AUGUST 2018

ACCELERATE

ADVANCING HVAC&R NATURALLY AMERICA

BARRIER BREAKERS

Person of the Year

CALIFORNIA STATE SENATOR RICARDO LARA

Award Winners

HENNINGSEN COLD STORAGE, ALDI US, COLMAC COIL, SOURCE REFRIGERATION AND SOUTHERN CALIFORNIA EDISON

P. 32

OVERCOMING INERTIA

— By Michael Garry

If there's one thing I have learned covering natural refrigerants for shecco (publisher of *Accelerate America*) over the past four years, it's that persuading an industry to move to a new technology is hard.

Even in an age of hyper-accelerated technological change, end users are inclined to stay with familiar HVAC&R systems rather than move to more efficient and sustainable alternatives, especially when cost is a factor.

In Europe, where the new generation of CO_2 systems were first developed and embraced – and where regulations are highly supportive of their adoption – only about 12% of the food retail sector uses transcritical CO_2 refrigeration (as of February 2018), according to sheccoBase, the research arm of shecco. The next largest rate of adoption (5%) is in Japan, while the U.S. and Canada are at 1%-1.5%.

Probably the biggest driver of natural refrigerant adoption is federal intervention, with either a stick (the EU's F-Gas Regulation) or a carrot (financial incentives in Japan to overcome cost premiums). The U.S. currently offers neither, leading end users to keep the status quo or use drop-in HFO blends; these have drawbacks, namely relatively high GWPs, the breakdown of HFOs into trifluoroacetic acid in the atmosphere, and their use of HFCs targeted for phase-down by the Kigali Amendment.

California is the one place in the U.S. where legislative action on HFC reduction and natural refrigerant adoption has been happening. This is why we selected California State Senator Ricardo Lara to receive our 2018 Person of the Year Award.

Since 2014, Lara has distinguished h imself through the authorship of legislation authorizing the California Air Resource Board (CARB) to regulate HFCs, establishing HFC-reduction goals and, most recently, creating an incentive program to defray the higher cost of natural refrigerant systems.

These are the kinds of policy measures that could help commercial and industrial end users in California overcome their inertia – whether based on cost or apprehension – about investing in natural refrigerant technologies.

Lara's bill containing the incentive program – the California Cooling Act – is in the home stretch of its journey through the legislature, with a final vote expected by the end of August. Lara has received support for the bill from the HVAC&R industry– including a letter from shecco containing the endorsements of 14 organizations – and we certainly hope that it prevails.

Lara is one of six award-winning "barrier breakers" profiled in this issue (see page 34). Three of these organizations – Colmac Coil, Source Refrigeration and Southern California Edison – have helped end users break through particular barriers. The other two – Henningsen Cold Storage and ALDI US – are end users themselves with an outstanding commitment to natural refrigerants.

ALDI US, with 130 installations of transcritical CO_2, is the leading food retail user of that technology in the U.S. as well as a leading user of self-contained propane cases. Henningsen, already an innovator with low-charge ammonia central systems, is among the first cold-storage plants to install transcritical CO_2.

All of the winners have engaged in the hard work of changing themselves, and ultimately, the industry as well. ■ MG

Michael Garry
Editor

In this issue

AUGUST 2018

ACCELERATE
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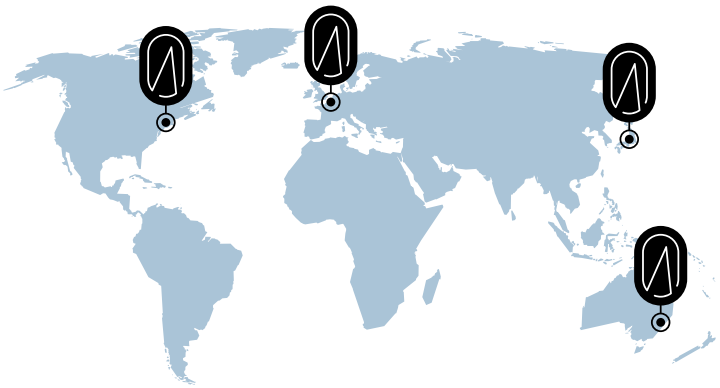

About *Accelerate America*

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.

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* Publisher reserves the right to modify the calendar.

LETTERS TO THE EDITOR

KEEPING HUMID AIR OUT OF THE STORE

In regard to "How to Determine the Efficiency of Your Refrigeration System (*Accelerate America*, June-July 2018), the EER (energy efficiency ratio) formula that Ed Estberg offers works for me, though this is a hard thing to do in an operating market. He has been at it a long time, so his method is sound, for sure. However, I would suggest adding the Pascal [unit of pressure measurement] positive pressure data into any HVAC system's EER.

The number-one issue we have in our markets is that we do not test the building-envelope pressure and ramp up AC motors to maintain a positive pressure so that humid air doesn't get into the store and affect case performance. As you walk into your local supermarket in the summer, you should feel a good amount of colder air come outside vs. warm air coming in with you. As Ed's article states, HVAC systems are a very integral part of any EER rating system.

Many markets have humid air enter the store because the stocking area door is open at the same time customers enter. If a fixture works in a humidity range not tested for by the OEM, then an EER is super difficult to monitor. Many OEMs prefer to leave this issue to others, which is a huge mistake in my opinion.

At one small IGA market here in Ohio, the racks have heat-reclaim solenoid valves assist in dehumidification by using "free heat" from the refrigeration system. However, this only works to drive more AC energy to be used so that the store gets colder. If untreated air gets inside a building, then this super expensive method keeps the cases in a proper environment so they consume less energy themselves.

Air infiltration, if untreated, affects all equipment operation and EER. The relative humidity (RH) and dew points are important inside the envelope, not just with water-cooled open towers. Sometimes we have to set the humidistats to 45% RH because the humidistats are located at the store entry area rather than where the cases are located.

The paper "Energy-Efficient Supermarket Heating, Ventilation, and Air Conditioning in Humid Climates in the United States," by J. Clark of the National Renewable Energy Laboratory (https://bit.ly/2LTaCRZ) explains why we need to determine each and every BTU/hr used in any envelope. It has very good data and should be read by those who are serious about their customers.

Joseph Kokinda
President/CEO
Professional HVAC/R Services, Inc.
Avon Lake, Ohio

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.

No matter what size your store footprint, from a small format store to a large chain grocery store, Hillphoenix, the pioneer in HFC-free CO_2 refrigeration systems has a CO_2 system sized to fit your exact needs. Why CO_2? It's a less expensive refrigerant option. It poses no threat to the environment. It's an abundant, renewable resource. It solves any compliance issues you'll likely see for today and the future. And it is where all the refrigeration technology is heading.

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A DOVER COMPANY

Advansor™ and AdvansorFlex CO_2 Systems are the ideal solution for everything from small to extra large sized retail establishments. Now all the benefits of efficient, economical and environmentally friendly CO_2 refrigeration can fit any-sized retail operation, anywhere.

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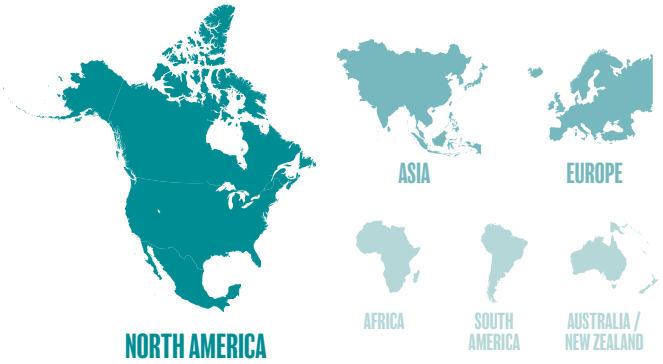
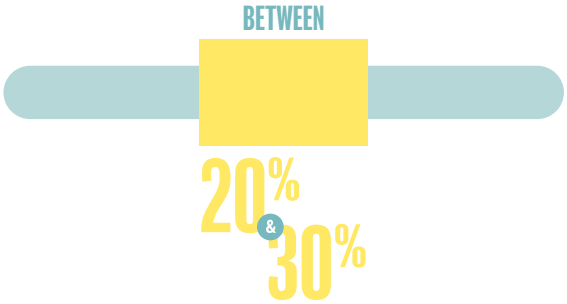
The Future of Natural Refrigerants

Where are natrefs going in North America and beyond?

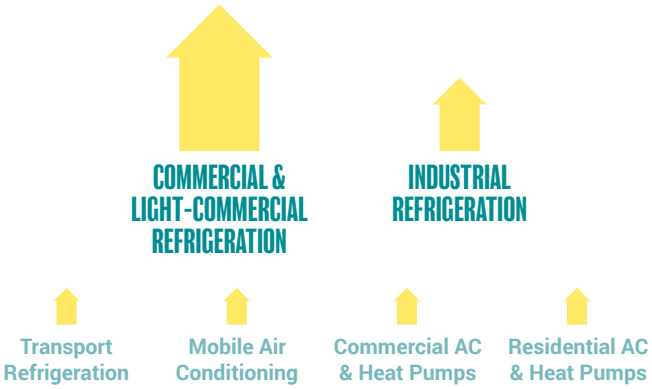
Which world region do you expect to experience the fastest growth in natural refrigerant adoption in the next 5 years?



By 2030, the world's share of natural refrigerant technology out of all HVAC&R applications will represent
(the current share is less than 10%)



Which market sector will see the highest uptake of natural refrigerants in North America in the next 5 years?



What is the main reason North American end users are interested in using natural refrigerant technology?

What is the biggest obstacle to natural refrigerant adoption in North America?

What is driving the uptake of natural refrigerants in North America?

Source: Polling conducted at ATMOsphere America, June 2018

shecco Base

AUG

07 2PM EASTERN

EPA GreenChill Webinar: Clearing The Hurdles - Top 3 Ways NASRC Is Removing The Barriers To Low-GWP Refrigerants

Online

Topics include: reducing first costs through incentives; NASRC's new "matchmaking" service for end-users and service contractors; and updating standards.

https://bit.ly/2NPc2JX

09 2PM EASTERN

NASRC Webinar: Understanding Refrigerants – Challenges And Best Practices

Online

Topics include: current state of refrigeration regulation; examples of compliance software; natural refrigerant alternatives to HFCs; and resources for refrigerant end-users.

https://bit.ly/2LFFrsE

21 1PM EASTERN

ASHRAE Webinar: Humidity Control – Design Tips and Traps

Online

The three-hour course covers how to remove moisture loads with equipment dedicated to that purpose alone, rather than relying on the occasional dehumidification effect of a building's cooling system. Attendees will learn what equipment is used for this purpose.

https://bit.ly/2K1PAL8

24-26

IIAR Natural Refrigeration Seminar XV and Safety Day

Guadalajara, Mexico

IIAR holds natural refrigeration seminars throughout the year in Latin American countries.

https://bit.ly/2mQnWaN

27-28

RETA: Central Florida Ammonia Refrigeration Regional Conference

Kissimmee, Fla.

Event includes exhibit hall showcasing industry manufacturers, service providers and contractors; manufacturer workshops; and workshops on compressor teardown and plate heat exchangers.

https://bit.ly/2OlzkIv

SEP

06 1PM EASTERN

FMI Webinar: How Consumers Are Adapting Their Grocery Shopping in a New Omnichannel World

Online

The Food Marketing Institute conducts food safety, public affairs, education, research, and industry relations programs for food retailers and wholesalers.

https://bit.ly/2vcglai

12-14

Global Climate Action Summit

San Francisco, Calif.

The Global Climate Action Summit will celebrate the achievements of states, regions, cities, companies, investors and citizens with respect to climate action. It will also be a launch pad for deeper worldwide commitments and accelerated action to prevent dangerous climate change.

http://globalclimateactionsummit.org

19-21

Women in HVACR: 15th Annual Conference

Denver, Colo.

Women in HVACR provides professional avenues to connect with other women in the HVACR industry. It aims to empower women through networking opportunities, mentoring and education.

https://bit.ly/2K1xTeP

19-21

FMI Energy & Store Development Conference

Atlanta, Ga.

The event offers an exhibition hall and sessions on refrigeration, energy efficiency, store design and merchandising.

https://bit.ly/2LTXh7W

24-28

Refrigerant Week

Online

Series of webinars hosted by Danfolss experts on topics ranging from global regulation trends to leading-edge CO_2 technologies.

https://bit.ly/2JsaVkV

AMERICA IN BRIEF

EPA Raises HC Charge Limit for Home Fridges

In a long-awaited move, the U.S. Environmental Protection Agency (EPA) on August 8 published in the Federal Register a final rule raising the charge limit for hydrocarbons in new domestic refrigerators and freezers to 150 g fro 57 g through the adoption of the 2017-enacted Underwriters Laboratories (UL) standard 60335-2-24.

The final rule raises the charge limit (a use condition) for three flammable (A3) refrigerants – isobutane (R600a), propane (R290) and R441A (a hydrocarbon blend) – in new household refrigerators, freezers and combination refrigerator/freezers under the EPA's SNAP (Significant New Alternatives Policy) program. The rule takes effect on September 7.

The 57 g limit was widely seen as an impediment to the adoption of hydrocarbon-based home fridges in the U.S. Elsewhere in the world, where 150 g has long been the charge limit for domestic refrigerators, units using isobutane have gained substantial market share. ■ MG

Germany Warns R1234yf Could Harm Drinking Water

In late June the German Federal Environment Agency (UBA) warned that the degradation in the atmosphere of HFO R1234yf – which is widely used in mobile air-conditioning systems – into trifluoroacetic acid (TFA) could contaminate the water supply over time.

The UBA stated this in an interview with the Frankfurt-based *Frankfurter Rundschau* and pointed to natural refrigerants as the alternative.

"We are watching with concern the increased use of the refrigerant R1234yf in car air-conditioning systems and stationary refrigeration systems," said Maria Krautzberger, UBA's president.

So far the TFA concentrations in German water supplies are at the 'precautionary level' (3 micrograms per liter of drinking water) recommended by the UBA, but the agency is worried that more cars entering the market containing HFOs will push levels up too far.

"TFA cannot be removed [from drinking water] with the usual treatment methods, so further [use] must be avoided at all costs," Krautzberger said.

According to the UBA, TFAs are classified as hazardous to water, degrade slowly and are poisonous to certain algae.

Krautzberger emphasized that CO2 can be used in mobile air-conditioning. She cited Daimler, which committed to using CO2 systems in mass-produced vehicles after it tested R1234yf in 2012 and found it ignited, and Audi, which is using CO_2 in a few vehicle lines.

Last year a report on HFOs by the Norwegian Environment Agency recommended that a number of "knowledge gaps" needed to be addressed before TFAs' ultimate effect on the environmental could be determined.

The HFO R1234yf has an atmospheric lifetime of about six days, after which it degrades completely into TFA, the report said. ■ CM

Weis Markets Deploys Its First TC System

Weis Markets, a 206-store regional food retailer based in Sunbury, Pa., last month opened a 54,000-sq-ft supermarket in Randolph, N.J., featuring the chain's first transcritical CO_2 refrigeration system, along with other environmental and energy-saving features.

The transcritical system – which the 106-year-old chain said "significantly reduces its carbon footprint and reduces overall energy usage" – was provided by OEM Hillphoenix.

The store's eco-friendly features also include LED lighting to reduce electrical needs; low-flow devices to support water conservation; energy control through demand response programs to reduce power usage during peak days and to reduce the store's load on the power grid; and enclosed refrigeration cases to reduce energy use. ■ MG

AHRI: Trade War Sparks Price Rise

In the wake of U.S. plans to roll out an additional 10% import tariff in September on 6,000 Chinese products, including HVAC&R products, AHRI (the Air-Conditioning, Heating and Refrigeration Institute) called the on-going trade war "disruptive" and said it is leading to price increases.

"Our position remains the same – the tit-for-tat tariff situation is disruptive to the business cycles of our members, to the global supply chain, and also to negotiations on treaties like NAFTA," said Francis J. Dietz, vice-president, public affairs at AHRI. "Many of these tariffs have forced our members to raise prices to cover the increased cost of raw materials, which is unfortunate."

Dietz added that "our industry remains vibrant and strong, but the longer this situation persists, the more negative the effects on U.S. industry."

The 6,000 additional products, worth an estimated $200 billion, include Chinese exports of air conditioners, heat pumps, refrigerators, two types of ammonia and HVAC&R components.

The list of 6,000 items came just days after another round of tariffs had been announced by the U.S. and China on each other's products. The U.S. targeted Chinese solar panels and washing machines, while China has placed taxes on "cars, soya beans and lobsters," according to the BBC.

On August 3, the Chinese government announced tariffs on imports of U.S. chest freezers, CO2 compressors and other refrigeration components ■ CM

CFATS is Good for Business and National Security

Bob Kolasky is Acting Assistant Secretary for the Office of Infrastructure Protection at the Department of Homeland Security. This is the text of a presentation he gave at a DHSChemSecurityTalks event in Chicago on July 19.

Congress should reauthorize the Chemical Facility Anti-Terrorism Standards program

— By Bob Kolasky

Illinois is home to more than 160 high-risk chemical facilities. Last year, one of these facilities took a direct hit by an F3 tornado that ravaged the building and left significant destruction.

The facility's security officer said that the security measures required under the Department of Homeland Security's (DHS) Chemical Facility Anti-Terrorism Standards (CFATS) program helped ensure everyone survived without injury, and the chemicals weren't affected.

This incident demonstrates that, in addition to enhancing chemical security, CFATS compliance is good business. While the program is designed to protect the nation against the ongoing threat of terrorists who are targeting chemical facilities, the protective measures that facilities implement under CFATS can have ancillary benefits, making it an even better investment.

Congress authorized the CFATS program to address gaps that existed in securing high-risk chemical facilities. While the threat of terrorism remains, the CFATS program provides risk reduction measures for high-risk chemical facilities in possession of certain levels of any of over 300 dangerous chemicals (including ammonia), and helps facilities implement a set of enhanced security standards. The program now covers over 3,400 high-risk chemical facilities—including the 160 in Illinois.

The Midwest is home to industries that rely heavily on chemicals—industries like agriculture, manufacturing, pharmaceuticals and paint. Facilities considered to be high-risk under CFATS are required to meet security standards that reduce the risk of chemical holdings being stolen, diverted, sabotaged or released in a terrorist attack.

Since the program was established 11 years ago, CFATS-covered facilities have implemented thousands of security measures. As a result, America's highest-risk chemical facilities have improved their overall security posture, and in the process made the nation safer and more secure.

Public-private collaboration

Shared commitment and collaboration between the public and private sectors has contributed significantly to the CFATS program's success. Through ongoing discussion with industry stakeholders around establishing a sustainable chemical security culture, the program has raised awareness of the threat and the methods to address it.

Furthermore, the CFATS program's structure and non-prescriptive nature has provided the flexibility needed to streamline and improve compliance. Of note, the regulated industry considers CFATS an important contributor to national security and has advocated for Congress to reauthorize the program.

CFATS was initially authorized annually through appropriations legislation, subjecting the program to constant uncertainty. In 2014, Congress reauthorized the program for four-years, directing DHS to streamline the process, while also granting industry stakeholders the confidence and stability to make long-term security investments. The 2014 legislation marked a real turning point and we thank Congress for their leadership in protecting our nation from the threat of chemical attacks.

Now, with just six months before the four-year authorization expires, CFATS needs legislative action to continue the vital work of securing America's highest-risk chemical facilities. Failing to reauthorize CFATS for the long term could be costly. The persistent terrorist threat that gave rise to the program continues today, and the consequences of a successful attack could be devastating to our economy and our people.

DHS is committed to continuing to work with Congress and stakeholders to reauthorize CFATS and build on the vital work that has been accomplished to reduce our risk and elevate security. As the January reauthorization deadline is fast approaching, we cannot let our guard down in protecting America's chemicals from terrorism. ■ BK

CURBING SUPER POLLUTANTS UNDER THE MONTREAL PROTOCOL

Countries are addressing how the Kigali Amendment should address energy efficiency during the transition away from HFCs

— By Anjali Jaiswal and David Doniger

This summer marks 30 years since NASA scientist James Hansen testified to the U.S. Congress about the dangers of climate change. His warning, delivered in the midst of a heat wave, was a harbinger of the warming to come—that year, 1988, was the hottest on record at the time, a record that has since been topped by more than 20 of the 30 following years.

Hansen's testimony was a timely reminder of the urgency to act on climate change as delegates gathered in Vienna for the mid-year meeting of the Montreal Protocol last month. The Montreal Protocol is the treaty that saved the ozone layer and, as a bonus, has done more than anything else to curb heat-trapping pollution that drives dangerous climate change.

Chlorofluorocarbons (CFCs) and their kin are major sources of climate-polluting emissions that were phased out under the Montreal Protocol. The current generation of these gases—hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs)—are hundreds to thousands of times more potent than carbon dioxide at warming the planet. These super pollutants are found in air conditioners (ACs), refrigerators, supermarket freezers, aerosols, building insulation, fire extinguishing systems, and other uses.

The Montreal Protocol and its amendments have been instrumental in phasing out CFCs and HCFCs, and nations adopted the Kigali Amendment in 2016 to phase down HFCs. The Kigali Amendment sets in motion an 85% reduction in HFC use worldwide over the coming decades, avoiding as much as 0.5°C of further warming. The Kigali Amendment focuses on a phase down, and not a phase out, since there are a few essential uses of HFCs where no substitutes exist, such as metered dose inhalers.

Key issues on the agenda at the Montreal Protocol meetings last month were HFCs and the Kigali Amendment, as well as emerging CFC compliance issues. With the Amendment going into effect in early 2019, world leaders convened in Vienna to work out the details needed for implementation.

The top issues to watch on the HFC phase down are energy efficiency and financing.

Energy efficiency and the Kigali Amendment

With strong support to include efficiency as part of the Kigali Amendment, countries are now hashing out how the Montreal Protocol should specifically address energy efficiency during the transition away from HFCs.

Switching refrigerants presents an opportunity to simultaneously upgrade designs and components to make more energy- efficient appliances. Many nations are already moving forward with standards and incentives to improve appliance efficiency through domestic policies, while others are awaiting clarity under the Montreal Protocol.

During the Vienna meetings, nations discussed findings by the Technology and Economic Assessment Panel to the Montreal Protocol (TEAP), which was asked for advice on incorporating energy-efficiency initiatives as HFCs are phased down in the AC, refrigeration, and heat pump sectors. A dedicated workshop on energy efficiency opportunities took place.

Countries such as India have made significant progress in improving efficiency in appliances, particularly with ACs. India's appliance labeling program has strengthened AC efficiency standards by about 35% since 2006.

Just this past month, India demonstrated further ambition by announcing that the government will consider setting the mandatory indoor default for ACs at 24°C (75°F), encouraging consumers to not over-cool their homes and to save both money and energy on electricity bills while aiming to reduce air pollution. In addition to domestic policies, India has signaled strong support for energy efficiency internationally under the Montreal Protocol.

The Natural Resources Defense Council (NRDC), along with the Energy and Resources Institute (TERI) and the Institute for Governance and Sustainable Development (IGSD), released a new fact sheet during the Vienna meeting profiling both government and market progress on climate-friendly ACs in India. The fact sheet also identifies strategies to further improve ACs in the Indian market, including opportunities under the Montreal Protocol. This fact sheet is a part of our "Cooling India with Less Warming" series, which highlights the business case for switching to climate-friendly ACs.

Financing efficiency improvements

Financing is key to the equitable transition away from dangerous refrigerants. The Multilateral Fund – which has financially supported the phase out of CFCs and HCFCs in developing countries – has been instrumental to the success of the Montreal Protocol. Financing energy efficiency improvements during the HFC phase down can help unlock the potential for vast reductions in energy use from AC and refrigeration products.

The Montreal Protocol can help guide investments in energy efficiency where needed to ensure that companies are able to improve the efficiencies of their products while switching to climate-friendly refrigerants.

In a decision accompanying the Kigali Amendment, nations agreed to fund HFC phase-down efforts while "maintaining and/or enhancing the energy efficiency" of climate-friendly replacement technologies, a nod to the opportunity to make efficiency improvements during the HFC transition. The decision indicated the possibility to fund these improvements, at least in part, through the Multilateral Fund.

The question before nations at the Vienna meetings was how to use the Multilateral Fund to support these efficiency efforts and leverage greater support from other international funds. Several nations are exploring strategies to use the Multilateral Fund to coordinate funding and incentive programs for energy-efficiency improvements.

NRDC hosted a side event during the Vienna meetings to discuss financing energy efficiency during the HFC transition. This event explored the potential for donor funding and finance institutions to improve AC and refrigeration energy efficiency in developing countries. Key discussions centered around mobilizing capital and other catalytic donor support to alleviate the cost burden on manufacturers, foster market demand, accelerate the commercialization of new technologies, and build enabling environments, with a focus on experience from the world of climate finance.

The Montreal Protocol is among the most successful international treaties in the world, but there is much work left to be done on global warming, as Hansen warned 30 years ago. But with nations working together on the treaty and a track record of a nearly 99% decline in the emissions of ozone-depleting chemicals, the Montreal Protocol has the infrastructure for proven success. With key decisions on efficiency, financing, and other important issues, the Vienna meeting can make significant progress towards a climate-friendly future. ■ AJ & DD

Anjali Jaiswal is senior director, India, International Program for the Natural Resources Defense Council (NRDC). David Doniger (below) is senior strategic director, Climate & Clean Energy Program for the NRDC.

Alex Hillbrand and Tasfia Nayem of the NRDC also contributed to this article, which originally appeared, in slightly different form, on nrdc.org.

AMMONIA AND CO_2 KNOCKING ON AC'S DOOR

Developments in ammonia and CO_2 air-conditioning technology could unlock the demand for this equipment in commercial buildings and motor vehicles, respectively, says Professor Pega Hrnjak

— By Charlotte McLaughlin and Michael Garry

Pega Hrnjak president of Creative Thermal Solutions, and research professor at the University of Illinois

Natural refrigerants have emerged as a success story in refrigeration applications – from commercial and industrial to residential markets – and now, thanks to improved technology, they are poised to enter the commercial- building and motor-vehicle air-conditioning markets.

That was the assessment offered by Pega Hrnjak, president of Creative Thermal Solutions, and research professor at the University of Illinois, Urbana-Champaign, who presented on technology trends for natural refrigerants at ATMOsphere America 2018, held in Long Beach, Calif., June 12-14. Hrnjak is a pioneering researcher in the field of natural refrigerants. (See "Pega's Quest," *Accelerate America*, February 2018.)

He said that small charges of ammonia could be effectively employed in chillers for air conditioning in commercial buildings such as hotels, arenas and malls. And CO_2 is returning as a viable refrigerant for mobile air conditioning (MAC), especially in electric vehicles where CO_2 heat pumps can be used.

A new opportunity

Traditional ammonia system manufacturers, Hrnjak said, need to recognize that the chiller air-conditioning market represents an exciting new opportunity, particularly as ammonia charge levels continue to drop and render packaged chillers safer for populated areas.

"Current charges in ammonia units [are] orders of magnitude lower than in typical industrial installations" – 50-to-100 lbs per 100 TR as opposed to thousands of

lbs per 284-853 TR, he said, noting that the Environmental Protection Agency (EPA) does not require leaks of under 100 lbs of ammonia to be reported.

Hrnjak would like to see a standard charge limit set for ammonia in chillers, like the 150-g limit for hydrocarbons in commercial display cases. "That would incentivize work on the maximization of capacity and efficiency, and consequently move the technology forward," he said. One barrier to an ammonia standard is the "concern that such an approach would identify current industrial charges as unsafe," he added.

He lamented that the industry is "still missing someone big" who would support ammonia chillers for AC. CTS has developed and made several efficient, ultra-low charge chillers, including a 7-10 TR unit using 430 g of ammonia, but is "probably too small a player to change the game," he acknowledged. So far, U.K.-based Star Refrigeration and its U.S. subsidiary Azane have developed low-charge ammonia chillers, he noted, while German company GEA launched one at Mostra Convegno in Milan, Italy, earlier this year.

If the ammonia industry does take advantage of the chiller AC market, it would tap into a large opportunity, he explained. "The chiller market is huge. [In 2015 it was] worth $5 billion per year for positive displacement compressors (scroll, screw and reciprocating) alone, and it's growing."

The global industrial refrigeration market reached just over $10 billion in 2017, according to the Japanese Air-Conditioning and Refrigeration Association (JARN).

Meanwhile, CTS is testing the performance of low-charge industrial packaged systems from Evapco and Mayekawa, with a tests on units from Hillphoenix/NXTCOLD unit planned and Azane in preparation. First results "show very good numbers, especially compared to a conventional approach," he said. "They reveal ways to improve further and realize the full potential of ammonia."

Hrnjak said that for manufacturers of ammonia-based equipment to take advantage of the chiller market, they must overcome four key challenges. The first – and the key one for Hrnjak – is technical. "We need to make the system look, feel and cost similar to what they are competing against," he said.

He explained that hermetic compressors for ammonia, suitable for use in chillers, are already available but are not yet widespread enough to compete with existing HFC-based compressors used in chiller applications.

Hrnjak acknowledged that the cost and weight of ammonia chillers would need to be reduced. The entry of more ammonia system manufacturers into the chiller market will help lower costs, he added.

Secondly, education is key for Hrnjak. "We need to support and educate technicians," he said, "[and] reduce initial resistance."

On the marketing side, manufacturers need to adjust the way they sell units, since buyers of chiller technology are often different than industrial refrigeration end users.

Finally, some manufacturers will gain from being first movers in bringing their ammonia chiller technology to market. But others "may lose or will need to shift [and we will need to] find them a role," he said.

CO_2 MAC back in play

In Europe, CO_2 MAC systems have experienced a two-steps-forward, one-step-back journey so far. Less than two decades ago, CO_2 appeared to be the refrigerant of choice to replace R134a, especially after the European MAC Directive required European car companies to start phasing out HFCs in cars in 2006.

CO_2 performs better than R134a in MAC systems, said Hrnjak. "We really have done a fair comparison of efficiency in almost identical types of systems" between 25°C and 35°C (77°F and 95°F).

However, most car manufacturers decided to instead opt for R1234yf (an HFO) instead of CO_2 as a replacement for R134a. Only Mercedes-Benz manufacturer Daimler, which found flammability problems in a study of R1234yf, has committed to using CO_2 in MAC, while Volkswagen has so far used CO_2 MAC in its luxury cars.

The use of microchannel heat exchangers and better materials in CO_2 MAC systems have been helping this technology become a little more mainstream, according to Hrnjak.

Electric cars will also mean further development for CO_2 MAC, particularly in heat pumps supplying both AC and heating. "We have lost the battle with conventional cars [but there might be] a possibility with electric cars," he said. "I can tell you on the research side it's like a big hive of activities about CO_2 in heat pumps for electric cars."

The cumulative number of electric and plug-in hybrid cars globally hit 3 million in November 2017, with China the biggest consumer, according to *The Guardian*. "Today one of the main changes that we see is the Chinese government threatening to stop any governmental support after 2022 to those companies that don't [have] at least 80% electric cars in their portfolio," he said.

By providing air conditioning and heat in cars, CO_2 heat pumps are considered much more efficient than alternatives, thereby extending battery life, Hrnjak said. Any opportunity to extend battery life will be exploited by manufacturers of electric vehicles, who are very concerned about how long consumers can drive their cars before needing to charge them, he added.

R1234yf, by contrast, does not yield good thermal properties when used in a heat pump in a car. "You use either a refrigerant other than R1234yf or CO_2," said Hrnjak, adding, "One thing is certain – we can make the CO_2 system not only efficient but also low-cost, and we can demonstrate that." ■ CM & MG

Bullish on Hydrocarbons

The growing interest in hydrocarbon refrigeration should continue, said Pega Hrnjak, president of Creative Thermal Solutions, and research professor at the University of Illinois, Urbana-Champaign,

"Hydrocarbons are going very strong," he said, attributing the growth to low costs and the easing of low-charge regulations. Propane (R290), he noted, is "almost a drop-in replacement for R22" in air conditioning or stand-alone commercial refrigeration, while isobutane (600a) is an "easy replacement for R12 or R134a in refrigerators. Moreover, hydrocarbons' flammability has been "mitigated by design and charge."

Hrnjak noted that the International Electrochemical Commission (IEC) is working on approving a higher charge limit (500 g, from 150 g) for commercial display cases (see page 26). On the AC side, the IEC charge limit remains at 1 kg of propane under specific conditions, though in the U.S. the UL limit is just 114 g. In China there are debates over using 1.5 kg of R290 in ACs. The IEC "is working on it, but it will take some time," he said.

The main flammability mitigation system involves air movement and the use of sensors, with the possibility of "smell tracers" in the future, he said. Meanwhile, UL is engaged in a study of hydrocarbons' flammability risk, with another study taking place in Japan; both will have results this year.

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ONLINE SALES, SMALLER STORES IMPACTING REFRIGERANT CHOICE

Major shifts in grocery retailing are leading to more use of hydrocarbon and downsized CO_2 systems, said panelists at ATMOsphere America 2018.

— By Charlotte McLaughlin and Michael Garry

AS refrigeration systems evolve to become more environmentally friendly and efficient, another factor will impact their development: how people shop. Increasingly, consumers are shopping online and in smaller stores, and these trends will have a lot to say about the type of natural refrigeration systems and accompanying technology installed in stores, observed panelists discussing market trends at the Long Beach, Calif.-located ATMOsphere America conference in June.

"Now 32% of retailers in North America have 'Click & Collect'" online grocery shopping programs, allowing shoppers to pick up their online orders in the store or store parking lot, said Andre Patenaude, director – food retail, growth strategy at Emerson Commercial & Residential Solutions. This is creating new challenges for refrigeration suppliers and contractors, he noted.

For example, to facilitate the transition to new shopping pattterns, "we have to invest in IoT [Internet of Things communications] to make systems simpler, smarter and more serviceable for technicians."

In Europe, German firm Viessmann and Austrian company Hauser created separate Click & Collect systems where orders are held at an external pick-up location – such as a train station, supermarket parking lot, gas station, bus stop or airport. These systems use propane or isobutane for cooling. So far the U.S. does not have such systems with natural refrigerants.

Smaller stores, particularly in populated urban areas, represent another growing trend, for which retailers are seeking help from their suppliers. "Smaller footprints and faster resets drive compact, flexible, multi-purpose equipment," said Patenaude. "Inventory, parts and technicians skills will all change to support [this].

In Europe, where smaller stores have long been common, a number of natural refrigerant-based solutions are available for small formats, such as CO_2 mini-boosters, CO_2 condensing units and hydrocarbon-based self-contained refrigeration systems. In the U.S., self-contained propane (R290) cases are gaining traction, not just in smaller stores but conventional supermarkets as well – in at least spot merchandisers, and in some instances throughout the store.

"Thirty percent of the U.S. market has already transitioned to R290," including 500,000 compressors, said John Prall, application engineer for Embraco. "We are seeing most beverage compressors [with R290]."

PROPANE'S ADVANTAGES, CHALLENGES

In a comparison of efficiency and thermal level (compressor heat build-up) conducted by Embraco, propane was found to be superior to three A2L refrigerants and R404A, said Prall. "Propane is the best solution for fractional horsepower compressors." Another energy-saving technology for R290 systems, the waterloop heat removal system, is "gaining ground," said Alvaro de Oña, chief operating officer and head of media for shecco, publisher of *Accelerate America*. And Prall said he is seeing more smart controls in self-contained R290 cabinets.

But Prall pointed to the continuing challenge posed by hydrocarbon charge limitations. In the U.S., the charge limit for household fridges was 57 g., though the Environmental Protection Agency was looking at raising it to the international standard of 150 g. UL approved an increase to 150 g, but the EPA reversed its original approval to increase the charge limit this year because of one adverse comment, said Prall. "But I'm confident it will go up; it's just a matter of time." (The EPA announced an increase to 150 g on August 8; see page 14.)

Prall also held out hope that the international charge limit standard for commercial stand-alone cases would increase to 500 g from 150 g. (See page 26.) At present, some applications can be completely accommodated by 150 g, including food service refrigerators and freezers, under counter/prep tables, household equipment, and medical coolers and freezers. About two-thirds of beverage dispensers can be covered by 150 g. In other appliances – food islands, ice machines, reach-in cabinets and walks-ins – many applications would benefit from a 500 g charge.

"If we could go up to 500g, we could cover a significant portion of [the commercial refrigeration] market," Prall said, adding that today the 150-g limit means that many larger stand-alone applications require dual or multiple circuits. Even with 500 g, complete-store stand-alone solutions would include multiple circuits, he said.

Prall also noted that more work needs to be done on standards in the U.S. For example, hydrocarbon vending machines cannot be placed in hallways

Clockwise, from top left:
John Prall, Embraco
Andre Patenaude, Emerson
Marc-André Lesmerises, Carnot Refrigeration
Scott Martin, Hillphoenix

or lobbies due to ASHRAE standards. Scott Martin, director of business development and industry relations for Hillphoenix, pointed out the discrepancies between U.S. and European standards, which make it difficult to use proven European components in the U.S. The resulting higher costs of equipment "hurts adoption rate in North America," he said.

Hillphoenix has a self-contained and integral line of hydrocarbon systems, noted Martin. The OEM also offers CO_2 mini-boosters for smaller stores. (It owns Danish OEM Advansor, which markets those units.) But Hillphoenix's most popular small-format CO_2 system is the AdvansorFlex transcritical unit, which has been installed in many of 130 ALDI stores that have transcritical systems. (See page 40.)

Hillphoenix's Learning Center has helped to fill the training void for technicians and others dealing with the new technology, noted Martin; through 2017, the company has trained more than 27,000 individuals, including technicians, end users and dealers. Transcritical systems reduce dependence on highly skilled technicians by relying to a great degree on electronic controls, he added.

Between 2013 and 2017, Hillphoenix has expanded its number of installed transcritical systems from 30 to 325, said Martin. (sheccoBase, the market research arm of shecco, puts the total U.S. transcritical installations at more than 340, and the number of Canadian installations at over 210, as of February 2018.) Over that same time period, the company has added a series of innovations to improve efficiencies, especially in warm climates, from high-pressure sub coolers and adiabatic gas coolers to parallel compression to ejectors. In 2017, ejectors with parallel compression deployed in 2017 have generated annual savings of 8%-10%, and peak savings of 15%-20%, Martin said.

CHANGING COSTS

Costs remain the most important factor impacting natural refrigerant adoption. The initial cost of natural refrigerant systems remains above those of conventional systems, though over time it is coming down. Martin highlighted the importance of looking beyond the initial cost of the system to consider total cost of ownership, which includes first cost, installed cost, energy and maintenance (including refrigerant cost).

Saving energy through heat recovery – to a greater degree than HFC systems – can be a selling point for CO_2. "Of the more than 250 [CO_2 transcritical] systems we have [installed in the U.S. and Canada], 90% have heat recovery capability," said Marc-André Lesmerises, president of Carnot Refrigeration. Carnot helps reduce service costs by remotely monitoring installed systems, which cuts service calls by 90%, he added.

The rising cost of HFC refrigerants is also impacting refrigeration investments. In Europe, the F-Gas Regulation has driven up HFC prices 1,050% to 23 euros ($26.6) per metric ton of CO_2e between 2014 and the first quarter of 2018, to according to German researcher Öko-Recherche.

The U.S. policy landscape with respect to HFC regulations remains uncertain, but Martin maintains end users cannot be complacent. "[Non-natural] refrigerants are a big expense for the customer," he said. Moreover, regardless of how HFCs are regulated in the future, natural refrigerant systems will not be regulated, eliminating the need for future retrofits, he noted.

"We spend a lot of time on natural refrigerants, added Patenaude. "We know the natural refrigerant trend will continue in North America, and we want to be part of it." ■ CM & MG

INDUSTRIAL CONTEST: AMMONIA VS. CO_2

One of the biggest questions confronting the industrial refrigeration market is whether to install CO_2 transcritical or a version of low-charge ammonia.

In the market trends panel discussion at ATMOsphere America 2018, Marc-André Lesmerises, president of Carnot Refrigeration – which has installed six large industrial transcritical CO_2 systems in the U.S. – explained why he favors CO_2 (though he has also supplied ammonia systems). "The first answer we have is CO_2 will eliminate the toxicity of refrigerant, of course" as well as a number of components. Another reason is "it's easy to maintain and simple, said Lesmerises, whose company motto is "simplicity is the ultimate sophistication." Moreover, he added, "you can design the system differently for different conditions."

Across all sectors (supermarket, industrial, data centers), Carnot has installed over 250 transcritical CO_2 systems in 170 projects, covering capacities between 15 TR and 1,500 TR, said Lesmerises. The most recent trend for Carnot is marketing CO_2 systems to industrial facilities and data centers, including the five largest telecommunication companies in Canada.

By incorporating technologies that deal with high ambient temperatures like ejectors, parallel compressors and adiabatic condensers, transcritical systems are "really efficient," Lesmerises said, adding, "It's possible technically to build CO_2 systems that are more efficient than any other system."

Hillphoenix sells both transcritical CO_2 and low-charge packaged systems to industrial operators. Scott Martin, its director of business development and industry relations, said low-charge packaged systems offer a better option for some applications. These packages, installed outside, don't need a machine room and don't have long lines to the refrigerated area. They also show energy savings compared to packaged HFC systems and conventional ammonia systems. (See page 30.)

Hillphoenix has partnered with NXTCOLD to distribute a low-charge ammonia system (0.5 lb/TR) to the North American market. The companies have 38 standard models configured to up to 150 tons of capacity. There are 75+ NTXCOLD units installed in North America, and that is expected to double annually, said Martin

Emerson has entered the low-charge marketplace through subsidiary Vilter's Modular Rooftop Unit (MRU), an ammonia/CO_2 packaged system.

Preliminary sheccoBase data inidcate there are 220+ low-charge installations in the U.S., 200+ in Canada, 1,440+ in Europe, 150+ in China, 500+ in Japan and 100+ in Australia.

HC Charge-Limit Increase Approved in Interim IEC Vote

Marek Zgliczynski, chair of the IEC SC61C subcommittee and manager of commercial refrigeration product engineering for Embraco

National committees vote 75% yes to 500g for commercial systems – final vote possible by end of '18.

— By Charlotte McLaughlin and Michael Garry

Last month national committees on the International Electrotechnical Commission (IEC) voted, with 75% "yes" votes, to increase the charge limit of A3 (flammable) refrigerants like propane in stand-alone commercial refrigeration equipment to 500 g from 150 g, setting the stage for a potential final vote on the standard by the end of 2018.

Also approved was an increase in the charge limit of A2L refrigerants to 1.3 kg.

The vote represents the latest stage – along a lengthy standards process that began in 2014 – that will determine whether a higher charge limit for hydrocarbons is ultimately adopted in the IEC commercial refrigeration standard (IEC 60335-2-89).

In the weeks preceding the vote by the national committees, there was speculation that the new charge-limit standard might not be approved by more than 67%.

Even now, as the process nears its end game, "the battle is not over yet," said said Marek Zgliczynski, chair of the IEC SC61C subcommittee (covering commercial and domestic refrigeration) and manager of commercial refrigeration product engineering for Embraco.

No greater risk

The SC61C created a working group (WG 4) in 2014 to address the charge limit challenge. WG4 comprises experts from major global manufacturers like AHT, Epta, True Manufacturing, Emerson, Hussmann, among others.

The risk posed by a charge higher than 150 g, "must be the same as we have with the current limit of 150 g," said Zgliczynski at the ATMOsphere America 2018 conference. In addition, the refrigerant circuit using hydrocarbons has to be hermetically sealed and be able to avoid flammable concentrations in the airflow beyond the boundary of the appliance.

During a plenary meeting last October in Vladivostok, Russia, SC61C decided to advance a draft amendment for higher charges, prepared by WG4, to the next stage in the voting process, known as CDV (Committee Draft for Vote), in which IEC national committees take a vote. By voting 75% "yes." they exceeded the minimum 67% required for the standard to advance to the final vote.

The next step is to address the comments from the CDV process during the next SC61C meeting in Busan, South Korea, in October. The subcommittee will then decide, based on whether the issues raised by the comments are resolved, whether the charge-limit draft should go to a final vote phase (FDIS) by the end of 2018. If a final vote takes place and gains more than two-thirds positive votes, the standard could be published in early 2019.

IEC is a worldwide body encompassing 171 countries that proposes rules governing how to use specific electrical, electronic and related products. IEC standards influence the development of the market by providing manufacturers and customers with guidelines as to what is safe to use and buy.

To be mandatory, however, IEC standards need to be adopted by region or country, noted Zgliczynski. If the IEC standard is approved in 2019, it would take at least a year to be adopted in the U.S., he said.

It is commonly accepted by experts that the 150g-charge limit does not allow manufacturers and end users to fully exploit the safe application of hydrocarbon refrigerants in stand-alone refrigeration. At 150 g, the maximum cooling capacity is 0.8 kW in low-temperature units and 1.5 kW in medium-temperature units, said Zgliczynski. ■ CM & MG

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THE HFC PLOT THICKENS

The future of HFC regulations in the U.S. remains uncertain as the Supreme Court is petitioned, the EPA is sued, and Trump considers the Kigali Amendment

— By Michael Garry and Charlotte McLaughlin

While the Trump administration mulls whether to refer the Kigali HFC phase-down Amendment to the Senate for ratification – something the HVAC&R industry would like him to do – the U.S. remains in policy limbo regarding HFC regulation.

The Environmental Protection Agency's (EPA) current policy regarding HFCs, announced in April, is that previously announced rules regarding the delisting of high-GWP HFCs by certain dates for certain applications no longer apply.

That policy stems from the August 2017 2-1 ruling by a panel of the U.S. Court of Appeals for the District Columbia Circuit in *Mexichem Fluor v. EPA* (Arkema was the other planintiff); the ruling said that the EPA lacked authority under its SNAP (Significant New Alternative Policy) program to require a manufacturer that already replaced an ozone-depleting substance like R22 with HFCs to then switch again to a safer alternative such as a natural refrigerant.

The EPA is proceeding with new rule-making on HFC regulation, though if the Senate were to ratify the Kigali Amendment to the Montreal Protocol, that would eventually compel the EPA to orchestrate a phase down of HFCs, as it did with CFCs and HCFCs per the Montreal Protocol. Meanwhile, California is pursuing its own course on HFCs. (See "The Policy Quagmire," *Accelerate America*, June-July 2018.)

But over the past six weeks the plot has thickened. Here are the latest developments.

Intervenors petition Supreme Court

In late June, HFO manufacturers Honeywell and Chemours jointly petitioned the U.S. Supreme Court to reverse the August 2017 decision regarding the EPA's authority regarding HFC regulation. The Natural Resources Defense Council (NRDC) petitioned the Supreme Court for the same reason in a separate action. Honeywell, Chemours and the NRDC were intervenors in the case; the defendant (the EPA) did not appeal.


U.S. Supreme Court

"The decision ignores Congress's intent in directing the EPA [under the SNAP program] to replace ozone-depleting substances with the safest available alternatives," Honeywell said in a press release on its decision to petition the Supreme Court.

"The petition [to the Supreme Court] shows how the panel decision, if allowed to stand, will let HFCs keep fueling dangerous climate change, increasing risks for the millions of Americans who are living through hurricanes and other extreme weather events, and experiencing many other climate impacts," said David Doniger, senior strategic director, climate & clean energy program at the NRDC, on the climate group's website.

Meanwhile, Brett M. Kavanaugh, the U.S. Court of Appeals judge who wrote the majority decision in the *Mexichem Fluor v. EPA* case, was nominated last month by President Trump to serve on the U.S. Supreme Court.

The nomination – heralded by conservatives – is now before the U.S. Senate, where a politically charged confirmation battle is underway.

In Kavanagh's decision, he said the court specifically vacated an EPA

Final Rule 20 released in 2015 "to the extent that it requires manufacturers to replace HFCs with a substitute substance." This "partial vacatur" allows the EPA to classify HFCs as unacceptable for systems that still use ozone-depleting gases.

"However much we might sympathize or agree with EPA's policy objectives, EPA may act only within the boundaries of its statutory authority," he wrote in the August 2017 ruling. "Here, EPA exceeded that authority."

States sue EPA for voiding HFC regulation

In late June, New York Attorney General Barbara D. Underwood, leading a coalition of 11 Attorneys General, filed suit in the U.S. Court of Appeals for the District Columbia Circuit against the EPA, challenging its decision to completely void EPA Final Rule 20's regulations pertaining to the use of HFCs.

The coaltion includes Attorneys General from 10 states (New York, California, Delaware, Illinois, Massachusetts, Minnesota, New Jersey, Oregon, Vermont and Washington) plus the District of Columbia; the Pennsylvania Department of Environmental Protection also joined the action.

The coalition charges that the EPA violated the federal Clean Air Act in April when it issued a guidance completely rescinding Rule 20's regulations enacted in 2015 under the SNAP program, which prohibited the use of HFCs in certain applications by certain dates.

The EPA, the suit alleges, needed to go through a public rulemaking process "as required by law" before it had the authority to completely rescind those regulations. The EPA did initiate this rulemaking process, but only after issuing the guidance.

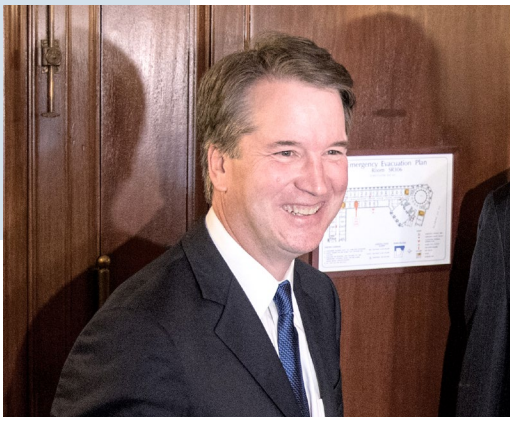
The guidance was the EPA's response to the ruling in the lawsuit filed by Mexichem Fluor and Arkema. The court broadly affirmed the EPA's authority to designate HFCs as prohibited replacements for ozone-depleting substances in cases where those substances were still in use. In its guidance, however, the EPA said it lacked the authority to prohibit HFCs in all cases.

"The Trump EPA is seeking to gut critical climate protection rules through the backdoor – once again endangering New Yorkers while thumbing their nose at the law," said Underwood in a statement. "My office will continue to fight back against the Trump Administration's brazen disregard for rule of law, and the health, safety and welfare of New Yorkers."

Conservatives urge Trump on Kigali

In June, 13 Republican senators and three conservative groups sent letters urging President Trump to send the Kigali Amendment to the Montreal Protocol to the U.S. Senate for ratification.

As of early August, the Kigali Amendment, which calls for a global phase-down of HFCs, had been ratified by 42 of 197 signatory nations. It will go into effect for ratified nations on January 1, 2019.



Brett Kavanaugh, nominee for the U.S. Supreme Court and judge in EPA SNAP case.

The thirteen senators, led by John Kennedy of Louisiana – where HFC and HFO manufacturer Honeywell is located – and Susan M. Collins (MA), include Bill Cassidy (LA), Lindsey Graham (SC), Lisa Murkowski (AK), Johnny Isakson (GA), Lamar Alexander (TN), Marco Rubio (FL), Jerry Moran (KS), Tim Scott (SC), Roy Blunt (MO), John Boozman (AR) and Todd Young (IN).

The three conservative groups were the Americans for Tax Reform, American Council for Capital Formation and FreedomWorks.

Last month, a new coalition of conservatives and businesses in the U.S., called Let America Lead pledged to work with "conservative leaders at the local, state and national level, manufacturers and businesses, and working Americans across the country, to demonstrate to President Trump why support for the Kigali Amendment is a win for American workers and urge him to send it to the U.S. Senate for ratification."

Founding members of Let America Lead include the National Association of Manufacturers, the U.S. Chamber of Commerce, the American Chemistry Council and the American Council for Capital Formation. ■ MG & CM

LOWER CHARGE, HIGHER REVENUES

Western Gateway Storage and KPAC General have each made room for additional business in their facilities – while cutting their energy bills – by installing low-charge ammonia rooftop units

— By Charlotte McLaughlin and Michael Garry

One of the advantages of installing packaged rooftop low-charge ammonia units rather than a centralized ammonia system is that the facility space that would have gone to an engine room can be employed as revenue-generating storage space.

Two cold-storage operators that have benefited from the extra space available with rooftop units are Ogden, Utah-based Western Gateway Storage and Southgate, Calif.-based KPAC General. Representatives of those companies shared their stories at ATMOsphere America 2018, which took place in Long Beach, Calif., in June.

In 2016, Western Gateway Storage became the first cold storage facility in the U.S. to install Evapco's Evapcold packaged low-charge ammonia system. (See "The Road to Low-Charge Ammonia," *Accelerate America*, June 2016.) The warehouse uses two Evapcold units, each containing 290 lbs of ammonia and providing 70 TR of cooling (4.1 lbs/TR); Western Gateway's total cooling load is 100 TR, so the units offer redundancy.

Because the two-unit system resides on the roof, floor space has been utilized to produce ice for retail sale in a separate business called Mountain Brand. "So we're now in the packaged ice business," said David Bornemeier, president and CFO. Western Gateway Storage expects $200,000 to 600,000 in ice purchase orders coming in over the next 12-36 months.

KPAC General began full-time operations at its new 84,000-sq-ft facility in January. (See "KPAC General's Great Leap Forward," *Accelerate America*, March 2018.) Like Western Gateway, the cold-storage operator gained additional space by using a low-charge ammonia system – in this case eight NXTCOLD/Hillphoenix packaged rooftop units. "With a conventional [ammonia] system you need an engine room," said Ronnie R. Ceballos, vice president and general manager. "Now we have [30% more] space" – accommodating 500-550 more pallets – "that's potential revenue space." He sees a possible annual revenue gain of $165,000-$192,500.

David Bornemeier, president and CFO. Western Gateway Storage

BETTER EFFICIENCY THAN EXPECTED

The two cold-storage operators have enjoyed other advantages with their low-charge systems.

Western Gateway projected a 20% savings in energy consumption compared to a conventional ammonia system, and Bornemeier reported that the system has delivered "higher than expected efficiency. The original projection earned him a $60,000 energy incentive from Rocky Mountain Power.

The Utah operator also reduced installation time (300 hours as opposed to 4,000 with a standard ammonia refrigeration system), as well as pollution insurance policy costs and maintenance costs. In addition, he noted, while "there is a perceived higher [capital] cost [for low-charge ammonia packages], I can confirm that is not the case." He also described the units as "easier to operate" than a conventional ammonia system. Overall, he described the units as offering "low maintenance, low charge and low drama."

Looking ahead, Bornemeier sees more opportunities to use natural refrigerants. "We want to invest in [hydrocarbon]-based [store] merchandisers for our ice sales," he said. This will involve some challenges, he said, like installing leak detection for flammable hydrocarbon refrigerants in retail fridges, adapting to new store designs and explaining to retailers that natural refrigerant products are safe.

He believes education is key to pushing end users toward natural refrigerant systems, declaring that ATMOsphere America and similar conferences can play this role. "We've got to move away [from synthetic refrigerants]. Why spend millions of dollars investing in a [chemical] refrigerant that will be phased out later on?"

Ronnie R. Ceballos, vice president and general manager KPAC General

LESS ENERGY USE IN BIGGER FACILITY

KPAC General, has also achieved energy savings with its low-charge deployment. During the first five months of operation, in which the facility averaged $20,000 in monthly electricity costs], Ceballos estimated the energy savings from the installation compared to the R22 system used at his old facility to be around $180,000-$210,000, a saving of 20%, despite a 30% increase in cubic feet.

KPAC General's NXTCOLD units are the subject of a study, sponsored by Southern California Edison (SCE), examining their energy efficiency and demand-response opportunities, compared to those of the R22 system. If the energy efficiency of the system meets expectations, KPAC General would receive an $82,000 rebate from SCE.

Maintenance costs for the low-charge units should be lower than for a conventional ammonia facility "since all components are localized in the penthouse," said Ceballos. Administrative costs would also be reduced, he said, due to less regulatory burden. In addition, personal and product risks are less as a result of the low ammonia charge.

Taking into account savings from energy, liability insurance, and installation cost, and adding in the rebate and additional storage revenue, Ceballos projects a net of $425,000-$482,500 for the low-charge system during its first year, compared to a traditional ammonia system. "From an accounting standpoint it looks pretty good," he said.

KPAC General's eight rooftop ("penthouse") NXTCOLD units include two above the freezer (-10°F), one above each of the four convertible rooms (two at 32°F-34°F, one at 48°F, and one at 55°F -60°F), and two above the dock area (45°F-50°F). Cool air is ducted down into each storage area.

The total capacity of the eight units ranges from 320 TR to 360 TR, with a total ammonia charge of 150 lbs to 240 lbs. This translates to an "ultra-low-charge" ratio of between .47 lb/TR to .67 lb/TR.

Ceballos testified to the improved safety of the low-charge system. "There is so much ammonia in these [traditional] systems, if there is a leak it can be pretty catastrophic," he said. ■ CM & MG

LEARNING ONSTAGE

Aditi Joshi, energy manager for biopharmaceutical company Amgen, came to ATMOsphere America 2018 seeking advice on a natural refrigerant system, including low-charge ammonia equipment, that could replace six 1,250-TR centrifugal chillers using R22 at Amgen's Thousand Oaks, Calif., headquarters.

She found some guidance in an unusual way – by participating onstage in the industrial end users session.

"I want to know what my options are," she said. "I'm looking for a total cost of ownership assessment." The system she is seeking would deliver air conditioning and process cooling (40°F to 42°F) at the 40-building Thousand Oaks campus, which includes manufacturing, laboratories and offices.

Kurt Liebendorfer, vice president of Evapco, pointed out that other pharmaceutical companies are using packaged ammonia chillers for processing and comfort cooling. A custom system offers between 1,000 TR and 2,000 TR, he said.

Ammonia-based technology exists, added Rick Watters, VP of refrigeration/food process piping, AMS Mechanical Systems. "You just have to connect with the right people."

HEINEKEN'S HYDROCARBON JOURNEY

The Dutch brewing giant's new retail fridges and dispensers use propane (mostly) or isobutane as it brings an environmental message to its markets throughout the world

— By Andrew Williams

Heineken has a penchant for "green" – the color of its iconic flagship beer bottle.

In 2010 the Dutch brewer, based in Amsterdam, decided to extend environmental green to the beer refrigerators and draught-beer dispensing equipment it provides to retail and restaurant outlets in most of the world.

The company – founded in 1864 and now the second largest brewer in the word by revenue – came up with the following four-part definition of what green equipment would comprise: hydrocarbon refrigerants, LED illumination, an energy management system and energy efficient fans.

"We discovered hydrocarbons as part of our 'Brewing a Better World' program," said Graeme Houghton, global category leader – commercial equipment & servicing, Heineken Global Procurement, in an interview with *Accelerate Europe* (a sister publication to *Accelerate America*). "We adopted them for two reasons – one, because they help to deliver the energy efficiency that we want; and two, because of their significantly lower GWP compared to the existing refrigerants we used in our fridges."

Most of its fridges and dispensers employ propane as the refrigerant, while some use isobutane, he said.

Heineken expects that by 2020, "the majority, if not all of our fridge population will be green, with natural refrigerants," Houghton said.

From left: Hans Donker and Graeme Houghton of Heineken

"Cooling is a significant part of our CO_2 footprint," said Hans Donker, global category buyer – fridges & draught beer equipment. "We've got over a million fridges out there in the field."

"We know our carbon footprint, and we're actively trying to reduce it," Houghton added.

Heineken works with an independent cooling advisory group, as well as manufacturers, to create its fridges and dispensing equipment. The company controls the distribution of its equipment throughout the world, with the notable exception of the U.S., where the three-tier alcohol distribution laws prevent it from owning or controlling fridges; instead this is the responsibility of wholesalers and retailers. However, Heineken does distribute its equipment in Canada and Mexico, where its green refrigeration footprint is particularly strong.

Heineken is making its proprietary draught beer dispenser called the Blade (which uses isobutane) and its propane-based David XL Green draught system available for sale in the U.S., said Houghton. Over 12,000 of the David XL Green systems have been installed in 25 markets across Europe, Africa & the Middle East, Asia and the Americas.

100% GREEN

Last year, almost 100% of the 137,818 new commercial refrigerators Heineken bought globally had one or more (and in many cases all four) green features. Since the beginning of 2018, 100% of the fridges Heineken is purchasing are green.

"We buy roughly 140,000 fridges a year," said Houghton. "All the fridges we buy are hydrocarbons. We're on a journey. It's about changing our entire fleet."

Adopting natural refrigerants is helping to Heineken to improve the energy efficiency of its fridge portfolio. Initially, the brewer saved 30% on energy consumption compared to HFC models, with 7% of the efficiency gain from refrigeration, 8% from LED lighting, and 15% from energy management. Today, "we're reducing their energy consumption by half," said Donker.

In terms of greenhouse gas (GHG) emissions, the company is targeting 50% lower emissions from fridges by 2020 compared to 2010 levels. In 2017, GHG emissions per fridge were already down by almost 48%.

"We are strong supporters of phasing out hydrofluorocarbons (HFCs), which contribute significantly to global warming today," said Heineken in a corporate statement. "Saving energy also means our customers incur less costs in their business."

Heineken's overall climate strategy is driven by its "Drop the C" program, which aims to significantly reduce carbon emissions across the business. In addition to cutting fridge emissions, the company is targeting 40% lower emissions in production, and and 20% lower emissions from distribution in Europe and the Americas, by 2020.

MEXICO: A GREEN LEADER

Heineken has "a significant [green] cooling footprint in Mexico, said Houghton. "Mexico is one of our countries that lead the green cooling agenda, placing 'green' fridges that use hydrocarbon refrigerants along with other energy-saving technologies. In addition, they use our David XL technology for draught beer."

Heineken started its hydrocarbon journey in Mexico in 2013. Its core models moved to hydrocarbons, with the rest of the line switching in 2014 and 2015. "Since then, all of our [new] Mexican fridges [and draught dispensers] use hydrocarbons," said Houghton. In Mexico this year, in a global first, Heineken launched fridges with variable-speed compressors to improve energy efficiency.

While Mexico is Heineken's leading market for green refrigeration in North America, in the continent as a whole, including the Caribbean, "we have over 300,000 fridges that will be green," said Houghton. In addition, the company has started the transition to green refrigerants in Brazil, following its acquisition of Kirin.

What challenges has Heineken faced around the world in placing hydrocarbon-based fridges and draught beer equipment?

"The apprehension, and the pushback from some of our markets, was that this is different technology," Houghton said. "We sometimes see this resistance when we introduce new technologies."

Heineken's new beer fridges use hydrocarbons, mostly propane.

Today, Heineken uses hydrocarbon equipment all over the world. "At first we didn't do it in Central Africa," Donker said. "We assessed the risk and we didn't want to introduce hydrocarbons there. But we have done so now."

Initially, the maturity of service organizations posed challenges in some parts of the world, including Mexico. "It was a gradual thing," Houghton said. "Europe was phase one, in terms of the maturity and pushing this through, followed by the Americas. Asia and Africa followed afterwards."

Heineken was familiar with the equipment suppliers present in those markets from working with them in Europe and the Americas, but "they took time to develop the service agents who could look after the equipment," Houghton added.

The equipment suppliers themselves provide training on how to work with hydrocarbons.

Overall, the brewer "went through a change process" in transitioning its clients and sub-contractors to hydrocarbons, said Houghton. "But we were pleasantly surprised by the robustness of the technology. We've had no misery. It proves that we've done the right thing." AW

Barrier Breakers

In the third annual Accelerate America Awards program, industry leaders are recognized for overcoming barriers and advancing the adoption of natural refrigerant-based technologies

— By Michael Garry

In June, during the ATMOsphere America conference in Long Beach, California, *Accelerate America* presented six awards recognizing five organizations and one individual for their exceptional commitment to furthering the adoption of natural refrigerants in North America.

The annual awards program, now in its third year, named California State Senator Ricardo Lara Person of the Year for spearheading efforts in the California legislature to cut emissions of super-polluting HFC refrigerants and replace them with natural refrigerant alternatives. He received the award following his keynote address during the first day of the conference.

The next day, at a pre-dinner ceremony at Parker's Lighthouse restaurant overlooking the Pacific Ocean, organizational awards were handed out to: Henningsen Cold Storage (Best in Sector/Industrial); ALDI US (Best in Sector/Food Retail); Colmac Coil Manufacturing (Innovation of the Year); Source Refrigeration and HVAC (Best Contractor); and Southern California Edison (Best Utility). The last two awards were introduced this year.

What all of the winners have in common is a determination to overcome the barriers to adoption of natural refrigerant systems, whether political (Lara), technological (Colmac Coil), educational (Source Refrigeration), financial (Southern California Edison) or resistance-to-change (Henningsen and ALDI US). They all understand the long-term value these technologies offer to businesses, consumers and the environment.

On the following pages are profiles of the winners explaining why they were selected by shecco (publisher of *Accelerate America* and organizer of ATMOsphere America), with input from industry experts. ■ MG

PERSON OF THE YEAR

CALIFORNIA STATE SENATOR RICARDO LARA

Fighting HFCs – the 'Silent Assassin'

When Ricardo Lara, a 43-year-old California State Senator, presented the keynote at the ATMOsphere America 2018 conference last June in Long Beach, Calif., it was a homecoming for him.

Not only is Long Beach part of the Senate district that he represents, but it's close to where he grew up in East Los Angeles, the son of a factory worker and seamstress who immigrated from Mexico. It was there that the seeds of his interest in environmental issues were planted.

"I grew up a couple of miles from here, surrounded by freeways, trucking companies and a rail yard," he told about 350 attendees at the conference (organized by shecco, publisher of *Accelerate America)*. "We had some of the worst air quality in the country, coupled with asthma and cancer clusters and low birth rates."

A Democrat, Lara won his first election in 2010, joining the California Assembly as the representative of the 50th district, which encompasses parts of Los Angeles and environs. Two years later, he successfully ran to represent the 33rd district in the State Senate, where he has authored a number of bills offering incentives for environmentally friendly technology, including natural refrigerant systems.

Over the past three years, Lara has staked out a leadership role in the fight to reduce emissions of short-lived climate pollutants (SLCPs), or what he calls "super pollutants" for their high GWPs relative to CO_2; these include HFCs, methane and black carbon. "I hate using the term 'short-lived' because people assume they're not dangerous," he said. "So we call them super pollutants because we know they are harmful to the environment and health."

In California, Lara's efforts have succeeded in raising the profile of refrigerants – an often-overlooked contributor to climate change. "People are talking about HFCs because of the work we've done to target these super pollutants," he said.

And given California's size – it has the 5th largest economy in the world – and its status as a national model for environmental regulation, Lara's work is being watched by other states, especially at a time of regulatory retrenchment at the federal level.

"In California, we have a trajectory of not waiting for the federal government to act before we take

leadership positions on issues important to us," he said. "So no matter what happens in Washington, D.C., California is going to push forward."

Moreover, Lara thinks California has a "global responsibility" to act on issues that affect climate change. "We actually believe in science here," he added.

For becoming one of the most outspoken advocates for reducing HFCs, and for developing an incentive program that supports the adoption of natural refrigerant systems in California, Lara is the recipient of the 2018 Accelerate America Person of the Year Award.

California State Senator Ricardo Lara

Committing to HFC reduction

Lara's foray into HFC reduction began in 2014, when his Senate Bill 605 directed the California Air Resources Board (CARB) to develop a comprehensive SLCP strategy, in coordination with other state agencies and local air quality management and air pollution control districts, to reduce emissions of SLCPs. That led to CARB's SLCP Reduction Strategy, a set of proposed regulations to rein in HFCs and other SLCPs that was approved in 2017.

In 2015, his Super Pollutant Reduction Act (Senate Bill 1383) became law, committing California to reduce HFC and methane emissions by 40% below 2013 levels, and black carbon emissions by 50% below 2013 levels, by 2030.

Last November, at the 23rd UN Climate Change Conference in Bonn, Germany, Lara proposed the California Cooling Act (CCA) to combat HFCs in refrigerators and air conditioners – what he termed the "silent assassin that threatens our global climate." (At the conference, CARB, Lara and California Governor Jerry Brown were recognized for their work on SLCPs, with Lara and Brown accepting on behalf of their state the inaugural Climate and Clean Air Award for Outstanding Policy, given by the Climate and Clear Air Coalition.)

The CCA, which Lara formally introduced as Senate Bill 1013 in February, will formalize certain provisions of federal SNAP (Significant New Alternative Policy) rules adopted by California in March. But the bill has gained the most attention for its provision allowing CARB to provide financial incentives to businesses switching to low-GWP refrigeration systems, including those using natural refrigerants.

Lara brings to the CCA considerable experience in shepherding environmental incentive programs through the California legislature, including incentives for dairy farmers, consumers and trucking companies to buy new technology. (See page 38.)

The CCA's incentives are designed to "assist end users with upfront costs (including installation) for low global-warming-potential systems," said a Lara staff member. This would be "the first statewide program to provide to help people make this transition," said Lara, adding that the program "sends the right market signals about investing in new technology."

The bill will target end users of supermarket refrigeration, cold storage equipment and commercial air conditioning systems. "We are looking at the big end users like supermarkets to get the most bang for the buck," said Lara.

Funding would be available for equipment in existing as well as new stores. Communities that have been "disproportionately impacted by pollution and climate change" would be first to receive funding, he said, though any end user in California would be able to apply for incentives.

After making it through three committees, the CCA passed in the California Senate on May 30. In the Assembly, it passed in the Natural Resources Committee 7-3 on June 18, and is being considered by the Appropriations Committee, which will likely vote on August 17. Lara is working on an amendment to the bill that would prevent old refrigeration equipment from being resold or repurposed.

The legislature would have to separately approve the allocation of incentive funding for the CCA from the state's highly competitive greenhouse gas reduction fund (GGRF) program, which is supported by cap-and-trade dollars.

To supplement the GGRF funding, the bill would also provide incentives through the California Public Utilities Commission and local utilities.

The CCA is not the first attempt to establish state incentives for HFC reduction. In his proposed 2016-2017 budget, California Governor Brown included $20 million for such incentives. However, without sufficient expressions of support from the HVAC&R community, those funds were not approved by the legislature. The Lara staff member said that $20 million "is in the ballpark of the amount we hope for."

"The governor is attuned to the work we're doing."

Final legislative action on the CCA will take place at the end of August, followed by a decision on incentives. If both pass, CARB would start making incentives available in 2019, with amounts determined on a case-by-case basis. Lara is still working on determining how many years the incentive program would remain in place.

In a May webinar on the CCA hosted by the North American Sustainable Refrigeration Council (NASRC), the Lara staff member said he was optimistic about the bill's prospects. But more recently, he said it was "hard to speculate how the bill would fair in Appropriations or on the Assembly floor."

On the day of his keynote at ATMOsphere America, HFC manufacturers Mexichem Fluor and Arkema (plaintiffs in the suit that resulted in the EPA no longer able to compel replacement of HFCs in existing equipment) were in Sacramento lobbying against the CCA, Lara noted.

With the opposition in mind, Lara is still assessing how much he can put into the CCA – in areas like retrofits – "and still get the votes we need to pass the legislation."

Lara and his staff have received feedback on the CCA from industry stakeholders, including letters of support. shecco sent a letter to Lara that included endorsements from 14 businesses involved with natural refrigerants, which represented the "pulse of businesses and provides a critical mass of the natural refrigerant community to support the legislation," said the Lara staff member.

Lara's Other Incentives

As he works on legislation in the California legislature to provide incentives for HVAC&R systems that eliminate HFCs, Senator Ricardo Lara already has to his credit other incentive bills that address short-lived climate pollutants (SLCPs) methane and black carbon, as well as other pollutants.

For example, Lara addressed methane reduction in discussions with dairy farmers in California about the flatulence produced by their cows. "Those were very interesting conversations," he said.

This resulted in a popular incentive program that helps small dairy farmers invest in digester technology that converts cow waste into energy supplied to the power grid. "That's happening today thanks to legislation," he said.

In 2017 Lara tackled the black carbon (smoke and particulate matter) produced by wood-burning stoves, which is bad for the environment and human health. The result: an incentive program to allow consumers to switch to cleaner stoves.

Last year, Lara helped form an incentive program for the purchase of clean, efficient trucks, buses and off-road vehicles, to the tune of nearly $1 billion. "Nowhere else in the world are they investing close to $1 billion in this," he said.

He is now working on providing consumers with incentives to purchase electric vehicles.

BEST IN SECTOR/INDUSTRIAL

HENNINGSEN COLD STORAGE

From Low Charge to No Charge

Over the past decade, Henningsen Cold Storage, Hillsboro, Ore., has carved out a reputation for reducing the ammonia charge in the centralized system at three of its 12 warehouses.

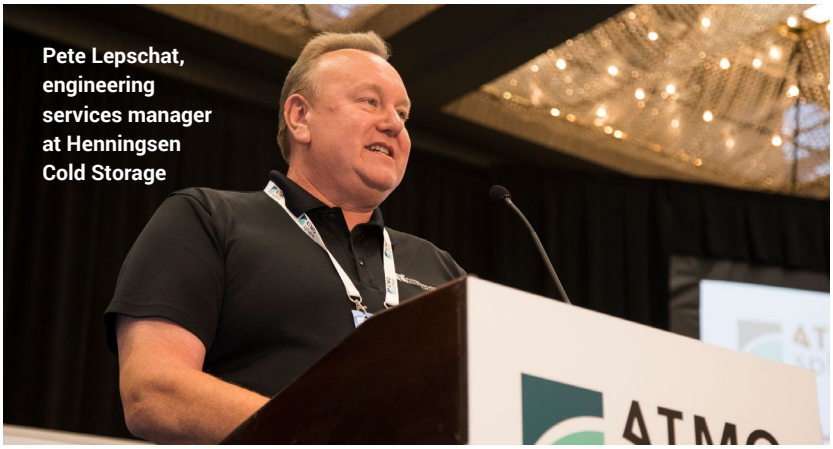
Under the leadership of Pete Lepschat, engineering services manager, 95-year-old, family-owned Henningsen has reduced its charge-to-capacity ratio from as much as 52 lbs/TR in 1993 to 12 lbs/TR at a plant in Salem, Ore., in 2014. Another Salem plant that opened last year has a charge of 16 lbs/TR, while operating below 0.3 kWh/cu ft/yr., less than one-third of the industry efficiency average. (See, "'We have met the enemy, and he is liquid,'" *Accelerate America*, August 2017.)

Low-charge designs "have been my windmill to tilt at over the past 10 years," said Lepschat at the ATMOsphere America conference in June.

In June, at its newly constructed 110,000-sq-ft facility in Grandview, Wash., Henningsen has made the transition from low-charge ammonia to "no-charge," using CO_2 for the first time as a refrigerant rather than ammonia. The rooftop transcritical CO_2 system was supplied by Carnot Refrigeration and installed by PermaCold Engineering.

While transcritical systems have been installed in many U.S. supermarkets, this is one of the first to be used by a cold-storage facility in the U.S. "It's a big jump for us and our industry," said Lepschat.

By September 1, Henningsen plans to install his second transcritical system (from Hillphoenix) at a facility in Scranton, Pa., replacing a low-temperature R404A system.



Pete Lepschat, engineering services manager at Henningsen Cold Storage

For developing innovative ways to reduce ammonia charge and energy consumption, and for installing one of the first transcritical CO_2 systems at a U.S. cold-storage facility, Henningsen is the recipient of the 2018 Accelerate America Best in Sector/Industrial Award.

How much ammonia?

At its low-charge plants, Lepschat has reduced the charge by scrutinizing every component of a centralized ammonia system, and deciding whether ammonia is needed in that part of the system, and whether the component itself is required. For example, at a warehouse in Greshem, Ore., he replaced a high-pressure receiver with a vessel that maintains a smaller level of liquid ammonia and holds it for less time.

Lepschat has also employed evaporators that use far less ammonia than traditional overfeed units. At Henningsen's first Salem plant, he installed an Evapco evaporator with an overfeed ratio of just 1.2:1; the facility also employs glycol rather than ammonia in the thermosyphon oil-cooling process.

The transcritical system in Grandview, which uses an adiabatic condenser/gas cooler, comprises about 3,000 lbs of CO_2 with a refrigeration capacity of 210 TR for a 0°F freezer nad a refrigerated dock. Lepschat regards the modular, rooftop system as scalable, so that it will accommodate future expansion of the plant to more than 400,000 sq ft.

In evaluating whether to install a transcritical system, Lepschat found that it would offer a number of advantages over a central low-charge system: $534,000 less in system cost; about $300,000 less in building costs (no engine room is needed); and a five-to-six week reduction in construction time.

Lepschat projects an energy savings of $46,000 kWh/yr, as well as less use of water and sewer, and a lower maintenance cost. Of course, he will be monitoring those metrics – and providing the results to the industry.

Apart from the learning curve for an ammonia operator, the biggest challenge in using transcritical for Henningsen was just that it was new. "We've never done it before," said Lepschat. "But we hadn't done a lot of things before we did them the first time."

BEST IN SECTOR/FOOD RETAIL

ALDI US

Marc Chasserot, CEO, shecco; and Amber Hardy, director of energy management, ALDI US

U.S. Transcritical Leader

With 130 of its stores using a transcritical CO_2 system, ALDI US is the leading supermarket user of this refrigeration technology in the U.S. That's almost twice the number (69) of ALDI US stores with a transcritical system a year ago.

By the end of this year, the chain, based in Batavia, Ill. – and an independently operated member of Mülheim, Germany-based ALDI South (Sud) – intends to have "all 130 [stores] certified Platinum" by the Environmental Protection Agency's GreenChill Partnership, said Amber Hardy, director of energy management for ALDI US.

ALDI US, which operates about 1,700 stores, plans to expand to 2,500 by the end of 2022, and remodel more than 1,300 stores by 2020. The number of transcritical installations "changes daily given our store growth and remodel plan," said Hardy.

The company's long-term strategy is to standardize its stores on transcritical CO_2 systems, said Aaron Sumida, an ALDI US vice president. (See "Leader of the Rack," *Accelerate America*, September 2017.)

Most of the transcritical installations have been in new stores, though some are in remodeled locations. Notably, about half of ALDI US's transcritical stores are situated in southern climates, where they employ an adiabatic condenser to maintain efficiency in warm ambient temperatures.

All of the transcritical systems have been supplied by Hillphoenix, with the exception of six provided by Hussmann. The majority of the Hillphoenix systems are the AdvansorFlex, the company's downsized transcritical model designed for small-format stores.

Over 900 ALDI US stores have self-contained spot merchandisers (chest freezers) operating with propane.

For becoming the leading supermarket user of transcritical CO_2 systems in the U.S., while also employing self-contained propane units, ALDI US is the recipient of the 2018 Accelerate America Best in Sector/Food Retail Award.

INNOVATION OF THE YEAR

COLMAC COIL MANUFACTURING

Embraced by the Marketplace

The mark of an innovative technology is that it not only solves a problem in a unique way, but is also embraced by the marketplace. Colmac Coil Manufacturing's ADX (Advanced DX) low-charge evaporator meets both of those criteria.

The ADX system, used in traditional centralized ammonia plants for both low- and medium-temperature applications, reduces the ammonia charge by 30-50 times compared to a traditional overfeed system, said the system's developer, Bruce Nelson, president of Colville, Wash.-based Colmac Coil.

The ADX system reduces evaporator charge via a patented design that ensures the liquid ammonia completely coats the inside of the evaporator tubes. In addition, the system optimizes the flow of ammonia throughout the evaporator tubes so that they each get the same amount of liquid.

The system also saves energy. Liberty Cold Storage, Bolingbrook, Ill., which employs the ADX system, uses 18% less energy than a comparable liquid-overfeed facility. (See, "How Liberty Cold Got Its Ammonia Charge Down," *Accelerate America*, April 2018.)

In terms of market acceptance, as of April 2018, Colmac Coil had installed 47 ADX systems around the world, mostly in the US, including 16 new facilities and 31 retrofits and expansions, in some cases multiple installations at the same facility. And this year, 35 more installations are expected.

In addition to Liberty Cold Storage, the end users of the ADX system include: Joliet Cold Storage, Preferred Freezer Services, Shepherd's Processed Eggs, U.S. Cold Storage, Bidvest Australia and Conestoga Cold Storage.

For developing a low-charge DX evaporator for low and medium temperatures that has been widely adopted in the industrial sector, Colmac Coil is the recipient of the 2018 Accelerate America Innovation of the Year Award.

BEST CONTRACTOR

SOURCE REFRIGERATION & HVAC

Installing and Explaining Natural Refrigerants

Source Refrigeration & HVAC, a division of CoolSys, got into the natural refrigerants game well before most other contractors.

In 2012, Anaheim, Calif.-based Source, led by Bryan Beitler, its vice president and chief engineer, participated in the design and installation of the first ammonia/CO_2 refrigeration system to be installed in a US supermarket, at a Supervalu store, now owned by Albertsons, in Carpinteria, Calif. (See, "The Facilitator," *Accelerate America*, August 2017.)

At that time, Source, which has around 46 branch locations with more than 1,250 technicians throughout the U.S., had just started installing CO_2 refrigeration (mostly pumped systems using HFCs on the high side).

Since then, Source has gone on to deploy many more CO_2 systems, including cascade and transcritical, for a total exceeding 50 – likely the most of any U.S. contractor.

In addition, Source has committed itself to teaching its technicians about the art and science of natural refrigerants, staking out an industry-leading position in the training arena. Its training facility in Anaheim, Calif., is equipped with a CO_2 subcritical system.

"Training is unbilled time, and travel to and from training centers is costly, but to not train is not an option," Beitler said at a contractor and training session at ATMOsphere America 2018 in June.

Source prides itself on playing a consultative role with its customers about which refrigerants they should use, often bringing natural refrigerants to their attention.

For its leading role in promoting the use of natural refrigerants in the food retail sector, Source Refrigeration & HVAC is the recipient of the 2018 Accelerate America Best Contractor Award.

BEST UTILITY

SOUTHERN CALIFORNIA EDISON

Looking for the Next Technologies

When it comes evaluating and incentivizing the adoption of natural refrigerant systems, Southern California Edison (SCE), the primary electricity supplier for much of Southern California, really stands out.

Based in Rosemead, Calif., SCE has engaged in several energy-assessment projects, both energy consumption and demand response, including some that have led to custom incentives for self-contained supermarket freezers using propane and low-charged ammonia packaged systems.

SCE "is pioneering research in low-GWP refrigerants by working with local refrigerant startups, maintaining a presence on regional and national expert groups, and undertaking pilots," according to SCE literature.

The prime driver of its efforts in this regard is Paul Delaney, its senior engineer, and technical area lead in SCE's Emerging Products group, whose specialties include industrial and commercial refrigeration. (See, "Southern California Edison Takes on Natural Refrigerants," *Accelerate America*, June 2015.)

"We look for the next technologies {that can be incentivized]," he said at the utilities session at ATMOsphere America 2018.

In one example, SCE funded a study of the energy performance of Mayekawa's NewTon ammonia/CO_2 refrigeration system at the Imuraya USA plant in Irvine, Calif. The system consumes 32% less energy than a baseline HFC system in the same plant. At the KPAC General cold-storage facility in South Gate, Calif., SCE is assessing the energy efficiency of a NXTCOLD low-charge packaged unit in order to award incentives. (See page 30.)

SCE runs its own Technology Test Centers in Irwindale, Calif., to understand the performance of new systems. It also partners with the Electric Power Research Institute (EPRI) and Creative Thermal Solutions, which is testing low-charge ammonia systems from Evapco and Mayekawa, with funding from SCE and EPRI.

For its leading role in assessing and incentivizing natural refrigerant systems, Southern California Edison is the recipient of the 2018 Accelerate America Best Utility Award.

Turbo air Completes Switch to Hydrocarbons

Several other OEMs at the NRA Show have started producing propane units, with further rollouts on the way.

— By Michael Garry

Turbo air, a Long Beach, Calif.-based foodservice equipment manufacturer, has completely transitioned its product line this year to hydrocarbons. either propane (R290) or isobutane (R600a), the latest in a series of OEMs that have converted to hydrocarbon refrigerants.

"It was a very expensive process to switch, but we said, it's the right thing to do, it's going to save energy, so we're going to do it," said Mike DiDaniels, a manufacturers representative for Turbo air.

The company had a slew of ETL-certified hydrocarbon units on display at the National Restaurant Association (NRA) Show in May, including club top beer dispensers (R600a), curved glass bakery cases (R290), back bars (R290/R600a), bottle coolers (R600a), glass/mug frosters (R290), vertical open display cases (R290) and swing-door merchandisers.

The hydrocarbon units are 20%-25% more efficient than R134a or R404A, said DiDaniels, adding that 75 models meet the ENERGY STAR 4.0 efficiency standard. They are designed for a wide range of food retailers, including grocers, convenience stores, drug outlets ands school cafeterias.

Turbo air runs its own service network across its 13 U.S. branches, noted DiDaniels. "We're one of the few companies that does. It makes servicing a lot easier."

Most of Turbo Air's units employ 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 buildup out of the unit.

In process

Following the lead of Turbo air and other major foodservice equipment OEMs like True Manufacturing, Beverage-Air and Welbilt/Delfield (see "More Foodservice Equipment Goes Natural," *Accelerate America*, June-July 2018), several other manufacturers are in the process of converting their units from HFCs to propane (R290).

Master-Bilt propane unit

The companies exhibited their products at the NRA Show in Chicago, where they discussed their plans.

Master-Bilt, New Albany, Miss., has converted its small "novelty" merchandising cases to R290, and is in the process of transitioning its other foodservice cabinets to R290 as well, including its Fusion line, according to a company representative who declined to be named.

Continental Refrigerator, Bensalem, Pa., has so far converted a sandwich-unit freezer to R290, and is engaged in R290 tests on its other foodservice units, said Sean Maloney, a salesperson for the company. In line with this transition, Continental has produced an R290 service manual on principles and best practices for servicing hydrocarbon refrigeration equipment.

Blue Air Commercial Refrigeration, Gardena, Calif., plans to transition its foodservice equipment to R290 in the near future, said James Pak, chairman/executive vice president.

Over the past year, Chinese manufacturer ICCOLD has switched to R290 for glass-door coolers sold in the U.S., said David Chee, sales manager.

SandenVendo America, Dallas, has partnered with a large beverage company to test 60 vending machines that use R290 as a refrigerant, and now plans to begin producing the R290 machines on a new production line, said Mike Weisser, president and CEO.

SandenVendo previously had used both CO_2 and R134A as refrigerants in its vending machines, but no longer uses CO_2, Weisser said. ■ MG

TRANSCRITICAL FIRSTS

Heatcraft installs its initial CO_2 system at cold storage plant, while Zero Zone deploys its first CO_2 ice rink system

— By Michael Garry

While ammonia still reigns as the primary refrigerant used by cold storage facilities and ice rinks, two OEMs – Heatcraft Worldwide Refrigeration and Zero Zone – have installed their first transcritical CO_2 refrigeration system for these applications, respectively.

They join several other OEMs that are supplying transcritical CO_2 systems for industrial applications, notably Hillphoenix and Carnot Refrigeration.

Climate Pros, an Illinois-based contractor, recently installed a CO_2 transcritical system from Carnot Refrigeration at the MaMa LaRosa dough-making facility in Michigan. Henningsen Cold Storage has also installed a transcritical CO_2 system at a cold storage plant in Grandview, Wash. (See page 39.)

And Hillphoenix has installed transcritical CO_2 systems at four ice rinks run by the Municipality of Anchorage, Alaska – the first transcritical ice rinks in the U.S. (See, "In Brief," *Accelerate America*, August 2017.)

These companies showcased their transcritical systems at the Global Cold Chain Expo, held in late June in Chicago alongside the United FreshTEC Expo.

> "There's going to be a lot more opportunity, and we want to play in this market."

From left: Grady McAdams and Ajit Kailasam, Heatcraft

No future issues

Heatcraft plans to install its first transcritical CO_2 system at a new cold-storage facility later this year.

The facility operator opted for CO_2 transcritical rather than a traditional halocarbon DX solution, said Grady McAdams, director of cold storage sales for Heatcraft. (He declined to name the company without its permission.) "They liked the idea of going green and not having any future issues," he said.

"This is the tip of the iceberg," added McAdams. "There's going to be a lot more opportunity, and we want to play in this market." Transcritical CO_2 is best suited for small-to-medium industrial plants, he noted.

Heatcraft has been receiving one or two inquiries per month about transcritical CO_2 for industrial applications, said Ajit Kailasam, cold storage manager for Heatcraft.

The transcritical system costs about 20% more than a traditional DX system using HFCs – 15% more after installation, Kailasam said, adding that the transcritical system will be 10% more efficient. The transcritical CO_2 system uses semi-hermetic reciprocating compressors.

> "We've adopted a lot of learning from retail into the industrial side."
>
> – John Collins, Zero Zone

Kristian Ellefsen, Frascold

Excitement about transcritical

Zero Zone, an OEM located in Ramsey, Minn., is installing its first ice rink-based CO_2 transcritical system.

The 170-TR chiller system, using glycol as a secondary fluid, will be deployed in a Minnesota facility over the next few months, said John Collins, industrial sales manager, Zero Zone.

The transcritical system will serve an existing ice rink, replacing an R22 system, as well as a new rink at the facility opening this fall, he said.

"There's a lot of excitement around transcritical CO_2 in the last few years," said Collins, who is responsible for Zero Zone's industrial sales. "The availability of components is making costs more attractive. We see a lot of opportunity."

Zero Zone's parallel rack transcritical systems can be deployed in an indoor machine room or as an outdoor application.

Zero Zone's experience with CO_2 systems in the commercial sector informs its industrial CO_2 systems, said Collins. "We've adopted a lot of learning from retail into the industrial side." For example, he noted, the extensive use of controls in commercial systems – needed in the absence of on-site technicians – is becoming more of the reality in industrial plants, he said. MG

Pharmaceutical Plant To Use Propane Chiller

Italian compressor manufacturer Frascold has sold three compact screw compressors that will be used in a propane chiller application by a pharmaceutical company in a San Francisco Bay Area plant, according to Kristian Ellefsen, CEO of Frascold's Everett, Wash.-based U.S. division.

"Propane is actually starting to become a refrigerant in chillers in the U.S.," said Ellefsen, in an interview at the Global Cold Chain Expo in late June.

He declined to name the pharmaceutical company or the OEM that assembled the propane chiller without their permission. Frascold has also supplied six propane screw compressors for an oil/gas application, he added.

The pharmaceutical chiller, to be located outside the plant, consists of three ATEX-certified 80-HP screw compressors, and contains a "couple of hundred pounds" of propane, Ellefsen said. It uses glycol as a secondary coolant.

He expects the chiller to be installed later this year as a replacement of an HFC system in the Bay area plant.

Ellefsen has been seeking to market its compressors for propane chillers in the U.S. market since at least 2016. Frascold supplies compressors for propane chiller applications in Europe.

The U.S. Environmental Protection Agency prohibits the use of more than 150 g of propane in commercial applications, but the pharmaceutical company was able to gain a waiver to that rule, Ellefsen said, though he could not provide details.

In 2016, Whole Foods Market received permission from the EPA to test market a propane chiller system containing about 285 lbs of propane at a store in Santa Clara, Calif. (See "Whole Foods Pushes the Propane Envelope," *Accelerate America*, October 2016.)

Ellefsen, who said he is "convinced" that the EPA will eventually allow higher charges of propane, sees potential growth for propane chillers in the U.S. market at end users like breweries.

The pharmaceutical company considered installing a CO_2 transcritical unit instead of the propane chiller, but felt the transcritical unit was "too complicated" for its service technicians, said Ellefsen.

Frascold USA is in the process of receiving UL certification for its CO_2 compressors, he noted.

STUDY: 5 MM TUBES CUT HC CHARGE AND CONDENSER SIZE

Purdue paper says MicroGroove-tube design uses 41% less internal volume with a 57% reduction in footprint, while maintaining heat transfer performance.

— By Michael Garry

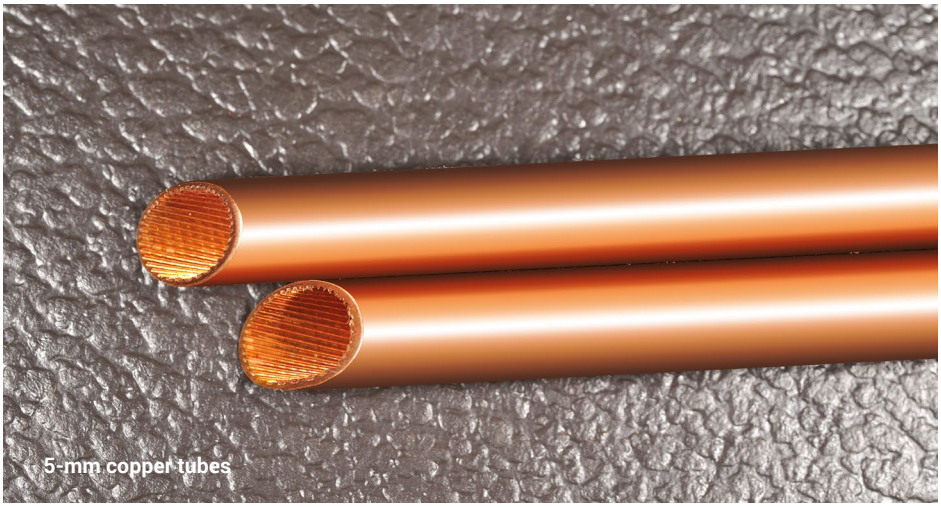
In a paper presented at the 2018 Purdue Conferences, optimized domestic refrigerator condenser coils using hydrocarbon refrigerants were shown to deliver needed cooling capacity while using smaller-diameter (5 mm) MicroGroove copper tubes that contain a small charge of refrigerant.

The paper, "Optimization of MicroGroove Copper Tube Coil Designs for Flammable Refrigerants," was authored by Nigel Cotton, International Copper Association; Adam Rhoads, Optimized Thermal Systems; Anderson Bortoletto, Sub-Zero, Inc.; and Yoram Shabtay, Heat Transfer Technologies. (it can be downloaded at https://bit.ly/2M8REX8.) The Purdue Conferences, encompassing 24th Compressor Engineering, 17th Refrigeration and Air Conditioning, and 5th High Performance Buildings, took place July 9-12 at Purdue University, Lafayette, Ind.

Reducing refrigerant charge – important for an R600a residential application, which has a 57 g charge limit in the U.S. – was the primary objective of the study. Secondary objectives included the reduction of the total footprint and the total tube-and-fin material mass.

"This study demonstrated the simulation and design of new heat exchangers that can maintain the heat transfer performance of the baseline and allow for lower refrigerant charge in a smaller, lighter envelope," the paper said.

The baseline design employs 6.35-mm (0.25-inch) outside diameter copper tubes with a minimum wall thickness of 0.41 mm (0.016-inch). By contrast, the new design uses 5-mm outer-diameter copper tubes and wavy-herringbone fins with reduced fin thicknesses.



5-mm copper tubes

The proposed design was found to have 41% less internal volume than the baseline along with a 57% reduction in coil footprint. "A significant reduction in refrigerant charge is achieved when this heat exchanger is used as a condenser in the refrigerator," the report said.

Besides equal or better performance and reduced refrigerant charge, the prototype was 21% lighter than the baseline.

The proposed design has a slight improvement in heat transfer performance at a given airside pressure drop – for example, an improvement of 2.33% at 0.033 inches H_2O of airside pressure drop. An even greater increase of heat transfer performance is expected once the proposed design is production-tooled with fins that include collars.

Push toward 150 g

The charge limit of hydrocarbons in domestic refrigerators stood at 57 g in the U.S. when the paper was released. In February, the Environmental Protection Agency (EPA) withdrew a "direct final rule" that would have raised the charge limit to 150 g from 57 g for hydrocarbon refrigerants in domestic refrigerators because of some adverse feedback.

However, an identical proposed rule raising the charge limit remained in play, and the EPA said it would address adverse feedback in any subsequent final action. "There is a lot of push [in the U.S.] to go to 150 grams," said Bortoletto of Sub-Zero, one of the authors of the study. (On August 8, the EPA announced it would raise the limit to 150 g; see page 14.)

The European Union and other regions have long used a 150 g limit for hydrocarbons in domestic refrigerators.

"About 80% of domestic refrigerators could be made with 57 g, but it would be easier to design with 150 g," said Bortoletto. "At 57 g, the system becomes very sensitive to the charge variations and require a tighter control of charge. Slight variations have big impact on performance at 57 g, compared to 150 g."

This low-charge limit motivated evaluation of optimized heat exchangers that could deliver the needed cooling capacity using smaller diameter copper tubes, the paper said. ■ MG

PURDUE PAPERS ADDRESS HC ALTERNATIVES

R600 and R1270 are tested in research presented at Purdue University

— By Charlotte McLaughlin

A series of papers on hydrocarbon-based technology, including research on the use of alternative refrigerants R600 (N-butane, also known as butane) and R1270 (propene), were presented at the Purdue series of conferences, held at West Lafayette, Ind.-based Purdue University July 9-12.

The conferences included 24th International Compressor Engineering Conference, 17th International Refrigeration and Air Conditioning Conference and 5th International High Performance Building Conference. Here is a sampling of the papers.

Liebherr challenges isobutane in domestic fridges

Mario Straub of German manufacturer Liebherr presented "Alternative Refrigerants For Household Refrigerators" (https://bit.ly/2OR7zHS), which aims to challenge the domination of R600a (isobutane) in household refrigerators.

"Since the beginning of the 1990s it is common in Europe to use R600a (isobutane) as a refrigerant in household appliances," Straub notes in the paper. "It is worth to evaluate if R600a is still the most suited refrigerant."

After testing over 100 refrigerants, the paper found two candidates – R600 and R290 (propane) that could be suitable to replace R600a in household fridges and freezers.

According to the paper, with R600 instead of R600a, the energy consumption of mainly small domestic refrigerators – which have a low heat load and high evaporating temperatures – can be reduced by 5%.

However, small freezers with propane were found to be less efficient "due to the higher specific cooling capacity of R290 compared to R600a and the resulting increase in temperature difference in the heat exchangers," the paper explains.

High-temp heat pumps with R600 and R290

The paper "Experimental Investigation of a Hydrocarbon Piston Compressor for High Temperature Heat Pumps," by Bamigbetan *et al* (https://bit.ly/2nkBLi2), also concerns using n-butane as a refrigerant.

"This study experimentally investigates the performance of a prototype butane compressor adapted for high-temperature heat pumps," which was installed In the high-temperature cycle in a 20 kW cascade heat pump, with propane on the low-temperature cycle, the researchers state.

The paper concludes that at a heat-sink outlet temperature of 115°C, the discharge temperature of the compressor would be 127°C on average, demonstrating an average of "74% for the total compression efficiency (suction head) across all operating conditions tested."

A cocktail of CO_2 and propene

The paper "Parametric Analysis and Optimization of a Cascade Refrigeration System using a CO_2/Propene Mixed Refrigerant," by Massuchetto *et al* (https://bit.ly/2Mv9pwr), looks into the effects of mixing the refrigerants R744 (CO_2) and R1270.

The analysis was done by theoretical simulations and a parametric analysis, which compared the CO_2/propene mixture to the use of the refrigerants in their pure forms in cascade systems.

The paper concludes that mixing natural refrigerants might yield efficiency gains.

Other hydrocarbon papers at the conference include:

- Optimization of MicroGroove Copper Tube Coil Designs for Flammable Refrigerants, by Cotton *et al*. (See page 46.)
- A Theoretical and Experimental Analysis of a Self-contained R-290 Refrigeration Unit Applied to a Glass Door Reach-in Supermarket Display Case, by Ronzoni *et al* (https://bit.ly/2vKY4Bj).
- A Charge Equation For Small Charge Hydrocarbon Based Commercial Refrigeration Appliances, by van Beek and van Gorp (https://bit.ly/2AR0Ef7).
- A Numerical Study on the Temperature Field of a R290 Hermetic Reciprocating Compressor with Experimental Validation' by Wu *et al* (https://bit.ly/2njRkqh).
- An Experimental Study of HC-600a Flow Through Variable Expansion Devices for Household Refrigerators' by Knabben and Melo (https://bit.ly/2KxBW2Q). ■ CM

Advancements in NatRefs Cited at Gustav Lorentzen Conference

Industry experts explain the effectiveness of CO_2, ammonia and hydrocarbons as refrigerants at event named for CO_2 pioneer

— By Andrew Williams and Dario Belluomini

Between 1988 and 1991, Norwegian researcher Gustav Lorentzen showed how the long-dormant refrigerant CO_2 could be used again as an effective working fluid. At the every-other-year conference named in his honor, industry experts carry on Lorentzen's work with reports on CO_2 and other natural refrigerants.

CO_2 technology for warm climates was one of the key themes of the 13th IIR Gustav Lorentzen Conference on Natural Refrigerants, held at the Polytechnic University in Valencia, Spain, June 18-20.

For example, technology innovations such as ejectors, evaporative condensers, energy storage, parallel compression, and heat recovery are helping to broaden the market for CO_2 as a refrigerant across climate zones, according to Armin Hafner, a professor at the Norwegian Institute of Science and Technology (NTNU),

Moreover, Hafner said: "Today it is possible to integrate heating and cooling into CO_2 transcritical systems to eliminate all applications of HFCs in supermarkets."

However, with more OEMs developing new technologies to improve efficiency in warmer climates, system design is becoming more complex. Training and support for installers and contractors, therefore, will be crucial in ensuring the continued success of CO_2 as a refrigerant as it takes on a greater market share, Hafner said.

"People are getting to know CO_2 systems, knowledge is being transferred, and that is very good," Hafner said.

He cited data from sheccoBase – the market development arm of shecco, publisher of *Accelerate America* – indicating that there are already over 14,000 supermarkets in Europe fitted with CO_2 transcritical systems,

Echoing Lorentzen, Hafner took aim at the latest generation of synthetic refrigerants: "It does not seem very logical to try to replace HFCs with another family of related halocarbons, HFOs, which are equally foreign to nature."

AMMONIA'S REINVENTION

The growing adoption of low-charge ammonia systems marks the "rediscovery" and "reinvention" of this most long-lived of natural refrigerants, said Andy Pearson, group managing director of U.K.-based Star Refrigeration, in an interview at the 13th IIR Gustav Lorentzen Conference.

"The take-up is extremely rapid, there's a huge level of interest," he said. "It's a very exciting time to be offering low-charge ammonia systems."

He attributed this development to "a huge leap forward in terms of reliability, efficiency and safety," he said. "All three of them are important, and with low-charge ammonia, you get all three in a single package."

While Star is focusing low-charge systems on existing industrial applications, he noted that "the door is also open to wider use of ammonia, for example in building services, or in chillers in ice rinks."

AMMONIA: GOOD FOR HEAT PUMPS

Ammonia came out on top as a refrigerant for heat pumps in a paper presented at the Gustav Lorentzen Conference by Kashif Nawaz, Moonis Ally Raza and Omar Abdelaziz of the Oak Ridge National Laboratory.

Armin Hafner, Norwegian Institute of Science and Technology

"Today it is possible to integrate heating and cooling into CO_2 transcritical systems to eliminate all applications of HFCs in supermarkets."

They assessed the performance of selected HFCs (R134a and R410A), ammonia and propane in four different heat pump systems. These range from a simple configuration made up of four components to more sophisticated ones using flash tanks.

For all systems, the evaporating (10°C) and condensing (40°C) temperatures were fixed to produce comparable results and allow for an efficient compression process.

In terms of COP, researchers found ammonia to have the highest efficiency in all the cases. The difference with R134a was particularly striking. Ammonia was also found to have the least mass flow rate among the selected refrigerants.

Together with its optimal volumetric capacity, NH_3-based systems were at the same time more efficient and more compact when compared to the HFCs under analysis.

The lab tests also highlighted the properties of propane. Despite its lower COP compared to ammonia and R410, it may serve as a sustainable replacement for R134a. It also presents a lower mass flow rate than the two HFCs considered, implying that R290-based systems require less compressor power consumption and refrigerant charge.

Thanks to ammonia's relatively smaller mass flow rate, NH_3 also has the smallest overall environmental irreversibility. By contrast, when using HFCs in thermodynamic processes such as heating and cooling, it is significantly more difficult to restore the environment to its own initial conditions.

HYDROCARBONS: BEST FOR LIGHT COMMERCIAL

The properties of hydrocarbons make them the best-performing refrigerants for light commercial applications, said Cláudio Melo, a professor at the Polo research lab, Federal University of Santa Catarina, Florianópolis, Brazil.

"Hydrocarbons have equal or better heat transfer performance and lower pressure drop compared to R22 and R134a," Melo said at the Gustav Lorentzen Conference.

In addition, "Hydrocarbons mix very well with mineral oils both in the liquid and vapor phases," he added. "The hygroscopic synthetic oils used with HFCs can thus be avoided."

Melo pointed out that most of the materials used in HFC refrigeration systems could also be employed for hydrocarbons. These include neoprene, Viton, nitrile rubber and nylon.

There is also a strong business case for adopting hydrocarbons over HFCs, Melo said, starting with cost. "Hydrocarbons such as isobutane and propane are substantially less expensive than HFCs," he said.

Moreover, a refrigeration system designed for hydrocarbons will typically need "50%-60% less refrigerant by mass when charged with hydrocarbons," Melo said.

In addition, the energy efficiency of hydrocarbon units is frequently claimed to be up to 30%-40% better than comparable HFC units," he said.

Of that, "5% to 10% of this improvement can be accredited to better thermodynamic and transport properties," Melo said. "The rest is most likely due to component modifications such as improved compressor or heat exchanger design, as well as variable speed drives." ■ AW & DB

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