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.

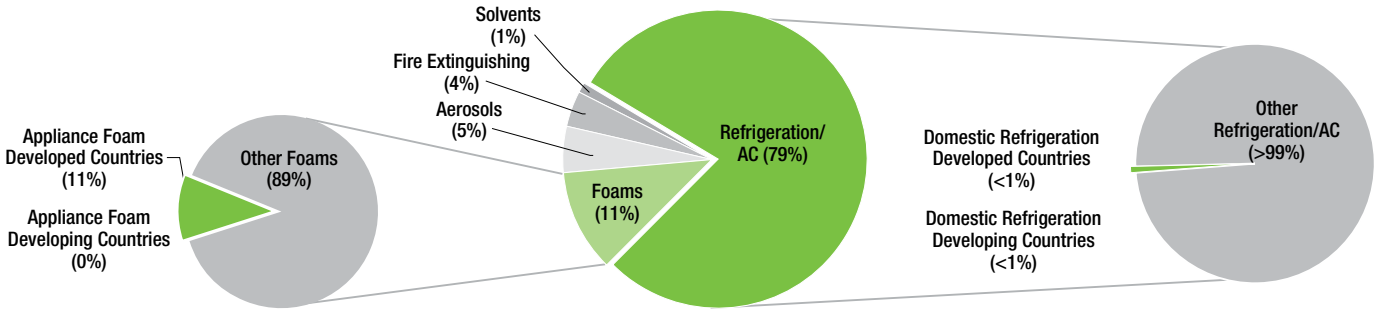
Domestic refrigeration accounts for less than 1% of HFC consumption in the refrigeration/AC sector and approximately 11% of HFC consumption in the foams sector; combined, this accounts for nearly 2% of global HFC consumption in 2010. Developing countries account for approximately 12% of the global HFCs 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

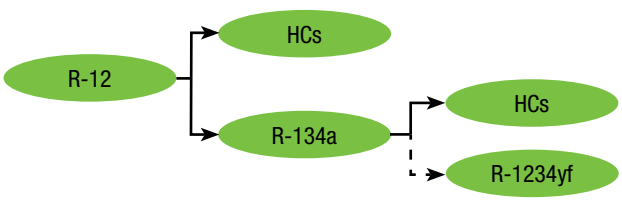
Methyl Formate

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

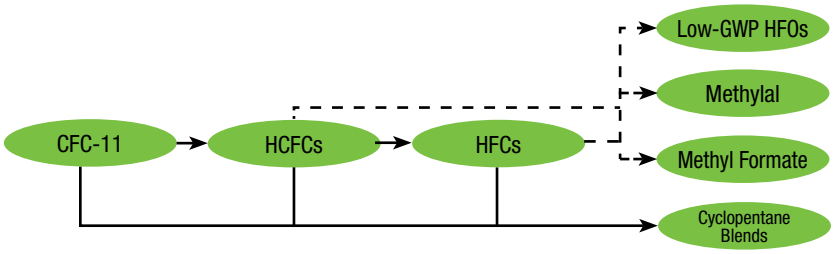
Chemical	GWP	ODP[a]
Refrigerant		
R-12	10,900	1
R-134a	1,430	0
R-1234yf	4	0
R-600a (isobutane)	3	0
Blowing Agent		
CFC-11	4,750	1
HCFC-142b	2,310	0.065
HCFC-22	1,810	0.055
HFC-134a	1,430	0
HFC-245fa	1,030	0
HFC-365mfc	794	0
HCFC-141b	725	0.11
Cyclopentane	<25	0
Methylal	<25	0
Methyl Formate	<25	0
HFO-1234ze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

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[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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