National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

The large contribution of projected HFC emissions to future climate forcing

Abstract

The emissions of hydrofluorocarbons (HFCs) are projected to increase substantially in the coming decades in response to the Montreal Protocol if developing countries replace HCFCs with HFCs using the same patterns as has been used by developed countries. The projected increases result from growth in demand for refrigeration, AC and insulating foam products in developing countries assuming no new regulation for HFCs. HFC scenarios are presented based on reported HCFC consumption, patterns of replacements of HCFCs by HFCs, and gross domestic product growth. Global HFC emissions in 2050 are 9–19% (CO_2-eq.) of projected CO_2 emissions in business-as-usual scenarios and contribute a radiative forcing equivalent to that from 6–13 years of CO_2 emissions growth near 2050.

Success of Montreal Protocol

Global use of CFCs and halons have decreased significantly as a result of the Montreal Protocol. This is not only beneficial for the ozone layer, but also for climate, since CFCs are greenhouse gases. The climate protection already achieved by the Montreal Protocol alone is 5 to 6 times larger than the reduction target for 2008-2012 of the Kyoto Protocol (Figure 2; Velders *et al.*, 2007). The use of HCFCs and HFCs have increased as replacements for CFCs in developed and developing. Ultimately, HCFCs will be phased out globally leaving much of the application demand for refrigeration, AC, heating and thermal-insulating foam production to be met by HFCs. HFCs do not deplete the ozone layer, but are greenhouse gases. Thus, the way in which the transition away from ozone depleting substances is made has implications for future climate.

New HFC baseline scenarios

We report new baseline scenarios for HFCs to 2050 based on existing policies and growth in demand based on GDP and population from the IPCC/SRES scenarios (Velders et al., 2009). The new scenarios incorporate recent information such as:

1) rapid observed growth in demand, substantiated by atmospheric observations, for products and equipment using HCFCs and HFCs in developing countries,
2) reported increases in consumption of HCFCs in developing countries (Figure 1a),
3) replacement patterns of HCFCs by HFCs as reported in developed countries (Table 1),
4) accelerated phaseout schedules of HCFCs agreed to in 2007,
5) increases in reported use of HFC-134a in mobile AC.

Authors: Guus J. M. Velders[1], David W. Fahey[2], John S. Daniel[2], Mack McFarland[3], and Stephen O. Andersen[4]

[1] National Institute for Public Health and the Environment, The Netherlands (guus.velders@rivm.nl)
[2] National Oceanic and Atmospheric Administration, ESRL, Chemical Sciences Division, USA
[3] DuPont Fluoroproducts, USA
[4] Technology and Economic Assessment Panel (TEAP), USA

Contact: guus.velders@rivm.nl

Published by
National Institute for Public Health and the Environment
P.O. Box 1 | 3720 BA Bilthoven
www.rivm.com

References

- IPCC/TEAP Special report: Safeguarding the ozone layer and the global climate system: Issues related to hydrofluorocarbons and perfluorocarbons, 2005.
- Velders, G.J.M., S.O. Andersen, J.S. Daniel, D.W. Fahey, M. McFarland, The importance of the Montreal Protocol in protecting climate, Proc. Natl. Acad. Sci., 104, 4814-4819, 2007.
- Velders, G.J.M., D.W. Fahey, J.S. Daniel, M. McFarland, S.O. Andersen, The large contribution of projected HFC emissions to future climate forcing, Proc. Natl. Acad. Sci., 106, 10949-10954, 2009.

002962

Figure 1. CFC, HCFC and HFC consumption (a, b), and HFC RF (c) in developing and developed countries. The CFC and HCFC mass consumption values in (a) are derived from reported UNEP data. The shaded regions in (b) and (c) are bounded by high and low limits as defined by the upper and lower ranges of the SRES data for GDP and population. The scenarios do not include HFC-23 because its use as a substitute for CFCs is negligible.

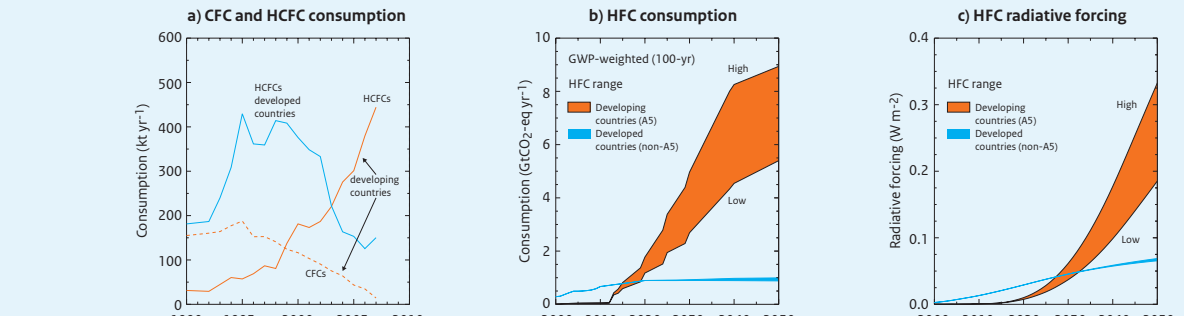

Figure 2. Global CFC, HCFC, HFC, and CO_2 emissions for the period 1960-2050, and global CFC emissions for 1987-2020 following a scenario in which there is no Montreal Protocol regulation.

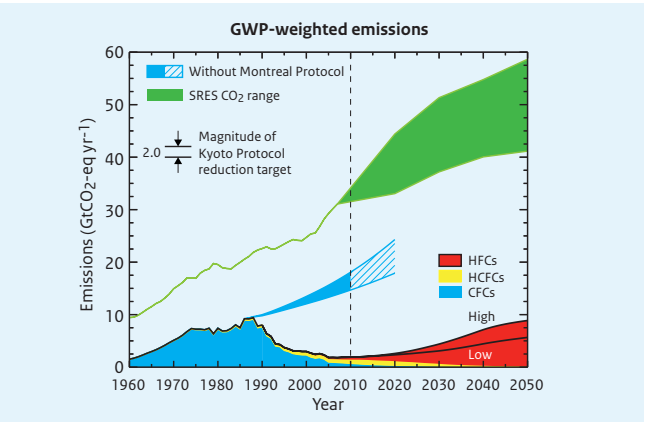

Figure 3. Global direct RF values for CFCs, HCFCs, HFCs, and CO_2 for the period 1960-2050, and global direct RF for CFCs during the period 1987-2020 following a scenario in which there is no Montreal Protocol regulation.

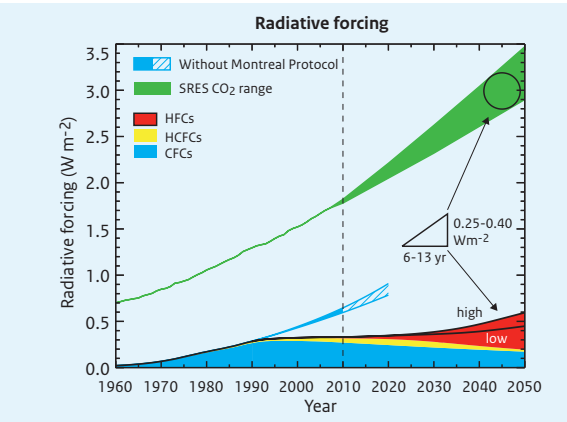

Table 1. Replacement pattern of HCFCs by HFCs assumed for developing countries.

	GWP (100 yr)	Consumption	R-404A	R-410A	HFC-134a	HFC-245fa	Not-in-kind
GWP (100 yr)			3,922	2,088	1,430	1,030	
HCFC-22	1,810	66.5%	35%	55%			10%
HCFC-141b	725	30.0%				50%	50%
HCFC-142b	2,310	3.5%			50%		50%

R-404A and R410A are blends of HFCs.

GWP weighted consumption and emissions

Total HFC GWP-weighted consumption grows strongly from 2012, primarily in developing countries, reaching 6.4–9.9 $GtCO_2$ eq yr^{-1} in 2050 (Figure 1b). The consumption in developing countries becomes larger than that in the developed countries before 2020 and exceeds that in developed countries by up to 800% by 2050. Total GWP-weighted HFC emissions are 5.5–8.8 $GtCO_2$ eq yr^{-1} by 2050 (Figure 2). Total direct-GWP-weighted emissions of CFCs + HCFCs decrease between 2000 and 2050, whereas HFC emissions monotonically increase, exceeding those of CFCs + HCFCs after about 2020. The total GWP-weighted HFC emissions for the new baseline scenarios are significantly larger than those of SRES past 2020. The new scenario results are put into context by comparing to projected global CO_2 emissions. In 2050 in the SRES scenarios, CO_2 emissions will be 40–60 $GtCO_2$ yr^{-1}. Projected HFC emissions are 9–19% of these CO_2 values.

Radiative forcing (RF)

Calculated RFs provide a more direct measure of the climate influence of greenhouse gas accumulation in the atmosphere than do CO_2-equivalent emissions. The projected RF from global HFCs monotonically increases throughout the baseline scenarios (Figure 1c). The RF contribution from developing countries surpasses that of developed countries around 2030. In 2050, the RF of global HFCs is in the range of 0.25–0.40 W m^{-2}, which is more than a factor of three larger than SRES HFC values. In a comparison with the SRES CO_2 scenarios in 2050, the HFC RF fraction is 7–12% of the CO_2 values (Figure 3). The HFC RF in 2050 is equal to 6–13 years of RF growth from CO_2 in the 2050 time frame.

Importance of energy efficiency

Here, only the direct contribution to climate forcing due to HFC emissions was considered. Indirect climate forcings associated with HFC or other halocarbon usage derive from the energy used or saved during the application or product lifetime and energy used to manufacture the product (IPCC/TEAP, 2005). An evaluation of the total climate forcing resulting from the global transition from HCFCs to HFCs requires consideration of both direct and indirect impacts over all associated application lifecycles.

Policy arena

The potentially large contribution of HFC emissions to future climate forcing in the coming decades has attracted the attention of policymakers seeking climate protection. HFCs are in the *'basket of gases'* of the 1997 Kyoto Protocol, which places limits on the emissions in developed countries. Currently proposals are being discussed to include HFCs in the Montreal Protocol that restrict the production and/or consumption in both developed and developing countries.