TRANSITIONING TO LOW-GWP ALTERNATIVES
in Commercial Refrigeration

Background

This fact sheet provides current information on low global warming potential (GWP)[1] alternative refrigerants to high-GWP hydrofluorocarbons (HFCs) for use in commercial refrigeration equipment. HFCs are powerful greenhouse gases (GHGs) with GWPs hundreds to thousands of times more potent per pound than carbon dioxide (CO_2); however, more low-GWP alternatives are becoming available.

Commercial refrigeration equipment is used to store and display chilled or frozen goods for customer purchase at supermarkets, convenience stores, restaurants, bars, cafeterias, hotels, and other food service establishments. In the federal sector, this equipment can be found in commissaries as well as hospitals, prisons, and school cafeterias. Equipment used in these applications have a typical lifetime of 10 to 20 years and generally fall into three main categories:

Stand-Alone/Self-Contained Refrigeration Systems

- Integrate all refrigerating components within their structures
- Examples include: reach-in refrigerators and freezers, beverage coolers, food service equipment, refrigerated food processing and dispensing equipment, refrigerated vending machines, ice makers, and water coolers
- Small refrigerant charge sizes (typically 0.5 – 6.5 lbs.); most often contain HFC-134a or R-404A (an HFC blend)

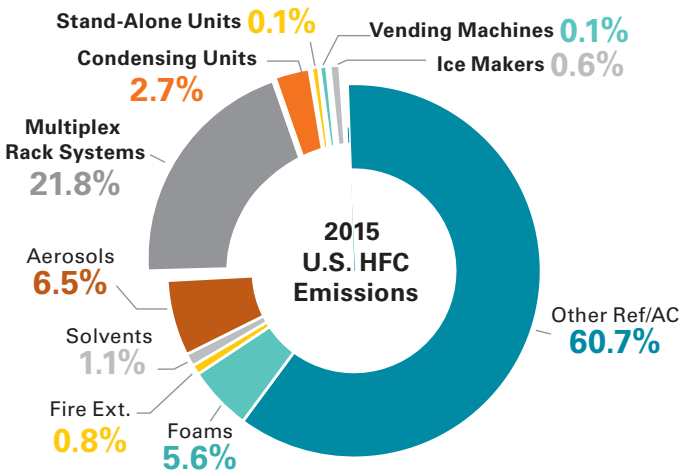
Condensing Unit Systems

- Consist of one or two compressors, one condenser, and one receiver assembled into a modular system; linked to one or more display case(s) or a cold room in the sales area through a piping network; commonly used in convenience stores
- Refrigerant charges typically range from 1 – 45 lbs.; most often contain HFC-134a or R-404A, although other HFC blends are also used (e.g., R-407A, R-407F, R-507A)
- While research on low-GWP refrigerants is ongoing, condensing unit systems can typically be substituted by stand-alone or rack systems using low-GWP alternatives

Multiplex Rack Systems

- Remote refrigeration systems consisting of racks of multiple compressors and other components that are connected to a remote condenser; linked to multiple display cases in the sales area through a refrigerant piping network; common in supermarkets
- Refrigerant charge sizes range from approximately 650 – 4,000 lbs. depending on supermarket size and system design; most often contain R-404A, R-507A, and R-407A, although many systems containing ozone-depleting hydrochlorofluorocarbon (HCFC)-22 still remain in use
- Centralized direct expansion (DX) systems, which circulate a refrigerant from the central machinery room to the sales area, are most commonly used, although more advanced designs that reduce or replace HFC refrigerant are gaining in popularity

In 2015, U.S. emissions from commercial refrigeration equipment were estimated at 41.6 million metric tons of carbon dioxide equivalent (MMT CO_2 Eq.), or roughly 25% of total national HFC emissions.



U.S. HFC Emissions: 169 MMT CO_2Eq.
U.S. HFC Emissions in Commercial Refrigeration: 41.6 MMT CO_2Eq.

Source: U.S. EPA (2016)

[1] GWP is a measure of a substance's climate warming impact compared to CO_2.

Low-GWP Alternatives & Market Trends

In the past, commercial refrigeration systems in the United States relied on chlorofluorocarbons (CFCs) and HCFCs, substances that both destroy the stratospheric ozone layer, which shields the Earth from the sun's harmful ultraviolet radiation, and contribute to climate change. In response to the phaseout of CFCs and the ongoing phaseout of HCFCs, refrigeration equipment manufacturers have transitioned to using non-ozone depleting refrigerants, primarily to HFCs. Today, many design strategies are becoming available to reduce the amount of refrigerant needed in multiplex rack systems while at the same time reducing the likelihood of leaks and mitigating the risks of potential leaks of flammable or toxic refrigerants. Although most of these advanced refrigeration systems still rely on HFC refrigerants, they have great potential for significantly reducing HFC emissions from large commercial refrigeration systems. In addition, a number of alternatives to CFC/HCFC/HFC refrigerants are available for use in various commercial refrigeration applications.

EPA's Significant New Alternatives Policy (SNAP) Program ensures the smooth transition to alternatives that pose lower overall risk to human health and the environment. Under SNAP, EPA has listed several alternatives as acceptable for use in retail food refrigeration equipment, including: propane (R-290), ammonia (R-717), and carbon dioxide (CO_2, R-744). Hydrofluoroolefins (HFOs) blended with other refrigerants are also listed as acceptable for use in some or all commercial refrigeration applications. Examples currently being used include R-448A, R-449A, R-450A, and R-513A. None of these alternatives deplete the ozone layer and all have significantly lower impacts to the climate system than CFCs, HCFCs, and HFCs.

SNAP rulemakings published in July 2015 and December 2016 list up to 33 refrigerants and refrigerant blends as unacceptable in newly manufactured supermarket systems (starting in 2017), remote condensing units (starting in 2018), vending machines (starting in 2019), stand-alone units (starting in 2019 and 2020), and refrigerated food processing and dispensing equipment (starting in 2021) (see Table 1).

Table 1. Changes in SNAP Listing Status for Refrigerants in Commercial Refrigeration

End-Use	Final Rule Change of Status Date*
Supermarket Systems (Retrofitted)	July 20, 2016
Supermarket Systems (New)	January 1, 2017
Remote Condensing Units (Retrofitted)	July 20, 2016
Remote Condensing Units (New)	January 1, 2018
Stand-Alone Retail Food Refrigeration Equipment (Retrofitted)	July 20, 2016
Stand-Alone Retail Food Refrigeration Equipment (New)	January 1, 2019 / January 1, 2020
Vending Machines (Retrofitted)	July 20, 2016
Vending Machines (New)	January 1, 2019
Refrigerated Food Processing and Dispensing Equipment (New)	January 1, 2021

*Please refer to the SNAP website for more detailed information about unacceptable refrigerants and more details on when the changes in listing status will become effective.

Significant New Alternatives Policy (SNAP) Program Facts

- Program authorized under Clean Air Act Title VI
- Evaluates substitutes and lists as acceptable those that reduce overall risk to human health and environment; lists acceptable with use conditions if needed to ensure safe use; or lists as unacceptable.
- Industrial sectors include: Refrigeration and Air Conditioning, Foam Blowing, Solvent Cleaning, Fire Suppression, Aerosols, Sterilants, Adhesives, Coatings and Inks, and Tobacco Expansion.
- Since it was established in 1994, SNAP has reviewed over 400 substitutes.
- SNAP considers:
  - Ozone Depleting Potential (ODP)
  - Global Warming Potential (GWP)
  - Flammability
  - Toxicity
  - Occupational and Consumer Health/Safety
  - Local Air Quality
  - Ecosystem Effects

Table 2. GWPs of Refrigerants for Commercial Refrigeration

Refrigerant	GWP*
CFC-12	10,900
R-502	4,657
R-507A	3,985
R-404A	3,922
R-407A	2,107
R-407F	1,825
HCFC-22	1,810
R-407C	1,774
HFC-134a	1,430
R-449B	1,412
R-449A	1,396
R-448A	1,387
R-513A	630
R-450A	601
R-290 (propane)	3.3
R-600a (isobutane)	3
CO_2 (R-744)	1
R-717 (ammonia)	0

Note: Chemicals in gray shading are no longer used in new equipment because of their ozone depletion potential.

*GWP values are from the Intergovernmental Panel on Climate Change Fourth Assessment Report: Climate Change 2007.

Advanced Refrigeration System Designs

- Advanced systems tend to operate with a smaller HFC refrigerant charge than a traditional centralized DX system—typically 50%-80%; these systems also often use a non-fluorinated refrigerant (e.g., CO_2, ammonia)
- Examples include distributed,[1] secondary loop,[2] compact chiller,[3] cascade,[4] and transcritical systems,[5] which collectively are estimated to account for at least 50% of new market sales in the United States

Propane (R-290)

- Growing use in stand-alone systems; for example, Ben & Jerry's has installed more than 4,500 propane ice cream freezer cabinets across the United States
- Some supermarkets are using multiple propane stand-alone units in lieu of a multiplex rack system to cool the majority of their refrigerated cases and walk-in coolers and freezers; in 2013, H-E-B at Mueller became the first supermarket in the United States to employ this novel application of stand-alone equipment
- R-290 in a cascade design is used in North America and Europe; in 2016, a Whole Foods supermarket in California installed a trial propane/CO_2 cascade rack system, which was the first of its kind in the United States

Ammonia (R-717)

- Proven refrigerant in industrial refrigeration systems, now entering the commercial refrigeration market
- Ammonia-based multiplex rack systems often use a cascade design with CO_2; in this design, ammonia is used to condense CO_2 which is then circulated throughout the store to cool the refrigerated cases
- In 2012, an Albertsons supermarket in California became the first of its kind to install a trial ammonia-based rack system; since then, three other supermarkets have installed ammonia/CO_2 cascade rack systems, including a Piggly Wiggly in Georgia, a Whole Foods in California, and the Lackland Air Force Base Commissary in Texas

Carbon Dioxide (CO_2, R-744)

- Used by major beverage companies (e.g., Coca-Cola, PepsiCo) to replace HFC-134a in vending machines
- In multiplex rack systems in the United States, most commonly used as the heat transfer fluid (i.e., secondary fluid) in secondary loop systems or in the low-temperature loop in cascade systems
- In 2013, the Hannaford supermarket in Turner, ME became the first store in the United States to install a CO_2 transcritical system; there are now over 50 supermarkets using CO_2 transcritical systems in the United States
- Development for use in condensing units in the United States is ongoing

HFO/HFC Blends

- New refrigerant blends (e.g., with HFCs and HFOs) with reduced GWPs, such as R-448A, R-449A, R-449B, R-450A, and R-513A, became acceptable for use in commercial refrigeration applications under SNAP in 2014 and 2015
- Use began in 2014; market penetration is expected to increase in the next few years

Transcritical CO_2 Refrigeration Systems Gain Momentum in the United States

The Hannaford supermarket in Tuner, ME became the first grocery store in the United States to use 100% CO_2 in its refrigeration system. The store opened in July 2013 and is running on what is known as a CO_2 transcritical system. The basic design of a CO_2 transcritical system is comparable to that of a traditional DX system. The key difference, however, is that CO_2 operates at higher pressures and thus requires specialized components with higher pressure ratings. Beside the benefit of using a low-GWP refrigerant, these systems also offer 5-10% better efficiency than conventional HFC-based DX systems in cooler climates. Since the opening of the Hannaford store, several other supermarket chains have opened over 50 stores using CO_2 transcritical refrigeration systems including Whole Foods, Sprouts Farmers Market, Kroger, Roundy's, ALDI, Giant, New Seasons Market, and Food Lion. The Sprouts store in Dunwoody, GA was the first to demonstrate that CO_2 transcritical refrigeration systems are also a viable option in warmer climates.

Future Outlook

Together, the suite of known alternative chemicals and new technologies can significantly reduce HFC use in both the near and long term. Although much work remains to fully adopt these chemicals and technologies, and some challenges lay ahead, the commercial refrigeration industry are working on developing new alternatives. Within the next few years, it is expected that many if not most new commercial refrigeration systems sold in the U.S. market will contain low-GWP alternative refrigerants.

[1] Distributed systems use an array of separate compressor racks located near the refrigerated cases rather than having a central compressor system.

[2] Secondary loop systems combine two refrigerants to provide cooling. An HFC is typically used as the primary refrigerant, which is used to cool a secondary fluid (e.g., glycol or CO_2) that is circulated throughout the store to the display cases.

[3] Compact chiller systems are a type of secondary loop system that rely on a lineup of 10–20 units, each using approximately 9–15 lbs. of refrigerant.

[4] Cascade systems use a compressor to raise the low-temperature coolant (often CO_2) from low-temperature conditions up to an intermediate temperature while a separate refrigerating system uses a different refrigerant to condense the coolant.

[5] Transcritical systems use CO_2 as the primary refrigerant and operate at a high pressure to accommodate the low critical temperature of CO_2.

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