Environmental and Energy Study Institute

Issue Brief

The Montreal Protocol and Its Implications for Climate Change

October 2009

EXECUTIVE SUMMARY

In the context of international environmental treaties, the Montreal Protocol has seen unparalleled success. Ratified by almost every country in the world, and with both the developed and developing world broadly achieving their production phase-out targets for ozone depleting substances (ODSs), the agreement is on track to significantly reduce a major environmental and health threat. Stratospheric ozone is expected to revert to pre-1980s levels during the second half of this century, achieving the primary goal of the protocol.

Yet the agreement failed to directly address another threat associated with these emissions: global warming. Both existing ODSs and their industry substitutes, hydrofluorocarbons (HFCs), have severe global warming potential (GWP)- in some cases more than 10,000 times that of carbon dioxide (CO2), the most prevalent greenhouse gas emitted by human activities. While focusing on the global phase-out of ODS production, the treaty has done little to address existing banks of ODSs or incentivize their controlled destruction. The next 20 years will be crucial in determining the ultimate impact of ODSs on the atmosphere. If ODS banks remain unaddressed, there is a considerable risk that these chemicals will be released into the atmosphere within this timeframe, with significant implications for global warming and ozone depletion. Only if these gases are collected and destroyed or recycled in a controlled, responsible manner can an environmental threat be considered to have been averted.

The treaty also has been instrumental in accelerating the growth of HFC production because they have no ozone-depleting potential and can be used in almost all the same functions in industry. The industry is only now completing a transfer from second generation ODSs to HFCs, and so their atmospheric prevalence continues to rise rapidly. The GWP of HFC emissions, by mass, surpasses that of CO2 by a factor of between 100 and 12,500, and a collaborative 2009 study reported that HFC emissions could account for 9 to 19 percent of projected global CO2-equivalent emissions by 2050 under the business-as-usual (BAU) scenario (Velders et al, 2009).

Climate change presents a growing threat to health, the environment, and national security. Emissions from ODSs and HFCs threaten to undermine efforts being taken to reduce atmospheric CO2. Consequently, there is increasing pressure for federal, international, or other climate legislation to address the threats posed by existing banks of ODSs and the growing production of HFCs.

INTRODUCTION

This issue brief addresses the magnitude of the risks posed by ODS banks and HFC production and the status of current U.S. legislation and policy surrounding these issues. Where proposed solutions are widely voiced, these are listed. However, the set of policy solutions discussed is only illustrative and not comprehensive.

With a worldwide phase-out of ODS production in place, this brief focuses on the fate of ODS banks. HFC volumes, on the other hand, are increasing rapidly. Therefore, projections are provided from accredited sources to set out the business-as-usual trajectory to 2050 for HFC production. There are no discernible reasons to oppose the safe destruction of existing ODS banks at the end of their useful lives. However, there are significant implications attached to a phase-down of HFC production for the relevant industries and consumers. These are summarized herein. Given fundamental differences, the report addresses ODS banks and HFC production separately throughout, including what policies are proposed and being applied to undertake each distinct issue.

BACKGROUND

By the mid-1980s, a thinning of the ozone layer that forms naturally in the stratosphere was observed by scientists over Antarctica. This effect was attributed to the increased atmospheric prevalence of a group of chemicals called chlorofluorocarbons (CFCs) and certain other substances, commonly found in consumer products like refrigerators, fire extinguishers and aerosol cans. These chemicals were leaked into the atmosphere throughout their production and use, breaking down ozone molecules that form in the stratospheric layer and absorb much of the ultraviolet radiation that reaches the Earth. This ozone depletion was shown to have serious health and environmental consequences for human skin and eyes, crops and marine life. As a result, in 1987, world leaders signed the Montreal Protocol, a global agreement for the phase-out of production of ODS. Since that time, continued scientific study has led to the strengthening of this protocol, which has now been ratified by 196 countries[1] (UNEP, 2009).

SPECIFIC TARGETS OF THE MONTREAL PROTOCOL

The Montreal Protocol identified both first generation and second generation ozone-depleting substances (see Fig. 1). The treaty was designed to restore the ozone layer by ending production of ODSs and by encouraging alternative substitutes through a systemic phase-out. In the United States, Congress amended the *Clean Air Act* (P.L. 101–549) in 1990 to provide a legislative framework for ensuring the targets identified by the treaty were met.

Globally, there has been equally significant progress, and a complete phase-out (including within developing countries) of ODSs is expected to occur by 2040. Assuming the current trajectory is maintained, scientists project that the Antarctic ozone layer may revert to pre-1980 levels somewhere between 2060 and 2075 (EPA, 2007).

[1] As of September 16, 2009

First Generation ODS

Chemical Group	Production Phaseout Dates	Deadline Met
Halons	January 1, 1994	✓
Chlorofluorocarbons (CFCs)	January 1, 1996	✓
Carbon tetrachloride	January 1, 1996	✓
Hydrobromofluorocarbons (HBFCs)	January 1, 1996	✓
Methyl chloroform	January 1, 1996	✓
Chlorobromomethane	August 18, 2003	✓
Methyl bromide	January 1, 2005	✓

Second Generation ODS

Chemical Group	Production Phaseout Dates	Deadline Met
Hydrochlorofluoro-carbons (HCFCs)	Cut production 35 percent by January 1, 2004	✓ (One year ahead of schedule)
	Cut production 65 percent by January 1. 2010 Cut production 90 percent by January 1. 2015 Cut production 99.5 percent by January 1. 2020 Complete phaseout by January 1. 2030	On track to meet all future requirements

Figure 1: Source EPA, Regulatory Summary, Updated September 11, 2008

ODS AND HFC: LIFE CYCLE AND GLOBAL WARMING POTENTIAL

ODSs, namely gases containing chlorine or bromine, and HFCs are synthetically produced. They are contained in appliances (e.g. refrigerators), chemical stockpiles, foams, and are referred to in this state as “banks”, which as of yet are not released into the atmosphere as emissions.

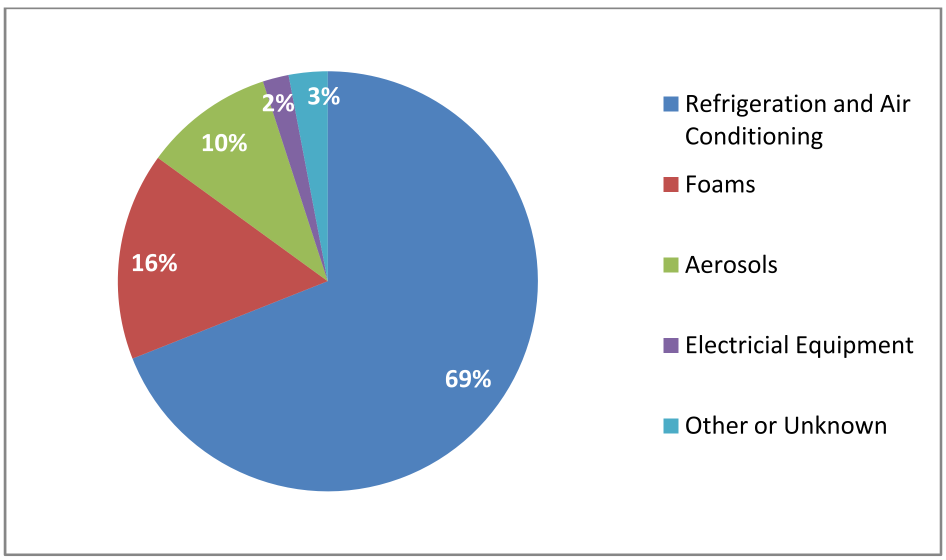

Figure 2: Estimated intended uses of fluorinated gases reported by companies in 2007 (tons), Source European Union Datasheet

In theory, banks should never be released as emissions, provided storage integrity remains intact, and the appliances are safely disposed of at the end of their useful life. In practice, this does not occur in the majority of cases. Emissions rates vary by sector and by country, but, for example in the United States and Europe, annual refrigerant leakage rate data from over 1700 full supermarket systems averaged 18 percent (IPCC, TEAP, 2005). Total volumes stored in banks can therefore reflect, along with storage standards, a measure of the potential risk of emissions.

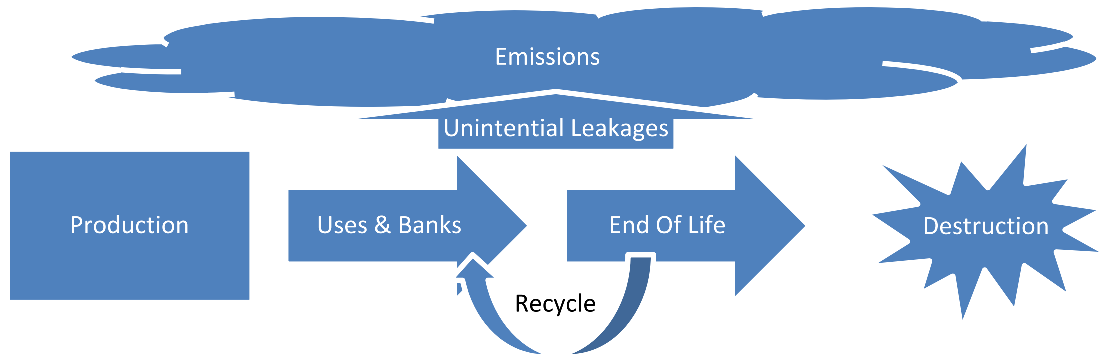

Figure 3: Life Cycle of ODSs and HFCs

ODS are regulated under the Montreal Protocol, while HFCs are currently included among the basket of six GHGs[2] regulated under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (hereafter referred to as the Kyoto Protocol).

The U.S. Environmental Protection Agency (EPA) defines the global warming potential (GWP) of a chemical by how a given mass contributes to global warming over a 100-year horizon compared to the same mass of carbon dioxide (CO2), whose GWP is defined as 1.0. ODSs and HFCs are powerful greenhouse gases, with potency up to 12,500 times that of CO2.

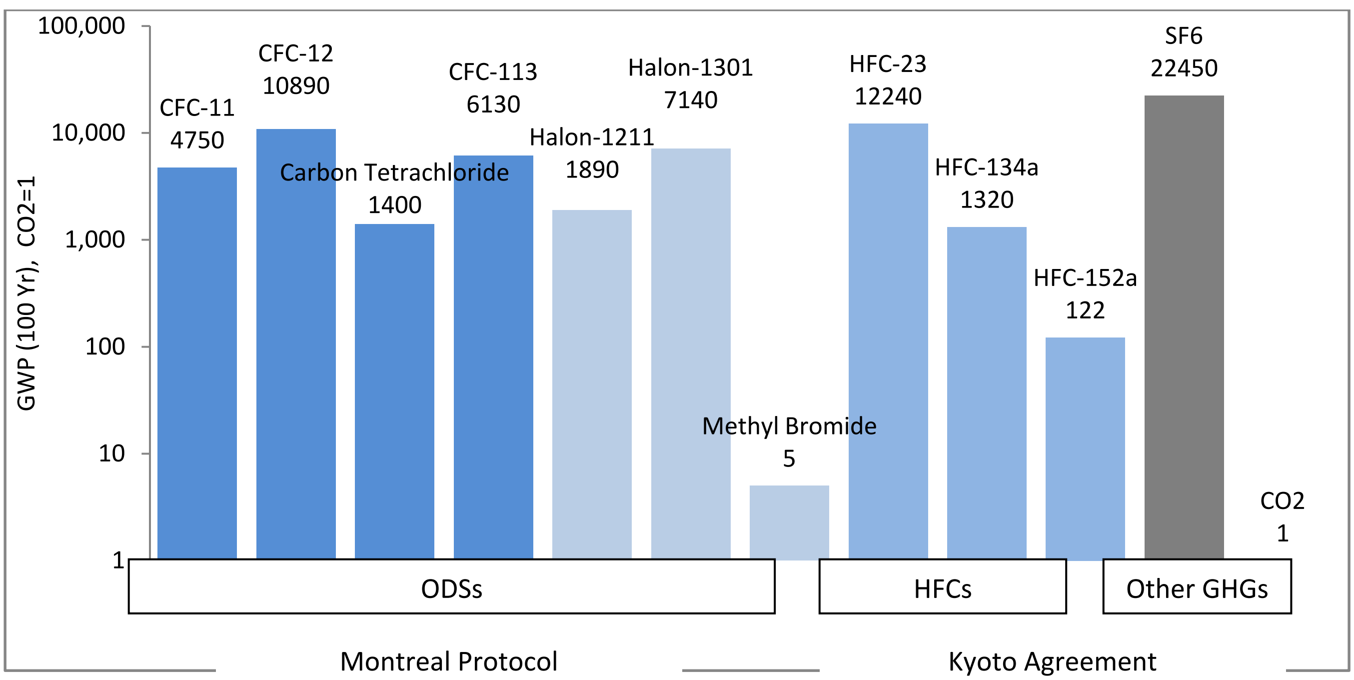

Figure 4: Global Warming Potential of Select ODSs and HFCs, Logarithmic Scale, Source: EPA

2 Carbon dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur Hexafluoride (SF6)

ODS BANKS AND POTENTIAL FOR EMISSIONS

At this time, there are no regulatory restrictions on emissions of ODSs from existing banks under either the Kyoto or Montreal Protocols, although nations have developed policies independently.

With little new production, CFC banks alone are estimated to decline from 16 Gigatons CO2-equivalent (GtCO2-eq) in 2002 to 8 GtCO2-eq in 2015, with most of the decline in the BAU scenario accounted for by emissions rather than controlled recovery. This cumulative decline is broadly equivalent to the entire global CO2 emissions resulting from the burning of fossil fuels in 2006. Over the next two decades, the prevention of these ODS banks' emissions would reduce the total warming impact of global anthropogenic GHG emissions by 3 to 4 percent (IPCC, TEAP, 2005).

Most relevantly, in the next decade alone (2011 – 2020), it is estimated that practicable and achievable improvements to end-of-life measures could reduce emissions by nearly 3 GtCO2-eq, and improvements during their use phase could contribute nearly 4 GtCO2-eq in reductions (TEAP, 2007). The need for urgent action is clear from the timeline associated with these emissions.

The total ODS volume readily accessible in U.S. equipment alone was estimated in 2005 to be 1.5 GtCO2-eq[3], reflecting the potential for action domestically (CCE, EPA, 2007).

CURRENT AND PROPOSED LEGISLATION ON ODS BANKS

Refrigeration, air conditioning and foams represent the most readily available ODS banks. In the United States, like most developed countries, bans exist on venting ODS, with only licensed technicians able to perform refrigerant recovery under specific guidelines. In the case of domestic appliances, however, no standards for recovery are in place as of yet, and no reporting requirements exist for refrigerant recovery operators in the commercial sector (ICF, 2008).
In developed countries outside the United States, certain policies have been implemented which include:

- Producer responsibility programs, mandating the recovery of both refrigerant and foam ODS (See Japan, UK, Germany. The U.S. has a voluntary partnership program)
- Producer responsibility programs in which rebates are provided for the return of used refrigerant, which is subsequently destroyed (See Australia, Canada)
- Recovery and destruction of fluorocarbons from mobile air conditioners (MACs), as well as the recycling of parts at vehicle end-of-life. In response, industry has implemented a recycling program under which end of life vehicles are sent to registered recovery operators, who recover ODS and are paid based on the number of MACs and quantity of refrigerant recovered (See Japan)

In the *American Clean Energy and Security Act of 2009* (H.R. 2454) (ACES, 2009), which passed the House on June 26, 2009, certain economic incentives for select ODS recovery are considered. The bill allows for the distribution of offset credits achieved through destruction of CFCs, equal to 0.8 times the number of tons of CO2-eq emissions destroyed. These credits would offset CO2 emissions that are not reduced under a cap and trade system, but it limits the buyers of these offsets to importers and producers of CFC substitutes (namely HFC producers). While these offsets provide a market incentive to destroy CFC banks, the limitations on who may buy these offsets may depress their cost. Critics of this provision argue that these GHG emissions would be more effectively regulated if these offsets were available to all

[3] 350 million tCO2-eq of CFCs, 1050 million tCO2-eq of HCFCs and 100 million tCO2-eq of Halons

buyers, and such a provision is contained in the bill that authorizes the EPA to do this at a later date. ODS gases whose consumption has not been completely phased out internationally, (except for essential use or similar exemptions), will not be eligible for destruction offsets.

A method that appropriately deals with the destruction or recovery of ODS banks while offering the lowest global warming impact is essential. To do this effectively, measures need to be implemented urgently with clear standards for quantifying and verifying ODS destruction or recovery projects.

HFC PRODUCTION AND THE POTENTIAL FOR EMISSIONS

In its 2000 Special Report, the Intergovernmental Panel on Climate Change (IPCC) set out potential scenarios for HFC emissions, and in 2005, updated its projections of future HFC emissions to account for its rapidly increasing use as a replacement for CFCs and HCFCs. This latter report estimates that, in a business-as-usual (BAU) scenario, direct HFC emissions will increase 300 percent between 2002 and 2015, from 0.4 GtCO2-eq per year to 1.2GtCO2-eq per year. The buildup of HFCs in banks is correspondingly projected to develop 400 percent, from 1 GtCO2-eq to 5 GtCO2-eq.

Velders et al, (2009) updated these scenarios and predicted that the baseline for 2050 global HFC emissions would range between 5.5 - 8.8 GtCO2-eq per year. While HFC emissions currently account for the equivalent of 2 percent of global CO2 emissions, they could ultimately represent anything from 10 percent to nearly 45 percent if CO2 emissions are successfully mitigated, but HFC production is not addressed in any meaningful way. The source of this growth will increasingly come from developing countries, whose HFC emissions are projected to overtake those from developed countries by 2020, and by 2050 exceed them by 800 percent.

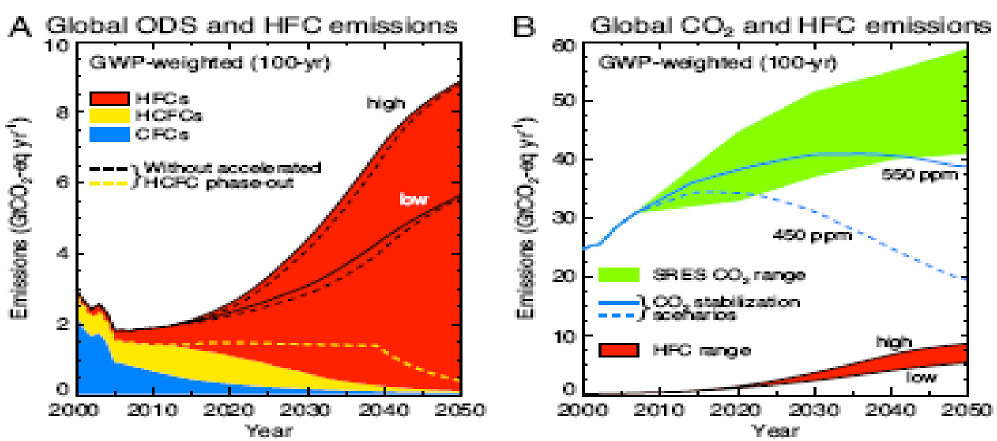

Figure 5: HFC, ODS, and CO2 Emissions to 2050. Source: Velders et Al, (2009)

Figure 5 represents the relative contributions towards to global warming of various GHGs. ODSs (CFCs and HCFCs) historically dominated anthropogenic warming impacts, but over the past five years, HFC prevalence has increased. Going forward, the climate forcing attributable to HFCs is expected to amplify. 5B places this growth in the context of global CO2 emissions; historically, HFC emissions were comparatively small, but going forward they are likely to become a very significant component of GHG emissions, increasingly so if CO2 stabilization plans are realized. And if CO2 mitigation efforts are not successful, HFCs will greatly exacerbate an already bad situation.

CURRENT AND PROPOSED LEGISLATION ON HFC PRODUCTION

HFCs are currently regulated internationally under the Kyoto Protocol as part of a group of six GHGs, and not singled out for separate regulation. Although they are not regulated under the Montreal Protocol, a recent proposal from the Federated States of Micronesia and Mauritius called for the Montreal Proposal to broaden its mandate to address HFCs (Micronesia and Mauritius, 2009). Support for this approach was announced by United States, Canada, and Mexico, on September 15, 2009.

Policy options to regulate and potentially mitigate HFC production include:

- Regulations like binding technological or performance standards or product bans
- Financial incentives to reduce emissions, production, import or consumption or incentivize collection, destruction or substitutes
- Voluntary agreements with industry and non-binding best practice standards

It is also necessary to develop plans for addressing HFC banks in the future. For the reasons discussed regarding ODSs in the previous sections, reducing emissions associated with production and consumption of HFCs is not a complete solution. A well structured phase down, rather than phase out, that supports intensified research into the development of HFCs with lower GWPs, or new alternatives, is the preferred action supported by several industry bodies.

The *American Clean Energy and Security Act of 2009* (H.R. 2454) includes provisions for HFCs to be regulated in a cap-and-trade program separate from other GHGs. Section 332 of H.R.2454 requires HFC consumption to be phased-down to 67 percent of the baseline[4] by 2020, and to 15 percent from 2032. Allowances would be distributed through a combination of annual auctions and allocations. Eighty percent of allowances would be placed into a producer-importer pool; of these, 10 percent would be auctioned in 2012, with the auction quota rising by 10 percent each year, reaching 90 percent in 2020 and remaining at that level thereafter.

IMPLICATIONS OF REGULATING HFC PRODUCTION

The industry is just now effecting a protracted transition away from HCFCs to HFCs. A workable HFC phase-down needs to be consistent with availability of substitutes. Piecemeal solutions exist, but there are sectors of industry where alternatives are not currently available. The most likely substitutes, ammonia and hydrocarbons (HCs), have short atmospheric lifetimes and are considered to have a negligible effect on global warming if used incrementally in HFC capacities. These substitutes have drawbacks however, among which is the flammability of hydrocarbons. New low GWP HFCs are in development and may ultimately present a viable option; however at this stage these are not yet widely available and the likelihood of a comprehensive solution is currently unclear (see EFCTC, 2009 & EPEE, 2009).

Some industry bodies feel inclusion of HFCs in a general emissions trading scheme is not appropriate but that a specific scheme for progressively reducing high GWP HFCs in the market would likely stimulate technological developments. Industry participants also point out that certain analyses only consider the direct impact of emissions through potential leakages. The energy efficiency of appliances that use any kind of refrigerant has to date been paramount, and switching to alternatives may decrease efficiency and increase CO2 emissions associated with increased energy usage. This needs to be considered when taking a holistic view towards decarbonization; reverses in efficiency gains achieved

[4] Between 280 and 370 million tCO2-eq, to be determined

by these appliances resulting from any policies that address HFCs must be taken into account (see Fischer et al, 1991). Furthermore, regulation of HFCs should not be detrimental to the phase-out of HCFCs, as a number of countries are in a critical phase of transition. The overall goal must be emissions prevention, and the relationship between supply and emissions should not be assumed to be static. Any system for HFC regulation may want to take into account potential improvements in containment or end of life destruction.

Ultimately, affected parties support regulation of the sector to contain or reduce HFC emissions, but are keen to point out that an international agreement, adhered to on a global basis, is vital if technological, environmental, and economic goals are to be met.

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