

CO₂ Leaves a Smaller Carbon Footprint in Large-Format Food Retail Market

Harmless environmental profile driving wider adoption



The large-format food retail market has always been at the leading edge of refrigeration technology. After all, these grocery and supermarket chains must continually deliver the fresh foods that feed much of the global population. Market drivers and refrigerant regulations in recent years have added an increased focus on sustainability to the list of priorities for large-format retailers. Among the natural refrigerant alternatives suitable for these centralized applications, CO₂ (or refrigerant R-744) leads the pack.

Offering zero ozone depletion potential (ODP) and a global warming potential (GWP) of 1, CO₂ is often considered the environmental standard by which all other refrigerants are measured. In a regulatory era when chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs) are being phased out due to their negative

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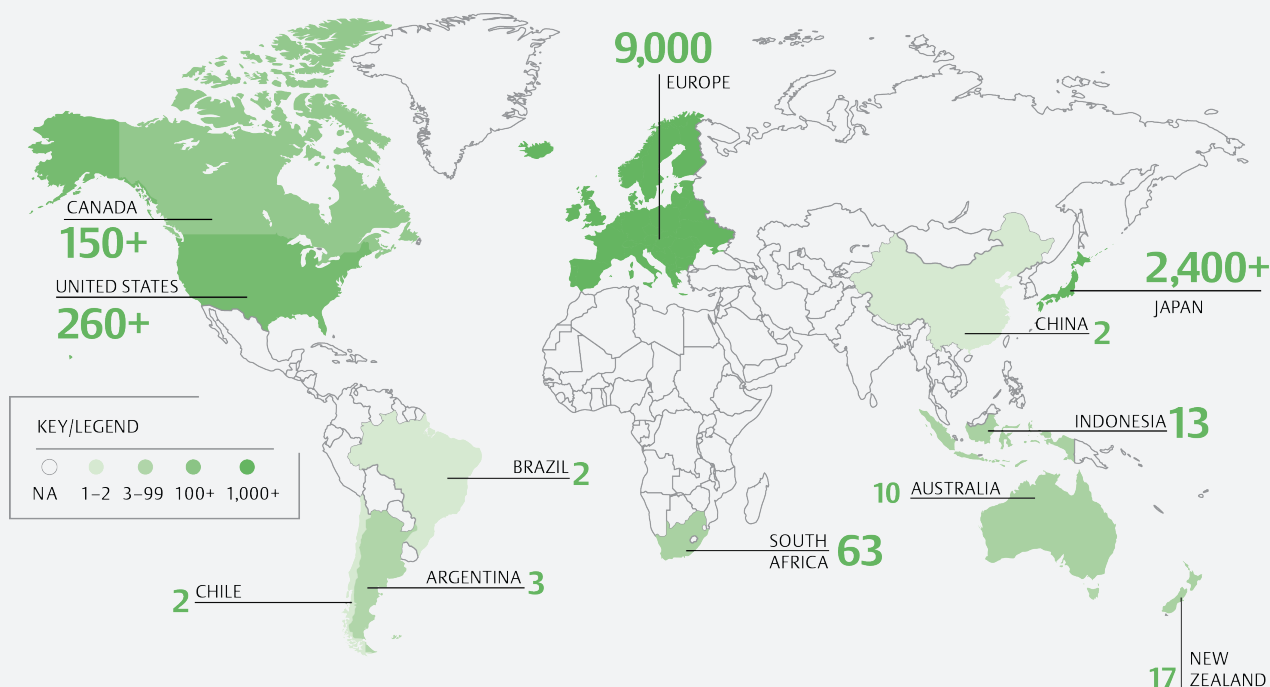
environmental impacts, CO₂'s harmless environmental profile has led to a broad global uptake in large-format refrigeration applications.

CO₂ has neither the flammability nor toxicity challenges posed by other natural refrigerant alternatives, providing an additional comfort level for consumer-facing refrigeration applications. As energy efficiencies and the reliability of CO₂ refrigeration systems rise, system costs are falling to levels typically found in traditional HFC systems. For these reasons, CO₂ has become the natural refrigerant of choice for large-format food retailers.

Global adoption of CO₂ refrigeration on the rise

CO₂ refrigeration systems were originally introduced in Europe nearly two decades ago and have since moved into other regions around the globe. Today, CO₂ adoption has migrated from Europe to Japan and North America. Here's a recent look at the amount of worldwide CO₂ refrigeration installations:

CO₂ TC STORES GROWING GLOBALLY (Feb. 2017)



Source: Shecco, *Natural Refrigerants: Global market trends*, ATMOSphere Australia, Sydney, May 2, 2017

The number of CO₂ stores in the E.U., Norway and Switzerland has tripled in the last three years, representing 8 percent of the overall food retail market share in these regions. In North America, retailers are still in an experimental "trial" phase to see how CO₂ — and other natural refrigerants for that matter — can be used in their facilities, and across varying climatic zones.

HFC phase-down driving refrigeration architecture changes

As older systems age and require upgrading or replacement, many large-format food retailers are making the transition from higher-GWP, HFC refrigeration architectures to lower-GWP systems. From a regulatory perspective, the Environmental Protection Agency's (EPA) 2015 ruling prohibits the use of R-404A and other higher-GWP refrigerants in new supermarket rack systems. Even though the Trump administration brings with it the potential for deregulation, most of the Obama-era commercial refrigeration regulations are still intact. Meanwhile, global regulatory efforts to phase down HFCs continue, including the recent Kigali Amendment to the Montreal Protocol, the E.U. F-gas regulations and Environment Canada's initiatives.

The trend toward eco-friendly refrigeration is also being driven by the private sector and discussed in corporate boardrooms. As industry organizations like the Consumer Goods Forum advocate the use of energy-efficient and environmentally friendly refrigeration systems, more retailers are now stating formal sustainability objectives.

In Europe, the phase-down of HFCs is already impacting the refrigerant supply chain. As a 37 percent reduction in F-gas quotas is set for 2018, retailers can expect price increases by HFC suppliers and manufacturers to put more pressure on their maintenance budgets. In fact, Europe recently saw the price of R-404A increase by 62 percent in one month. Globally, the industry can also expect HFCs to become scarce and more expensive.

California, led by the California Air Resources Board (CARB), is an example of how the HFC phase-down is being more aggressively pursued. CARB estimates that more than 2,400 facilities still use R-22 in commercial refrigeration systems in California; R-22 is an HCFC refrigerant that was banned from use in new equipment by the EPA in 2010. As the sixth-largest global economy in the world, the state has a tremendous amount of global influence.

Through CARB, California proposed a ban on the sale or distribution of refrigerants with 100-year GWP values of 2,500 or greater. Only refrigerants that are certified reclaimed or recycled would be exempt from the sales ban. CARB has not yet confirmed the exact date of this ban, though it was originally slated for 2020.

Operating costs and considerations

The steady increase in global CO₂ refrigeration adoption has led equipment and component manufacturers to not only increase production, but also make continued investments in research and development to refine CO₂ technologies. These economies of scale are helping to lower CO₂ system costs and reduce complexities for end users and service technicians alike.

CO₂ refrigerant characteristics

From a maintenance and operations perspective, it's important to understand CO₂'s unique performance characteristics.

Higher operating pressure

- Around 1,500 psig (103 barg) on the high-pressure lines (discharge and return lines connected to the gas cooler only)
- Between 200 and 540 psig (14 and 37 barg) for the low- and medium-temperature suction groups, and the liquid line
- Robust components, smaller diameter piping, additional pressure relief valves and check valves required

Low critical point: 88 °F

- Well suited for cooler climates
- Back-up power and refrigeration unit recommended to avoid system pressure increase in the event rack is off
- Excellent heat reclamation opportunities
- Smaller equipment footprint due to its thermodynamic characteristics

Emerging warmer climate technologies

To expand CO₂'s applicability in warmer climates (where it faces operational challenges), OEMs and component manufacturers have developed new technologies:

- Parallel compression
- Ejectors
- Adiabatic gas cooling
- Mechanical sub-cooling

CO₂ training—both formal and hands-on types—has greatly improved as the industry becomes much more familiar with CO₂ architectures and performance characteristics. Even refrigeration consultants are becoming well-versed in CO₂ systems and can make more educated recommendations.

Unlike HFC systems, CO₂ system requirements introduce the need for additional electronic components for refrigeration cases, including: a case controller, pressure transducer, temperature sensor and electronic expansion valve. While these components may contribute to increased system costs, case controllers provide end users with precise temperature controls and ongoing, optimized energy efficiencies.

CO₂ system architectures: opportunities in food retail

Food retailers seeking to make the move to CO₂ refrigeration have two primary system types from which to choose: CO₂ transcritical booster and cascade systems. A closer look at each option may help you decide which is a better fit for your operations.

CO₂ transcritical booster is a 100 percent R-744 system, utilizing direct expansion (DX) for low- and medium-temperature suction groups. This system is called *transcritical* because it is designed to operate at pressures above CO₂'s critical pressure (or 1,500 psig). Heat produced from low-temperature case compressors are rejected into the medium-temperature suction group's compressors. Medium-temperature compressors must be sized to handle the total heat of rejection of low-temperature loads, 100 percent of the medium-temperature load and the flash tank bypass load. Only one condenser or gas cooler is needed for all low- and medium-temperature cases. CO₂ pumped technology — where CO₂ is used as a secondary fluid — is also available on both low- and medium-temperature stages. The system requires the use of high-pressure controllers and electronic expansion valves to optimize pressures and refrigerant quality to the cases.

Cascade systems utilize two distinct refrigeration circuits: a CO₂ circuit for the low-temperature suction group, and an HFC-based circuit (such as HFC-134a) is for the medium-temperature needs. It's called *cascade* because the heat produced from the low-temperature circuit is discharged into the suction stage of the medium-temperature circuit via an intermediate heat exchanger. Medium-temperature compressors send gas to an air-cooled condenser on the roof. Like a standard refrigerant, CO₂ is maintained below its critical point (or subcritical) of 88 °F. Electronic expansion valves and case controls are still required in the low-temperature, CO₂-fed cases. Some retailers have even experimented with using NH₃ (ammonia) as the medium-temperature refrigerant for an all-natural cascade system.

CO₂ likely to grow in the U.S.

Economies of scale and equipment improvements will continue to drive down first costs and increase CO₂ adoption in North America. While the U.S. is still in the early phases of trials and experimentation, every successful implementation increases the likelihood of more stores making the transition to CO₂. Safe, environmentally friendly, economical and reliable: CO₂ has all the characteristics that make it a candidate for the large-format refrigerant of the future.

The benefits of going green



For those U.S. retailers who have begun the transition to CO₂ refrigeration, the benefits are obvious. New Seasons, for example, is a Northwestern grocer whose first CO₂ system delivered on its green promise. When the retailer opened a new store in a location previously owned by another grocer, they installed a CO₂ transcritical booster system to replace the existing HFC system. The transition earned the store a GreenChill Platinum Certification award for green refrigeration and delivered the following improvements:

- Up to 30 percent lower total equivalent warming impacts (TEWI)
- 95 percent fewer refrigerant emissions
- Smaller refrigeration footprint

New Seasons has plans for CO₂ installations in other stores.