

High Global Warming Potential (GWP) Gases

You are here: EPA Home Climate Change High GWP Gases Science

Science

High GWP Gases and Climate Change

There are three major groups or types of high GWP gases: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). These compounds are the most potent greenhouse gases. In addition to having high global warming potentials, SF6 and PFCs have extremely long atmospheric lifetimes, resulting in their essentially irreversible accumulation in the atmosphere once emitted (see below).

Global Warming Potential (GWP)

The concept of a global warming potential (GWP) was developed to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas. The definition of a GWP for a particular greenhouse gas is the ratio of heat trapped by one unit mass of the greenhouse gas to that of one unit mass of CO2 over a specified time period.

As part of its scientific assessments of climate change, the Intergovernmental Panel of Climate Change (IPCC) has published reference values for GWPs of several greenhouse gases. While the most current estimates for GWPs are listed in the IPCC's Fourth Assessment Report (AR4), EPA analyses use the 100-year GWPs listed in the IPCC's Second Assessment Report (SAR) to be consistent with the international standards under the United Nations Framework Convention on Climate Change (UNFCCC) (IPCC, 1996). (See the following table titled 2.14 (Errata) (PDF) (5 pp, 360K, About PDF) for a listing of GWPs and atmospheric lifetimes of methane and the other major species of greenhouse gases for comparison. The table is taken from Climate Change 2007: A Physical Science Basis: The Working Group I Contribution to the IPCC Fourth Assessment Report as the SAR is not available on-line.)





Many of the links on this page are to sites outside of EPA. See EXIT Disclaimer to learn more.

few (if any) natural sources of emissions.

The following sections describe some fundamental characteristics of high GWP gases and their presence in the atmosphere:

- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur Hexafluoride (SF₆)

Hydrofluorocarbons (HFCs)

HFCs are man-made chemicals, many of which have been developed as alternatives to ozone-depleting substances (ODS) for industrial, commercial, and consumer products. The global warming potentials of HFCs range from 140 (HFC-152a) to 11,700 (HFC-23). The atmospheric lifetime for HFCs varies from just over a year for HFC-152a to 260 years for HFC-23. Most of the commercially used HFCs have atmospheric lifetimes less than 15 years; e.g., HFC-134a, which is used in automobile air conditioning and refrigeration, has an atmospheric life of 14 years.

The HFCs with the largest measured atmospheric abundances are (in order), HFC-23 (CHF3), HFC-134a (CF3CH2F), and HFC-152a (CH3CHF2). The only significant emissions of HFCs before 1990 were of the chemical HFC-23, which is generated as a byproduct of the production of HCFC-22. HFCs are primarily used as a substitute for ozone-depleting chemicals. Between 1978 and 1995, HFC-23 concentrations have increased from 3 to 10 parts per trillion (ppt), and continue to rise. Since 1990, when it was almost undetectable, global average concentrations of HFC-134a have risen significantly to almost 10 ppt (parts per trillion). HFC-134a has an atmospheric lifetime of about 14 years and its abundance is expected to continue to rise in line with its increasing use as a refrigerant around the world. HFC-152a has increased steadily to about 0.3 ppt in 2000, however its relatively short life time (1.4 years) has kept its atmospheric concentration below 1 ppt (IPCC, 2001).

Perfluorocarbons (PFCs)

Primary aluminum production and semiconductor manufacture are the largest known man-made sources of two perfluorocarbons – CF4 (tetrafluoromethane) and C2F6 (hexafluoroethane). The GWP of CF4 and C2F6 emissions is equivalent to approximately 6,500 and 9,200 tonnes, respectively. PFCs are also relatively minor substitutes for ozone-depleting substances (ODSs).

PFCs have extremely stable molecular structures and are largely immune to the chemical processes in the lower atmosphere that break down most atmospheric pollutants. Not until the PFCs reach the mesosphere,

about 60 kilometers above Earth, do very high-energy ultraviolet rays from the sun destroy them. This removal mechanism is extremely slow and as a result PFCs accumulate in the atmosphere and remain there for several thousand years. The estimated atmospheric lifetimes for CF4 and C2F6 are 50,000 and 10,000 years respectively. Measurements in 2000 estimate CF4 global concentrations in the stratosphere at over 70 parts per trillion (ppt). Recent relative rates of increase in concentrations for two of the most important PFCs are 1.3% per year for CF4 and 3.2% per year for C2F6 (IPCC, 2001).

Sulfur Hexafluoride (SF6)

The global warming potential of SF6 is 23,900, making it the most potent greenhouse gas the IPCC has evaluated. SF6 is a colorless, odorless, nontoxic, nonflammable gas with excellent dielectric properties. SF6 is used for insulation and current interruption in electric power transmission and distribution equipment, in the magnesium industry to protext molten magnesium from oxidation and potentially violent burning, in semiconductor manufacturing to create circuitry patterns on silicon wafers, and as a tracer gas for leak detection.

Like the other high GWP gases, there are very few sinks for SF6, so all man-made sources contribute directly to its accumulation in the atmosphere. Measurements of SF6 show that its global average concentration has increased by about 7% per year during the 1980s and 1990s, from less 1 ppt in 1980 to almost 4 ppt in the late 1990's (IPCC, 2001).

Print As-Is