APRIL - MAY 2019

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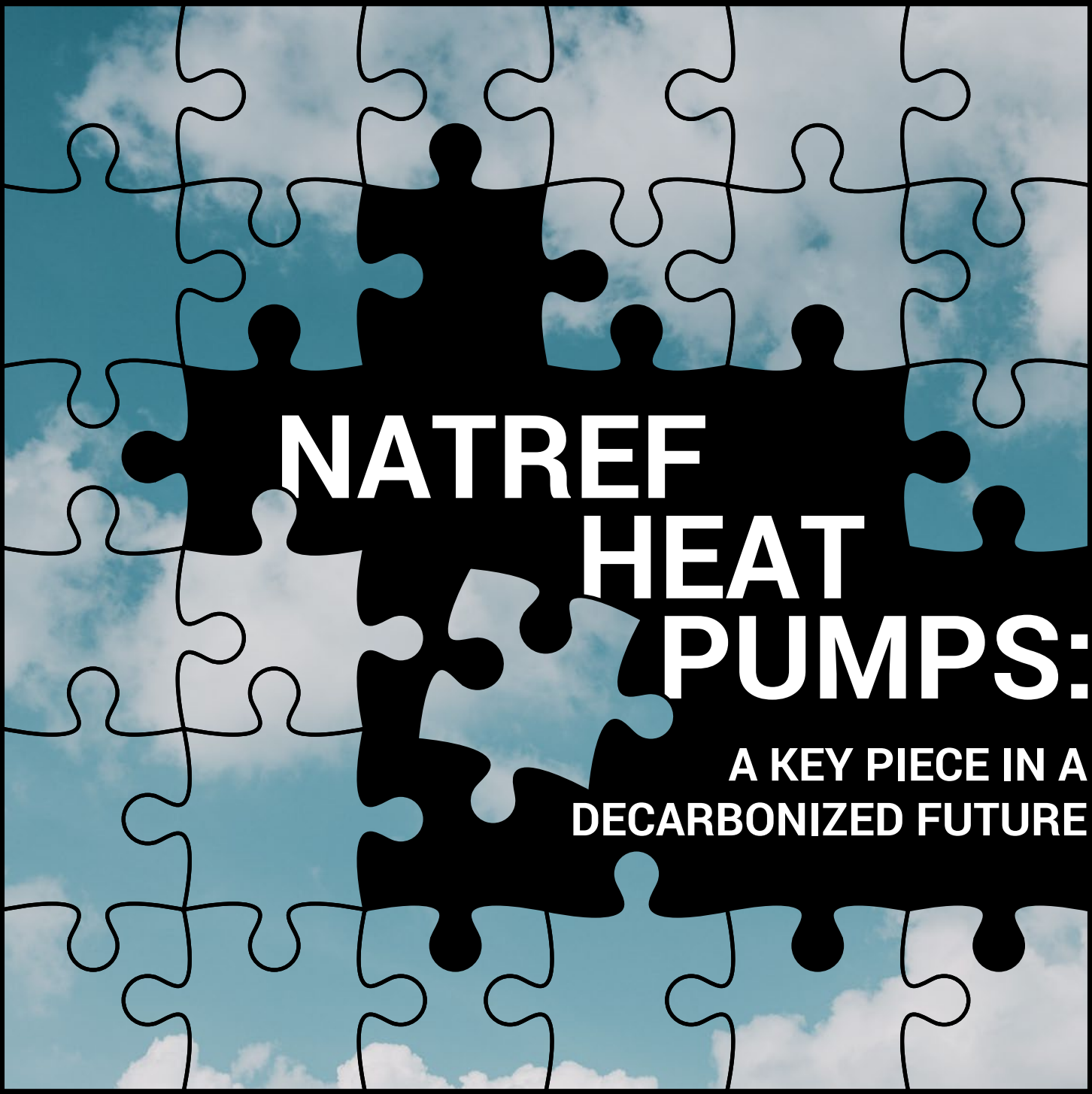

NATREF HEAT PUMPS:

A KEY PIECE IN A DECARBONIZED FUTURE

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NatRefs and Climate Change

— by Michael Garry

In covering the world of natural refrigerants, *Accelerate America* takes a two-pronged approach: showing examples of the operational (especially efficiency) advantages that underscore the business case for natural-refrigerant-based technology, and highlighting the environmental benefits that make natural refrigerants immune to regulatory pressures now and in the future.

As the world continues to grapple with the growing threat posed by climate change, the environmental benefits of natural refrigerants are becoming increasingly relevant. So, too, are the policy measures that help phase down the use of climate-damaging refrigerants and support the adoption of natural alternatives.

In the U.S., of course, federal policy on refrigerants has unfortunately become muddled as a result of an ill-advised U.S. Court of Appeals decision and the Trump administration's efforts to roll back virtually all Obama-era environmental policies. But I now see cause for some optimism on the policy front.

First is the continuing growth of the U.S. Climate Alliance, a bipartisan coalition of 23 U.S. state governors (plus the governor of Puerto Rico), that represent 55% of the U.S. population and 60% of U.S. gross domestic product. The Alliance as a whole is committed to phasing down high-GWP HFC refrigerants, and five of its states – California, Connecticut, Maryland, New York and Washington – have taken or are taking steps to jettison HFCs. California, of course, is the leader that has established a template for other states to follow; the most recent is Washington state, as outlined on page 30.

I am very excited to announce that Julie Cerqueira, executive director of the U.S. Climate Alliance, will be participating on the policy and standards discussion panel at the ATMOsphere America conference on natural refrigerants taking place in Atlanta June 17-18 (http://www.atmo.org/America2019). (The conference is organized by shecco, publisher of *Accelerate America*.) Julie's participation sends a message to the HVAC&R industry that the Alliance is serious about its HFC-reduction mission and recognizes the opportunity for natural refrigerants to serve as an alternative to HFCs.

Another promising development is the growing movement to decarbonize and electrify buildings and replace gas-fired space and water heating with electric heat pumps (and gas stoves with induction cooktops, among other changes). As this month's cover story (page 44) explains, electric heat pumps have been identified as a vital part of any effort to transition away from natural gas and other fossil fuels (oil and propane) used in homes and buildings.

As usual California, the state with the most renewable energy, is leading the decarbonization charge. New reports from Energy and Environmental Economics and the Building Decarbonization Coalition are calling for dramatically increasing the use of heat pumps in the state.

There are two large caveats here. One is, the national electric grid has to convert faster to renewables and away from fossil fuels. And the heat pumps that are adopted need to use natural refrigerants and not HFCs. Natural refrigerant heat pumps are the most efficient on the market, and though costly now, will become more affordable with economies of scale.

With states like California promoting HFC-reduction and decarbonization, natural refrigerants are poised to play a significant role in the fight against climate change.

.

Michael Garry
Editor

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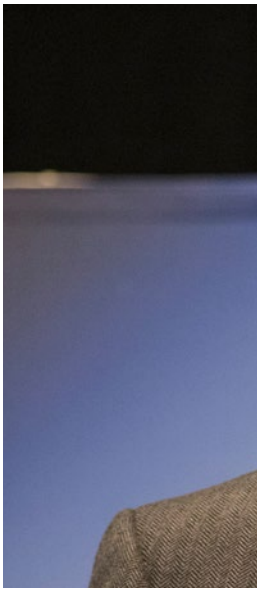

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The Modular Rooftop Unit employs CO_2 or glycol as a secondary fluid.

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In August 2018, Lidl France opened its first supermarket to use propane for 100% of refrigeration, creating a standard for new stores.

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As buildings seek alternatives to fossil fuels for heating, electric heat pumps using CO_2 and other natural refrigerants are finding a growing market in North America.

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Kysor Warren Epta US Corp. positions Epta to bring its CO_2 systems to North and Central American markets, following its acquisition of Lennox subsidiary.

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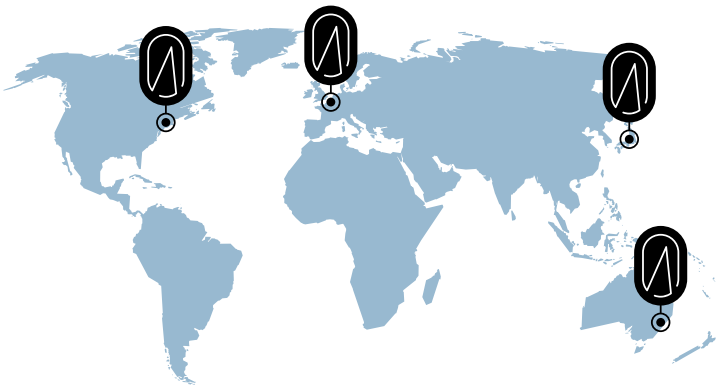

About *Accelerate America*

Brought to you by shecco, the worldwide experts in natural refrigerant news, *Accelerate America* is the first news magazine written for and about the most progressive business leaders working with natural refrigerant solutions in all HVAC&R sectors.

http://acceleratena.com

Accelerate America publisher shecco's network spans the globe with offices in Brussels, Tokyo, New York and Sydney.

WANT TO ADVERTISE?

/ Ad Sales

Silvia Scaldaferri
silvia.scaldaferri@shecco.com
+39 331 961 3956

GOT A STORY IDEA?

/ Editor

Michael Garry
michael.garry@shecco.com
203-417-0767

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Publisher
Marc Chasserot
marc.chasserot@shecco.com

Editor
Michael Garry
michael.garry@shecco.com

Contributing Writers
Pilar Aleu
Marie Battesti
Dario Belluomini
Jan Dusek
Eda Isaksson
Charlotte McLaughlin
Klara Zolcer Skacanova
Andrew Williams
Devin Yoshimoto

Ad Coordinator
Silvia Scaldaferri

Art Director
Charlotte Georis

Graphic Designer
Juliana Gomez

Photographers
Ben Beech
Scott Chasserot


#GoNatRefs

LETTERS TO THE EDITOR

AMMONIA INDUSTRY'S EFFICIENCY CHALLENGE

In regard to "How to Save More Energy in a NatRef System," (*Accelerate America*, March 2019), the ammonia industry is facing a huge energy-efficiency challenge. This challenge almost exclusively comes down to system design and control.

What the industry must do is absolutely minimize or eliminate the presence of liquid in all suction lines during all operating conditions. This is exactly what a centralized, low-charge NH_3 system does.

In a typical freezer plant, the saturated ammonia liquid is about 800-1000 times heavier than the saturated vapor at the same temperature. This provides an impression of the amount of energy required to lift this liquid out of all the low points of the plant and return it to the central plant, where liquid and vapor are separated upstream of the compressors.

It is very clear that the presence of relatively heavy liquid in the wet return line network of conventional large centralized liquid-overfeed ammonia systems virtually destroys the advantage of the relatively low molecular weight of this refrigerant.

In view of the above, it is no surprise that transcritical CO_2 systems that employ multiple small reciprocating compressors (some with speed control) and do not have any or very limited amounts of liquid in the suction lines sometimes display better annualized energy performance than large-scale centralized NH_3 systems.

Multiple small reciprocating compressors in a central two-stage system deliver far better part-load performance than larger slide-valve controlled screw compressors. This is not new. Gustav Lorentzen pointed this out in some modeling results published in 1981.

The ammonia industry has been using fewer, larger compressors to reduce system capital costs for decades, and this has in many cases been absolutely detrimental to the energy performance outcomes delivered.

The path to long-term survival for the ammonia industry as a whole is energy-efficiency improvement. Nothing will match the energy performance of an ammonia refrigeration system done well. Therefore, the industry has to start doing these systems well, or lose significant market share.

Stefan Jensen
Managing Director
Scantec Refrigeration Technologies
Murarrie, Australia

FINDING LEAKS FAST

I read with interest your Editor's Note on "The Truly Green Option" in November-December 2018 issue of *Accelerate America* at the AHR Expo this year. I agree that the move toward HFOs being controlled is a good one. At Bacharach, we are trying to get the users of refrigerants, whether in supermarkets, food industries, cold storage, etc., to find leaking refrigerant fast and early, to not only save them money, but to save our environment. Our products can monitor down to 1 ppm of refrigerants for many different types.

Shelli Cosmide
Marketing Communications Manager
Bacharach
New Kensington, Pa.

LETTERS ARE WELCOMED!

Accelerate America invites readers to submit letters to the editor at michael.garry@shecco.com. They can be about a recent article; an industry issue that readers would like us to cover in greater detail; or the value of *Accelerate America* and ATMOsphere America in educating the industry about natural refrigerants, including what we can do better. Letters may be edited for clarity or length.

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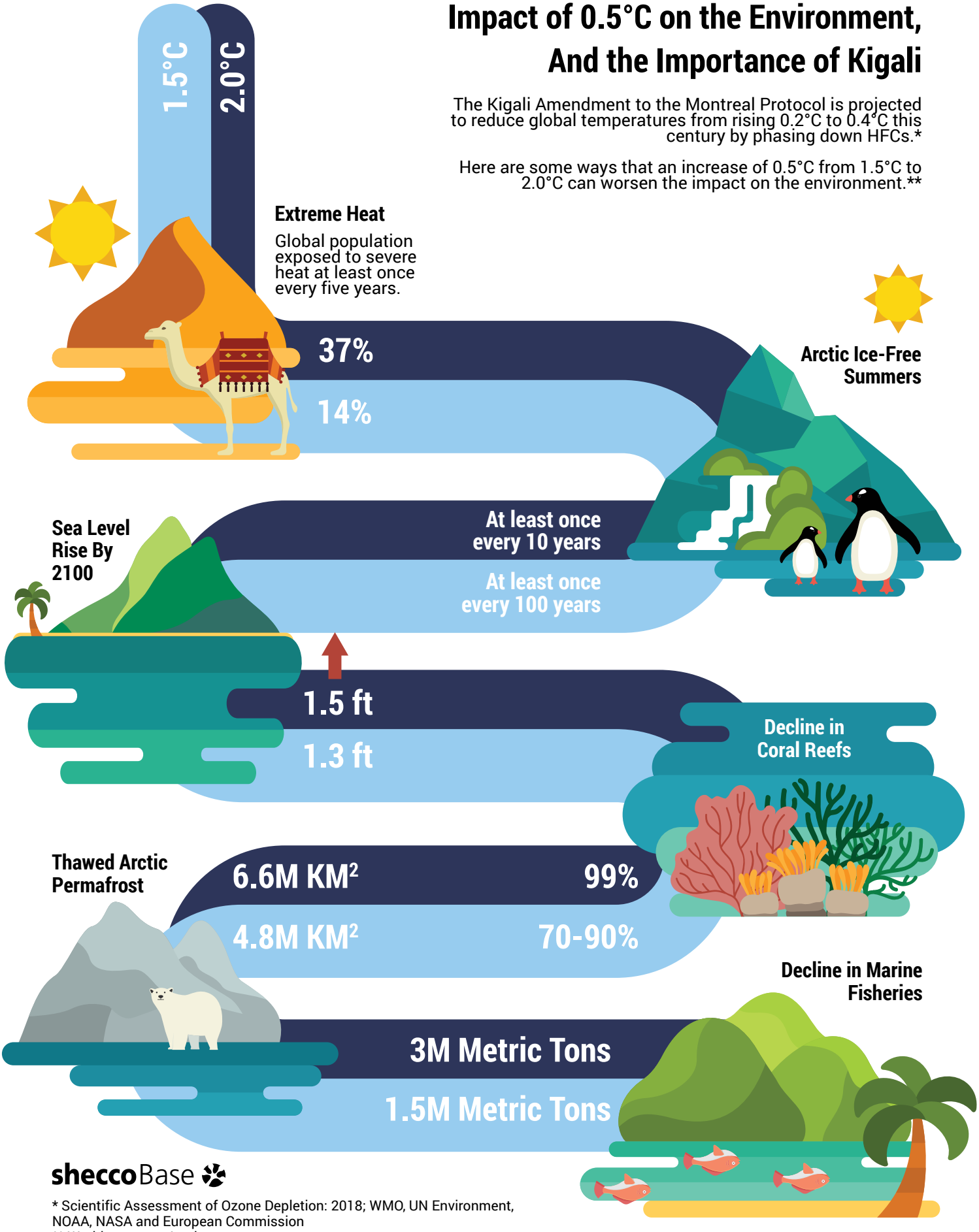
Impact of 0.5°C on the Environment, And the Importance of Kigali

The Kigali Amendment to the Montreal Protocol is projected to reduce global temperatures from rising 0.2°C to 0.4°C this century by phasing down HFCs.*

Here are some ways that an increase of 0.5°C from 1.5°C to 2.0°C can worsen the impact on the environment.**



shecco Base

* Scientific Assessment of Ozone Depletion: 2018; WMO, UN Environment, NOAA, NASA and European Commission

** World Resource Institute

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NATURAL REFRIGERANTS

PROTECTING THE FUTURE WITH NATURAL SOLUTIONS

In recient years, the refrigeration industry has been discussing and evaluating the enviromental impact of the increased concentration of gases in the atmosphere and the greenhouse effect, as well as new laws and regulations for energy efficiency and use of refrigerant gases.

Embraco has been conducting research for many years and belives that the use of natural refrigerants is the future for refrigeration.
Embraco has been applying natural refrigerants such as **R290** and **R600a**, and found that these alternative solutions reduce the negative effects on the ozone layer and improve equipments energy efficiency rating. One of **Embraco's goals is to offer the best refrigeration solutions for customers and educate the market about the importance of adopting alternative to HFCs gases for the planet's future.**

TO LEARN MORE ABOUT NATURAL REFRIGERANT SOLUTIONS,
VISIT **NATURALREFRIGERANTS.INFO.**

embraco

NATURAL REFRIGERANTS

MAY

06-08

AHRI Spring Meeting, Baltimore, Md.

This event will feature the first meetings of the all-new Industry Sector Leadership Councils, as well as policy updates for members. Several certification, regulatory, and technical working groups will meet to discuss sector- and product-specific issues.

https://bit.ly/2F89ncW

@AHRIEngage

14 2PM ET

GreenChill Webinar. Navigating Technician Shortages: How Service Contractors Are Preparing Staff to Handle New Refrigerants in Advanced Systems, Online

Environmental Protection Agency's GreenChill program hosts webinar featuring Bryan Beitler of Coolsys and a community college representative.

https://bit.ly/2VTMKyi

@EPAgreenchill

18-21

NRA Show 2019, Chicago, Ill.

The 100th anniversary of the National Restaurant Association Show will feature more than 43,000 restaurant industry executives and suppliers, including refrigeration equipment manufacturers.

https://bit.ly/2HuFkgQ

@NatlRestShow

21 2PM ET

GreenChill Webinar. Real-World Applications and Operation of Ammonia/Carbon Dioxide Systems, Online

Environmental Protection Agency's Green-Chill program hosts webinar featuring Rob Arthur of CTA, and food retailers.

https://bit.ly/2TI9xzH

@EPAgreenchill

21-24

North American Rink Conference & Expo, Buffalo, N.Y.

The North American Rink Conference & Expo (NARCE), presented by the United States Ice Rink Association, is an annual meeting of ice rink and ice sport industry professionals. The four-day event will bring together hundreds of ice rink profes-sionals, ice sport national governing body representatives and industry suppliers.

https://bit.ly/2F8MmXb

@usicerinkassoc

JUN

04 2PM ET

GreenChill Webinar. Data in the Driver's Seat: Leak Patterns in Observed Data and How It Can Help Reduce Emissions

Environmental Protection Agency's GreenChill program hosts webinar featuring Matt Collins and Jim Ayres of Parasense and Jeff Rupert of Fazio Mechanical.

https://bit.ly/2CTRTzp

@EPAgreenchill

10-12

Global Cold Chain Expo, Chicago, Ill.

Attendees include representatives of retail, foodservice, processing, production, distribution, logistics, and transportation involved with frozen, refrigerated, ambient and fresh operations.

https://bit.ly/1PQyRFQ

@gccaorg

13

GCAP Ammonia Safety Day, Kansas City, Kan.

The event will feature about 40 vendors and a program that will include how to prevent false alarms, secondary coolants and emergency management.

https://bit.ly/2YSF1CY

@NH3Training

17-18

ATMOsphere America, Atlanta, Ga.

The eighth annual event brings together end users, contractors, manufacturers and policy makers to learn about the latest developments in natural refrigerant technology.

https://bit.ly/2OOPdro

@ATMOEvents

22-26

ASHRAE Annual Conference, Kansas City, Mo.

This event will feature a technical program along with committee meetings and bookstore.

https://bit.ly/2KPf5QW

@ashraenews

AMERICA IN BRIEF

CGF, shecco Booklet Covers NatRef Systems

The Consumer Goods Forum (CGF) and shecco, publisher of Accelerate America, have launched a booklet exploring the environmental impact of refrigerant systems, as well as the main challenges in implementing HFC- free cooling.

The booklet – called "Understanding the Most Cost-Effective Way to Fight Climate Change" – also highlights the benefits of using natural refrigerant-based technologies and features case studies from companies who have already made the switch to natural refrigerants. An abbreviated version can be accessed at https://bit.ly/2GwL3AD. To request the full report, contact klara.skacanova@shecco.com.

The booklet includes testimonies provided by industry end users who have successfully implemented energy-efficient, HFC-free technology. Success stories include those from a number of CGF members: Campbell Soup, Carrefour, Heineken, Lawson, METRO AG, Recheio (Jeronimo Martins) and Woolworths.

"Thanks to the actions of these leading retailers and manufacturers, we now have a much better understanding of the HFC-challenge and how we can drive positive change and phase out these harmful, chemical refrigerants," said Ignacio Gavilan, CGF's environmental sustainability director. ■ MG

Apple's Vehicle Patent Features CO_2 System

California-based Apple Inc. has submitted a patent application for a new thermal management system designed for electric vehicles.

The application was published by the U.S. Patent & Trademark Office and can be found at https://bit.ly/2Y0lQoe.

The patent identifies "an increased need for more efficient power management systems, particularly in the area of vehicle thermal management," for battery-powered electric or hybrid vehicles.

The use of R744 as a refrigerant is described within the patent's detailed description.

"Through use of R744 refrigerant," the patent states, "the system can operate as a heat generator in temperatures down to -30 degrees Celsius. In this manner, the refrigerant loop operates as a heat pump to generate heat from a refrigerant cycle."

According to the website Patently Apple, the patent application is related to "Project Titan" — the code name for Apple's long-rumored electric vehicle project. ■ DY

'Naturally Cool' Initiative Launched

The North American Sustainable Refrigeration Council (NASRC) has launched an environmentally focused movement called Naturally Cool (http://nasrc.org/naturallycool), which is designed to raise awareness about natural refrigerants and how they benefit the environment.

NASRC (nasrc.org) is a 501c3 nonprofit organization focused on taking action to eliminate the barriers preventing the adoption of natural refrigerants in supermarkets.

"Over the past three years, we've received tremendous support from supermarket industry stakeholders, who have been the driving force behind our accomplishments to date," said Danielle Wright, executive director of the NASRC, in a statement. "What we've realized is that a lack of awareness of natural refrigerants outside of the industry is slowing our impact. We're trying to change that with Naturally Cool."

Naturally Cool's first project will be to develop an educational video to raise awareness about natural refrigerants and expand support for the industry.

NASRC is seeking volunteers to work on media relations, content creation, speaking opportunities, marketing and local leadership in support of Naturally Cool. ■ MG

U.S. Plans to Restore Credits for CO_2 in MAC

The Trump administration is planning to alter its rollback of Obama-era clean car rules to allow credits for automakers that install less-polluting air conditioners in their vehicles, including those that use CO_2 as a refrigerant, according to a report in *E&E News*.

The move came in response to complaints from AC manufacturers and Chemours and Honeywell, manufacturers of R1234yf, a low-GWP refrigerant that would also qualify for the credits. The EPA allows CO_2 (R744), R1234yf and R152a as low-GWP alternatives to R134a, the common mobile AC refrigerant that has a GWP of 1,430.

With the exception of German manufacturers Volkswagen and Daimler, which have selected CO_2 as a mobile air conditioning (MAC) refrigerant, car makers have largely opted for R1234yf as a substitute for R134a.

In its original proposal for the rollback of clean car rules, the Trump administration suggested eliminating the compliance credits for low-GWP MAC. But in its final rule expected this spring or summer, the administration plans to restore the credits, according to *E&E News*. But the final rule would still roll back the Obama plan to nearly double fuel-economy standards in cars by 2025.

The Trump administration has previously turned a deaf ear to industry requests regarding refrigerants, such as moving the HFC-reduction scheme under the Kigali Amendment to the Montreal Protocol to the Senate for ratification.

One of the abandoned Obama HFC regulations, Significant New Alternatives Policy (SNAP) Rule 20, ruled that R134a would be unacceptable in New Light-Duty MAC systems as of 2021. ■ MG

What Is Refrigeration, Anyway?

New standard definitions of 'refrigeration,' 'cooling' and other key terms will help explain the low-temperature sector to society, and raise awareness of an often underappreciated industry

— By Kostadin Fikiin

People are often confused by the multiple definitions of refrigeration, published in different sources, which are often overlapping but never identical.

How many ordinary people know what the term "refrigeration" really means? Certainly, the number is not very impressive! The matter is often "terra incognita" even for those who are expected to shape the industrial, agri(aqua)cultural, food and energy policies of the future.

There are numerous individual perceptions and claims, such as "Refrigeration is about food, while cooling is about building or car air conditioning." However, this is absolutely wrong! Refrigeration is not defined by a particular application. Another widespread misconception is that "refrigeration" and "cooling" mean one and the same. But, are they really the same? No, in fact! Whereas "cooling" is a generic notion, "refrigeration" is much more specific and means artificial (human-made) cooling.

Artificial cooling (refrigeration) is a mostly invisible industry that removes heat from homes, offices, warehouses and trucks. It is largely taken for granted by contemporary society – from the cold chains that, behind the scenes, safely deliver our food and vaccines, to the air conditioners that make our workplaces and homes comfortable, and to many industrial processes, such as the one that keeps our data centers operating.

Several years ago, the U.K.'s Royal Society named refrigeration the most significant invention in the history of food and drink. Sociological polls regularly place the household fridge on the very top of the rankings for domestic appliances that contemporary consumers could not live without.

People are often confused by the multiple definitions of refrigeration, published in different sources, which are often overlapping but never identical. Such a terminological mess would not be so dramatic if it did not lead to some adverse consequences. For example, in some cases, qualified refrigeration professionals are not approached to do specialized work or to implement a relevant program because preference is given to generalists with unproven competence. Moreover, it is difficult to explain refrigeration to today's society or to present it to younger generations as a wonderful métier of the past, present and future.

Two years ago, I suggested creating a unified international definition of refrigeration. I am now delighted to announce that a joint expert group from the International Institute of Refrigeration (IIR) and the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) has established, after working hard for over a year, common definitions of the five most essential terms in the refrigeration sector. The definitions are as follows:

COOLING:

(1) Removal of heat, usually resulting in a lower temperature and/or phase change.

(2) Lowering temperature.

REFRIGERATION:

(1) Cooling of a space, substance or system to lower and/or maintain its temperature below the ambient one (removed heat is rejected at a higher temperature).

(2) Artificial cooling.

CHILLING:

Cooling of a substance without freezing it.

FREEZING:

Solidification phase change of a liquid or the liquid content of a substance, usually due to cooling.

COLD CHAIN:

Series of actions and equipment applied to maintain a product within a specified low-temperature range from harvest/production to consumption.

The IIR's Science and Technology Council has endorsed these new definitions, which entered into force on February 8, 2019. Furthermore, IIR strongly recommends the global use of the newly defined terms to all its member and non-member countries, and calls upon all refrigeration-related national and regional organizations and professional associations to adopt and disseminate these definitions. This would ensure their universal application and worldwide harmonization.

Simultaneously, the definitions were approved by ASHRAE, whose president, Sheila Hayter, observed, "The new definitions will help those within our industry, as well as the general public, gain a clearer understanding of important refrigeration keywords that are often misused or too broadly defined. We appreciate the contributions of IIR and anticipate that the adoption of these definitions will be positive."

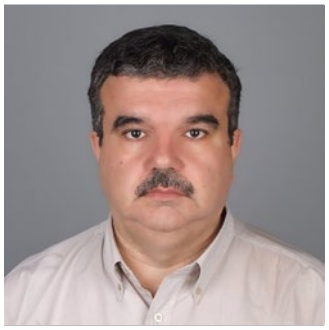
As part of the definition-creating exercise, I am proud of achieving this accomplishment in advance of the forthcoming 25th IIR International Congress of Refrigeration, to be held August 24-30, 2019, in Montreal, Canada. This event will bring together over 1,000 refrigeration scientists, engineers and entrepreneurs, 111 years after the first event of this kind took place in Paris. In addition, as a modest present to the refrigeration community, the new, hopefully universal, definitions arrive in time for the first celebration of World Refrigeration Day on June 26, 2019.

At the EU level, the new definitions for the refrigeration sector – which is responsible for 17% of worldwide electricity consumption and 7.8% of global greenhouse gas emissions – should affect relevant sectoral policies and legislation, such as the EU heating and cooling strategy, F-gas regulations, eco-design, energy efficiency and energy labelling directives, etc. The importance of the sector in Europe is not always adequately appreciated, often remaining in the shadow of its heating counterpart.

These five, seemingly simple, definitions are expected to put in order the puzzle of terminology, technologies and industrial policies by making research players, entrepreneurs, project managers, investors, governmental representatives and international policy makers much more aware of the refrigeration sector's nature, scope, development and needs.

The definitions should also help the industry meet the stringent requirements of the Paris Climate Agreement, the Katowice climate-change conference, the Kigali amendment to the Montreal Protocol, and the UN's Sustainable Development Goals, as both radical and incremental technology innovations are actively sought to ensure a carbon-free cold economy by 2050.

(*This article was adapted from an original online publication in the European media platform for policymaking, EurActiv.com.*)



Kostadin Fikiin is an international R&D project manager (Technical University of Sofia, Bulgaria); chairman of the Food Refrigeration Equipment Working Group (European Hygienic Engineering & Design Group - EHEDG); and an academician (International Academy of Refrigeration).

LOW-CHARGE AMMONIA GUIDELINES: A WORK IN PROGRESS

Kurt Liebendorfer, Evapco

IIAR seeks feedback on its recently developed ARM-LC documents, which explain how to operate low-charge systems in compliance with the General Duty Clause

– By Charlotte McLaughlin and Michael Garry

Last November, the International Institute of Ammonia Refrigeration (IIAR) released its first guidelines for users of low-charge ammonia systems that use a charge of 500 lbs or less, but the trade group is open to suggestions on how the guidelines can be improved.

> *"With this low-charge program we are just filling a void."*

The guidelines, called Low Charge Ammonia Refrigeration Management (ARM-LC), are contained in two documents – a 13-page Summary and an 86-page Guidebook – that deal with safely installing, using and servicing low-charge ammonia systems in compliance with the General Duty Clause of the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA).

The Guidebook includes forms and templates in which manufacturers and contractors can provide end users with information on their low-charge ammonia installation. (Both documents can be purchased at IIAR's website here: https://bit.ly/2UIcIJ9.)

The guidelines, which cover packaged and stick-built low-charge ammonia systems, are designed to help end users of low-charge systems who may not have used ammonia before or be familiar with the requirements of the General Duty Clause, and "need to have a reference document," said Kurt Liebendorfer, vice-president of Evapco, in a presentation at the IIAR Natural Refrigeration Conference and Expo, held in Phoenix March 4-6.

"With this low-charge program we are just filling a void," he said.

ARM-LC is a follow-up to IIAR's ARM guidelines, issued in 2005 for ammonia systems using charges of between 500 and 10,000 lbs. Systems with more than 10,000 lbs of ammonia are subject to the more stringent regulations established by OSHA and the EPA, known as Process Safety Management (PSM) and Risk Management Program (RMP), respectively.

ARM-LC generally covers systems with ammonia charge/capacity ratios of 0.5-7.0 lbs/TR; by contrast, large conventional ammonia systems have ratios of 20-30 lbs/TR or more.

One of the key messages of the guidelines is that low- charge systems reduce the regulations that ammonia operators face. However, "we know there is more peeling away of regulatory burden that can occur," said Liebendorfer.

The IIAR's Compliance Guideline Committee is therefore seeking input on ways the ARM-LC guidelines can be updated to reflect low-charge systems' safety advantages, said Liebendorfer, a member of the committee.

For example, a leak of under 100 lbs of ammonia does not require an operator to notify an emergency response center. "But what additional layers of regulations could you remove?" he asked. "These are areas we want to explore with the next version of the program."

In leaks from low-charge systems, there are typically no off-site consequences. "That has to be evaluated so we can determine how the program can be made easier for low-charge systems," added Liebendorfer.

"Any input we would get back, we would try to incorporate into the workings of the committee and develop a revision of the document," he said.

OPERATIONAL ADVANTAGES

Low-charge systems offer many operational advantages to end users, noted Liebendorfer. For example, unlike large ammonia systems, low-charge equipment allows end users to rely on manufacturers and contractors to provide safety guidelines and explain the day-to-day operation of the system.

Under the guidelines, contractors that install low-charge ammonia systems are responsible for training on-site employees, although the training would be significantly less intensive than for large, industrial facilities that use bigger ammonia charges.

For packaged systems, the ATM-LC guidelines suggest that manufacturers should conduct a hazard review before the equipment is installed, rather than the full-scale process hazard analysis (PHA) that would normally be conducted at facilities with large ammonia systems.

> *"We know there is more peeling away of regulatory burden that can occur."*

Packaged ammonia systems are typically pre-engineered with strong quality control. Moreover, an owner of a low-charge system can treat it as personal property, which can also translate into big tax savings, said Liebendorfer. "And they have a lower life-cycle costs."

The ARM-LC guidelines recommend that end users amend their existing emergency response program with instructions on how to respond to the smell of ammonia. It should trigger a call to the contractor, and could include an evacuation plan.

Packaged low-charge ammonia refrigeration and chiller systems are being produced by a growing number of U.S. manufacturers, including Azane (a division of U.K.-based Star Refrigeration Group), Mayekawa, Evapco and Vilter (see page 34). "There are a lot of package providers out there that are bringing these low charge systems to market," Liebendorfer said. "IIAR didn't want to fall behind in establishing guidelines and creating expectations for these systems."

The low-charge units are being used in a wide range of applications, including data centers, manufacturing facilities and ice rinks. They are also being employed in places outside the core market for ammonia refrigeration, such as small distribution centers, food-preparation facilities and supermarkets, where a handful of stores are testing ammonia/CO_2 cascade systems, he noted. (See page 36.)

The ARM-LC guidelines are designed to help the latter end users, who typically don't employ technicians on site and where a service contractor business model is the general practice.

The guidelines also contain information on operating and maintenance procedures. "So if a leak occurs, you have a methodology to investigate it," Liebendorfer explained. They also provide a qualification program for contractors so that in the event of an emergency "you have the basis for an action plan."

IIAR does not plan to incorporate the guidelines into IIAR codes and standards. However, the latest version of IIAR's safety standard, IIAR-2, includes a chapter on ammonia packaged systems. "IIAR wants to expand on that," he added. ■ CM & MG

New EIA Website Spotlights HFC-Reducing U.S. Grocers

ALDI US leads the way with 100 more transcritical CO_2 stores in 2019

– By Michael Garry

A new website launched on April 22 – Earth Day – by the Environmental Investigation Agency (EIA) highlights U.S. retailers committed to reducing HFCs, in part by installing natural refrigerant-based systems.

As part of this initiative, ALDI US announced its intention to add 100 more stores in 2019 with transcritical CO_2 refrigeration. To date, the retailer, which operates more than 1,800 stores, has installed transcritical systems in over 220 stores, making it the leading U.S. retail user of the technology. ALDI US also employs self-contained equipment running on propane in over 900 stores, as well as ammonia refrigeration systems in all warehouses.

"ALDI is deeply committed to reducing its refrigerant emissions and believes natural refrigerants are the best long-term solution for the planet," said Aaron Sumida, vice president at ALDI.

"Smart companies, such as ALDI US, committed to rapidly scaling up energy-efficient HFC-free technologies, demonstrate that it makes business and climate sense to lead in adopting future-proof refrigeration systems not reliant on potent super-pollutants," said Avipsa Mahapatra, climate campaign lead for EIA.

In addition to ALDI US, the new EIA web platform – https://www.climatefriendlysupermarkets.org – identifies other food retailers engaged in HFC-reduction and energy-efficiency initiatives, including Whole Foods, Target, Sprouts, and Ahold Delhaize USA. The site provides a map of supermarket locations in the U.S. using climate- friendly cooling, and highlights specific company actions in three key areas: adopting technologies, refrigerant management, and engaging in technical and policy dialogue.

STILL LAGGING

Mahapatra noted that, apart from these leading retailers, the U.S. retail sector as a whole "has remained a laggard in adopting climate-friendly cooling compared to their counterparts in rest of the developed world."

"We commend this small group of leading companies, but there is much more the U.S. supermarket sector can and must do," added Christina Starr, climate policy analyst, EIA. "These leading companies represent just 15% of U.S. supermarkets so there's a big opportunity for more to make commitments such as phasing out the worst HFCs like R404A, adopting climate-friendly refrigerants in new refrigeration systems, or joining the EPA's GreenChill Partnership and taking steps to limit leaks."

If all U.S. supermarkets join the EPA's GreenChill Partnership and achieve similar reduced leak rates, it would mitigate an additional 15.5 million metric tons of CO_2e annually, EIA said.

Other U.S. retailers included on the website commented on their HFC- reduction initiatives.

"We currently have 30 stores using low-GWP refrigeration systems including CO_2, propane and ammonia, and have adopted propane self- contained cases across the entire chain," said Aaron Daly, global director of energy management at Whole Foods. "We have seen great results from our low- GWP projects to date and continue to invest in innovation, exploring new approaches to reducing HFCs while addressing the varying needs of food retail refrigeration."

Added Frank Davis, director of facilities and engineering at Sprouts Farmers Market: "At Sprouts, we are committed to lowering HFC emissions from cooling by reducing leaks and piloting sustainable refrigeration technologies in stores. We continue to follow through on this commitment through our participation and certification of stores in EPA's GreenChill Partnership." ■ MG

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HC CHARGE-LIMIT INCREASE VOTED DOWN

Marek Zgliczynski, Embraco

Proposed standard falls just short of approval, preventing charge limit for A3 refrigerants from rising to 500 g from 150 g in commercial refrigeration

– By Michael Garry and Marie Battesti

In an extremely close vote concluded on April 12, the National Committees of the Internationa Electrotechnical Commission (IEC) voted against a proposal to increase the charge limit for A3 (flammable) refrigerants to 500 g from 150 g in self-contained commercial refrigeration cabinets.

They also voted down raising the charge limit for A2 and A2L (low flammable) refrigerants to 1,200 g from 150 g in the same equipment.

The vote ended a five-year process that many expected would result in a higher charge limits for flammable refrigerants like propane (R290) under IEC's 60335-2-89 standard. The effort to raise the limit could be revisited, though its fate is unclear at present.

The vote on the proposal – known as the Final Draft International Standard (FDIS) – in effect fell just one-third of a vote short of being approved. Out of 35 total votes cast by National Committees, nine (25.7%) voted against; for the proposal to be enacted, the opposing votes could not exceed 25%. The full results of the voting, including votes cast by each country, can be found here: https://bit.ly/2UeBdZa.

The vote was received as a major setback to many who saw raising the charge limit as a way to boost the market for hydrocarbon refrigerants. "We are very disappointed by the news, especially to lose by such a small margin," said Danielle Wright, executive director of the North American Sustainable Refrigeration Council (NASRC), which had strongly supported the 500-g charge limit. "But the upside to losing by [a small margin] is that it's an indication that it is a matter of 'when' and not 'if' the higher charge limit will be passed in the future."

"The main outcome of a negative vote will be in itself another barrier for the deployment of climate-friendly alternatives to refrigerant gases," said ECOS (European Environmental Citizens' Organisation for Standardization) in a position paper co-signed by several NGOs, including NASRC, and companies (including shecco, publisher of *Accelerate America*) on March 4, 2019.

The votes included participating (P) members (countries) on the IEC's subcommittee (SC) 61C, which was responsible for the development of the proposed charge limit, as well as observer (O) members. (In a separate vote by only P-Members, the proposal passed by a 70.8% vote, surpassing the two-thirds minimum required.)

Participating members are obliged to vote at all stages and to contribute to standard development, while observer members follow the work, receive committee documents and have the right to submit comments. They also attend meetings and can vote.

Seven participating countries (Israel, Japan, Republic of Korea, Malaysia, Netherlands, Turkey and the U.S.) voted against the charge increase as well as two observer countries (Serbia and Hungary). Ten countries abstained and six observer countries did not participate in the vote.

"I was hoping it would succeed," said Marek Zgliczynski, chair of SC 61C, and director of research and development for compressor manufacturer Embraco. "The quantity of resources dedicated to developing the standard was great – all this work has not given fruit."

FIVE-YEAR PROCESS

An amendment to the 60335-2-89 standard with a higher charge for flammable refrigerants has been in development since 2014, when SC 61C created a Working Group (WG4) to address raising the charge limit. In July of 2018, the National Committees voted 75% in the affirmative (surpassing the two-thirds minimum) to increase the charge limit in an interim procedure called the committee draft for vote (CDV).

Zgliczynski noted that some countries that voted against the 500-g standard in the FDIS voting had not participated in the CDV process.

"I'm upset that some people who voted against didn't show up before to develop requirements that would be satisfactory to them," said Zgliczynski. "They showed up only in the last vote." He added that some manufacturers of commercial refrigeration equipment also "didn't show up enough."

Zgliczynski declined to cite any particular group that lobbied against the charge increase, saying that each National Committee has "its own opinions and ideas." He did note that the safety of flammable refrigerants was a concern in the U.S. and Japan, though risk assessments showed that the requirements for the higher charge made it safer than the current 150-g charge limit.

Danielle Wright, NASRC

The charge-limit increase to 500 g from 150 g would have widened the use of hydrocarbons as natural refrigerants worldwide by allowing a single circuit to be employed in larger cabinets, rather than multiple circuits using no more than 150 g of refrigerant.

However, even with the 150-g limit, hydrocarbon cabinets have proliferated around the world, and are becoming a growing presence in food stores and restaurants. "With 150 grams you can make a system up to 1.5 kW [0.4TR] in a medium-temperature unit," noted Zgliczynski. Using multiple compressors that can be used as needed in a larger cabinet is "not a bad solution," he added.

Had the higher charge limit been approved, it would have served as a model for individual countries to enact their own standards. "I don't expect any country to make its own local standard to address this problem," said Zgliczynski.

The standard, had it passed, would have also widened the use of A2 and A2L refrigerants. Only very small systems can operate with 150 g of A2Ls, said Zgliczynski,

THREE OPTIONS FOR HYDROCARBONS

The negative vote does not necessarily herald the end of the road for a higher charge limit for hydrocarbons.

Zgliczynski outlined three options that could be adopted by the SC 61C committee. One is that the Working Group will continue the standards-making process, first by addressing the comments made in the recent vote.

A second option is that the higher charge limit could be published as a "technical specification" rather than as a standard. "For me, this is not solving the problem," Zgliczynski said. And finally, the attempt to raise the charge could be cancelled, though even then it could be revived at a later point.

Zgliczynski hopes to get the charge issue on the agenda at the next plenary meeting of the SC 61C, which will take place May 28-29 in Vienna. The meeting was originally scheduled to address safety improvements in household fridges, including better back-panel materials and upgraded capacitors.

If the Working Group resumes addressing the charge issue, it would take "years, not months" to get to another final vote, said Zgliczynski. "It's very difficult to predict how long the process can take." ■ MG & MB

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IIAR'S 'HUGE OPPORTUNITY' WITH HYDROCARBONS

Code consultant Jeff Shapiro thinks the trade group can offer safety guidelines for flammable refrigerants where ASHRAE and code bodies fall short

– By Michael Garry

The International Institute of Ammonia Refrigeration (IIAR) has carved out a reputation as the primary source of information on the safe use of ammonia in industrial, and increasingly, commercial refrigeration. Its standards, such as IIAR-2, have been widely adopted by international code bodies.

But IIAR sees itself as a trade group that also addresses other natural refrigerants. For example, in March, it released a 128-page safety standard for CO_2 closed-circuit systems, and collected comments on the standard during an initial public review period that ended on April 15. (See "IIAR's New Natural Refrigerant Safety Standards," *Accelerate America*, March 2019.)

Now, IIAR has turned its attention to hydrocarbon refrigerants. It has begun work on a safety standard for flammable (A3) hydrocarbons in commercial and industrial applications, including chillers and heat pumps (not store display cases).

Hydrocarbons like propane and isobutane are becoming more widespread in a host of applications due to their near-zero GWPs. Can IIAR establish itself as an authority on the safe use of hydrocarbon refrigerants?

Jeff Shapiro, president of International Code Consultants, and a consultant for IIAR, thinks there is a "huge opportunity" to do so by supporting existing guidelines in the ASHRAE-15 standard and other codes.

Overall, A3 and A2L refrigerants are governed by ASHRAE-15, one building code, two mechanical codes and two fire codes.

The abundance of codes "is weighing down the ability to use those refrigerants," Shapiro said at the IIAR Natural Refrigeration Conference & Expo, held in Phoenix Match 4-6.

And while ASHRAE and the mechanical codes allow 150 g charges of hydrocarbons in indoor display cases as well as outside applications, "they offer very little guidance on how to do it safely," said Shapiro.

Moreover, he added, ASHRAE-15 "is primarily a design document. It doesn't touch on installation and other rules. So there are a lot of places where we can clearly step in to assist and not step on ASHRAE's toes."

In particular, he pointed out that IIAR could develop rules for supplemental design, installation, commissioning, operation, ITM (inspection, testing and maintenance), decommissioning and RAGAGEP (recognized and generally accepted good engineering practices). "Those are all fair game," he said.

> "THERE ARE A LOT OF PLACES WHERE WE CAN CLEARLY STEP IN TO ASSIST AND NOT STEP ON ASHRAE'S TOES."

SAFETY FIRST

Shapiro stressed that in its standards development for hydrocarbons, IIAR needs to keep the safety issues surrounding flammable hydrocarbon refrigerants top of mind. He pointed out that, unlike natural gas and propane piped through buildings, hydrocarbon refrigerants are

> **AS WE STEP INTO THE A3 WORLD, WE NEED TO REMEMBER THAT WE UNDERSTAND THE REFRIGERATION WORLD – AND WE ALSO NEED TO GET INTO THE FIRE PROTECTION WORLD.**

not "odorized" and therefore are not self-alarming (in contrast to ammonia, which has a natural odor and is difficult to ignite).

"Do we really want to advance the presence of odorless flammable gases where people live, work and sleep?" he said. "How will occupants know if a dangerous situation develops?"

This puts a premium on maintaining a functioning leak-detection system, he noted, adding that most people are lax in checking their smoke alarms.

"As we step into the A3 world, we need to remember that we understand the refrigeration world – and we also need to get into the fire protection world," he said. "The two need to exist in harmony."

Shapiro expressed similar safety concerns about A2L refrigerants, which are flammable but not easily ignited, with a maximum burning velocity of 10 cm/s. "They are supposedly too slow to explode or sustain combustion, and lab tests say they are safe with ventilation, but you can't ignore them."

He noted that in ASHRAE-15-2016, A2Ls are permitted in human comfort systems and industrial refrigeration; the residential standard is "in process." A2Ls are allowed in UL listings for small equipment via UL's 60335-2-40 standard.

Shapiro thinks IIAR is up to the task of tackling flammable refrigerants. IIAR has already demonstrated with ammonia refrigeration that it's possible to promote a refrigerant that is good for the environment while addressing safety issues, he noted. "And I sincerely believe we will do the same as we move forward with other natural refrigerants. We have a path to do that, and it's probably the next step for our industry." ■ MG

JEFF'S CODES UPDATE

The international code bodies, which oversee safety standards for refrigeration and other systems, develop their codes well in advance of adoption, and are currently working on the 2021 editions.

At the IIAR Natural Refrigeration Conference & Expo, held in Phoenix, Ariz., March 4- 6, Jeff Shapiro, president of International Code Consultants, and a code consultant for IIAR, offered an update on progress toward 2021 codes.

- IFC (International Fire Code), IMC (International Mechanical Code) and IBC (International Building Code) are done.

- NFPA (National Fire Protection Association) 1 is up to public comments.

- UMC (Uniform Mechanical Code) will be done this year following public comments.

IIAR has had a great deal of success getting its ammonia wstandards adopted, not only by in ASHRAE-15, but by model code organizations.

For example, the IIAR-2 safety standard is now referenced by the 2021 IFC, the 2021 IMC, the 2020 NFPA, the 2020 NFPA 70 NEC (National Electrical Code), and is in the process of being referenced by the 2021 UMC. Other IIAR standards are also cited by the code bodies.

In the case of the IFC, IIAR-2 is now equivalent, not subordinate, to ASHRAE-15, noted Shapiro, adding that he plans to get rid of any regulation of ammonia refrigeration in the 2024 IFC edition.

Some changes in the 2021 IFC pertaining to refrigeration include: stationary fire extinguishers are waived for warehouses primarily accessed by forklifts and powered trucks, if the forklifts and trucks are equipped with the extinguishers; emergency pressure control systems are only required for machinery rooms; and atmospheric release evaluations no longer require fire and environmental evaluations.

U.S. APPEALS COURT MAINTAINS BAN ON HFC REPLACEMENTS

Following 2017 precedent, court partially nullifies EPA SNAP Rule 21, leaving HFC prohibition in new ODS retrofits

— By Michael Garry

Drawing on a similar 2017 decision, a three-judge panel in the U.S. Court of Appeal for the District of Columbia Circuit on April 5 partially vacated a 2016 U.S. Environmental Protection Agency (EPA) rule that banned the use of high-GWP HFC refrigerants in certain applications.

But the rule – EPA's SNAP (Significant New Alternatives Policy) Rule 21 – was only nullified "to the extent that it requires manufacturers to replace HFCs that were previously and lawfully substituted for ozone-depleting substances (ODS)."

Notably, the court left in place the part of the rule that classified HFCs as unacceptable substitutes for ODS in equipment in which the ODS have not yet been removed, affirming the EPA's authority to change the status of an ODS substitute from safe to prohibited.

The court's decision came in response to a request made last month by U.S. chemical manufacturers Honeywell International and Chemours, along with the Natural Resources Defense Council, to maintain the EPA's authority to ban high-GWP HFCs in certain applications covered in SNAP Rule 21, enacted in 2017 during the Obama administration. Those applications include cold-storage warehouses, certain chillers, household refrigerators and freezers, retail food processing and dispensing equipment, and foam-blowing uses.

But the court deferred to its previous ruling, made in August 2017 in the case *Mexichem Fluor, Inc. v. EPA*, that the EPA cannot require companies to replace HFCs with low-GWP substances under the agency's 2015 SNAP Rule 20. Under Rule 20, HFCs could not be used in a variety of retail food refrigeration applications, among others, after specified dates.

The Court of Appeals declined to reverse that ruling on appeal, and the U.S. Supreme Court later declined to hear the case. The reversal of the SNAP rule has since roiled the U.S. HVAC&R industry, leading California to adopt SNAP Rules 20 and 21, with other states following suit. (See, "The Policy Quagmire," *Accelerate America*, June-July 2018.)

"We concluded that [section 612 of the Clean Air Act] does not grant the EPA authority to place such a burden on manufacturers," the court said in the new ruling. However, the court noted that the 2017 decision "sustained as well-reasoned the EPA's decision to ban further substitution of ozone-depleting substances with certain HFCs."

COMPLICATED QUESTIONS

Christina Starr, climate policy analyst for the Environmental Investigation Agency (EIA), noted that the new ruling on SNAP Rule 21 raises the possibility that the EPA could leave HFC bans intact in cases where there are systems using ODS. "It seems like common sense, if you're an owner of a cold storage facility, to just opt for refrigerants that aren't subject to these complicated regulatory questions," she said.

Meanwhile, some pending actions may yet impact the final disposition of the EPA's ability to regulate HFCs. Last year the Natural Resources Defense Council and a coalition of 11 Attorneys General separately sued the EPA over its decision to completely void SNAP Rule 20's regulations pertaining to the use of HFCs.

And EPA said last year that it would begin a notice-and-comment rulemaking process to "address the remand of the 2015 rule."

"We support the legal challenge to EPA's guidance that fully revoked Rule 20 pending a proposed rule," said Starr. "The court's decision was only a partial vacature, so revoking the entire rule with no proposal to replace it was unlawful." ■ MG

Washington State Legislature Passes HFC-Reduction Bill

Bill calls for study of ways to boost use of products with alternative refrigerants, following California's lead

– By Michael Garry

As part of a series of bills addressing climate change, the Washington state legislature on April 22 (Earth Day) passed House Bill 1112, which phases out the use of HFCs in various applications and calls for a study of how to increase the use of products that do not contain HFCs. (See https://bit.ly/2I-Uq0Lu for complete bill.)

The bill passed 30-19, with every Democrat supporting it, along with two Republicans. It then went to Governor Jay Inslee, who supports climate change legislation and is running for the Democratic party nomination for U.S. president on a platform largely focused on addressing climate change.

In a tweet, Inslee thanked the Washington legislature for agreeing to phase down use of "super-polluting hydrofluorocarbons," in particular citing state representative Joe Fitzgibbon and state senator Reven Carlyle. "This bill had tremendous support from the private sector [and] I look forward to more states taking action on HFCs through [the U.S. Climate Alliance]."

The bill describes HFCs as "air pollutants that pose significant threats to our environment," adding that "safer alternatives for the most damaging hydrofluorocarbons are readily available and cost-effective."

Washington is the latest member of the U.S. Climate Alliance, a bipartisan coalition of 23 state governors (and the governor of Puerto Rico) co-founded by Inslee, to commit to phasing down the use of HFCs. The other states are California, New York, Maryland and Connecticut. The alliance formed in response to the decision by the Trump administration to leave the global Paris climate-change accord. (See, "The Policy Quagmire," *Accelerate America*, June-July 2018.)

The states addressing HFC reduction are coalescing around efforts spearheaded by California, which last year passed the California Cooling Act. That bill incorporates HFC regulations abandoned by the U.S. Environmental Protection Agency (EPA) and calls for incentives for natural refrigerant equipment. "It falls to the states to provide leadership on addressing hydrofluorocarbons," said the text of House Bill 1112. "Doing so will not only help the climate, but will help American businesses retain their positions as global leaders in air conditioning and refrigerant technologies."

$959,000 to phase out HFCs

Last December, Inslee unveiled a $273 million climate action plan – including $959,000 to phase out HFCs – that would reduce greenhouse gases to 25% below 1990 levels by 2035. (See "Washington Governor Proposes Cutting HFCs," *Accelerate America*, January 2018.)

House Bill 1112 puts Washington state on a course to phase down HFCs "in a manner similar to the regulations adopted by the [EPA] and that have been subsequently adopted or will be adopted in several other states around the country." The EPA regulations include SNAP (Significant New Alternatives Policy) Rules 20 and 21, which stipulated the delisting of high-GWP HFCs in a variety of applications. The bill prohibits the sale or lease of equipment using those HFCs.

The law also calls for the state's Department of Ecology, in consultation with the Department of Commerce and the Utilities and Transportation Commission, to complete a report by December 1, 2020, that recommends how to "increase the use of refrigerants with a low global warming potential in mobile sources, utility equipment and consumer appliances" and incentivize "the elimination of legacy uses of hydrofluorcarbons." ■ MG

CARB Seeks Stakeholder Feedback on GWP Refrigerant Caps

The California agency, which is setting GWP limits for new AC and refrigeration systems, also urges HVAC&R stakeholders to push for incentive funding with state legislators

– By Marie Battesti and Michael Garry

The California Air Resources Board (CARB) is seeking feedback from stakeholders as it proceeds to develop regulations that will cap the GWP of refrigerants used in new air conditioning and refrigeration systems, as well as the GWP of virgin refrigerant supplies.

In a webinar hosted on April 16 by the U.S. Environmental Protection's GreenChill program, representatives of CARB also encouraged stakeholders to contact members of the California legislature to express support for funding of incentives for natural refrigeration systems. An incentive program was established by the California Cooling Act (SB 1013) but still requires funding to be allocated by the legislature from the state's Greenhouse Gas Reduction Fund (GGRF). (See "California Passes Cooling Act," *Accelerate America*, September 2018.)

"It's up to end users, OEMs and distributors to make their wishes known to the senate and assembly," said Glenn Gallagher, air quality scientist at CARB. Elected officials, he added, usually listen to their constituents or "people who ask the loudest and most often."

Kathryn Kinett, air pollution specialist at CARB, suggested that stakeholders could contact trade associations to get the contact details of relevant elected officials.

California aims to cut HFC emissions in the state, now at about 20 million metric tons of CO_2e, by 50% as of 2030. To accomplish that, the state is using a multi-pronged approach, including regulations CARB adopted in March 2018, SB 1013 (which incorporates former EPA rules) and other programs.

CARB is now proposing stricter regulations, including a 750-GWP cap for stationary air conditioners by Jan 1, 2023, a 150-GWP cap for refrigeration systems with more than 50 lbs of refrigerant by January 1, 2022, and a ban on sales of virgin refrigerants with a GWP above a threshold – currently 1,500 – by January 1, 2022.

The refrigeration system proposal could include a 1,500-GWP limit for some smaller systems, and a possible exemption for hybrid systems. In the refrigerant ban there would be an exception for R410A used in air conditioning.

PUBLIC INPUT THIS YEAR

CARB plans to continue workshops and stakeholder meeting, and seek public input in 2019 as it develops HFC rulemakings. Board consideration of GWP limits in new AC and refrigeration equipment is expected in late 2019 to early 2020, said Richie Kaur, air pollution specialist at CARB.

One of the issues CARB is looking at in regard to the 750-GWP cap on new AC systems is how it should track compliance. Methods under consideration include labels, recordkeeping and reporting. "We seek stakeholder feedback to develop the most robust regulation possible," said Kinett.

Another issue about which CARB would like to hear from stakeholders is whether "new systems" would include just new construction, or also replacements in existing stores, noted Kaur. CARB is also still taking stakeholder input on the GWP limit for its ban on virgin refrigerants, she added.

The three CARB officials can be reached at: glenn.gallagher@arb.ca.gov; kathryn.kinett@arb.ca.gov; and richie.kaur@arb.ca.gov. ■ MG

R290 SETTLES IN FOR CABINET OEMS

Having made the transition to propane refrigerant, Turbo air and Fogel see stable market with major customers

– By Charlotte McLaughlin and Michael Garry

The NAFEM (North American Association of Food Equipment Manufacturers) Show, held every other year, has served as a platform for a number of stand-alone refrigeration manufacturers to highlight their transition from HFC refrigerants to the hydrocarbons propane and, in some instances, isobutane.

In this final installment of coverage of the 2019 NAFEM Show, held February 7-9 in Orlando, Fla., two major exhibitors, Turbo Air and Fogel, discuss the growing maturity of the market for R290 units. (For the previous installment, see "NAFEM Show Highlights, Part 2, *Accelerate America*, March 2019.)

SERVICE NO LONGER AN ISSUE FOR TURBO AIR

Turbo air, a Long Beach, Calif.-based manufacturer, says foodservice and food retail end users using its hydrocarbon-based fridges are no longer worried about the availability of technicians to service the units.

"The technicians are trained," said Dan Cho, COO of Turbo air, at the NAFEM Show. "It's not a big deal."

Turbo air completely transitioned its product line in 2018 to hydrocarbons, including R290 and R600a, the latest in a series of U.S. OEMs that have converted to hydrocarbon refrigerants.

The company runs its own service network across 13 U.S. branches, which covers 65%-70% of its warranty work, with the rest coming from third-party technicians, Cho said.

Turbo air sells hydrocarbon units to such outlets as 7- Eleven, CVS, Burger King, Wendy's and Dunkin' Donuts, through dealers or directly to franchisees and corporate offices, he said.

The company's hydrocarbon units are 20% more efficient than HFC equipment, Cho said; seventy-five models comply with ENERGY STAR 4.0 efficiency standard.

A key foundation of its technology is a self- cleaning condenser, which includes a fine mesh filter at the front to catch dust, and a rotating brush that moves up and down once a day to push excess build-up out of the unit.

The company plans to transition away from HFCs in its blowing foams, according to Daniel Kwon, supermarket equipment sales manager for Texaking, Grand Prairie, Texas, part of the Turbo air group. "We will be changing to cyclopentane," Kwon said.

FOGEL'S BEER COOLERS FIND HOME IN STADIUMS

Guatemala-based Fogel is selling propane-cooled beer coolers in North and South America to Anheuser-Busch, part of world's biggest beer manufacturer, AB InBev.

"We've done that for a while," Federico Barquero Tefel, vice president of commercialization for Fogel said at the NAFEM Show. "And everything we've forwarded to them has been R290."

The coolers are used in sports stadiums and at retail outlets in U.S. states that allow branded equipment to be displayed. The units chill the beverages down to 25°F to produce "really cold beer," he said.

Howard McCray, a manufacturer based in Philadelphia, Pa., owns and distributes Fogel units in the U.S.

When Fogel began selling R290 coolers in 2010, some contained refrigeration circuits in a cassette that could be easily removed for servicing and replaced by another module. But because that model comes with a 12%-18% higher price tag, Fogel largely sells split units.

The cassette models helped to "break the ice" for people concerned about flammability of R290, he said. "The cassette introduced [R290] to the market. Now people feel more comfortable and have moved over to the split system." ■ MG & CM

R290 Turbo air unit

VILTER PREPARES FOR RELEASE OF LOW-CHARGE AMMONIA PACKAGE

The Modular Rooftop Unit employs CO_2 or glycol as a secondary fluid

– By Charlotte McLaughlin and Michael Garry

Vilter Manufacturing, a subsidiary of Emerson, will release its NH_3/CO_2/glycol packaged Modular Rooftop Unit (MRU) later this year, following a series of tests at Vilter's headquarters in Cudahy, Wis.

The penthouse unit is the latest low-charge-ammonia packaged unit to enter the marketplace as industrial end users seek safer, smaller and more flexible systems that reduce their regulatory responsibility.

The Vilter modular unit has been designed to offer end users a choice between a glycol-based secondary system serving coolers and docks, and a CO_2 secondary system for low-temperature applications. In both cases, ammonia does not enter the refrigerated space.

"The industry is changing, so we designed this product with [the market] in mind," said Gary Chafee, district sales manager, Vilter, in a presentation at the IIAR Natural Refrigeration Conference & Expo, held in Phoenix March 4-6.

"Obviously we have a low-charge system so we have helped reduce the leak rate, compliance costs and regulatory burdens dramatically," Chafee said.

Series of tests

Vilter introduced the MRU at the 2018 IIAR Natural Refrigeration Conference & Expo. (See "IIAR Highlights Low Charge," *Accelerate America*, April 2018.) Since then the company has conducted a series of tests on the ammonia and CO_2 skids; the last tests are on the cascade heat exchanger and the defrost system. "We are happy with the modifications we made to the unit," said Wayne Wehber, VP business development, Vilter, who also spoke at the 2019 IIAR event.

The company initially said the ammonia charge would be under 200 lbs, but is still working on getting down to the "lowest possible charge," said Wehber.

The MRU ranges in capacity from 55-85 TR for freezing, 28-40 TR for blast freezing, 75 TR for coolers, and 95 TR for docks. The unit contains two ammonia circuits for redundancy, each with a 143-mm single-screw compressor designed to operate with a variable frequency drive. It also features: an air-cooled condenser on the roof, evaporators in the penthouse rather than hanging evaporators that would take up storage space; two glycol pumps; and four to six CO_2 semi-hermetic reciprocating compressors.

Each of the ammonia skids comes with its own cascade heat exchanger, where ammonia condenses CO_2. An advantage of that configuration is that in the event that CO_2 and ammonia accidentally mix to form system-clogging ammonium carbonate in one skid, the other takes over.

Vilter elected to use an air-cooled condenser because "water usage is more of an issue," Chafee explained. "For an 80 ton load running 6,000 hours a year, you're going to use 1.3 million gallons of water with the a fluid cooler or evaporative condenser. That's a lot of water."

Vilter sees the MRU being employed in the retrofit market and in expansions as well as new construction. It can be employed as a "plug-and-play package, or components can be used individually. ■ CM & MG

Single-screw Vilter compressor used in low-charge Modular Rooftop Unit

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SHOULD GROCERS FEAR AMMONIA?

No, say the people involved in four of the five ammonia/CO_2 systems installed (or soon to be installed) at U.S. supermarkets, though initial cost remains a significant hurdle

– By Charlotte McLaughlin and Michael Garry

To date there are only four U.S. supermarkets – five by the end of the year – that have been willing to install a refrigeration system that uses ammonia, along with CO_2. This makes an NH_3/CO_2 system one of the most unusual of natural refrigeration technologies (propane/CO_2 is in only one Whole Foods Store), despite the efficiency and environmental advantages it offers.

The reason for this is twofold: fear and cost. The fear stems from ammonia's toxic properties as well as the noxious odor it exudes; an ammonia leak is not something that most grocers would happily contemplate. As for cost, ammonia/CO_2 systems typically run 150% higher than that of conventional DX supermarket systems, according to Keilly Witman, owner of KW Refrigerant Management Strategy, a Boise, Idaho-based consultancy, and former manager of the Environmental Protection Agency's GreenChill program.

But the fear factor may be overblown, said four panellists at a discussion of these systems at the International Institute of Ammonia Refrigeration (IIAR) Natural Refrigeration Conference and Expo, held March 4-6 in Phoenix. The discussion, hosted by Witman, included speakers who have worked with three of the four existing NH_3/CO_2 stores – operated by Whole Foods Market, Albertsons and the Defense Commissary Agency – and with a Raley's NH_3/CO_2 store that will open later this year. (A Piggly Wiggly store operated by JTM Corp., which uses this system, was not represented.)

While the retailers who ventured into testing ammonia had some trepidations about the refrigerant, they found their concerns were mostly dismissed by the local Authority with Jurisdiction (AHJ) or fire official.

"From a safety standpoint it was literally laughable to [the fire department] that we were concerned about having [300 lbs of] ammonia in a grocery store," said Richard Heath, director of enterprise energy and sustainability, Insight Sourcing, who worked for Supervalu when it opened the first NH_3/CO_2 store (an Albertsons) in Carpinteria, Calif., in 2012. (Albertsons now owns the store.)

> "FROM A SAFETY STANDPOINT IT WAS LITERALLY LAUGHABLE TO [THE FIRE DEPARTMENT] THAT WE WERE CONCERNED ABOUT HAVING [300 LBS OF] AMMONIA IN A GROCERY STORE."
>
> – Richard Heath, Insight Sourcing

> I RECOMMEND YOU FORGET ABOUT THE INTERIM STEPS AND GO RIGHT TO ZERO [GWP].
>
> – Ed Estberg, Raley's

The Carpinteria store, which was also the first all-natural refrigerant store in the U.S., uses ammonia on the roof on the high side with CO_2 circulated in the store in a cascade configuration. It also employs a redundant R407A system to run energy-efficiency comparisons with the ammonia/CO_2 system.

Heath acknowledged that Supervalu had been "overly concerned" because of the "horror stories" about ammonia, stemming from the time when it was replaced by synthetic refrigerants in some applications. "We truly thought we were going to have an uphill battle in California for permitting."

Tristam Coffin, director of sustainability and facilities, Whole Food Market's Northern California region, had a similar experience when opening an ammonia/CO_2 cascade store at a Dublin, Calif., location four years ago.

"The fire department laughed us off in terms of our concerns with the potential safety of the system," Coffin explained. "They were fine for whatever we intended to do in large part because there was more serious precedent on the industrial side."

RALEY'S UNORTHODOX SYSTEM

Ed Estberg, a refrigeration consultant for Raley's who served as senior director of facilities for the Californian chain from 1989 to 2009, has helped it develop its own unorthodox system that employs ammonia DX with liquid overfeed CO_2 and no CO_2 compressors. He expects the Sacramento store with the system to open in October. (See "Raley's Opts for Ammonia/CO_2 in Most New Stores, *Accelerate America*, September 2018.)

"All the mechanical heating and cooling in our building is tied to our system," said Estberg. "We have capacity for everything from ice cream to air conditioning."

Raley's was motivated to develop the all-natural refrigeration system because of the expectation that California's Air Resources Board will cap the GWP of refrigerants in commercial systems at 150. (See page 31.)

"When California first announced two years ago that we had to be under 150 GWP, I went to the [Raley's] ownership and said you really don't have a choice," Estberg said. "You can go to a lower GWP and then in five years they're going to come at you again. So instead of being 150, it's going to be 99 and that is going to be a 50. I said let's just go to zero and they agreed with that."

California's fire and mechanical codes are paving the way for ammonia in commercial applications. "It's very clear that they expect that to happen," said Estberg. The chain, he added, "got no comments from the fire department."

Estberg urged other supermarket operators in California to make up their minds about the type of refrigeration system they will use after the state enacts its new GWP rules. "I recommend you forget about the interim steps and go right to zero [GWP]." Outside of California, other U.S. states are following California's model in regulating HFCs. (See page 30.) "Certainly within 10 years everybody in this room's going to be faced with it; I don't care where you are in the United States," he said.

The U.S. Defense Commissary Agency (DeCA) – the worldwide "supermarket to the military" – installed an ammonia/CO_2 cascade system at its Lackland Air Force Base commissary in San Antonio, Texas, in 2014, replacing an aging R404A system. Given the store's proximity to day care center, a church and shopping center, the installation has a keen focus on safety. It separates the 81-lb ammonia charge on the roof into nine separate modules, such that a leak from any one module would pose a minimal hazard.

Nonetheless, the project met considerable resistance from the base, including a maintenance representative who "was almost pounding his fist on the table saying, 'not on my base,'" said Rob Arthur, director of refrigeration engineering, CTA Architects Engineers, who worked on DeCA's ammonia/CO_2 project.

To allay their concerns, CTA did a "plume study" examining a worst-case scenario in which 100 lbs of ammonia would be released at once under the least favorable conditions, a cold foggy day. The study found that "by the time that amount of ammonia could reach anywhere there would be [people], there would only be an odor; there was no health hazard," said Arthur.

Once the results were explained to the base personnel, coupled with the sustainable benefits of theysystem, "they really got on board," he added.

Arthur thinks the fear factor regarding ammonia has been overcome. "You can do them without a risk to operators in the store or the shoppers," he said. "I think there's space for these kinds of systems."

With local authorities satisfied with the safety of the ammonia/CO_2 systems, both Heath and Coffin have found that the insurance costs associated with the systems are no different than for other refrigerants.

THE COST OBSTACLE

While anxiety about ammonia appears to be an obstacle that can be overcome, the high cost of ammonia/CO_2 systems remains a major deterrent to the implementation of these systems by food retailers, who operate in the very low-margin grocery business.

Heath pointed out that the Carpinteria store was a "proof-of-concept" implementation in 2012, and that greater demand for the technology will be needed to create economies of scale and lower prices. Take LED lights, he said. "Some supermarkets put them into freezer cases, and luckily we had an end user that said build it and we will buy it. The volume is what makes LED lights now affordable for us."

Coffin concurred. "I think economies of scale is the biggest piece that we need to recognize," he said, adding that Whole Foods' ammonia/CO_2 installation carried a 102% premium over the baseline cost of an R407 DX system with adiabatic condensers.

Reflecting that the session on supermarket refrigeration – organized by the North American Sustainable Refrigeration Council – was taking place at an industrial refrigeration conference, Coffin suggested that there's a "great opportunity" for commercial and industrial systems to be manufactured together to create favorable economies. "Obviously the systems and sizes are going to be very different but I think there are still some opportunities in that space."

" I THINK ECONOMIES OF SCALE IS THE BIGGEST PIECE THAT WE NEED TO RECOGNIZE. "

– Tristam Coffin, Whole Foods Market

> "YOU CAN DO THEM WITHOUT A RISK TO OPERATORS IN THE STORE OR THE SHOPPERS."

– Rob Arthur, CTA Architects Engineers

Raley's is in a different situation because Estberg has designed the system, saving Raley's a considerable amount of money. He said its cost is driven by the price of the liquid CO_2 overfeed racks.

All told, he calculated that the cost of the ammonia/CO_2 system would run 15% more than that of a standard system – or about $300,000 more than a $2 million system. In estimating the payback on that premium, he includes not only energy but also water and natural gas, which will be reduced by the use of heat reclaim for domestic hot water. His "long-term analysis" is that Raley's will save about $35,000 per year in utility costs, producing a payback over 8.6 years (which he rounded to 10 years).

Typically the supermarket industry looks for a three-year payback period. However, even a 10-year payback "isn't such a bad thing when you really start looking at total cost of ownership," Coffin said. "Ideally your system will be operating for 15-20 years."

In its initial ammonia/CO_2 installation, Raley's is receiving a rebate of $250,000 from the Sacramento Municipal Utility District (SMUD), of which $150,000 is for installing a natural refrigerant system, and $100,000 for improved energy efficiency. (See "Game Changer, *Accelerate America*, May 2017.) That would cover most of the premium, but only for the first store.

Some of the ammonia/CO_2 systems in supermarkets have demonstrated energy-saving capabilities just via the refrigeration. At a Piggly Wiggly store in Columbus, Ga., operated by JTM Corp., Heatcraft Worldwide Refrigeration found that the ammonia rack consumed 22% less energy on average than an HFC rack in the same store during a four-month period. (See "Energy Savings Continues at Piggly Wiggly," *Accelerate America*, January 2017.)

At the Carpinteria store, Supervalu was able to compare the energy consumption of the ammonia/CO_2 system and the redundant R407A system, and found the former 12%-16% more efficient than the latter, said Heath.

Other stores were not as successful on the energy side. Arthur said the DeCA ammonia/CO_2 system achieved "energy parity" with a "finely tuned" R407A or R449A system. Whole Foods found that its ammonia/CO_2 system performed less efficiently than other systems, including a transcritical CO_2, propane/CO_2 and R407A distributed.

Witman asked the panellists whether sustainable ammonia/CO_2 refrigeration systems could be perceived as a "competitive advantage" that should be publicized.

Heath noted that neither the Carpinteria store nor Whole Foods' multiple natural refrigerant stores are well known to the public for their environmentally progressive refrigeration systems. "I think you should toot your own horn," he said. "If you're doing a great job with anything, that should be recognized."

Coffin pointed out that the Project Drawdown study cited synthetic refrigerants as the number one climate impact. Replacing them with natural refrigerants is "a story that's been tough to tell but one that I think we're all trying to achieve." ■ CM & MG

Lidl France banking on propane

In August 2018, Lidl France opened its first supermarket to use propane for 100% of refrigeration, creating a standard for new stores

— By Andrew Williams

Operating some 1,500 stores throughout France, and employing some 35,000 people, 25-year-old Lidl France is acutely aware of the responsibility it shares to help put the world on a more environmentally sustainable footing. That very much includes HVAC&R, which represents a significant proption of any food retailer's carbon footprint.

In 2010, Europe's commercial refrigeration sector represented 40% of refrigerant consumption, 85% of which was attributed to large refrigeration systems in supermarkets (which primarily used R404A), according to a 2012 study conducted by UK-based environmental consultants SKM Enviros.

"This implies that supermarkets are the largest consumers of HFCs in Europe," the SKM Enviros study said.

Another report, produced in 2016 by Swedish research institute KTH for the EU-funded SuperSmart project, found that 18%-30% of annual carbon-equivalent emissions in European supermarkets are attributed to their choice of refrigerants.

Lidl France is expects to have 250 propane stores by the end of its fiscal year.

Propane cases in Lidl Valenton, the first Lidl France store to be 100% propane-based.

Against this background, Lidl France decided to act. In August 2018, Lidl Valenton in the Paris region (Créteil) became the first Lidl France store to use propane (R290) for 100% of its refrigeration needs. "Since then and from now on, our strategy is for all new stores to be 100% propane-based," said Nabil Rehab, project manager – refrigeration systems, Lidl France.

The retailer is also changing its cases in existing stores to propane. By the end of the fiscal year 2018 (which ended in February 2019), it had converted the cooling cabinets to propane in 40 stores.

"This fiscal year, we'll convert an additional 10% of our stores, pursue a program of 'store transfer,' and open new stores using propane," said Yassine Rami, head of department (purchasing and store investments) at Lidl France..

"In total, we'll have 250 propane stores by the end of this fiscal year," Rami explained.

Going forward, the retailer intends to change the cooling equipment in around 100 stores per year. And by 2022, Lidl France expects around 50% of it's 1,500-store portfolio to be equipped with propane-based cooling equipment.

German roots

Lidl France is part of Lidl Stiftung & Co. KG, founded in 1930 by Joseph Schwarz and headquartered in Neckarsulm, Germany.

The parent company operates over 10,000 stores across 28 European countries and the United States. Its chairman and CEO, Dieter Schwarz, also holds the same positions in hypermarket chain Kaufland.

Lidl first used propane as a refrigerant in 2016, when it tested a propane system in a supermarket in Munich, Germany. Having initially also considered CO_2, Lidl ultimately selected propane.

What motivated Lidl France to follow suit and also adopt propane? Propane doesn't just reduce Lidl France's greenhouse gas emissions – it also delivers energy savings, Rehab said.

Moreover, installing plug-in and remote semi plug-in cabinets avoids the need for a centralized refrigeration plant. "What we're doing is decentralizing prduction," Rehab noted.

The retailer is also acting out of concern for the climate. "The impact of HFCs on the environment today is significant. Rami said. "They make a major contribution to the greenhouse effect, and that's why climate science requires them to be phased down. We want to stay one step ahead of that curve.

Cost is another factor. Lidl France estimates that the cost of HFCs has increased four times in recent years. "Part of the reason for this is that it's brutally overtaxed," said Rehab. "By choosing propane, we're anticipating such issues.

But the move to propane, he added, was not driven primarily by economic considerations. "It was environmental."

Even manufacturers recognize Lidl France's commitment to sustainability. "The choice that Lidl has made for natural refrigerants – not just in refrigerated cabinets but also for frozen goods, for cold stores, and so on – is ideological," said Sylvain Gillaux, managing director (France) at Hauser, an Austrian OEM and cooling furniture maker that provides Lidl France with cabinets. "Lidl has decided that it must use natural refrigerants, for environmental reasons."

Gillaux also praised the retailer for its business acumen. "What Lidl France has done is rare – it organizes regular meetings between the frigoristes (refrigeration technicians), the technology providers, and Lidl France itself," he said. "Lidl France plays a kind of 'gentleman organizer' role to ensure that everyone is aligned, and to make their vision concrete."

> *"Our strategy is for all new stores to be 100% propane-based."*
>
> – Nabil Rehab, Lidl France

Lidl France's commitment to natural refrigerants extends to cold storage, where it uses either CO_2 or ammonia in all new warehouses, with a familiar objection to HFCs. "The objective is to no longer use HFCs – they're polluting, there's going to be less and less of them, and they're really expensive," Rami said.

While the positive environmental impact of choosing natural refrigerants is clear, some HVAC&R practitioners believe more could be done to demonstrate their economic advantages to end users.

Gillaux thinks the onus is on manufacturers to communicate the business case for natural refrigerants more clearly. "Most retailers would expect to make huge energy savings, if they were to take the risk of changing to a new technology," he said.

> *"The objective is to no longer use HFCs – they're polluting, there's going to be less and less of them, and they're really expensive."*
>
> – Yassine Rami, Lidl France

Gillaux also stressed the importance of training France's frigoristes to use natural refrigerant-based technologies. "This doesn't just take place in training institutes. Manufacturers such as us hold training sessions on new technologies," he said.

Charge concerns

Regulations and safety concerns can present obstacles to wider uptake of hydrocarbons, which are flammable substances.

For example, international standard IEC 60335-2-89 limits the use of flammable refrigerants in hermetically sealed commercial refrigeration equipment with an incorporated or remote refrigerant unit or compressor to 150g.

To comply with the regulations, Lidl France uses three circuits per cabinet. "Using three separate circuits of 150 g gives us the capacity we need," said Lidl France's Rehab.

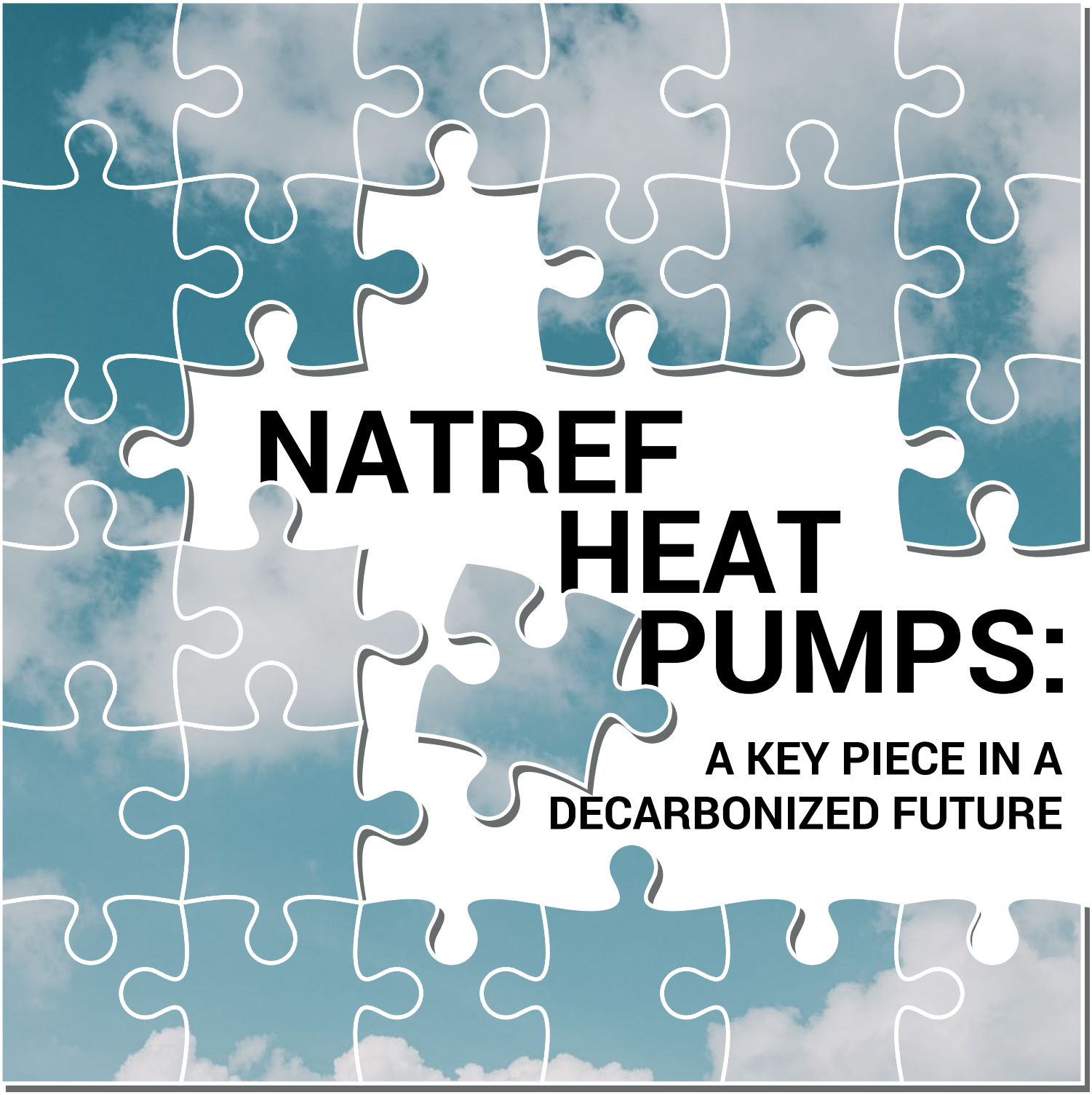
Many stakeholders believe the 150-g limit prevents refrigeration equipment manufacturers and end users from fully exploiting the safe and efficient application of hydrocarbon refrigerants in the commercial refrigeration sector. But an effort to raise the limit to 500 g recently fell short. (See page 22).

"Clearly, the furniture would be cheaper if the rules were adapted to allow up to 500 g in a single circuit," Rehab said. "The update would have allowed us to reduce the equipment acquisition costs. We'd have been able to reduce the number of circuits, compressors and heat exchangers required."

To strengthen the business case for natural refrigerants, Rehab stressed the importance of looking at energy savings in a holistic manner, including the use of doors on cabinets.

Six hundred of Lidl France's supermarkets already have cooling cabinets with doors, for example. "We hope to put doors on all our cabinets by 2022," Rehab said.

The environmental and energy benefits of using propane, wedded to the efficiency of other measures such as cabinet doors, air curtains and heat reclaim, are a powerful combination, said Rehab. "It's about improving the whole cold chain." ■ AW



NATREF HEAT PUMPS:

A KEY PIECE IN A DECARBONIZED FUTURE

As buildings seek alternatives to fossil fuels for heating, electric heat pumps using CO_2 and other natural refrigerants are finding a growing market in North America

– By Michael Garry

For the past decade, Troy Davis, energy group manager for Mayekawa USA MYCOM, has been promoting the Japanese company's CO_2- and ammonia-based heat pumps for space heating and domestic water heating in North America.

But unlike in Japan and Europe, where heat pumps using natural refrigerants have been widely used in commercial and residential applications, the North American market has been difficult to penetrate. "Ten years ago, I thought we'd have thousands [in North America] by now," said Davis. Instead the number is about 25 CO_2-based UNIMO units.

But that's beginning to change.

Over the last four to six months, Davis has been getting "a lot of phone calls and emails" about a wide variety of heat pump applications, particularly from multi-family apartment buildings on the West and East Coasts of the U.S. seeking domestic hot water heaters. One example is Stuy Town, an apartment complex in Manhattan. Multi-family buildings are considering both water-source and air-source CO_2 units.

"CO_2 heat pumps are great for domestic hot water heating where you take cold water and heat it to a higher temperature," he said.

In general, Davis said he is seeing "huge potential" in the U.S. for heat pump technology using CO_2, and to a lesser degree, ammonia. "The market is untapped here," he said. "But things are starting to line up," though he acknowledged that Mayekawa needs to "fine-tune" its large Japanese units to make them a better fit for the U.S. market.

John Miles, general manager – eco systems, Sanden International (USA), said sales of home heat pumps (still largely for units using R410A) are "booming" in Northeastern U.S. states like Maine and Vermont, which are aggressively marketing the products with rebates. But heat pumps are still a small slice of the overall market for hot water heaters in the U.S.; for example, only 1,800 were sold in Connecticut in 2017.

Miles, who is marketing Sanden's CO_2 heat pumps for domestic water heating and space heating, has been crisscrossing the U.S. to train contractors and distributors, and raise awareness about the advantages of the technology.

For Sanden, the greatest growth for its CO_2 hot water heat pumps is in the commercial sector, which includes multi-family apartment buildings and restaurants, though that currently represents 40% of installed units compared to 60% for residential homes.

"Multi-family homes use more hot water and typically can see a quicker ROI than residential homes," noted Miles, adding that apartment buildings can amortize the capital cost of the equipment. Examples of multi-family homes using the Sanden equipment include Kingway Apartments in Seattle, Wash., and Edwina Benner Plaza apartments in Sunnyvale, Calif., both low-income housing complexes. (See, "Hot Water, Courtesy of CO_2" *Accelerate America*, January 2018.)

THE DECARBONIZATION MOVEMENT

Probably the biggest driver of the new interest in heat pumps is the growing movement toward "decarbonization" and "electrification" of building heating systems – switching from natural gas, oil or propane boilers to electric heat pumps – and the development of renewal energy sources like solar and wind energy to produce electricity for utilities.

SIlver Oak's winery in Healdsburg, Calif., which heats water with solar energy and CO_2 heat pumps

"Utilities are interested now in electrification [of heating in buildings]," Davis said. "They're promoting heat pump electrification and taking gas customers off natural gas or propane."

States, he added, will be hard-pressed to achieve their carbon emission goals "unless they do a lot more with heat pumps and other technology."

In April, Energy and Environmental Economics, a research firm based in San Francisco, Calif., issued a report, "Residential Building Electrification in California," which analyzed the economic, environmental and electric grid impact of converting from natural gas to electricity in California homes.

The report found that building electrification – substituting electric technologies like heat pumps for gas-burning ones like furnaces – "is a relatively low-cost, low-risk way to reduce California's building-related GHG [greenhouse gas] emissions."

Another California-based group, the Building Decarbonization Coalition, in February issued a report called "A Roadmap to Decarbonize California's Buildings" that lays out a plan for the state to cut building emissions 20% in the next six years and 40% by 2030. In the report, the group calls for an increase in the share of high-efficiency heat pumps for space heating from 5% of sales in 2018 to 50% in 2025 and 100% in 2030.

To make the switch to heat pumps possible, the California Public Utilities Commission is implementing SB (senate bill) 1477, which deploys $200 million in incentives for manufacturers and builders.

California is better prepared to make the transition to electrification because of its high usage of renewable energy. In 2018, California generated 34% of its electricity from renewable sources (solar, wind, geothermal, biomass and hydro), according to the California Energy Commission.

However, in the U.S. as a whole, only 17% of electricity came from renewables (and 19.3% from nuclear energy) in 2017, according to the U.S. Energy Information Administration. But even while the grid is largely linked to fossil fuels, an appliance with a COP (coefficient of performance) over 3.0 is "incrementally better [in terms of emissions] than burning natural gas in the home," said Miles.

The effort to decarbonize homes and transition to electric heat pumps is being opposed by the American Gas Association (AGA). Richard Murphy, managing director of energy marketing for AGA, argues that heat pumps are not competitive in colder parts of the U.S., according to a report in *E&E News*. AGA also contends that electrification of homes would raise average home energy costs up to 46%.

Miles noted that "the gas industry has to do everything it can to stop decarbonization as it threatens their very future." He added that new technology such as inverter compressors and improved controls "are providing much better heat pump performance in lower temperatures and we are slowly seeing this technology being applied."

The Sanden CO_2 heat pump's COP is 5.2 at an ambient temperature of 67°F, making it more efficient than other heat pumps and heating appliances. But its COP drops to 4.5 at 47°F, 3.0 at 23°F, 2.25 at 5°F and 1.6 at -20°F, which is its lowest operating temperature. Averaged over the entire winter, the COP is more favorable, noted Miles. By contrast, "the very best gas water heaters have a COP of 0.96 and can never get higher than 1.0," he said. On the other hand, the low cost of gas makes gas water heaters overall "a wash" cost-wise compared to the Sanden heat pumps.

About 20% of Sanden's North American installations, which number "a couple of thousand," Miles said, are used for both radiant space heating and domestic hot water in residential homes. One homeowner in the San Francisco area who installed Sanden's combination space heating-hot water heater system, and compared it to a previously used gas heating system, found a 74% drop in energy consumption (kBTU/day) and a 78% decline in GHG emissions (kgCO_2/day).

Haley Duncan, SIlver Oak Cellars

COOLING, TOO

In addition to providing heat, CO_2 heat pumps are used for cooling in some applications. "Everybody looks at hot water and cooling as separate, but there's a lot of potential in water source units to integrate the two," said Davis. "It really helps with the COP." At least 80% of Mayekawa's water-source units produce cooling that is leveraged rather than discarded, he said.

The use of cooling also helps produce an ROI for the water-source units, which Davis acknowledged can be a "little pricey." Compared to an electric-resistance water heater, the much more efficient CO_2 heat pumps offer a payback in 1.5 years. But the payback is much longer compared to a gas water heater because of the low cost of gas, he noted.

Sanden's heat pump water heaters, Miles acknowledged, are the most expensive water- heating products on the market, at about $3,000 per unit, compared to about $1,300 for traditional (HFC refrigerant) heat pump water heaters and $600 for gas and electric-resistance water heaters. Although Sanden's heat pumps are 30%-40% more efficient than conventional heat pump water heaters, "we need a dedicated home owner for ours," he said. "Water heating is a first-cost market."

But the cost of heat pumps in the U.S. is expected to drop as the market for them grows and manufacturers achieve economies of scale, according to the Rocky Mountain Institute.

Mayekawa also makes low-charge ammonia-based heat pumps for medium or large facilities like office buildings and industrial plants. To date, most have been deployed in Europe, the Middle East and Japan but Mayekawa has installed a few in North America food processing facilities. Ammonia would not have been considered a year or two ago in North America but that has changed with the advent of low-charge systems, more robust components, and semi-hermetic components that eliminate leak points, said Davis.

Davis sees "some potential" in North America for hydrocarbon-based heat pumps, which have a significant presence in Europe but not on this side of the pond. Isobutane, he noted, "is great for hot water heaters." But their prospects are constrained by very high costs in the U.S. where they have to be "explosion-proof," he noted.

MEETING THE LIVING BUILDING CHALLENGE

Silver Oak Cellars, a family-owned Northern California wine producer, is focused on making superb Cabernet Sauvignon, and doing so in the most environmentally friendly way possible.

Silver Oak's most recently constructed, facility is a 110,000-sq-ft production facility and tasting room, located in Healdsburg (Alexander Valley), Calif., that began operationsin 2017. It is the first new production winery to be

designated LEED platinum, and is now being considered for an even more exacting certification by the Living Building Challenge, which will be determined in early 2020. (Silver Oak's other facility, in Oakville, Calif., was the first retrofit winery to achieve LEED platinum.)

To meet the Living Building Challenge (becoming the first winery to do so), Silver Oak chose two Mayekawa water-source CO_2 heat pumps (each providing up to 146.2 MBH on the hot side, with an average heating COP of 2.1), as well as a solar thermal heating system, in lieu of a traditional boiler system. The Living Building Challenge precludes combustion heating, but the winery was granted an exception to use a propane-fired boiler as a supplemental heating source during the harvest system (roughly August to November) when there is peak hot water demand.

"We're very invested in creating a system that has very little impact on global warming," said Haley Duncan, Silver Oak's project manager. "That's our motivation."

"Silver Oak made it clear early in the design process that they wanted to be the greenest winery in the world," said Andy Souza, licensed mechanical engineer and project manager for TEP Engineering, Santa Rosa, Calif. He worked with TEP Engineering president Rob Main on the design of the production facilities' water heating systems heating system at Silver Oak's Healdsburg facility.

The water heating system, supported by 2,595 solar voltaic panels and 48 solar thermal collectors across three building rooftops and the two CO_2 heat pumps, is designed to produce outlet hot water temperatures around 140°F that is used for barrel washing, fermentation tank cleaning, floor and equipment washdown. "Everything in a winery needs to be incredibly clean and sanitized," noted Duncan.

The facility also employs a membrane bioreactor to collect, clean and recycle the winery's process wastewater and turn it into essentially potable recycled water that can be used in floor rinsing and the initial washdown of barrels and tanks. This process vastly reduces Silver Oak's water usage.

The heat pumps and solar thermal systems handle two separate water flows for winery uses – one for recycled process water, which does most of the initial cleaning, and one for potable (not recycled) process water that is used for final rinse and washdown.

Domestic hot water, for the tasting room, employee showers and administration restrooms, is generated only by the solar thermal water heating system, with back up from a solar-powered electric water heater. There is also a separate glycol water flow used for heating and cooling of the fermentation tanks and barrel rooms, The heat pumps provide both the heating and cooling, with excess cooling rejected outdoors.

Initially, the incoming well water (about 50°F) is preheated by the heat exchanger coils inside of a large solar water thermal tank. "It would be ideal if we could get 140°F water out of the

CO_2 heat pumps at the SIlver Oak's Healdsburg, Calif., winery

solar tank all year long," said Souza. (Recently, the solar tank water reached 151°F.)

After the solar thermal heating process, the recycled water and the potable process water can pick up additional heat as needed via a separate heat exchanger fed by hot water from the CO_2 heat pumps, which raises the water temperature to 194°F. The extra heat is required when the solar thermal tank is not producing outlet temperatures of 140°F.

These water heating systems are managed by an elaborate building management system that logs data on water usage and sends out alerts to maintenance staff if something is amiss.

The equipment and installation cost of the systems was more than a conventional boiler setup, Duncan noted. But Silver Oaks cut its energy costs dramatically last year at the Healdsburg facility by generating 86% of its electricity from the solar panels; overall it achieved a 73.7% energy cost savings compared to similar buildings, said Duncan. With additional panels installed at a nearby warehouse, Silver Oak will be producing more than 105% of its energy from solar energy by the end of 2019, which is another requirement of the Living Building Challenge.

The elaborate hot-water system design "is the first combined solar thermal and CO_2 heat pump system] has ever been done that I'm aware of," said Souza. "It's one of the most complex projects I've worked on."

Duncan acknowledged that it took a while to get used to the complexity of the water heating system. "It was a big learning curve," she said. "But, overall, it has worked well for us."

SAVING ENERGY IN ALASKA

Another highly innovative project involving Mayekawa water-source transcritical CO_2 heat pumps took place in Seward, Alaska, where in January 2016 the 120,000-sq-ft Alaska SeaLife Center, an aquarium and research facility, installed four 20-TR units.

The grant-supported project, orchestrated by Anchorage, Alaska-based YourCleanEnergy, leveraged ocean water from nearby Resurrection Bay to heat glycol that supports the heat pumps. (See, Tapping CO_2 and Seawater in the Last Frontier," *Accelerate America*, May 2016.) It is one of the first examples in the U.S. of CO_2 heat pumps replacing conventional oil burners in a commercial facility.

A SANDEN TINKERER

On his website (http://greencomfort.nationbuilder.com), Dave Sweet calls himself an "eco-friendly homeowner and builder" whose goal is to "use as little energy as possible while maximizing comfort for my wife, my daughters and I."

Sweet, who has been building his own homes since the 1980s, described the steps taken in building his current (and ninth) home in Old Saybrook, Conn., in a series of videos on his website. One of the innovations was the installation of two Sanden CO_2 heat pumps outside the house to generate hot water and space heating. He's also using an induction cooktop and an electric fireplace, and generating more than half of his electricity from 42 solar panels (13 kW). "The idea was to totally decarbonize," he said.

Sweet admires the efficiency of the Sanden units, derived from the large differential (from 60°F to 100°F) between the temperature of the return water from the house and the temperature to which the temperature is heated in the units. Sanden's hot water temperature setting ranges from 130°F to 175°F.

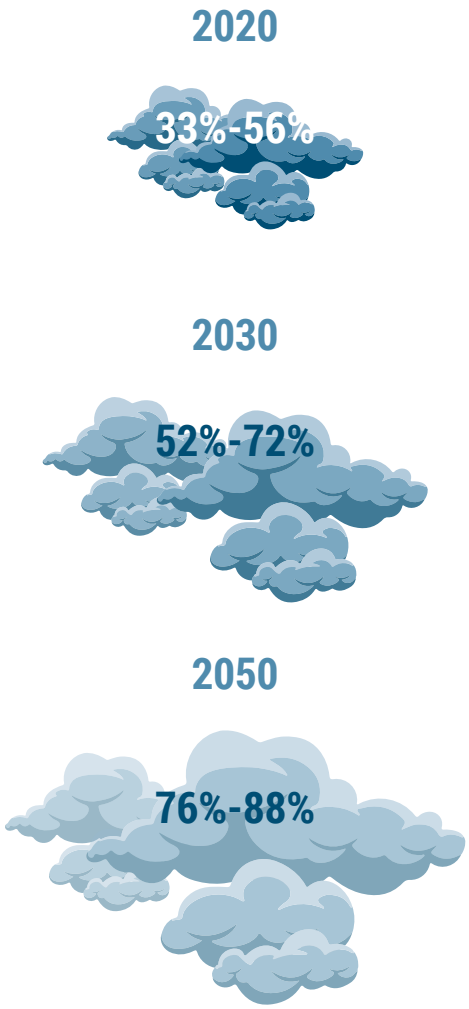
The standard Sanden system that supplies space heating and hot water employs only water, a water tank and a separate heat exchanger. Sweet created his own design that employs a glycol solution. "I'm a tinkerer," he said.

The heat pumps, each with a capacity of about 14,000 BTUs/hr, generate a hot glycol solution that is delivered to a 119-gal tank with a heat exchanger coil at the bottom, where potable water is heated and pumped out to the house. Separately, the heat pumps deliver heated glycol to the radiant heating systems in his home. He uses an electric element backup.

Though the Sanden units are more expensive than alternative heating systems, Sweet believes there is a good payback. "I can't imagine a conventional piece of equipment being able to do space heating and domestic hot water; this is the only product in that classification." He also recommends it as a domestic water heater only.

Sanden CO_2 heat pumps outside of Dave Sweet's home in Connecticut.

Percentage Drop in Greenhouse Gas Emissions As a Result of Switching from Natural Gas to All-Electric in California Single-Family Homes



Source: Energy and Environmental Economics, Inc.

shecco Base

The project was driven by the SeaLife Center's need to replace its oil burners due to the skyrocketing cost of oil in Alaska, which has sub-arctic temperatures in the winter. By installing the heat-pump system – which handles a variety of heating loads, from outside pavements and domestic hot water to baseboards in offices and labs to coils in public areas – the facility was able to save $15,000 per month at existing oil and electricity rates, a savings that still holds. Absent grants, the $1.5 million project (including $200,000 for the four CO_2 heat pumps) would have an ROI of less than nine years, according to the Sealife Center.

The SeaLife Center initially purchased two 90-TR Trane heat pumps, but that still left 40% of its heating generated by an electric boiler. To handle higher-temperature loads, the Mayekawa CO_2 heat pumps were installed, cutting back the electric boiler's usage to 2%. The CO_2 units produce hot water at 194°F, with an initial COP of 2.25. Hot water is distributed in the facility through an elaborate network of water pipes architected by Andy Baker, owner of YourCleanEnergy, in a design that he dubbed "loopsametrics."

The power of the CO_2 heat pumps, Baker said, comes from their ability to raise the temperature of return water to 194°F with about the same energy input even as the return temperature drops (down to a minimum of 90°F at the SeaLife Center). "The Mayekawa units put out 194°F water no matter what you throw at it."

Initially the return temperature of the system, after supporting multiple loads, was 130°F, but additional loads would lower it further and raise the COP – with a minimal energy penalty, noted Baker. In 2017, the return temperature was lowered to between

Andy Baker, YourCleanEnergy

100°F and 110°F with the addition of a basement condensation load, raising the COP to 2.3; that makes the CO_2 system's energy consumption less than half the cost of an electric boiler and half the cost of an oil boiler, he said.

The system also provides cooling via ocean-warmed glycol (starting at 40°F) to fan coils in a mechanical room and an electrical room, boosting the temperature of the glycol and reducing the work required by the heat pumps. Baker is now overseeing the installation of fan coils in two more parts of the facility – a server room and a freezer room. The additional waste heat absorbed by the glycol in those rooms will allow the SeaLife Center to turn off the seawater flow in the summer for the CO_2 heat pumps, he noted.

This use of heat reclaim is important, he said, because it demonstrates how facilities that can't tap into ocean water heat can still employ CO_2 heat pumps.

Baker's next grant-supported project is to deploy six water-source Mayekawa CO_2 heat pumps to provide heating to four municipal buildings in Seward, Alaska – City Hall, City Hall Annex, the Community Library and Fire Hall. He expects the district-heating project to be completed by the end of 2019.

The heat pumps will be located in the library basement, with oil and electric boilers as a backup. Hot water will be circulated to the other three buildings through an Alfa Laval heat exchanger to prevent contamination of the heat pumps. Baker projects using the heat pumps for 80%-90% of the heating load in the buildings, and achieving a COP of 2.4, with the temperature of return water reaching 100°F "more consistently with big radiant heat loads in the library."

Source heat for the project will come from ocean tides in nearby Resurrection Bay, tapped through a 200-ft-deep closed glycol loop and delivered to the library 500 ft away. A nearby hydroelectric energy plant under consideration in Seward could be a future source of waste heat for the district-heating project.

It is estimated that the district heat pump system will save Seward $25,000 in annual heating costs compared to a fossil-fuel system – another step toward a decarbonized society. ■ MG

SMTI'S HEAT PUMP ALTERNATIVE

Stone Mountain Technologies, Inc. (SMTI), based in Johnson City, Tenn., is developing what it calls a "next-generation heating innovation" – a compressor-free, thermally driven heat pump that uses low-charge ammonia- water absorption, triggered by natural gas, to generate space heating and domestic hot water.

Having undergone a series of field tests in homes and restaurants, SMTI's residential space heating and water-heating systems are slated to hit the market in early 2021, said Scott Reed, SMTI's vice president of strategy and marketing. The restaurant unit, which also supplies cooling to the kitchen area, will have a later release, he said.

SMTI's systems will be marketed by an HVAC manufacturer that has not been named.

The units comes in different sizes and configurations, including a 10,000 BTU/hr heat pump attached to a water tank; an 80,000 BTU/hr combination space/domestic hot water unit; and a 140,000 BTU/hr system that can handle space heating and domestic hot water for light commercial applications. The COP is about 1.6 (2.0 in the restaurant application), said Michael Garrabrant, founder and CEO of SMTI.

Garrabrant sees the SMTI unit mainly competing against gas-fired water heaters and boilers, using half the gas with twice the efficiency. He contends that his system works better than an electric heat pump in cold climates where the heat pump's COP suffers. "We feel we have a better path forward to reducing carbon emissions for space heating in cold climates," he said.

The growth of renewable natural gas will help make SMTI's system a greener alternative, noted Reed. "Methane can be made in ways that are renewable and carbon neutral," he said.

SMTI ammonia-absorption heat pump

EPTA FORMS U.S. COMPANY WITH KYSOR WARREN PURCHASE

Kysor Warren Epta US Corp. positions Epta to its CO_2 systems to North and Central American markets, following its acquisition of Lennox subsidiary

– By Michael Garry

Italian OEM Epta S.p.A announced the acquisition of Kysor Warren from U.S. conglomerate Lennox International on April 1, and said the acquisition will result in the creation of a new company called Kysor Warren Epta US Corp.

The $49 million cash deal closed on March 29, 2019, according to Lennox.

Columbus, Ga.-based Kysor Warren, previously a division of Lennox subsidiary Heatcraft Worldwide Refrigeration, manufactures refrigerated merchandisers and systems – including transcritical CO_2 and ammonia/CO_2 cascade systems – for grocery and convenience stores, with applications in other retail and foodservice sectors.

Kysor Warren has over 500 employees, with operations in the U.S. and Mexico. Epta has over 5,000 employees, 11 manufacturing plants and a worldwide sales and technical service network; in 2017 it recorded sales of 888 million euros ($995 million).

Epta has been a leading manufacturer of CO_2 refrigeration systems in Europe, and has expanded its marketing of CO_2 technology to Australia, South America and Southeast Asia. With the Kysor Warren acquisition, Epta gains a foothold in North and Central America.

"The establishment of Kysor Warren Epta US Corp. is a milestone for the Group," said Marco Nocivelli, president and CEO of Milan, Italy-based Epta, in a statement. "We have risen to the challenge and we are ready to enter a geographical area that is highly competitive, innovative and with significant numbers: North and Central America are worth over one-third of the world refrigeration market.

"This operation," he continued, "will allow us to accelerate our growth plans thanks to the reputation of the Kysor Warren brand that boasts a prominent role nationally, innovative natural refrigerant systems such as those operating with CO_2, structured and efficient production facilities and a strong team of motivated experts."

Francesco Mastrapasqua, advocacy & regulatory affairs manager at Epta, credited Kysor Warren with "a long-standing experience in technologically advanced systems, even with natural refrigerants." That aligns, he said, with the "pillars of Epta's success, [which] are a strong commitment towards an

Damon Wyatt, Kysor Warren Mexico

eco-friendly approach to refrigeration, along with constant investments and a solid know-how in performing and energy-saving systems adopting low-GWP natural refrigerants."

The acquisition, added Mastrapasqua, "will thus result in an even higher focus on sustainability and efficiency, raising awareness on the need of the commercial refrigeration sector to accelerate the green transition."

Epta said the transaction is in line with its expansion strategy, which aims to grow through a combination of organic expansion and mergers/acquisitions.

Commented Parke Adamson, former general manager of Kysor Warren: "Epta and Kysor Warren have a shared vision and highly compatible cultures, founded on similar values, such as quality, sustainability, innovation, design and efficiency. The across-the-board skills of the Epta Group and its know-how in the development of natural refrigerant systems will dovetail with our long-established experience serving North American retailers.

"This is a synergy that will further strengthen the Kysor Warren brand, which will allow us to grasp, with renewed strength, the opportunities in a dynamic, continuously evolving market," added Adamson.

Marco Nocivelli, Epta

Multiple brands

Epta's commercial refrigeration brands also include Costan, Bonnet Névé, George Barker, Eurocryor, Misa, Iarp and Knudsen Køling. Epta describes itself as a "turnkey partner able to manufacture and provide complete refrigeration systems through the integration of specific product lines such as traditional refrigerator cabinets, vertical and semi-vertical chillers, vertical and horizontal freezers, plug-in units for Retail and F&B, medium and large capacity refrigeration systems and cold rooms."

Epta has gained attention as a CO_2 innovator. In 2017, the company launched its Full Transcritical Efficiency (FTE) solution for improving the efficiency of CO_2 refrigeration systems in warmer climates. Epta has also developed its EptaBlue CO_2 integrated water-loop system for medium-sized and small supermarkets.

Kysor Warren has also made news with its natural refrigerant systems. In 2015, the company installed an ammonia/CO_2 cascade refrigeration system at a Piggly Wiggly outlet in Columbus, Ga., which has reported energy savings compared to an HFC system running in the same store.

In 2018, Kysor Warren installed a transcritical CO_2 system at a Casa Ley store that it called the first supermarket installation of transcritical CO_2 in Mexico.

Following its sale of Kysor Warren, Lennox International Chairman and CEO Todd Bluedorn, said in a statement that divesting the Kysor Warren refrigerated display case business "enables us to focus on our commercial refrigeration businesses where we have strong market positions in North America and Europe and that fit our growth profile."

In a report on its fourth-quarter and full year 2018 results issued on February 5, Lennox announced its plans to sell Kysor Warren, adding that it was aiming to close the sale in the first quarter.

Lennox purchased Kysor Warren from the Manitowoc Company in 2011.

The announcement of the sale of Kysor Warren follows the sale last year of Lennox's refrigeration businesses in Australia, Asia and South America. ■ MG

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