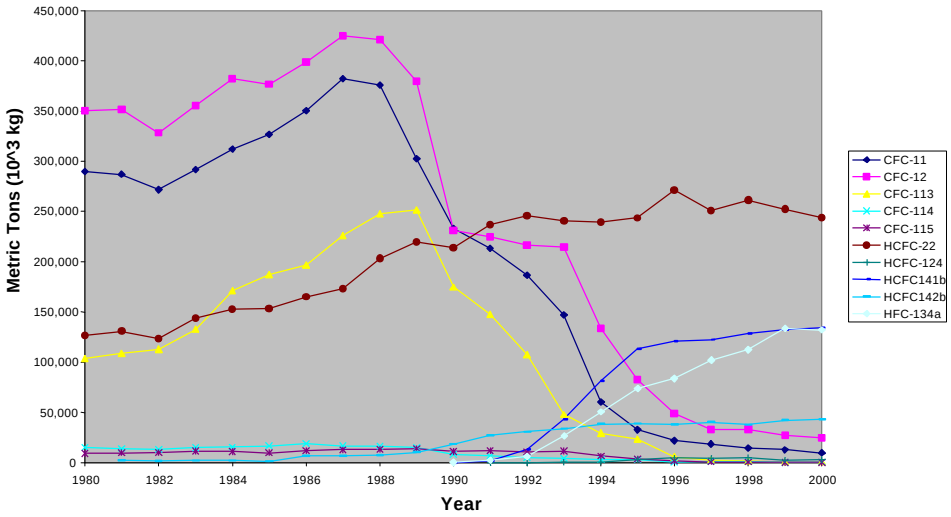
Production, Sales and Atmospheric Release of Fluorocarbons through 2000

Introduction

Since 1976, the chemical industry has voluntarily reported the production and sales of fluorocarbons through a survey compiled by an independent accountant, Grant Thornton LLP. The purpose of the survey is to provide the scientific community with data estimating the atmospheric release of CFCs and the alternative fluorocarbons. Data are available through 2000 for CFCs 11, 12, 113, 114 and 115; HCFCs 22, 124, 141b and 142b; and HFC-134a. Reported CFC production has continued to decline as shown in the graph below, and is now down to the level of 52 years ago. The sum of all CFCs reported to AFEAS in 2000 is only 3% of the total in the peak year, 1988. The alternatives initially grew rapidly after their introduction to replace CFCs but now have varied growth rates, with some leveling off as they become more mature products.

	2000 Production (metric tons)	**Change between 1999 and 2000**	
CFC-11	9,900	decreased by 2,971 metric tons	(–23%)
CFC-12	24,564	decreased by 2,568 metric tons	(– 9%)
CFC-113	942	decreased by 58 metric tons	(–6%)
CFC-114	505	increased by 213 metric tons	(+73%)
CFC-115	213	decreased by 183 metric tons	(–46%)
HCFC-22	243,847	decreased by 8,528 metric tons	(–3%)
HCFC-124	3,220	increased by 215 metric tons	(+7%)
HCFC-141b	134,393	increased by 2,038 metric tons	(+2%)
HCFC-142b	43,109	increased by 693 metric tons	(+2%)
HFC-134a	132,013	decreased by 1,649 metric tons	(–1%)

Annual Production of Fluorocarbons Reported to AFEAS (1980-2000)

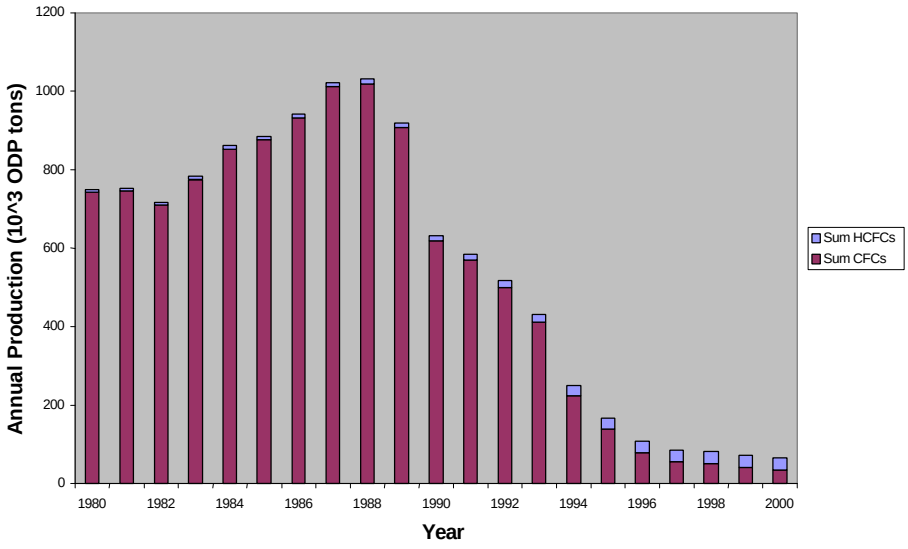


NOTE: "Production" (as defined in the Montreal Protocol) does not include feedstock uses.

The companies surveyed include subsidiaries and joint ventures that have or had CFC, HCFC or HFC production in the following countries: Argentina, Australia, Brazil, Canada, European Union, Japan, Mexico, United States, and Venezuela. The data collected by AFEAS for 2000 are estimated (by comparison with UNEP totals) to represent about 30% of global CFC production. It is known that CFCs are also produced by companies that do not participate in the AFEAS survey, such as those in China and India. Global coverage is much greater in the AFEAS survey for the HCFCs and HFCs. The AFEAS data account for more than 93% of all non-feedstock HCFC production, and are thought to represent about 98% of global HFC-134a production.

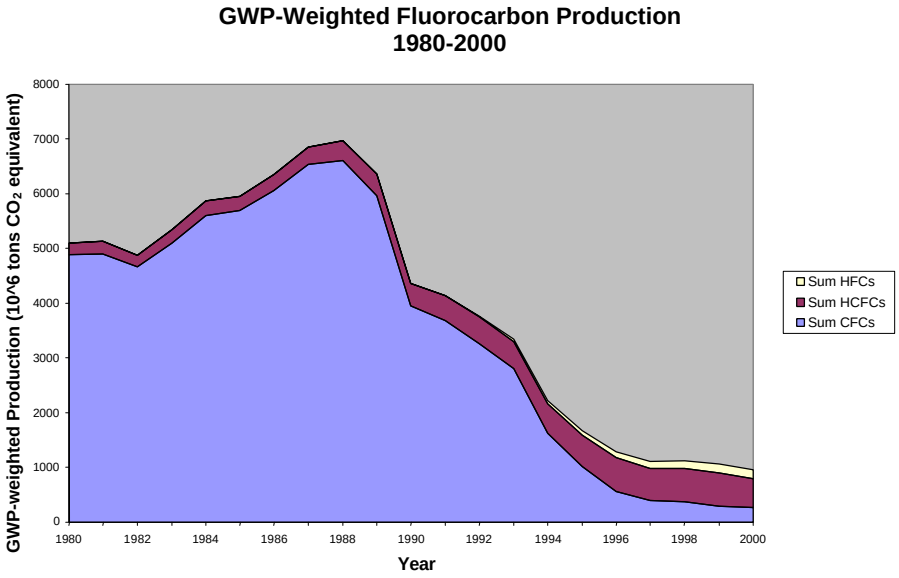
Under the Copenhagen Amendments to the Montreal Protocol, CFC production in the developed world after January 1996 was only permitted to supply the basic domestic needs of less-developed countries plus a very small allowance for “essential uses” (mostly for laboratory and pharmaceutical purposes). As illustrated in the plot below, the production of CFCs reported to AFEAS has decreased rapidly since the Montreal Protocol came into force. Production of CFCs and HCFCs by AFEAS reporting companies, weighted according to the ozone depletion potential (ODP) of each compound, has been reduced by 94% from the peak year, 1988.

ODP-Weighted Fluorocarbon Production
1980-2000



NOTE: Calculated from production reported to AFEAS with ozone depletion potential (ODP) values from "Production and Consumption of Ozone Depleting Substances 1986-1998," UNEP, October 1999. The ODP of HFCs is zero because they do not contain chlorine. Therefore, they do not appear in the above figure.

Similarly, when reported production is weighted by the global warming potential (GWP) for each compound, the total has declined by about 85% from 1988, the peak year.



NOTE: Calculated from production reported to AFEAS with global warming potentials for a 100-year time horizon from the Intergovernmental Panel on Climate Change (1995). [Note: The Kyoto Protocol is based on actual emissions, not production.]

The emission patterns and release delays currently applied to HCFCs 124, 141b, and 142b, and HFC-134a were derived from those developed earlier for CFCs and HCFC-22. However, there have been considerable changes in use practices in the wake of the Montreal Protocol. In 1997, AFEAS commissioned a review of current practices in the foam industry to assess the validity of the existing emissions assumptions. Based on this review, revised emission functions have been derived and applied to the production data (McCulloch et al., 2001). The changes are shown for the first time in this report.

Overview of the Data

Annual production and sales data for each of the 10 compounds are presented. Sales are divided into use categories -- such as refrigeration, foam blowing, aerosols, solvents, and other uses -- to the best knowledge of the producers. Some degree of geographical breakdown is also provided but the AFEAS survey does not distinguish between Article 5 (developing) countries and non-Article 5 (developed) countries. An estimate of atmospheric releases of the individual fluorocarbons is also included. The full set of production, sales and emissions data can be downloaded from http://www.afeas.org/prodsales_download.html.

Bibliography

Further detail of the data collection and emission estimation procedures and associated uncertainties, and of the geographical distribution of emissions has been published in the papers listed below.

R.L. McCarthy, F.A. Bower and J.P. Jesson, The Fluorocarbon-Ozone Theory – I. Production and Release: World Production and Release of CCl_3F and CCl_2F_2 (Fluorocarbons 11 and 12) Through 1975, *Atmos. Environ.*, 11, 491-497, 1977.

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P.M. Midgley and A. McCulloch, Estimated National Releases to the Atmosphere of Chlorodifluoromethane (HCFC-22) during 1990, *Atmos. Environ*., 31, 809-811, 1997.

A. McCulloch and P.M. Midgley, Estimated Historic Emissions of Fluorocarbons from the European Union, *Atmos. Environ*., 32, 1571-1580, 1998.

M.A. Aucott, A. McCulloch, T.E. Graedel, G. Kleiman, P.M. Midgley and Y.-F. Li, Anthropogenic Emissions of Trichloromethane (Chloroform) and Chlorodifluoromethane (HCFC-22): Reactive Chlorine Emissions Inventory, *J. Geophys. Res.*, *104 (D7),* 8405-8415, 1999.

P.M. Midgley and A. McCulloch, three chapters in *The Handbook of Environmental Chemistry, Vol. 4 Part E: Reactive Halogen Compounds in the Atmosphere*, P. Fabian and O.N. Singh (eds.), Springer-Verlag, Heidelberg, 1999.

- Properties and Applications of Industrial Halocarbons
- International Regulations on Halocarbons
- Production, Sales and Emissions of Industrial Halocarbons

A. McCulloch, P. Ashford and P.M. Midgley, Historic Emissions of Fluorotrichloromethane (CFC-11) Based on a Market Survey, *Atmos. Environ.*, 35, 4387-4397, 2001.

Companies Participating in 2000 Survey

Asahi Glass Co., Ltd. (Japan)

Atofina S.A. (France) *(formerly Elf Atochem)*
- Atofina Espana (Spain)
- Atofina N.A. (U.S.)
- Produven (Venezuela)

Ausimont S.p.A. (Italy)
- Ausimont USA (U.S.)

Central Glass Co., Ltd. (Japan)

Daikin Industries, Ltd. (Japan)
- Daikin America, Inc. (U.S.)

DuPont-Mitsui Fluorochemicals Co., Ltd. (Japan)

E.I. DuPont de Nemours & Company, Inc. (U.S.)
- DuPont Argentina S.A. (Argentina)
- DuPont do Brasil (Brazil)
- DuPont Canada, Inc. (Canada)
- E.I. DuPont International S.A. (Europe)
- DuPont S.A. de C.V. (Mexico)

Honeywell International, Inc. (U.S.) *(formerly AlliedSignal)*
- Honeywell (Canada)
- Honeywell Fluorochemicals (Europe)

INEOS Fluor Ltd. (U.K.) *(formerly ICI Klea)*

LaRoche Industries Inc. (U.S.)

Phosphoric Fertilizer Industry S.A. (Greece) *(formerly Société des Industries Chimiques du Nord de la Grèce)*

Rhodia Organique Fine, Ltd. (U.K.) *(formerly Rhône-Poulenc Chemicals, Ltd.)*

Showa Denko, K.K. (Japan)

Solvay S.A. (Belgium)
- Solvay Fluor Iberica S.A. (Spain)
- Solvay Fluor und Derivate GmbH (Germany)
- Solvay Fluorés France S.A. (France)