Overview of HCFC Consumption and Available Alternatives For Article 5 Countries

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Introduction

The information presented here provides a brief overview of HCFC consumption by HCFC type, sector, and region, as well as available alternatives. This paper is not intended to provide a comprehensive treatment of each of these topics, but rather an introduction to each issue. The following topics are discussed:

- A presentation of the recent adjustments to the HCFC schedule for developed and developing countries and projections of HCFC consumption over time;
- An overview of HCFC use by sector and by gas, as well as a more specific discussion of HCFC use in the refrigeration and air conditioning and foams sectors; and
- A listing of alternatives to HCFCs by sector and application.

Projected HCFC Consumption (Article 5 and Non-Article 5)

More than 190 countries have now signed the Montreal Protocol. The global success of this effort to protect our environment requires that the world's developed (non-Article 5 [non-A5]) and developing (Article 5 [A5]) countries eliminate emissions to the atmosphere of most ozone depleting substances (ODS). To ensure the complete and timely phaseout of ODS, phaseout schedules for A5 and non-A5 countries have been established for each category of ODS.

Chlorofluorocarbons (CFCs) were mostly phased out in non-A5 countries by 2004, and will be phased out in A5 countries by 2010. However, the consumption of hydrochlorofluorocarbons (HCFCs), the intermediary replacements for CFCs, still remains high, particularly in A5 countries. To address this issue, at the recent 19th Meeting of the Parties (MOP), the Parties established an HCFC phaseout schedule that calls for a more rapid step-down in HCFC consumption for non-A5 countries than the original phaseout schedule set by the Copenhagen Amendment (1992) agreed to by the 4th MOP. In addition, the new schedule also established a step-down in consumption for A5 countries, previously only required to freeze consumption in 2016 and halt the use of HCFCs in 2040. The differences between the two phaseout schedules for both Article 5 and non-Article 5 countries are presented in Table 1 (next page).

Key Assumptions for Consumption Projections

- Based on 2005 HCFC consumption by country, as reported under Article 7 to the Ozone Secretariat.
- Standardized 7% growth rate assumed for all countries and years, beginning in 2006.
- HCFC consumption is assumed to equal the maximum allowable consumption for both A5 and non-A5 parties.

The impact of the HCFC phaseout schedules are also illustrated graphically in Figure 1 and Figure 2 below. Figure 1 shows projected consumption if the previous HCFC phaseout schedule (as approved in the Copenhagen Amendments) were to continue; Figure 2 shows projected consumption under the new HCFC phaseout schedule (as approved at the 19th MOP), as well as the consumption reductions associated with the shift to the new phaseout schedule. In addition, for A5 countries, Figure 3 presents projected HCFC consumption under the new phaseout schedule by country and region.

Figure 1. Projected HCFC Consumption in A5 and Non-A5 Countries, based on Montreal Protocol Phaseout Schedule from Copenhagen Amendments (1992)

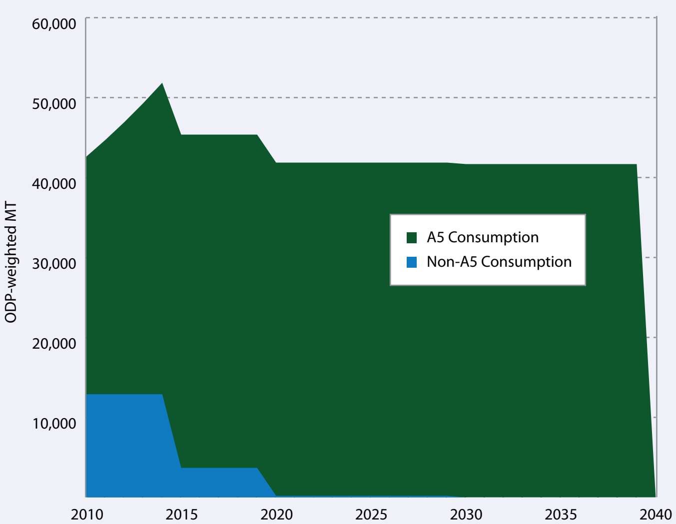


Figure 2. Projected HCFC Consumption in A5 and Non-A5 Countries, based on Montreal Protocol Phaseout Schedule as Approved at the 19th Meeting of the Parties

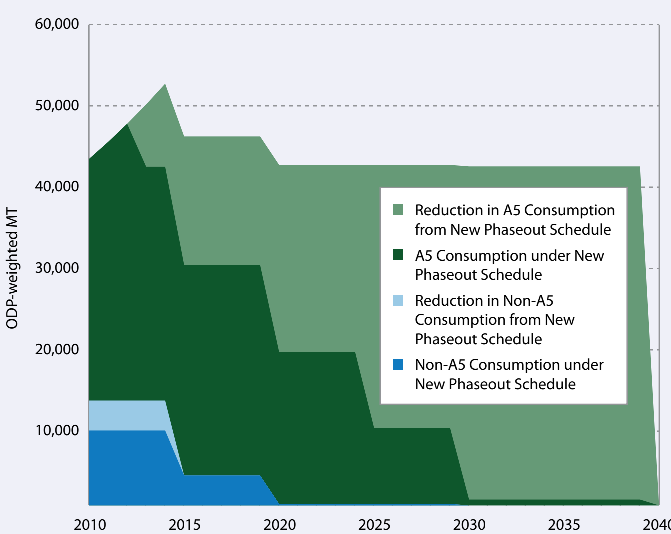
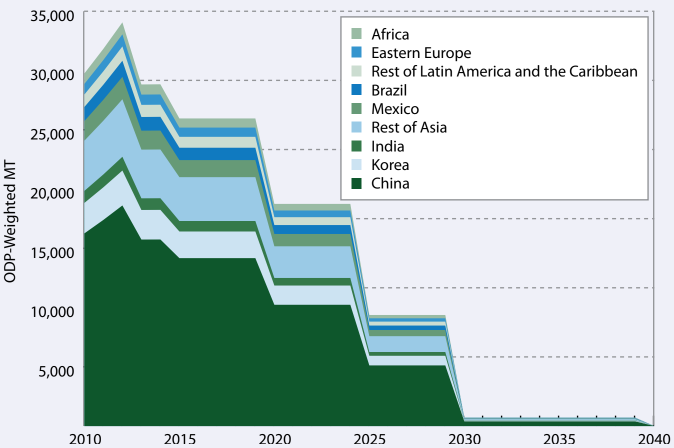


Table 1. HCFC Consumption Controls Under the Montreal Protocol

Previous Montreal Protocol HCFC Schedule (As approved in the Copenhagen Amendment [1992])		New Montreal Protocol HCFC Schedule (As approved in the Montreal Adjustment from the 19th MOP)	
Control Date	HCFC Control Measure	Control Date	HCFC Control Measure
NON-ARTICLE 5(1) COUNTRIES			
Base level: 1989 HCFC consumption +2.8% of 1989 CFC consumption		Base level: 1989 HCFC consumption +2.8% of 1989 CFC consumption	
1 January 1996	Freeze	1 January 1996	Freeze
1 January 2004	35% reduction	1 January 2004	35% reduction
1 January 2010	65% reduction	1 January 2010	75% reduction
1 January 2015	90% reduction	1 January 2015	90% reduction
1 January 2020	99.5% reduction	1 January 2020	99.5% reduction
1 January 2030	100% reduction	1 January 2030	100% reduction
ARTICLE 5(1) COUNTRIES			
Base level: 2015 HCFC consumption		Base level: Average of 2009 and 2010 HCFC consumption	
1 January 2016	Freeze	1 January 2013	Freeze
		1 January 2015	10% reduction
		1 January 2020	35% reduction
		1 January 2025	67.5% reduction
		1 January 2030	97.5% reduction
1 January 2040	100% reduction	1 January 2040	100% reduction

Figure 3. Projected HCFC Consumption in A5 Countries, by Country and Region



HCFC Use by Sector

HCFCs are used in several industry sectors, including refrigeration and air conditioning (AC), fire extinguishing, foams, and solvents. However, the majority of HCFC consumption occurs in the refrigeration/AC (about 88 percent) and foams (about 10 percent) sectors, as shown in Figure 4 below (HCFC Task Force 2007). The primary HCFCs in use in these sectors, as well as the other sectors, are shown in Table 2. HCFC-22 and HCFC-141b are the primary HCFCs used in the refrigeration/AC and foams sectors, and as such, represent the majority (97 percent) of HCFCs used; the percentage of each HCFC as a portion of total consumption is presented in Figure 5 (HCFC Task Force 2007).

Figure 4. HCFC Consumption by Sector (HCFC Task Force 2007)

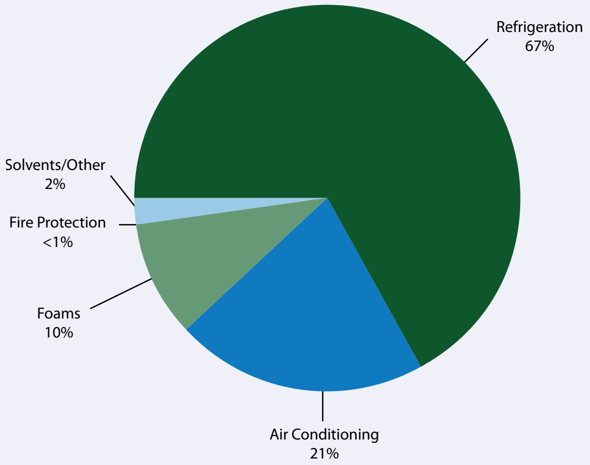
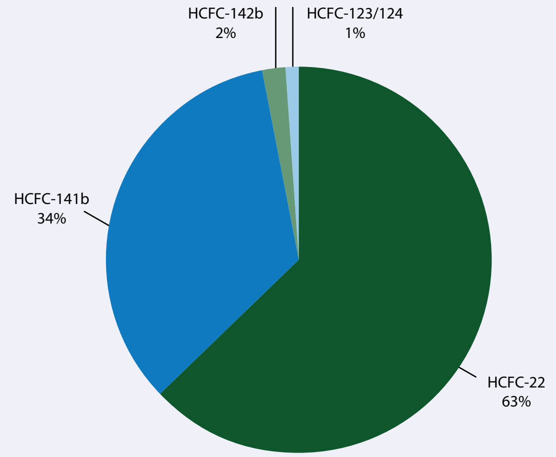


Figure 5. HCFC Consumption by Gas (HCFC Task Force 2007)



Note: The HCFCs shown in this graph are the primary HCFCs in use; the consumption breakdown does not include all HCFCs in use.

Table 2. Common HCFCs, ODPs, and Global Sectors of Use

Substance	ODP	Use Sector			
		Refrigeration and Air Conditioning	Fire Extinguishing	Foams	Solvents
HCFC-22	0.055	X		X	
HCFC-123	0.02	X	X		
HCFC-124	0.022	X			
HCFC-141b	0.11			X	X
HCFC-142b	0.065	X		X	
HCFC-225ca	0.025				X
HCFC-225cb	0.033				X

Refrigeration and Air Conditioning

As discussed above, HCFC-22 is the primary refrigerant in use in the refrigeration/AC sector. This sector includes a broad range of equipment. Table 3 lists the HCFCs and HCFC-blends used in each type of equipment.

Table 3. HCFCs Currently in Use by Refrigeration and Air Conditioning Equipment Type (RTOC 2007)

Equipment Type	Currently in Use
Refrigeration	
Stand-Alone Retail Food Equipment	HCFC-22
Vending Machines	R-401A, R-401B, R-402A, and R-402B
Condensing Units	HCFC-22
Large Supermarket Systems	HCFC-22, R-402B, R-408A, R-502
Cold Storage	HCFC-22, R-502
Refrigerated Transport	HCFC-22, R-401A, R-401B, R-409A
Industrial Process Refrigeration	HCFC-22, R-502
Air Conditioning	
Heat Pumps	HCFC-22, R-401A, R-401B, R-402A, R-402B, R-408A, R-409A. R-502
Unitary AC (ducted and non-ducted)	HCFC-22
Window Units	HCFC-22
Packaged Terminal AC	HCFC-22
Chillers	HCFC-22, HCFC-123, R-502

Table 4. HCFCs Currently in Use by Foam Type (FTOC 2007)

Foam Type	Currently in Use
Polyurethane: Rigid	
Domestic Refrigerators and Freezers	HCFC-141b, HCFC141b/22, HCFC-142b/22,
Other Appliances	HCFC-141b, HCFC-22, HCFC-22/HCFC-142b
Reefers & Transport	HCFC-141b, HCFC-141b/-22
Boardstock	HCFC-141b, HCFC-141b/-22
Panels-Continuous	HCFC-141b, HCFC-22, HCFC-22/HCFC-142b
Panels-Discontinuous	HCFC-141b
Spray	HCFC-141b
Blocks	HCFC-141b
Pipe	HCFC-141b
One Component Foam	HCFC-22
Polyurethane: Flexible	
Slabstock and Boxfoam	HCFCs are not technically necessary for this end use
Moulded	HCFCs are not technically necessary for this end use
PU Integral Skin	HCFC-141b, HCFC-142b/-22
PU Miscellaneous	HCFC-141b, HCFC-22/CO_2
Phenolic	No HCFCs are currently in use
Extruded Polystyrene	
Sheet	HCFCs are not technically required for this end use
Boardstock	HCFC-142b
Polyolefin	HCFC-142b, HCFC-22

Foams

The foam sector currently relies primarily on HCFC-141b, HCFC-142b, and HCFC-22, as shown in Table 4. However, there has already been significant market penetration of non-ODS alternatives in the sector.

HCFC Alternatives by Sector

Because the refrigeration/air conditioning and foams sectors consume the greatest percentage of HCFCs, transitioning to non-ozone depleting alternatives in these sectors will make a significant contribution to the recovery of the ozone layer. A range of HCFC alternatives has been developed for the refrigeration/air conditioning and foams sectors. These alternatives include hydrofluorocarbons (HFCs) and natural refrigerants (e.g., carbon dioxide, ammonia, and hydrocarbons). While neither HFCs, nor natural refrigerants, contribute to ozone depletion, HFCs do have significant global warming potentials (GWPs). As such, it is important to consider the climate impact of refrigerants and foam blowing agents when selecting alternatives for these sectors. Table 5 lists the GWPs of the HCFCs and alternatives (i.e., HFCs and natural refrigerants) in use in the foam and refrigeration/AC sectors.

Refrigeration and Air Conditioning

As presented in Table 6, there are a variety of HCFC alternatives that can be used in retrofitting of old equipment and/or in new equipment in the refrigeration/air conditioning sectors. Technologies using HFCs, ammonia, hydrocarbons, and CO_2 are already available in the marketplace. In certain end-uses, such as domestic refrigeration, natural refrigerants (e.g., CO_2, ammonia, hydrocarbons) are common in certain regions of the world. In other regions, safety requirements restricting the use of these technically viable natural refrigerants have resulted in incomplete market penetration and a lower incentives for product development/marketing.

Table 5. GWPs of HCFCs and Alternatives

Gas	IPCC Second Assessment Report (SAR)	IPCC Fourth Assessment Report (AR4)
HCFC-22	1,500	1,810
HCFC-123	90	77
HCFC-124	470	609
HCFC-141b	600	725
HCFC-142b	1800	2,310
HFC-23	11,700	14,800
HFC-32	650	675
HFC-125	2,800	3,500
HFC-134a	1,300	1,430
HFC-143a	3,800	4,470
HFC-152a	140	124
HFC-227ea	2,900	3,220
HFC-236fa	6,300	9,810
HFC-245fa	NA	1,030
HFC-365mfc	860	794
R-404A	3,260	3,922
R-407C	1,526	1,774
R-410A	1,725	2,088
R-507A	3,300	3,985
CO_2	1	1
Ammonia	<1	<1
Propane	NA	3.3
Butane	NA	4.0
Pentane	<25*	
Cyclopentane	<25*	
Ethylene	NA	3.7
Propylene	NA	1.8

Source: IPCC (1996), IPCC (2007)
*** denotes source is FTOC (2006)**

Table 6. Current and Potential HCFC Alternatives in the Refrigeration/Air Conditioning Sector by End Use (RTOC 2006)

Equipment Type	Zero ODP Alternatives
Refrigeration	
Domestic Refrigerators	HFC-134a, R-413A, hydrocarbons
Stand-Alone Retail Food Equipment	HFC-134a, HFC-404A, hydrocarbons, CO_2
Vending Machines	HFC-134a, hydrocarbons, Stirling and transcritical CO_2 technology
Condensing Units	R-404A, R-507A
Large Supermarket Systems	HFC-134a, R-404A, R-407C, R-417A, R-422B, distributed systems (using HFCs, HCs, or CO_2), indirect systems (using HFCs, ammonia, hydrocarbons, or CO_2), two-stage cascade systems using CO_2
Cold Storage	HFC-134a, R-404A, R-410A, R-507A, hydrocarbons, ammonia, CO_2, distributed systems (using HFCs, HCs, or CO_2), indirect systems (using HFCs, ammonia, hydrocarbons, or CO_2)
Refrigerated Transport	HFC-23, HFC-134a, R-404A, R-407C, R-410A, R-507A, ammonia, CO_2, hydrocarbons
Industrial Process Refrigeration	HFC-134a, R-404A, R-507A. ammonia, CO_2, water, distributed systems (using HFCs, HCs, or CO_2), indirect systems (using HFCs, ammonia, hydrocarbons, or CO_2),
Air Conditioning	
Heat Pumps	HFC-134a, R-404A, R-407C, R-410A, hydrocarbons, ammonia, CO_2
Unitary AC (ducted and non-ducted)	HFC-134a, R-404A, R-407C, R-410A, hydrocarbons, ammonia, CO_2
Window Units	HFC-134a, R-407C, R-410A, R-417A, R-419A, R-422B, hydrocarbons, CO_2
Packaged Terminal AC	HFC-134a, R-404A, R-407C, R-410A, hydrocarbons, ammonia, CO_2
Chillers	HFC-134a, HFC-245fa, R-407C, R-410A, ammonia, hydrocarbons

Foams

For foams, a variety of HFCs (and HFC blends) are available as are other foam blowing agents such as hydrocarbons and CO_2. Table 7, below, lists the most common alternatives available for each foam type.

Table 7. Current and Potential HCFC Alternatives by Foam End Use (FTOC 2006)

Foam Type	Zero ODP Alternatives
Polyurethane: Rigid	
Domestic Refrigerators and Freezers	HFC-245fa, HFC-134a, hydrocarbons
Other Appliances	CO_2 (water), hydrocarbons, HFC-134a, HFC-245fa, HFC-365mfc/-227ea, methyl formate
Reefers & Transport	HFC-245fa, HFC-365mfc/-227ea
Boardstock	HFC-245fa, HFC-365mfc/-227ea, hydrocarbons
Panels-Continuous	HFC-134a, hydrocarbons, HFC-245fa, HFC-365mfc/-227ea
Panels-Discontinuous	HFC-134a, hydrocarbons, HFC-245fa, HFC-365mfc/-227ea
Spray	CO_2 (water), HFC-245fa, HFC-365mfc/-227ea, supercritical CO_2
Blocks	Hydrocarbons, HFC-245fa, HFC-365mfc/-227ea
Pipe	CO_2 (water), cyclopentane
One Component Foam	HFC-134a or HFC-152a/dimethylether/propane/butane
Polyurethane: Flexible	
Slabstock and Boxfoam	CO_2 (water, LCD), methylene chloride, variable pressure, LCD, special additives
Moulded	Extended range polyols, CO_2 (water, LCD, GCD)
PU Integral Skin	CO_2 (water), HFC-134a, HFC-245fa, HFC-365mfc/-227ea, hydrocarbons, methyl formate
PU Miscellaneous	CO_2 (water)
Phenolic	Hydrocarbons, 2-chloropropane, HFC-245fa, HFC-365mfc/-227ea
Extruded Polystyrene Boardstock	
Sheet	CO_2 (LCD), hydrocarbons, inert gases, HFC-134a, HFC-152a
Boardstock	CO_2 (LCD) or with HC blends, HFC-134a, HFC-152a, hydrocarbons and blends
Polyolefin	CO_2 (LCD), hydrocarbons, inert gases, HFC-134a, HFC-152a

References

Intergovernmental Panel on Climate Change (IPCC). 1996. IPCC Second Assessment - Climate Change 1995. Available at http://www.ipcc.ch/ipccreports/assessments-reports.htm.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007 - The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. Available at http://www.ipcc.ch/ipccreports/ar4-wg1.htm.

HCFC Task Force. 2007. Response to Decision XVIII/12: Report of the Task Force on HCFC Issues and Emissions Reduction Benefits Arising from Earlier HCFC Phase-Out and Other Practical Measures. August 2007. Available at http://ozone.unep.org/Assessment_Panels/TEAP/Reports/TEAP_Reports/TEAP-TaskForce-HCFC-Aug2007.pdf.

RTOC. 2006. Report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee. Available at http://ozone.unep.org/Assessment_Panels/TEAP/Reports/RTOC/rtoc_assessment_report06.pdf.

FTOC. 2006. Report of the Rigid and Flexible Foams Technical Options Committee. Available at http://ozone.unep.org/teap/Reports/FTOC/ftoc_assessment_report06.pdf.

World Meteorological Organization (WMO). 2007. Scientific Assessment of Ozone Depletion: 2006. World Meteorological Organization. Global Ozone Research and Monitoring Project—Report No. 50. Available at http://ozone.unep.org/Assessment_Panels/SAP/Scientific_Assessment_2006/index.shtml.