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Other matters

Making the transition to low-global-warming-potential alternatives in domestic refrigeration

Note by the secretariat

The annex to the present note contains information submitted by the United States of America about making the transition to low-global-warming-potential alternatives in domestic refrigeration. It has been reproduced as received, without formal editing.

* UNEP/OzL.Pro.22/1.

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Annex

TRANSITIONING TO LOW-GWP ALTERNATIVES IN DOMESTIC REFRIGERATION

Background

This fact sheet[1] provides current information on low-Global Warming Potential (GWP) alternatives in newly manufactured domestic refrigeration equipment relevant to the *Montreal Protocol on Substances that Deplete the Ozone Layer*.

In 2009, an estimated 1.5–1.8 billion domestic refrigerators and freezers were in operation worldwide. Approximately 100 million new units are produced and sold annually. Domestic refrigerators/freezers typically contain 0.05–0.25 kg of refrigerant and up to 1 kg of blowing agent for the insulating foam. Charge sizes in the United States have decreased over the years but are larger than those in Europe and Japan; units in Europe and Japan typically contain about 15–25% less refrigerant charge and 50% less blowing agent. The expected lifetime of these units is 15–20 years.

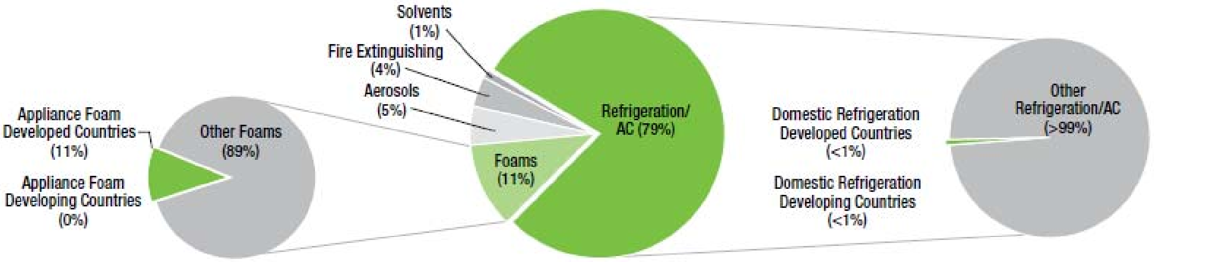
Domestic refrigeration accounts for less than 1% of HFC consumption in the refrigeration/AC sector and approximately 11% of HFC consumption in the foams sector; combined, this accounts for nearly 2% of global HFC consumption in 2010. Developing countries account for approximately 12% of the global HFCs consumed as refrigerants and blowing agents within the domestic refrigeration end-use.

Japan's Experience

In 2002, Japan, a major producer of domestic refrigerators/freezers, introduced its first hydrocarbon (HC) refrigerators onto the market. HC refrigerants, especially R-600a, have since dominated the Japanese domestic refrigeration market and are continuing to grow in market share.

2010 HFC Consumption

(Estimates Presented in $MMTCO_2eq.$)



Global HFC Consumption Total: 1,087 $MMTCO_2eq.$
Global HFC Consumption Domestic Refrigeration: 16 $MMTCO_2eq.$

Global HFC Consumption Foams Total: 124 $MMTCO_2eq.$
Global HFC Consumption Appliance Foam: 13 $MMTCO_2eq.$

Global Consumption Ref/AC Sector Total: 858 $MMTCO_2eq.$
Global Consumption Ref/AC Sector Domestic Refrigeration: 3 $MMTCO_2eq.$

HFC Alternatives and Market Trends

CFC-12 refrigerant and CFC-11 blown foam were historically used in this equipment. In response to the CFC phaseout, HFC-134a was selected as the substitute refrigerant in most countries, while hydrocarbons (HCs) were widely adopted throughout Europe and Japan. The majority of new domestic refrigerators/freezers are manufactured with R-134a. More than 400 million HC units are in use worldwide. In China alone, 75% of new domestic refrigerators/freezers use isobutane refrigerant (R-600a). It is predicted that in 10 years, 75% of new units globally will use HC refrigerants.

CFC-11 foam blowing agent was replaced in most countries with HCFC-141b, which in turn has been replaced by HFC-134a, HFC-245fa, HFC-365mfc, or HCs. Units produced in Europe and Japan have relied on HC foam blowing agents for years, while a smaller percentage have transitioned to this alternative in other developed countries (e.g., an estimated 20% of units sold today in the United States contain HC blown foam).

Refrigerants: R-134a has been the primary refrigerant used in domestic refrigerators/freezers since the phaseout of R-12. However, due to the high GWP of R-134a, there has been increasing interest in adopting climate-friendly refrigerants.

R-600a (Isobutane)

- Contains 40% less refrigerant charge than R-134a systems
- Used in all European and Japanese refrigerators/freezers and majority of Chinese units
- R-600a units will be available in the United States and Brazil soon

HFO-1234yf[2]

- Developed for use in motor vehicle air conditioners, but could become viable for refrigerators/freezers pending additional research and development
- Expected to have comparable efficiency to R-134a

Foam Blowing Agents: Multiple climate-friendly blowing agents have been or are being developed for use in domestic refrigerators, including HCs, HFCs, methylal, and methyl formate as described below.

Cyclopentane Blends

- Cyclopentane, cyclopentane/isopentane, and cyclopentane/isobutane blends are globally the most used blowing agents in domestic refrigeration
- Minimal cost and favorable physical properties
- Significant progress in meeting fire resistance requirements

HFO-1234ze[3]

- Low flammability and good thermal insulation properties
- Acceptable under U.S. EPA's Significant New Alternatives Policy (SNAP) Program
- Other low-GWP compounds under development

Methylal

- Typically used in combination with an HC or HFC blowing agent
- Currently being evaluated in pilot projects supported by the Multilateral Fund

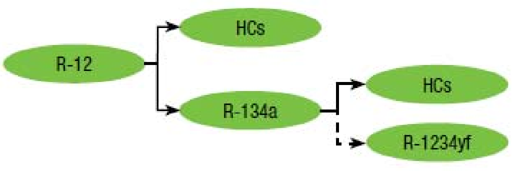
Methyl Formate

- Excellent insulation properties, thermally efficient, and noncorrosive
- Some Latin American countries are currently transitioning

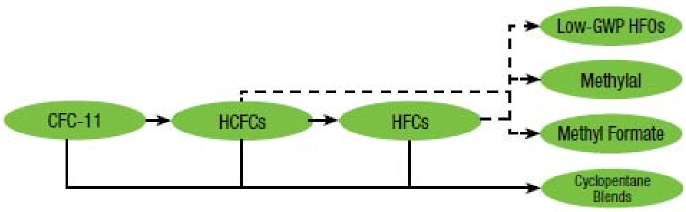
Chemical	GWP	ODP[a]
Refrigerant		
R-12	10,900	1
R-134a	1,430	0
R-1234yf	4	0
R-600a (isobutane)	3	0
Blowing Agent		
CFC-11	4,750	1
HCFC-142b	2,310	0.065
HCFC-22	1,810	0.055
HFC-134a	1,430	0
HFC-245fa	1,030	0
HFC-365mfc	794	0
HCFC-141b	725	0.11
Cyclopentane	<25	0
Methylal	<25	0
Methyl Formate	<25	0
HFO-1234ze	6	0

[a] ODP = ozone depletion potential

Refrigerant Transition in the Domestic Refrigeration End-Use*



Blowing Agent Transition in the Domestic Refrigeration End-Use*



*Solid arrows represent alternatives already available in the market for these systems; dashed arrows indicate those likely to be available in the future.

Challenges to Market Entry and Potential Solutions

The following table summarizes the challenges associated with the various alternatives as well as potential solutions to overcoming them.

Alternative	Challenges to Market Entry	Potential Solutions
Refrigerants		
R-600a	• High Flammability	• Safety Devices • Standards and Service Procedures • Engineering Design
R-1234yf	• Slight Flammability • Long-Term Reliability • Market Availability	• Engineering Design • Research and Development
Blowing Agents		
Methylal	• Limited Experience as the Sole Blowing Agent	• Research and Development
Methyl Formate	• Exposure Concerns • Slight Flammability	• Engineering Design • Research and Development
Cyclopentane Blends	• High Flammability • Insulation Efficiency	• Engineering Design
HFO-1234ze	• Slight Flammability at Elevated Temperatures • Market Availability	• Engineering Design • Research and Development

Future Outlook

Together, the suite of known alternative chemicals, new technologies, and better process and handling practices can significantly reduce HFC consumption in both the near and long term, while simultaneously completing the HCFC phaseout. Although much work remains to fully adopt these chemicals, technologies, and practices, and some unknowns still remain, the industries currently using HCFCs and HFCs have proven through the ODS phaseout that they can move quickly to protect the environment.

References

Appliance Magazine. 2001. "Matsushita Launches Japan's First HC Refrigerator." November 8, 2001.

Babyak, Richard. 2009. "Insulation, Alternative Blowing Agents." *Appliance Design*. March 2009. Available online at: http://www.ecomatesystems.com/pdfs/news/alternative_blowing_agents.pdf. Accessed September 30, 2010.

California Air Resources Board (CARB). 2008. Letter from Michael Scheible of the California Air Resources Board to Air Pollution Control Officers in response to volatile organic compounds exemption petitions received for methyl formate. May 19, 2008. Available online at: *http://www.arb.ca.gov/research/reactivity/methyl-formate-letter.pdf.* Accessed September 30, 2010.

Center for Sustainable Production and Consumption (C-SPAC). 2005. "Ecofridge: Make the Right Choice Now." *Consumer Unity & Trust Society (CUTS)*. Available online at: http://www.cuts-international.org/sc98-1.htm. Accessed September 20, 2010.

Earthcare. 2008. Personal communications between Earthcare Products Ltd and ICF International. May 2008 and October 2008.

Ecomate by Foam Supplies, Inc. 2010. "Refrigeration." Available online at: http://www.ecomatesystems.com/resources/refrigeration.php. Accessed September 24, 2010.

Greenpeace. 2010. "Cool Technologies: Working Without HFCs—2010, Examples of HFC-Free Cooling Technologies in Various Industrial Sectors." Presented at the 30th Open-Ended Working Group of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer. June 2010. Available online at: http://www.unep.ch/ozone/Meeting_Documents/oewg/30oewg/conf-ngos/COOLING%20%20WITHOUT%20HFCs%20-%20 2010-GREENPEACE.pdf. Accessed September 30, 2010.

International 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 Intergovernmental Panel on Climate Change. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (Eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. September 2007. Available online at: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html. Accessed September 30, 2010.

International Panel on Climate Change (IPCC)/Technology and Economic Assessment Panel (TEAP). 2005. "Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons." Metz, B., K. Lambert, S. Solomon, S.O. Andersen, O. Davidson, J. Pons, D.d. Jager, T. Kestin, M. Manning, and L. Meyer (Eds.). Cambridge University Press, United Kingdom. Available online at: http://www.ipcc.ch/publications_and_data/publications_and_data_reports_safeguarding_the_ozone_layer.htm. Accessed September 30, 2010.

Quintero, Miguel. 2010. "Latest Technology Development and Industry Trends in the PU Sector." Presented at the Workshop on Low-GWP HCFC Replacement in the Foam Sector. Seoul, South Korea. May 6, 2010. Available online at: http://www.slideshare.net/ozonaction/state-of-the-art-in-the-pu-sub-sectortechnology-options-and-trends-4680731. Accessed September 30, 2010.

Shecco. 2010. "BeyondHFCs position paper on 2010 TEAP report presented at 30th Open-Ended Working Group of Parties to the Montreal Protocol." Presented at the 30th Open-Ended Working Group of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer. June 2010. Available online at: http://www.unep.ch/ozone/Meeting_Documents/oewg/30oewg/conf-ngos/Beyond%20HFCs%20position%20on%202010%20 TEAP%20report.pdf. Accessed September 30, 2010.

Technology and Economic Assessment Panel (TEAP). 2010. "TEAP 2010 Progress Report, Volume 1: Assessment of HCFCs and Environmentally Sound Alternatives, Scoping Study on Alternatives to HCFC Refrigerants under High Ambient Temperature Conditions." May 2010. Available online at: http://www.unep.ch/ozone/Assessment_Panels/TEAP/Reports/TEAP_Reports/teap-2010-progress-report-volume1-May2010.pdf. Accessed September 30, 2010.

Technology and Economic Assessment Panel (TEAP). 2010. "TEAP 2010 Progress Report, Volume 2: Progress Report." May 2010. Available online at: http://ozone.unep.org/Assessment_Panels/TEAP/Reports/TEAP_Reports/teap-2010-progress-report-volume2-May2010.pdf. Accessed September 30, 2010.

Technology and Economic Assessment Panel (TEAP). 2009. "Task Force Decision XX/8 Report, Assessment of Alternatives to HCFCs and HFCs and Update of the TEAP 2005 Supplement Report Data." May 2009. Available online at: http://www.unep.ch/ozone/Assessment_Panels/TEAP/Reports/TEAP_Reports/teap-may-2009-decisionXX-8-task-force-report.pdf. Accessed September 30, 2010.

United Nations Environment Programme (UNEP). 2006. "2006 Assessment Report of the Rigid and Flexible Foams Technical Options Committee." March 2007. Available online at: http://ozone.unep.org/teap/Reports/FTOC/ftoc_assessment_report06.pdf. Accessed September 30, 2010.

[1] The four fact sheets in this series (October 2010) cover domestic refrigeration, commercial refrigeration, motor vehicle air conditioning, and unitary air conditioning. These four end-uses represent about 85% of HFC consumption in the refrigeration/AC sector. The remaining HFC consumption in the refrigeration/AC sector comes from other end-uses including chillers, cold storage, industrial process refrigeration, and refrigerated transport. Any service-related consumption is attributed to the specific end-use.

[2] HFOs (hydrofluoro-olefins) are unsaturated HFCs. HFO-1234yf refrigerant is also commonly referred to as HFC-1234yf or R-1234yf, as it is referred to in the remainder of this fact sheet.

[3] HFO-1234ze is also commonly referred to as HFC-1234ze or R-1234ze.

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