E360 Outlook SEPTEMBER 2017

Natural selection

More retailers opt for natural refrigerant systems

By Andre Patenaude, Director, CO_2 Business Development Copeland

COPELAND
Engineered for Sustainability

In an era driven by the necessity to deploy more environmentally responsible refrigeration systems, very few refrigerants can achieve regulatory compliance and meet corporate sustain.ability objectives. On this short list are three natural refrigerant options: carbon dioxide (CO_2 or refrigerant name R-744); the hydrocarbon propane (refrigerant name R-290); and ammonia (NH^3 or refrigerant name R-717).

With all the debate about which synthetic refrigerant blends will replace common hydrofluorocarbons (HFCs) targeted for phase-down by the Environmental Protection Agency (EPA), some consider these natural refrigerant alternatives to be not only the best current options, but also "future-proof" in their ability to support the next generation of system architectures. Make no mistake: these refrigerants are by no means perfect — each has its own caveats — but in terms of thermodynamic properties, operational efficiencies and eco-friendliness, natural refrigerants are truly in a class by themselves.

The term *natural refrigerant* refers to substances that naturally occur in the environment. From a historical perspective, natural refrigerants were among the first to be used in refrigeration applications. In recent decades, as synthetic chlorofluorocarbon (CFC) and HFC refrigerants were found to have either ozone depletion potential (ODP) or global warming potential (GWP), natural refrigerants have made their way back into the commercial refrigeration conversation.

While new synthetic refrigerants are being developed that offer lower GWP levels and much reduced environmental threats, many of these substances have yet to be fully vetted or deemed as acceptable substitutes by regulatory bodies. In contrast, natural refrigerants are not only the benchmark for ultra-low GWP and ODP, they're also listed as acceptable for use in most refrigeration applications (subject to use conditions).

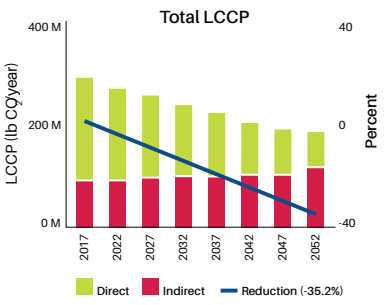
Refrigerant phase-down calculator

Copeland has developed a useful tool to help retailers make the transition from higher-GWP HFC refrigerants to lower-GWP natural and synthetic refrigerant alternatives. The web app helps decision makers forecast the life cycle climate performance (LCCP) of a franchise or store based on their preferred refrigeration architectures and refrigerant choices. As CO_2 systems become more common in larger food retail applications, this tool will help retailers demonstrate the impacts of phasing down their current carbon footprint impacts while phasing in lower-GWP options.

End users start by inputting key information about their current and proposed system architectures, such as: design temperatures for stores; store counts of current and future architectures; leak rates; and refrigerant choice. Then, the end user can calculate the phase-down impacts and down-load graphical charts that will help them demonstrate the impacts. The refrigerant phase-down calculator provides grocers with the following insights:

- Total carbon footprint impacts and LCCP in individual stores and across an enterprise
- Forecasts the impacts of phase-down and phase-in of new refrigerants and system architectures
- Key metrics that can be downloaded as charts, including: total LCCP per franchise; total LCCP per store; weighted GWP per store; and total weighted GWP

System architecture store count								
Year	2017	2022	2027	2032	2037	2042	2047	2052
Centralized:	50	45	40	35	30	25	20	15
Distributed:	0	5	10	15	20	25	30	35
CO_2 Booster:	0	2	4	6	8	10	12	24
Total:	50	52	54	56	58	60	62	74



Grocers can use Copeland's refrigerant phase-down tool to forecast the impacts of phasing down higher-GWP systems and phasing in new refrigerant architectures.

Innovative installations

Today, the use of natural refrigerants is on the rise. As technologies improve, equipment manufacturers are working closely with early adopters to develop innovative solutions. This has resulted in several creative natural refrigeration applications that belie their traditional uses — like ammonia being used in supermarket systems and CO_2 playing a larger role in industrial process cooling.

Ammonia trials in food retail

In September 2015, the Piggly Wiggly supermarket company opened a new 36,000 square-foot store in Columbus, Ga., that utilizes an NH_3/CO_2 cascade system manufactured by Heatcraft Worldwide Refrigeration. The all-natural refrigerant system uses an ultra-low charge of ammonia (53 pounds) located away from occupied spaces (on the facility's roof). The ammonia condenses the CO_2 and is circulated to the store's low-temperature cases via direct expansion; the medium-temperature circuit is cooled by a CO_2 liquid pump overfeed. Since the total refrigerant charge of the system has a GWP under 150, this store is one of 10 supermarkets in the U.S. to receive the highest certification level (platinum) from the EPA's GreenChill Partnership. It's also the fourth supermarket in the U.S. to use this NH_3/CO_2 cascade architecture.

CO_2 adoption in industrial cooling

In cold storage applications, where ammonia has been the pre.ferred refrigerant for decades, companies are also seeking to lower ammonia charges. As older ammonia systems near replacement, many operators are evaluating the best option to expand their facility's low-temperature capabilities. They're accomplishing this by adopting NH_3/CO_2 cascade systems that not only utilize very low charges of ammonia, but also keep the R-717 circuit out of occupied spaces. There's also a regulatory driver behind this trend.

Propane in food retail

When major retailers like Target publicly announce their intentions to use only propane in their self-contained units, it's an indication that the perceptions about the mainstream viability of R-290 are shifting. The smaller charge limits make R-290 a logical fit for Target's smaller, stand-alone refrigerated display cases and coolers. All of this is part of the retailer's pledge to become a sustainability leader in the food retail space.

While efforts are needed to mitigate their associated risks and ensure their safe use, natural refrigerants represent true sustainable alternatives without sacrificing performance. As regulatory bodies and industry organizations work to refine these standards, natural refrigerants will continue to play a key role in the future of commercial and industrial refrigeration.

Evolving safety standards

There are currently several global efforts in effect and underway to evaluate refrigerant classifications, ensure safety standards, and govern the charge limits of R-290 and R-717.

R-290

- International Electrotechnical Commission (IEC) has formed a working group to evaluate the potential of raising the charge limit from 150g to 300g–500g in the U.S. This has broad implications for expanding the size and efficiency of self-contained applications.
- $5.2M partnership by AHRI, ASHRAE and the DOE to study flammable refrigerant behavior in real-world applications

R-717

- Occupational Safety and Health Association (OSHA) created the Process Safety Management of Highly Hazardous Chemicals (29 CFR 1910.119) standard to ensure the safety of systems that require more than 10,000 pounds of ammonia.
- OSHA's National Emphasis Program (NEP) on process safety management-regulated industries has recently stepped up enforcement, requiring owners and operators of large ammonia systems to maintain continuous record keeping in preparation for NEP inspections.

Know your naturals

Ammonia

R-717 was among the first refrigerants to be used in refrigeration applications. Its superior thermodynamic properties made it a logical first choice, but its toxicity (classified as B2L: low flammability and high toxicity) has been a deterrent to operators unwilling to risk potential leaks. The advent of CFC refrigerants in the mid-twentieth century drove the refrigeration industry away from R-717 toward lower-risk synthetic alternatives. To this day, ammonia's suitability in low-temperature applications has made it a mainstay in industrial, process cooling, cold storage and ice rink applications. Through leak detection protocols, careful adherence to safe application procedures and lower refrigerant charges, R-717 systems can be used safely and effectively in a broad range of refrigeration applications.

Propane

Propane is a hydrocarbon that was also identified in the early days of refrigeration as an effective refrigerant. Its high-capacity, energy-efficient performance and very low GWP are offset by its classification as an A3 (highly flammable) substance. But, as synthetic refrigerants became available for many refrigeration applications, R-290 was largely abandoned in lieu of its CFC-based counterparts. Since the 2000s, R-290 has been regaining global popularity as a lower-GWP, effective alternative to HFCs like R-404A and HFC-134a — especially in a wide range of low-charge, reach-in displays.

Carbon dioxide

Non-toxic and non-flammable, CO2 has proved to be a very effective alternative to HFCs in both low- and medium-temperature applications. CO2-based refrigeration systems have been successfully deployed in commercial and industrial applications in Europe for nearly two decades. Because of its low critical point (87.8 °F) and high operating pressure (around 1,500 psig or 103 bar), CO2 refrigeration strategies — such as cascade, secondary and transcritical booster — must be designed to account for its unique characteristics. In light of current environmental regulations, the popularity of these systems has increased significantly in North America in recent years.

Natural refrigerant	GW	ODP	Special considerations	Trends in refrigeration system
Ammonia (R-717)	0	0	• Potentially toxic • Slightly flammable	• Very low charge requirements • Used in the high stage to absorb heat and/or cool R-744 • Far removed from occupied spaces
Carbon dioxide (R-744)	1	0	• High pressure • Low critical point • High triple point	• Very little danger to occupants in the event of leaks • Used in medium and low stages • Pumped into the fixtures used in occupied spaces, rather than R-717
Propane (R-290)	3	0	• Highly flammable	• Very low charge requirements (currently 150 grams is the max)

About Copeland

Copeland is a global leader in sustainable heating, cooling, refrigeration and industrial solutions. We help commercial, industrial, refrigeration and residential customers reduce their carbon emissions and improve energy efficiency. We address issues like climate change, growing populations, electricity demands and complex global supply chains with innovations that advance the energy transition, accelerate the adoption of climate friendly low GWP (Global Warming Potential) and natural refrigerants, and safeguard the world's most critical goods through an efficient and sustainable cold chain. We have over 18,000 employees, with feet on the ground in 50 countries - a global presence that makes it possible to serve customers wherever they are in the world and meet challenges with scale and speed. Our industry-leading brands and diversified portfolio deliver innovation and technology proven in over 200 million installations worldwide. Together, we create sustainable solutions that improve lives and protect the planet today and for future generations. For more information, visit copeland.com.

To learn more, visit **copeland.com**

COPELAND
Engineered for Sustainability