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Alternative refrigerant options for a new decade

How lower-GWP systems are forging a path to the future of refrigeration

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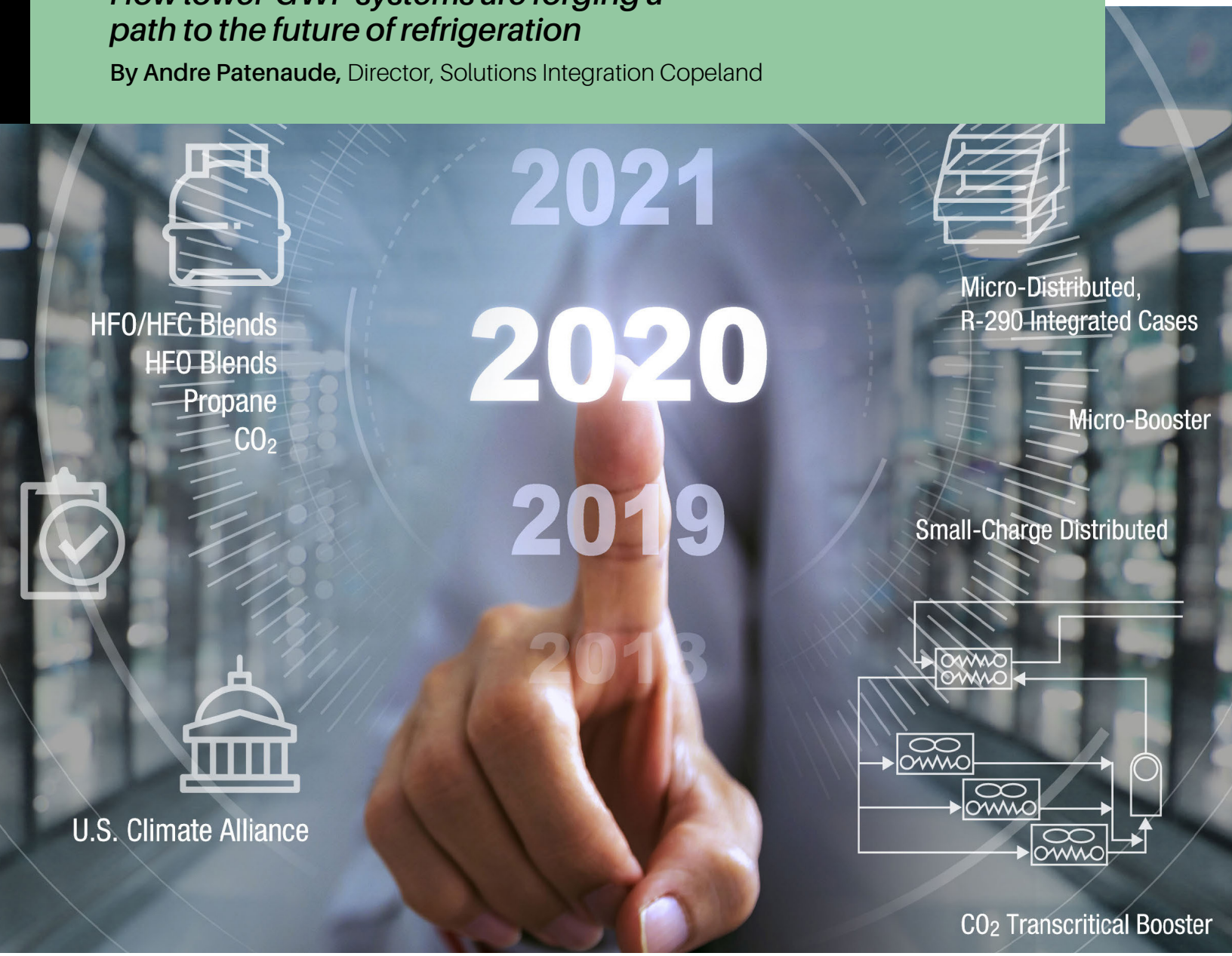

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With regulations potentially varying from state to state, owners and operators are attempting to make refrigeration equipment decisions that align with both their regional. environmental mandates and unique operational objectives.

As we enter a new decade, it's apparent that the global movement toward environmentally friendly refrigeration systems is more than a temporary trend. For more than a decade, component manufacturers, OEMs, contractors and end users have been developing and introducing technologies based on refrigerants that offer lower global warming potential (GWP)—both natural and synthetic options—which represent viable alternatives to traditional hydrofluorocarbon (HFC)-based systems.

In the United States, where a patchwork of regulatory efforts has created a fragmented approach to environmental standards, the absence of a clear path forward has created some confusion throughout the commercial refrigeration sector. With regulations potentially varying from state to state, owners and operators are attempting to make refrigeration equipment decisions that align with both their regional environmental mandates and unique operational objectives.

But implementing a sustainable refrigeration strategy in a highly competitive retail environment is a complex process, requiring a sophisticated understanding of the options available in the face of myriad regulatory, architectural and operational constraints. Fortunately, a variety of options that manufacturers have refined over the last decade address a spectrum of applications, store formats and sustainability objectives.

And because the future state of regulations is still uncertain, some of these new refrigerant system options are allowing operators to take a gradual approach toward adopting systems that utilize lower-GWP refrigerants. In some cases, this would allow them to deploy new systems that utilize available low-GWP refrigerants today, and then switch to an even lower-GWP option in the future.

States take the lead on climate initiatives

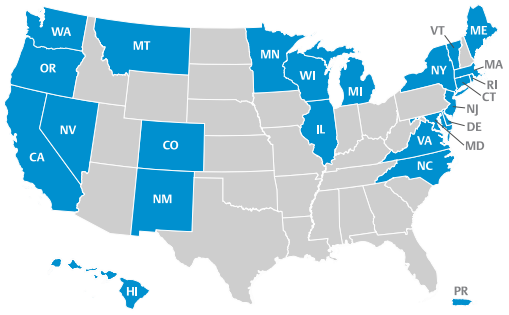
In the absence of a U.S. federal mandate to phase down HFCs, the California Air Resources Board (CARB) has taken the lead—one that a growing number of other states are following. In 2018, CARB codified the Environmental Protection Agency's (EPA) now-vacated Significant New Alternatives Policy (SNAP) Rules 20 and 21 into law with the passing of the California Cooling Act (Senate Bill 1013).

Another companion bill, Senate Bill 1383, takes this measure a step further by requiring the state of California to reduce its collective HFC emissions by 40 percent below 2013's levels by 2030.

In response, CARB has proposed a GWP limit of 150 for new stationary refrigeration systems containing more than 50 pounds of refrigerant and a ban on virgin refrigerant sales above 1,500 GWP—which if approved would take effect on Jan. 1, 2022. This proposal would have significant impacts on refrigeration system architectures, dictating the use of designs with smaller refrigerant charges, less centralized architectures and lower-GWP alternatives.

For those who think that refrigeration system changes will be required by only a minority of operators in a few states, think again. While California has taken the most aggressive stance on HFCs to date, currently it is one of 25 member states—representing more than 55 percent of the U.S. population—in the U.S. Climate Alliance which have vowed to implement climate-related initiatives.

U.S. Climate alliance member states



U.S. Climate Alliance states make up more than 55% of the U.S. population and 60% of the U.S. gross domestic product (GDP).

Wheter you're preparing for compliance with a regionalregulation or generally seeking to lower your carbon equivalency, a number of refrigerant categories have emerged as proven, viable alternatives to traditional HFCs.

Among these states, Washington and Vermont have joined California in adopting EPA SNAP Rules 20 and 21, and others such as New York, Connecticut, Delaware and Maryland have committed to similar actions. Most recently, legislators in the state of New Jersey introduced a new proposal to also adopt EPA SNAP rules.

Evaluating lower-GWP refrigerants

Today, there is more data than ever to help end users make informed decisions about which of the emerging and/or new lower-GWP refrigerant systems align best with their business and sustainability objectives. This includes experiential data about the primary refrigerant categories available to meet this challenge, as well as the more commonly applied refrigeration options proliferating in retail segments—especially in global markets where the European F-Gas Regulation has accelerated the transition from HFCs.

Whether you're preparing for compliance with a regional regulation or generally seeking to lower your carbon equivalency, the following refrigerant categories have emerged as proven, viable alternatives to traditional HFCs.

Lower-GWP A1s (HFO/HFC blends)—Traditional A1 refrigerants are prized for their ease of use and wide applicability in commercial refrigeration architectures. Unfortunately, their high GWP levels are the source of the current regulatory quagmire. But it's important to remember that not all A1s are created equally. Refrigerant manufacturers have blended hyrdrofluoroolefins (HFOs) with HFCs to create a new generation of lower-GWP A1 alternatives.

While these may not achieve the very low-GWP levels (below 150 GWP) that seem to be the low watermark of many global HFC regulations, they do give end users and operators an opportunity to take a gradual approach toward lowering their GWP levels. Today, manufacturers are creating new equipment and architectures that utilize blends such as R-448A and R-513A yet are compatible with the very low-GWP options likely to be used in the future (see A2L HFO blends).

A2L HFO blends—Synthetic HFO blends offer widespread applicability within commercial refrigeration for operators seeking lower-GWP alternatives. Classified as A2L, these refrigerants cover a spectrum of cooling capacities/pressures and come in a range of low-GWP options—roughly from 1 to 500 GWP.

While the development of updated U.S. safety codes and standards for A2Ls is currently underway, many operators anticipate exploring the potential of A2Ls in the next several years. Already, manufacturers are providing A1 HFO-based equipment and system options designed with A2L compatibility to help operators make the transition to A2Ls when codes allow it.

Propane (R-290)—Propane is a natural refrigerant that's prized for its energy efficiency and very low GWP of 3. Per U.S. building codes, its classification as an A3 refrigerant has primarily limited its use to small-charge applications, such as integrated display cases. While the recent IEC ruling has raised R-290's charge limits internationally to 500g, current U.S. safety standards still limit applications to 150g. Typically, self-contained, R-290 units are charged and hermetically sealed at the manufacturing facility.

CO2 (R-744)—Non-flammable and with a GWP of 1, CO2 has demonstrated its effectiveness in both low-temperature (LT) and medium-temperature (MT) applications. Centralized, CO2-based refrigeration systems have been successfully deployed in Europe for nearly two decades.

Selecting a future-proof refrigeration system

In the U.S., centralized direct-expansion HFC racks have been the standard commercial refrigeration system for decades, and still make up the majority of current systems. But in California, and likely other regions within the U.S. Climate Alliance, this may soon change—especially considering CARB's proposed 150 GWP limit in systems charged with more than 50 pounds of refrigerant.

When considering lower-GWP refrigeration system alternatives, there is no one-size-fits-all solution, and the next generation of refrigeration technologies must address a much broader set of operational concerns, including: leak identification and mitigation; energy-efficiency goals; sustainability initiatives; maintenance, servicing and operational requirements; and system costs (both first and lifecycle costs). Operators must also attempt to align evolving store formats and layouts to these available architectures.

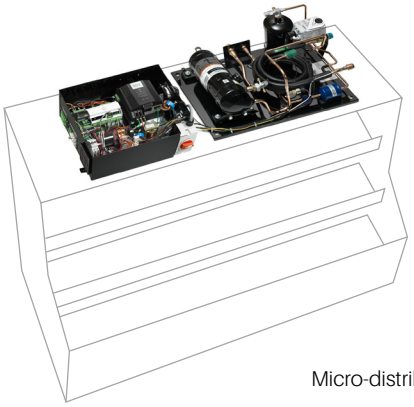
With all these factors in mind, let's look at some of the leading refrigeration architectures that utilize low-GWP refrigerants.

Micro-distributed, R-290 integrated cases—Flexible and efficient, these R-290-based, self-contained units feature the refrigeration system built (or integrated) into the refrigeration case. Multiple-unit configurations feature a water-cooled condensing unit in each case and utilize a shared water/glycol loop to remove excess heat from the store. These low-charge systems, which operate on 90 percent less refrigerant than a centralized system, are based on factory-built, hermetically sealed systems—which are considered less likely to have issues with potential refrigerant leaks. Because floor layouts are relatively easy to change, new stores (or retrofits) can be deployed and opened faster.

Of course, there are some challenges with using R-290 integrated cases. Namely, its small charge limits require the use of more compressors than would be needed for other approaches. But as future charge limits increase, operators have the potential to more than double the size of current R-290 systems—making micro-distributed architectures even more viable as an alternative to traditional and new low-GWP A1 systems.

Macro-distributed (large) integrated cases—As an alternative to R-290's low-charge limitations in micro-distributed systems, a macro-distributed approach offers the capability to support larger cases with a single compressor and refrigeration circuit—where potentially multiple R-290 circuits would be needed to supply the same refrigeration load. Utilizing the same shared water-loop, heat-rejection design as micro-distributed systems, these systems are designed to use available lower-GWP A1 refrigerants (such as R-448A at 1,300 GWP) and stay below the 50-pound CARB threshold.

As very low-GWP A2L and A3 refrigerants become approved for use in higher charge limits, operators can utilize the same equipment and architecture—maximizing their investments to take a gradual approach to adopting sustainable refrigeration and regulatory compliance.



Micro-distributed system

Timing of flammability safety standards drives building code changes

The safety standards governing the use of A3 (flammable) and A2L (mildly flammable) refrigerants are an important consideration when making refrigeration equipment decisions. In 2019, the International Electrotechnical Commission (IEC) ruled to increase the charge limits of A3s and A2Ls from 150g to 500g and 1,200g, respectively, for commercial refrigerators and freezers.

However, U.S. building codes don't follow IEC guidelines, and instead rely on standards put forth by the Underwriters Laboratory (UL) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Currently, both groups are proposing updates to flammable refrigerant safety standards for commercial refrigeration under UL 60335-2-89 and AHSRAE 15. Impacts of these efforts would affect both self-contained and remote equipment as follows:

- Allow up to 300g of R-290 in self-contained systems
- Align with A2L rules for commercial AC, where remote commercial refrigeration equipment could use up to 80kg (176 pounds) per system, but would require leak detection and leverage the concept of a releasable charge

Industry working groups are helping to ensure workable standards by participating with the UL and ASHRAE update processes. The target date for completion of these updates is summer 2020, which would make the earliest possible code application date Jan. 1, 2021. And since building code changes take place in three-year cycles, the earliest possible adoption or change to building codes would be in 2024.

When making equipment decisions for the future, it's important for operators to stay informed, understand the timing of these standards, and plan accordingly.

Micro-booster (distributed)—This innovative system architecture utilizes low-GWP, low-pressure A1 refrigerants (such as R-513A at 573 GWP) and features a booster compressor on each LT case that's designed to discharge refrigerant into the MT suction group. Thus, it eliminates high-discharge temperatures and the high compression ratio issue common with traditional low-temperature systems while offering greater reliability and much improved energy efficiencies. The system also provides future-proof readiness via compatibility with A2Ls below 150 GWP while relying on simple, reliable and familiar components.

Small-charge distributed—Another way store owners and operators are moving away from centralized systems is to distribute multiple "mini racks" in proximity to refrigerated aisles and cases. This strategy reduces the length of piping lines and keeps charges much lower than centralized systems, though they may still exceed 300 pounds. Because these mini racks utilize A1 refrigerants, systems would need to be kept below 50 pounds to meet CARB's proposed requirement. But the advantages include reliable operation, high energy efficiency, familiar components and simplified installation

CO2 transcritical booster—In large supermarkets where centralized architectures are preferred, CO2 transcritical booster technology is a globally established, viable solution for providing both low- and medium-temperature cooling. This all-CO2 system is called transcritical because it is designed to operate at temperatures and pressures above CO2's critical point. While CO2 transcritical booster systems deliver high energy-efficiency levels in moderate climates, they experience declining efficiencies in warmer regions. Technology enhancements, such as parallel compression, adiabatic gas coolers and ejectors, can be used to improve CO2 system energy efficiencies in these regions.

In Europe, more than 20,000 CO2 transcritical booster systems are already installed in food retail operations. And in North America, adoption has grown to nearly 900 systems (550 in U.S.; 320 in Canada). To ensure a successful CO2 deployment, operators should have access to a trained, skilled workforce for service and maintenance and utilize a robust design to avoid shutdowns and charge losses.

CO2 sub-critical (cascade)—CO2 cascade systems utilize two distinct refrigeration circuits: one CO2 circuit for the LT suction group, and an HFC- (or HFO/HFC blend)-based circuit for the MT needs. Heat produced from the LT circuit is discharged (i.e., cascaded) into the suction stage of the MT circuit via an intermediate heat exchanger; MT compressors send gas to an air-cooled condenser on the roof. This design keeps CO2 pressures low—below its critical point (or subcritical mode)—much like a standard refrigerant.

While eliminating the need for HFCs on the LT circuit significantly improves system sustainability, the MT refrigerant may yet be subject to future regulatory action.

Preparing for a quickly changing landscape

Over the next few years, the commercial refrigeration industry will have to keep a close watch over the potential changes in our dynamic regulatory climate. While the landscape may currently be in flux in the U.S., there's no question that the pace of transition away from HFCs is quickening. Many operators, such as those in California, are evaluating their refrigeration options and preparing for a future that utilizes lower-GWP refrigerants. Others simply want to align their refrigeration strategies with corporate sustainability objectives.

Regardless of what's driving your future refrigeration strategy, Copeland is developing technologies to address a full spectrum of refrigeration considerations—from small to large retail formats, low-GWP to very low-GWP refrigerants, and distributed to centralized architectures. Since the early phases of this refrigerant transition, we have partnered with equipment manufacturers and end users alike to design and develop future-ready, low-GWP refrigerant technologies. From our wide range of energy-efficient compressors, flow controls and smart electronics to fully integrated packaged systems, we're helping our customers transition to sustainable refrigeration strategies that align with their unique facility requirements and business objectives.

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