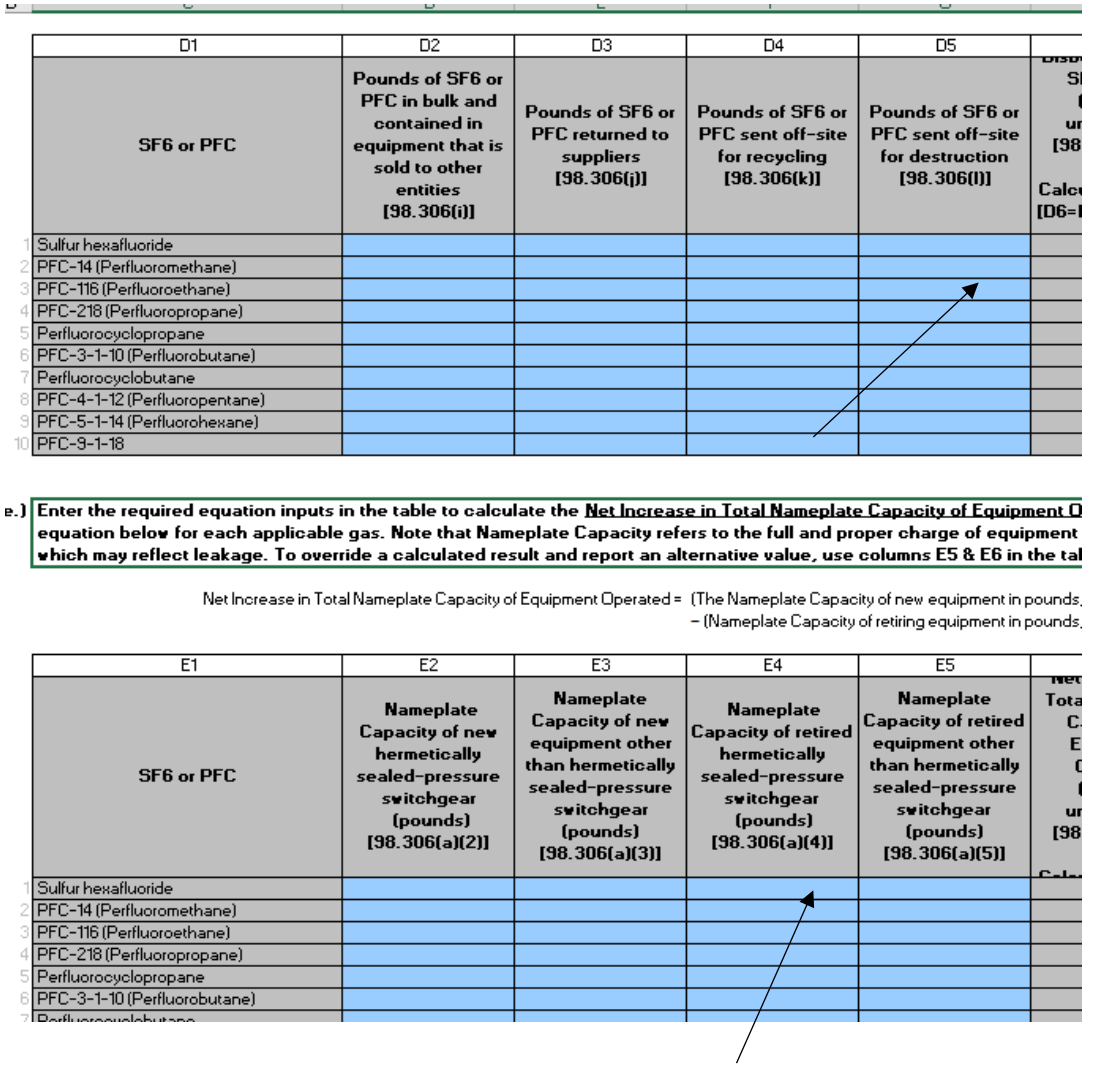
- **Subpart SS – Eq. SS-6**

Emissions from Equipment Installation = (Total Mass used to Fill Equipment) + (Total Mass used to charge Equipment Prior to Leaving the Manufacturer Facility) – (Total Nameplate Capacity Installed at Electric T&D Facility)

- Emissions that occur during installation while filling the equipment off-site from the electrical equipment manufacturing facility must be calculated and reported by the electrical equipment manufacturer under Subpart SS *until the title of the equipment has transferred to the electric power T&D entity*.
- Once the title has transferred to the equipment user, the subpart DD facility is responsible for reporting emissions even if third-party conducts installation.

Mass Balance in the Reporting Form

- For the reporting form to accurately calculate a facility's emissions, gas needs to be tracked as it moves to a new location (e.g. from the inventory into a piece of equipment) and each is reflected in two tables of the reporting form.
  - e.g. acquiring new equipment, installing and/or filling equipment, retiring equipment, etc
- Example 1: Equipment is removed from service and the gas is recovered and sent off-site for destruction.



	D1	D2	D3	D4	D5	
	SF6 or PFC	Pounds of SF6 or PFC in bulk and contained in equipment that is sold to other entities [98.306(i)]	Pounds of SF6 or PFC returned to suppliers [98.306(j)]	Pounds of SF6 or PFC sent off-site for recycling [98.306(k)]	Pounds of SF6 or PFC sent off-site for destruction [98.306(l)]	Sl (ur [98 Calcu [D6=I
1	Sulfur hexafluoride					
2	PFC-14 (Perfluoromethane)					
3	PFC-116 (Perfluoroethane)					
4	PFC-218 (Perfluoropropane)					
5	Perfluorocyclopropane					
6	PFC-3-1-10 (Perfluorobutane)					
7	Perfluorocyclobutane					
8	PFC-4-1-12 (Perfluoropentane)					
9	PFC-5-1-14 (Perfluorohexane)					
10	PFC-9-1-18					

e.) **Enter the required equation inputs in the table to calculate the Net Increase in Total Nameplate Capacity of Equipment O equation below for each applicable gas. Note that Nameplate Capacity refers to the full and proper charge of equipment which may reflect leakage. To override a calculated result and report an alternative value, use columns E5 & E6 in the tal**

Net Increase in Total Nameplate Capacity of Equipment Operated = (The Nameplate Capacity of new equipment in pounds, − (Nameplate Capacity of retiring equipment in pounds,

	E1	E2	E3	E4	E5	
	SF6 or PFC	Nameplate Capacity of new hermetically sealed-pressure switchgear (pounds) [98.306(a)(2)]	Nameplate Capacity of new equipment other than hermetically sealed-pressure switchgear (pounds) [98.306(a)(3)]	Nameplate Capacity of retired hermetically sealed-pressure switchgear (pounds) [98.306(a)(4)]	Nameplate Capacity of retired equipment other than hermetically sealed-pressure switchgear (pounds) [98.306(a)(5)]	Net Tota C E (ur [98
1	Sulfur hexafluoride					
2	PFC-14 (Perfluoromethane)					
3	PFC-116 (Perfluoroethane)					
4	PFC-218 (Perfluoropropane)					
5	Perfluorocyclopropane					
6	PFC-3-1-10 (Perfluorobutane)					
7	Perfluorocyclobutane					

Mass Balance in the Reporting Form

- Example 2: Gas is acquired in equipment but equipment is not installed yet. Gas is included as part of gas stored in containers

2b.) Enter the required equation inputs in the table to calculate the Decrease in SF6 and PFC Inventories according to the equation below for each applicable gas. To override a calculated result and report an alternative value, use columns B5 & B6 in the table.

Decrease in SF6 or PFC Inventory = (pounds of SF6 or PFC stored in containers, but not in energized equipment, at the beginning of the year)
− (pounds of SF6 or PFC stored in containers, but not in energized equipment, at the end of the year)

	B1	B2	B3	B4	B5	B6	B7
	SF6 or PFC	Pounds of SF6 or PFC stored in containers, but not in energized equipment, at the beginning of the year [98.306(d)]	Pounds of SF6 or PFC stored in containers, but not in energized equipment, at the end of the year [98.306(e)]	Decrease in SF6 or PFC Inventory (pounds, unrounded) [98.303(a)/(b)] --- Calculated Result [B4=B2-B3]	What result do you want to report to EPA? (Calculated result initially selected by default)	Decrease in SF6 or PFC Inventory (pounds, unrounded) [98.303(a)/(b)] --- User Override Value	Decrease in SF6 or PFC Inventory (pounds, rounded) [98.303(a)/(b)] --- Reported Value
1	Sulfur hexafluoride			0	Use the calculated result rounded		0
2	PFC-14 (Perfluoromethane)			0	Use the calculated result rounded		0

2c.) Enter the required equation inputs in the table to calculate the Acquisitions of SF6 and PFC according to the equation below for each applicable gas. To override a calculated result and report an alternative value, use columns C6 & C7 in the table.

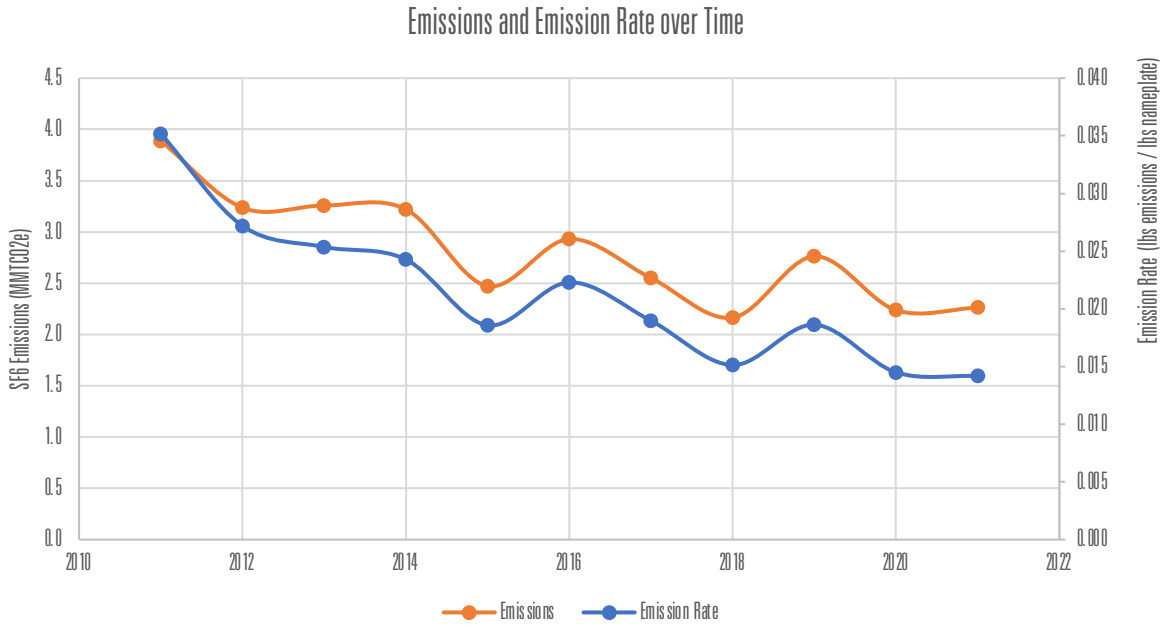
Acquisitions of SF6 or PFC = (pounds of SF6 or PFC purchased from chemical producers or distributors in bulk)
+ (pounds of SF6 or PFC purchased from equipment manufacturers or distributors with or inside equipment, including hermetically sealed-pressure switchgear)
+ (pounds of SF6 or PFC returned to facility after off-site recycling)

	C1	C2	C3	C4	C5	C6	C7	C8
	SF6 or PFC	Pounds of SF6 or PFC purchased from chemical producers or distributors in bulk [98.306(f)]	Pounds of SF6 or PFC purchased from equipment manufacturers or distributors with or inside equipment, including hermetically sealed-pressure switchgear [98.306(g)]	Pounds of SF6 or PFC returned to facility after off-site recycling [98.306(h)]	Acquisitions of SF6 or PFC (pounds, unrounded) [98.303(a)/(b)] --- Calculated Result [C5=C2+C3+C4]	What result do you want to report to EPA? (Calculated result initially selected by default)	Acquisitions of SF6 or PFC (pounds, unrounded) [98.303(a)/(b)] --- User Override Value	Acquisitions of SF6 or PFC (pounds, rounded) [98.303(a)/(b)] --- Reported Value
1	Sulfur hexafluoride				0	Use the calculated result rounded		0
2	PFC-14 (Perfluoromethane)				0	Use the calculated result rounded		0

Emissions from Use of Electrical Equipment (Subpart DD)

	2011		2017	2018	2019	2020	2021
Number of Reporters	117		77	85	86	89	90
Emissions ($MMTCO_2e$)	3.89		2.55	2.16	2.76	2.24	2.26
Beginning Nameplate Capacity (lbs)	10,687,279		13,001,785	13,831,537	14,339,634	14,920,282	15,427,009
Avg. Emission Rate*	3.5%		1.90%	1.51%	1.86%	1.45%	1.42%

*Weighted average

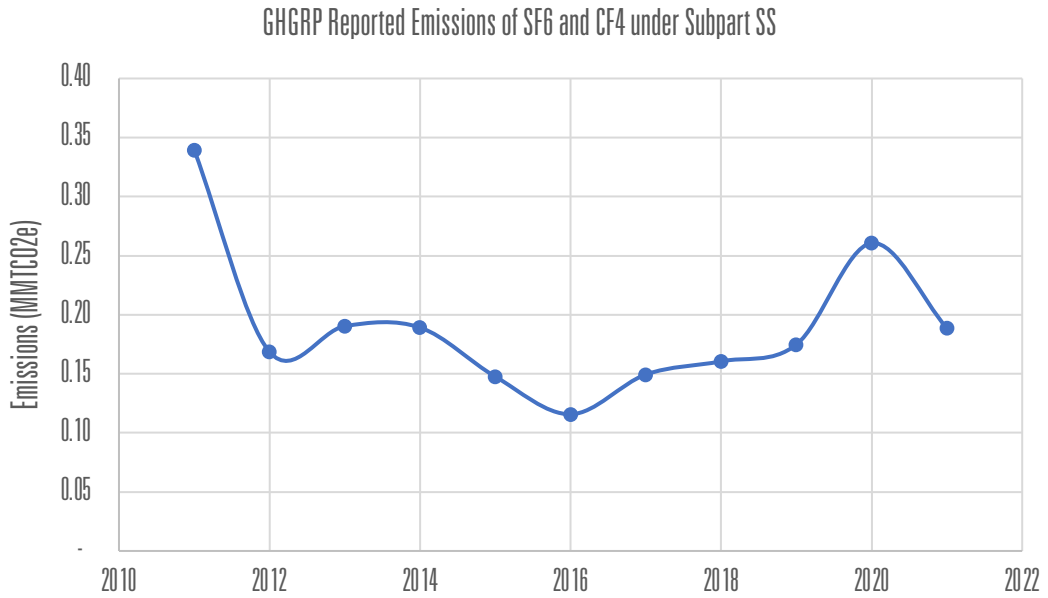


- Over the eleven years of reporting, there has been a 42% percent reduction in reported emissions
- The emissions reduction is due to both a drop in the emissions rate and a decrease in the number of facilities over time as facilities with low emissions exit the GHGRP.

Emissions from the Manufacture of Electrical Equipment (Subpart SS)

	2011		2017	2018	2019	2020	2021
Number of Reporters	6		6	5	5	5	5
Emissions ($MMTCO_2e$)*	0.34		0.15	0.16	0.17	0.26	0.19
% CF4 (% $MMTCO_2e$)	0.2%		0.1%	0%	0.3%	0.1%	0.6%
Annual Emission Changes			+29%	+7.5%	+8.8%	+49%	-27.6%
Total Emission Changes			-56%	-53%	-49%	-23%	-44%

**Does not include combustion emissions reported under subpart C*



- Emissions from the manufacture and refurbishment of equipment includes emissions of both SF_6 and CF_4.
- CF_4 is mixed with SF_6 to avoid liquefaction at low temperatures. Mixed gas circuit breakers are more common in extremely cold climates in geographies outside of the United States. No user of electrical equipment report CF_4 use or emissions.
- Emissions from electrical equipment manufacture reached a low of 0.12 MMTCO2e in 2016 (a reduction of 66%)
- However, emissions have increased since 2016, from 0.12 to 0.19 MMTCO2e in 2020

GHGRP Proposed Revisions

- EPA proposes to update the GHGRP through rulemaking to address changes in industry and emission trends, to adopt improved methodologies, and to fill important data gaps
- EPA conducted a comprehensive program review, including a decade of data verification and analysis, new studies, industry and technology advancements, stakeholder feedback, and EPA data needs, and identified proposed revisions in the following areas:
  - Addressing Data Gaps: Potentially significant emission sources that are not currently accounted for
  - Updating Emission Factors: New data support updating emission factors that will result in more accurate emission calculations
  - Improving Calculation Methods: Updating methods to reflect more complete understanding of emission sources or more recently developed methods
  - Adding or Modifying Data Elements: Collecting new data to eliminate data gaps, improve verification, support national estimates, and inform other EPA programs
  - Technical Clarifications: Clarifying requirements to better reflect EPA's intent or respond to common questions
  - Streamlining Program Implementation: Providing flexibility in calculation requirements or monitoring methods, removing redundant data elements
- EPA is also requesting comment on potential future revisions that would expand the GHGRP to several new source categories
- In addition, this action proposes confidentiality determinations that establish whether data would be entitled to confidential treatment
- Comment period closed on October 6, 2022

Proposing to Update Source Category for DD and SS to include all F-GHGs

- Proposed revisions to source category for DD: "The electrical transmission and distribution equipment use source category consists of all electric transmission and distribution equipment and servicing inventory insulated with or containing fluorinated GHGs, including but not limited to sulfur hexafluoride (SF_6) and perfluorocarbons (PFCs)…"

- This proposed change impacts both applicability and the emissions calculations.

Proposed Applicability Calculation (Subpart DD)

- Proposing to base applicability on the total nameplate of insulating-gas-containing equipment for each GHG, the weight fraction of each fluorinated GHG, the GWP, and an assumed emission factor of 10%.
- $E = \sum_j \sum_i NC_{EPS,j} * GHG_{i,w} * GWP_i * EF * 0.000453592$

E = Annual emissions for threshold applicability purposes (metric tons CO2e).

$NC_{EPS,j}$ = For a facility other than an electric power system, the total nameplate capacity of insulating gas j containing equipment (excluding hermetically sealed-pressure equipment) located within the facility

$GHG_{i,w}$ = The weight fraction of fluorinated GHG i in insulating gas j in the gas insulated equipment included in the total nameplate capacity $NC_{other,j}$, expressed as a decimal fraction. If fluorinated GHG i is not part of a gas mixture, use a value of 1.0.

GWPi = Gas-appropriate GWP as provided in Table A-1 to subpart A of this part.

EF = Emission factor for electrical transmission and distribution equipment (lbs emitted/lbs nameplate capacity). For all gases, use an emission factor or 0.1.

Proposed Emissions Calculation (Subpart DD)

- Proposing that emissions calculations would include emissions of all F-GHGs

  - User Emissionsi = $GHGi_{,w} * [($Decrease in Insulating gas j Inventory) + (Acquisitions of Insulating gas j) – (Disbursements of Insulating gas j) – (Net Increase in Total Nameplate Capacity of Equipment Operated Containing Insulating gas j)]

- Proposal would require that reporters track their inventories, acquisitions, disbursements and changes to total installed nameplate capacity by F-GHG and composition.

Proposed Requirements for (Optional) Facility-Measured Nameplate Capacities

- Proposed revision would apply to closed-pressure electrical equipment with a voltage capacity greater than 38 kV.
- Proposing that measurement be voluntary, but if facility measured the nameplate capacity (NC) of any equipment, it would have to measure NC of all eligible equipment that was installed or retired in that year or subsequent years.
- Proposing that if facility-measured NC was more than two percent different from manufacturer-specified NC, facility would have to adopt measured value. If facility-measured NC was within two percent of manufacturer-specified NC, facility would not be required to adopt measured value, but if facility elected to adopt, it would be required to adopt all facility-measured NCs within two percent of manufacturer-specified value.

Facility-Measured Nameplate Capacities (cont.)

- Proposed Procedure for measuring nameplate capacity would be similar to CARB's, except draft proposed rule would allow facilities to recover part of charge (e.g., if retiring equipment had leaked) and to calculate full charge (NC) based on ratio of pressures:

$$NC_C = \frac{P_{NC}}{\left(P_i - P_f\right)} \times M_R$$

- Requesting comment on including compressibility factors in the equation, which would make it more accurate but also more complicated.
- Proposing that measuring devices be “precise” as well as “accurate” to within same limits as CARB. (These limits may need to be tightened for facilities using calculation approach above.)
- Requesting comment on specifying a minimum temperature equilibration time.

For Additional Information

- For information on the GHGRP: https://www.epa.gov/ghgreporting
  - Information and resources for reporting facilities
    - https://www.ccdsupport.com/confluence/display/faq/FAQs
  - View and/or download the latest GHGRP Data
    - Envirofacts
    - Facility Level Information on GHGs Tool (FLIGHT)
    - 2017 Data Highlights
    - Industrial Profiles
- For more information on proposed revisions to the GHGRP:

  https://www.regulations.gov/docket/EPA-HQ-OAR-2019-0424
- For Information on the 2019 Inventory of US Greenhouse Gas Emissions and Sinks: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks
- Contact: Stephanie Bogle (bogle.stephanie@epa.gov)