

TechTopics No. 111

SF₆ gas and U.S. greenhouse gas emissions

The use of sulfur-hexafluoride (SF₆) gas globally has been the subject of a large amount of discussion for many years, both in the U.S., and worldwide. SF₆ is recognized as an extremely potent greenhouse gas, primarily because of its atmospheric lifetime of about 3,200 years, with a global warming potential (GWP) of 22,800 years. The reference gas for GWP values is CO₂, which is assigned a GWP of 1.0. The EPA considers SF₆ as the most potent greenhouse gas that they have investigated.¹

SF₆ was introduced in the 1950s in electrical equipment, and was quickly adopted for high-voltage outdoor circuit breakers, particularly above 38 kV. It ultimately led to obsolescence of oil circuit breakers, and also of air-blast circuit breakers. The early gas-filled circuit breakers in the high-voltage arena had relatively high leakage rates, and hence a relatively large amount of SF₆ was released into the atmosphere. Exacerbating this situation was the common practice when maintenance of these circuit breakers was needed that involved removal of the gas from the circuit breaker, some users simply released the gas to the atmosphere instead of recovering the gas for recycling and/or reuse.²

About the same time that users and manufacturers became sensitive to the environmental impact of simply releasing the gas, substantial rises in the cost of SF₆ gas took place, so users and manufacturers had a real economic interest in conserving the gas and reusing it. Both factors led to a very substantial reduction in the amount of gas released to the environment.³

The data indicates that emissions by manufacturers have remained at a low level through the period of 1990-2013, with emissions by users declining by 80 percent in the same period, with much of the reduction occurring in the 1990-2009 period.

Over time, information on the nature of SF₆ as a greenhouse gas became available, and designs for the circuit breakers were improved. Today, many designs for products that use SF₆ gas (for insulation only-not for interruption) have leakage rates of the order of 0.1 percent per gas compartment per year, far lower than leakage rates of historic products. For circuit breakers that use SF₆ gas for insulation and interruption, the leakage rate of present designs is under 0.5 percent per year.

For a more extensive discussion of SF₆ and its properties, and usage in metal-enclosed, medium-voltage switchgear, refer to TechTopics No. 53.

On April 15, 2015, the U.S. Environmental Protection Agency released a report entitled "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013". This report contains a great deal of information (564 pages), but the information in the report that relates to SF₆ gas is quite interesting.⁴

The data indicates that the largest share of greenhouse gas net emissions in 2013 is from combustion of fossil fuels, accounting for approximately 77 percent of total GWP-weighted emissions. Of this value, about 40 percent of the CO₂ from fossil fuel combustion came from use of fossil fuels for generation of electricity.⁵

The report indicates that total net emissions of SF₆ in 2013 were 6.9 MMT CO₂-equivalent (million metric tons CO₂-equivalent), of which net emissions in electrical transmission and distribution were 5.1 MMT CO₂-equivalent and the remainder of the emissions were from magnesium production and processing and from semiconductor manufacture.⁶

Also for 2013, total emissions and sinks (i.e., net emissions) of greenhouse gases were reported as 5,791.2 MMT CO₂-equivalent. Therefore, net emissions of SF₆ comprised $5.1/5791.2 = 0.088$ percent (less than 0.1 percent) of total net emissions in the U.S.⁷

Total net emissions for 1990 were shown as 5,525.2 MMT CO₂-equivalent, and the emissions of electrical transmission and distribution were 25.4 MMT CO₂-equivalent.

Thus, the data shows that the emissions from electrical transmission and distribution declined 79.9 percent from 1990 to 2013!

The EPA report supports the opinion that emissions of SF₆ gas from modern designs of high-voltage and medium-voltage switchgear and circuit breakers is not a significant factor in global warming and climate change.

Switchgear and circuit breaker manufacturers have been researching alternatives to SF₆ gas for many years, but this work has not resulted in a suitable substitute.

At this time, there is no indication that the U.S. EPA will restrict the use of SF₆ in electrical equipment. The California Air Resources Board (CARB) has mandated that leakage of SF₆ be reduced to one percent in 2020. The Siemens types 8DA and 8DB medium-voltage, gas-insulated switchgear designs, with a leakage rate of less than 0.1 percent per year, are already below the 2020 limits mandated by CARB.

CARB also instituted inventory reporting requirements for owners of SF₆ or equipment using SF₆, applicable to owners with 17,800 lbs of SF₆. 17,800 lbs of SF₆ gas is about the amount of gas in 2,700 units of single-bus type 8DA switchgear, or about 1,400 units of double-bus type 8DB switchgear

There are no known efforts to impose a tax on SF₆ usage. The Australian government enacted such a tax in 2013 but recinded the tax in mid-2014.

References:

- U.S. EPA web page on the report: <http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html>
- Report: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013: <http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Main-Text.pdf>
 1. Report, pages 1-8 and 1-9 (AR4 data used as required by international reporting requirements)
 2. Report, pages 4-101, 4-102, and 4-107
 3. Report, page 4-102
 4. Report, section 4.24, pages 4-101 to 4-110
 5. Report, pages ES-9 and ES-12
 6. Report, pages 2-5, 2-17, and ES-7
 7. Report, page ES-7
 8. Report, pages ES-7 and ES-16.

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