MAY 2016

ACCELERATE AMERICA

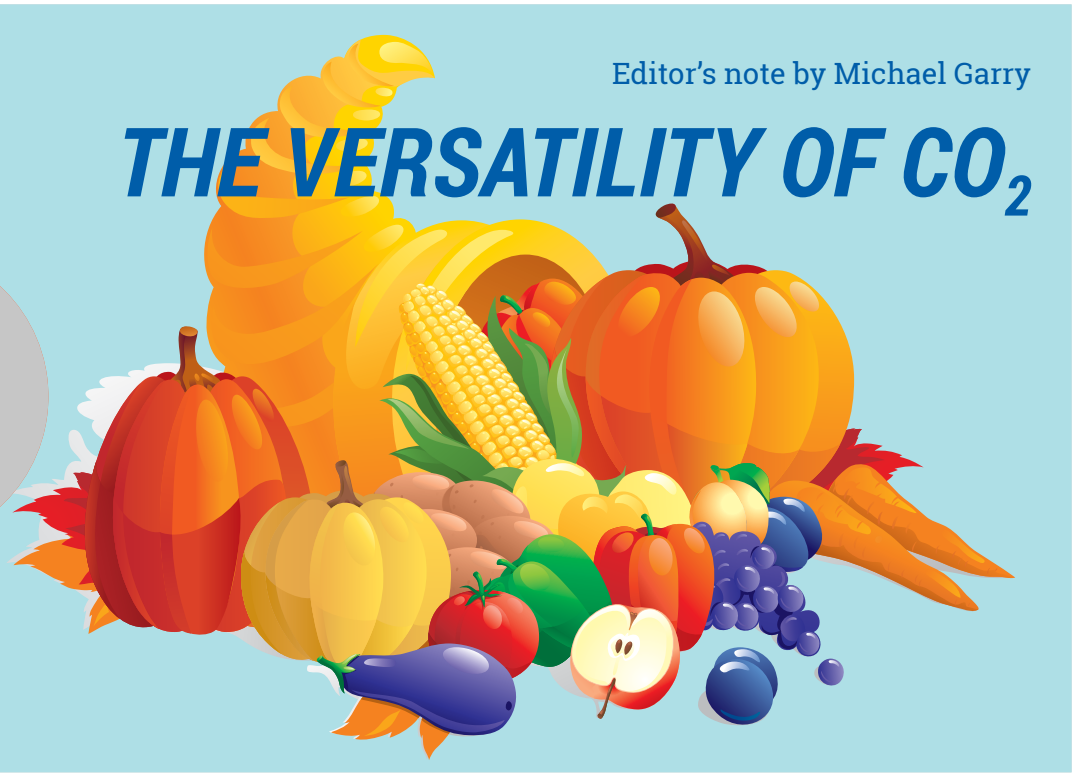
ADVANCING HVAC&R NATURALLY

Darryl Schaefermeyer, Alaska SeaLife Center p. 20

CO_2 HEAT PUMPS HELP SAVE ALASKA SEALIFE CENTER

Editor's note by Michael Garry

THE VERSATILITY OF CO_2



In many of the articles that have appeared in the 14 issues of *Accelerate America* that precede this one, the attention has been on how natural refrigerants are used in the food industry, including food retail, foodservice, food processing and cold storage.

That's understandable, since the food industry is the primary sector where natural refrigerants are being employed, and for which natural refrigerant systems are being made, and it represents the majority of our readership.

But as we demonstrate in this issue, natural refrigerants, particularly CO_2, are finding a place in many other sectors and applications. For example, CO_2 is an excellent refrigerant for heat pumps, both residential and commercial. Our cover story gives an in-depth look at how a CO_2 heat pump system is helping the Alaska SeaLife Center, an aquarium, research and animal rescue facility in Seward, Alaska, to run more efficiently while greatly cutting its carbon emissions. (Page 20.)

In the ice rink industry, rink owners are finding CO_2 to be a good substitute for R22 systems that are being retired. A prime example is the municipality of Anchorage (just north of Seward), which is in the process of converting four rinks from R22 to CO_2. (Page 30.)

One of the fastest growing industries in the world is the data center industry, responsible for running the servers that support our digital world. All of those servers need cooling, and CO_2 is up to the task. Carnot Refrigeration, which makes CO_2 systems for a variety of sectors, is taking aim at data centers with its Aquilon CO_2 transcritical system. The system is often able to shut down its compressors and leverage "free cooling" when the ambient temperature drops below that maintained in the server room. (Page 60.)

One CO_2 application not covered in this issue (but will be in the future) is mobile air conditioning, where it is in its infancy. Daimler and Volkswagon are probably doing the most to develop a MAC system using CO_2, and will unveil one in the next year.

Returning to the food business for a moment, another fairly new application of CO_2 as a refrigerant is in refrigerated transport. Carrier Transicold has taken the lead here in developing a CO_2 transcritical unit for shipping containers, and now for truck trailers. (page 64.)

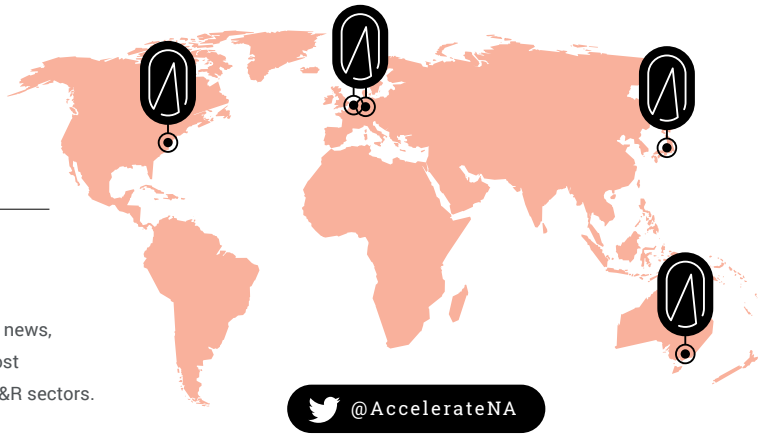
Of course, CO_2 has its limitations, such as operating less efficiently in high ambients, though that is being addressed with new technology (page 52). But of all natural refrigerants, CO_2 may be the most versatile and applicable to the widest array of industries and applications. CO_2's thermophysical properties make it a powerful refrigerant, capable not only of high-capacity cooling and heating, but also of generating heat for reclaim.

As noted in our cover story, the gas most responsible for global warming is also one that can help solve it.

VOLUME 2, ISSUE #15, MAY 2016

ACCELERATE

ADVANCING HVAC&R NATURALLY AMERICA



About Accelerate America

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

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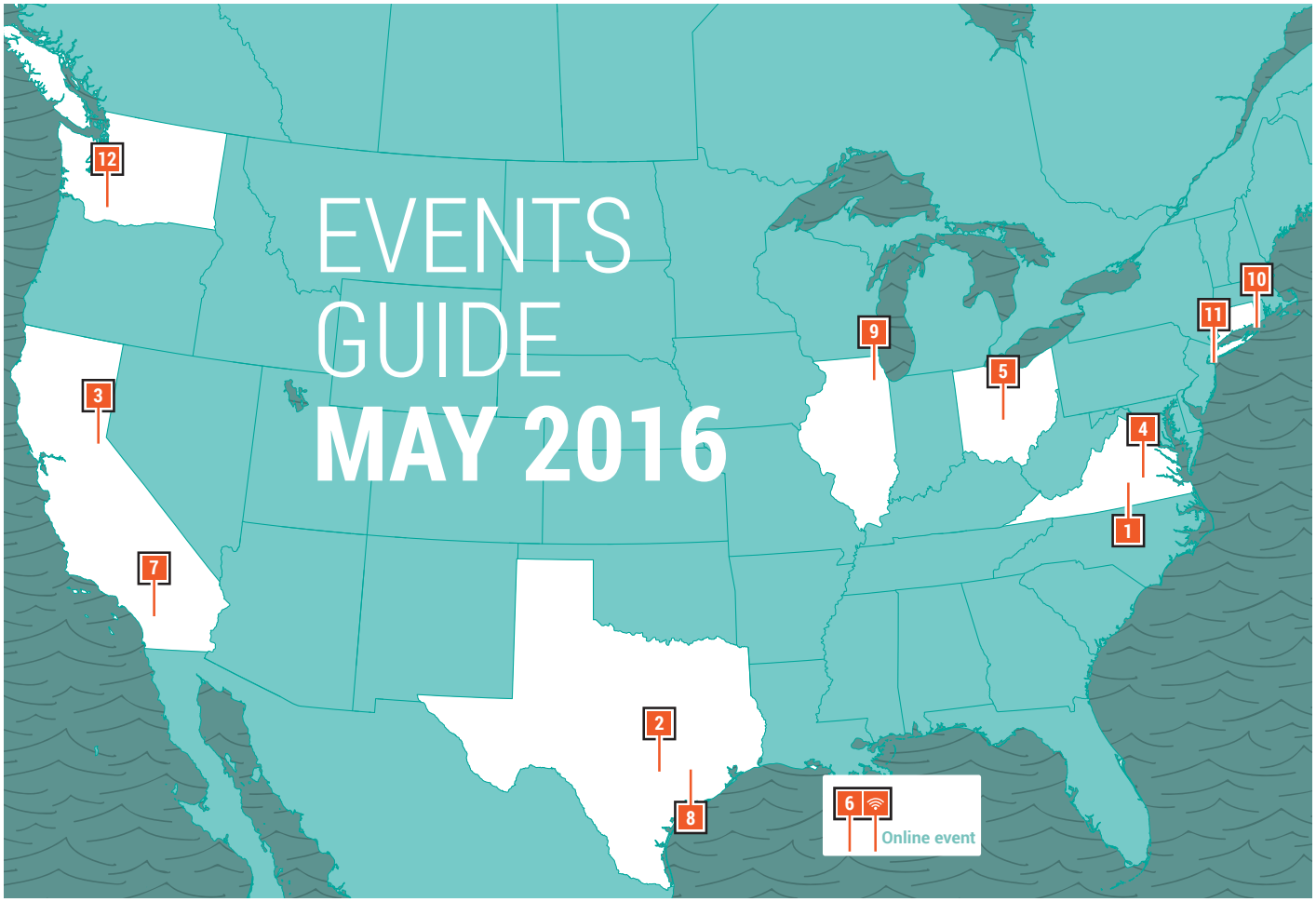


1
May 2-4, Reston, VA
AHRI 2016 Spring Meeting
http://www.ahrinet.org/site/946/News-Events/Meetings-and-Events/AHRI-2016-Spring-Meeting
twitter: #AHRIspring

2
May 3-4, Austin, TX
NFMT High-Performance Buildings & Workplaces - National Facilities Management & Technology
http://www.nfmt.com/highperformance/default.aspx
twitter: #NFMT16 @nfmt_conference

3
May 4-6, Tahoe City, CA
Utility Energy Forum 2016
http://utilityforum.org/
twitter: #2016UEF @UtilityForum

4
May 11-12, Washington, D.C
Energy Efficiency Global Forum (EE Global 2016)
http://www.eeglobalforum.org/
twitter: #energyefficiency @ToSaveEnergy

5
May 16-19, Columbus, OH
14th NARCE - North American Rink Conference and Expo
http://www.narce.com/page/show/149176-14th-annual-north-american-rink-conference-and-expo

6
May 18, 9 AM PDT / 12 PM EDT / 6 PM CET, online
Webinar Wednesday powered by shecco - Danfoss: CO_2 systems - a global approach and U.S. trends
http://www.webinarwednesday.net/
twitter: #WebinarWednesday @shecco

7
May 18-19, Anaheim, CA
Southern California Facilities Expo 2016
http://www.fesc.facilitiesexpo.com/
twitter: @Facilities_Expo #fenw2016

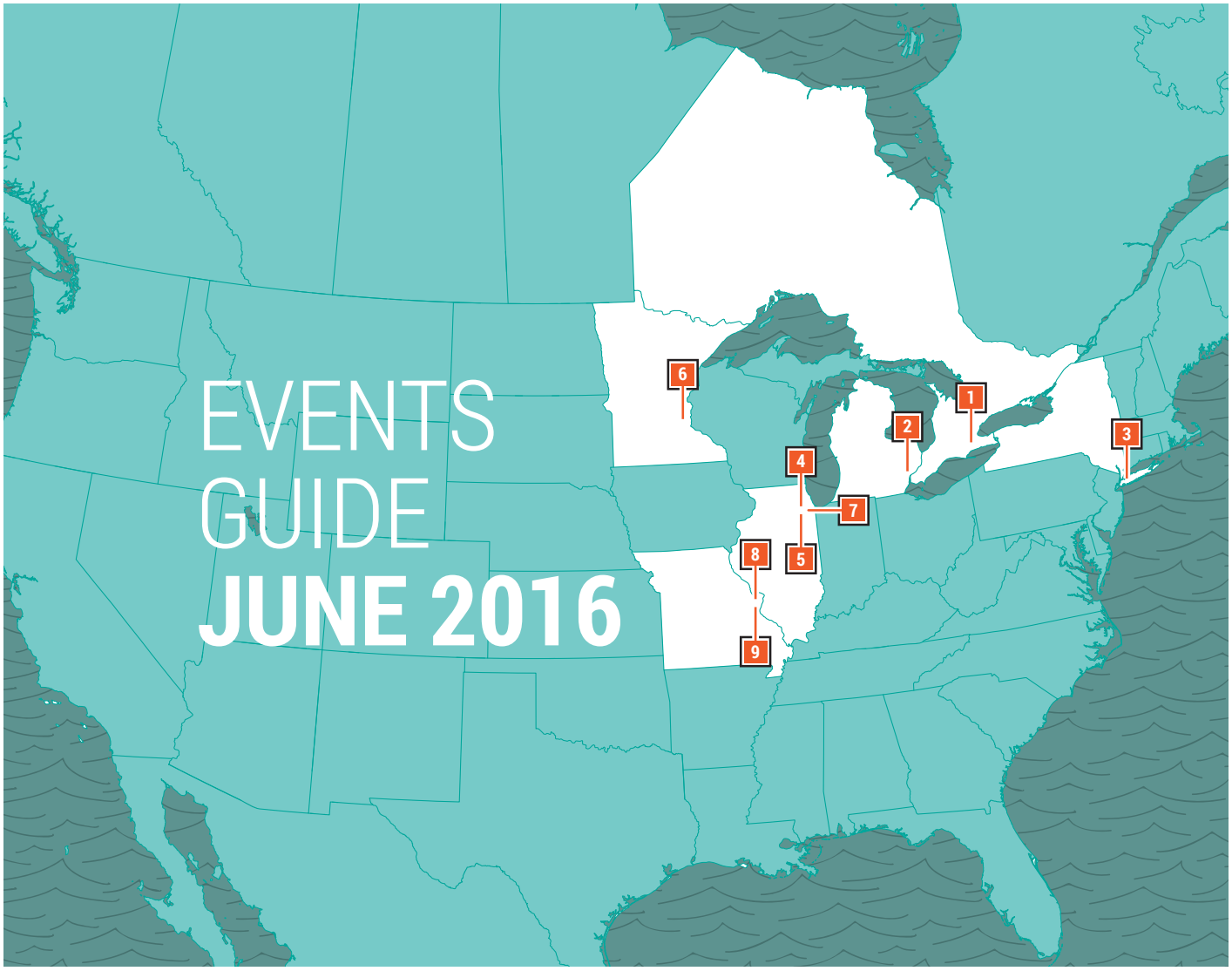
8
May 18-19, Conroe, TX
Houston Industrial & Tool Show
http://www.expoindustrialshows.com/houston.htm

9
May 21-24, Chicago, IL
NRA Show
https://show.restaurant.org/Home
twitter: #NRAShow @NRAShow

10
May 22-26, Mashantucket, CT
Eastern Energy Expo 2016 - AREE / OESP / PPA Trade Shows - Atlantic Region Energy Expo
http://easternenergyexpo.com/

11
May 24-25, New York, NY
BuildingsNY 2016 (BuildingsNY and GreenBuildingsNY)
http://www.buildingsny.com/
twitter: #buildingsny @BuildingsNY

12
May 25-26, Seattle, WA
34th West Coast Energy Management Congress (EMC)
http://www.energyevent.com/
twitter: #EMCexpo



1 June 1-4, Toronto, ON
Grey to Green Conference & Trade Show
http://greytogreenconference.org/
twitter: @GRHCna

2 June 8-11, Detroit, MI
CNU 24: Detroit - Congress for New Urbanism
https://www.cnu.org/cnu24
twitter: @NewUrbanism

3 June 13-14, New York, NY
The NAPHN 2016 Conference & Expo: Decarbonize Our Future Today
http://naphnetwork.org/2016-naphn-conference-is-announced/
twitter: #naphn16 @NAPHN_info

4 June 16-17, Chicago, IL
ATMOsphere America 2016
http://www.atmo.org/events.details.php?eventid=44
twitter: #ATMOAmerica @ATMOEvents

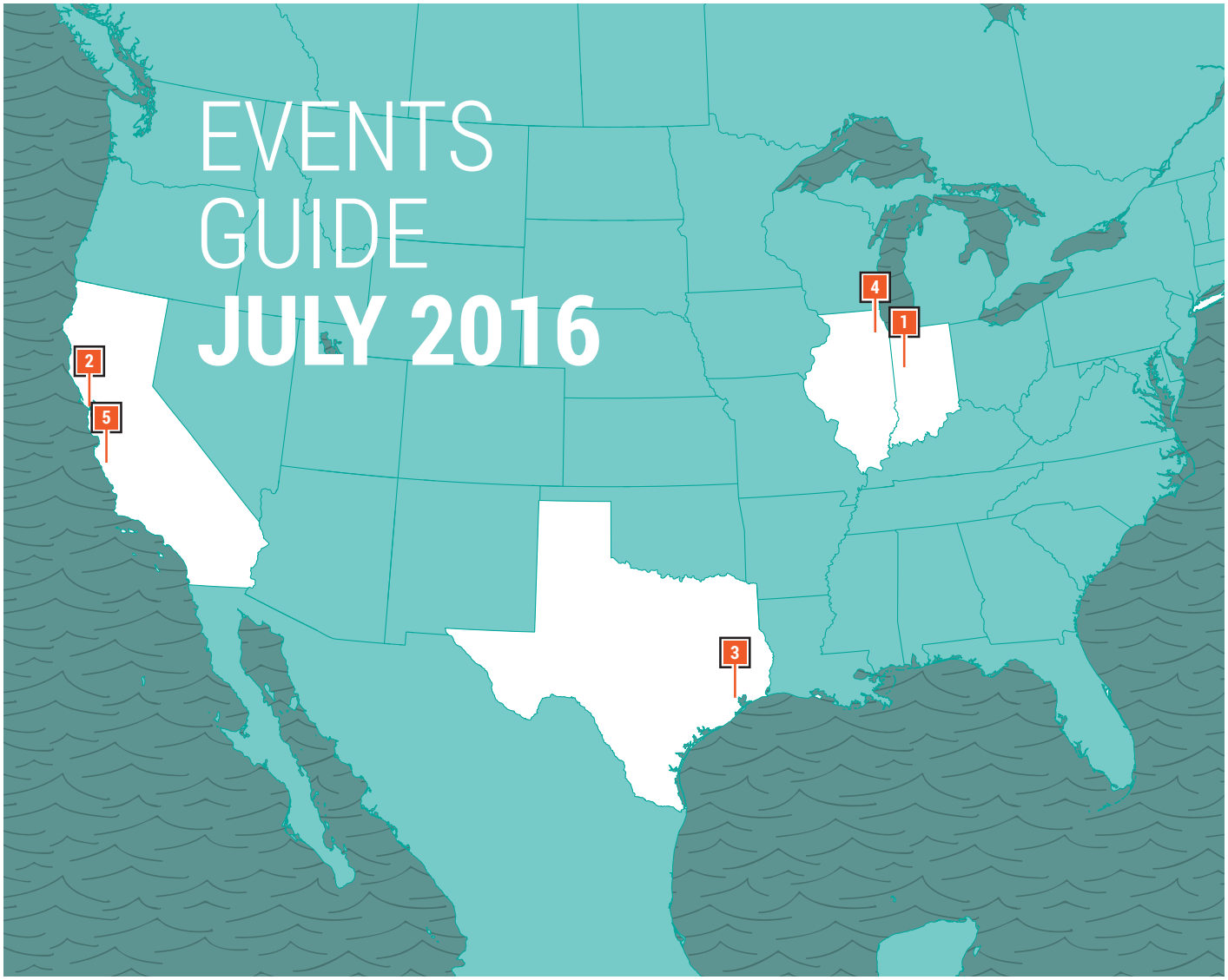
5 June 20-22, Chicago, IL
Global Cold Chain Expo 2016
http://www.globalcoldchainexpo.org/
twitter: #GCCE2016 @coldchainexpo

6 June 20-23, St Paul, MN
IDEA 2016 "Embracing Change", 107th Annual Conference and Tradeshow
http://www.idea2016.org/

7 June 20-23, Chicago, IL
FMI Connect
http://www.fmiconnect.net/

8 June 25-29, St. Louis, MO
ASHRAE Annual Conference
https://www.ashrae.org/membership--conferences/conferences/2016-ashrae-annual-conference

9 June 29-30, St. Louis, MO
NEBFM'16 - 11th Annual Northeast Buildings & Facilities Management Show & Conference
http://www.proexpos.com/NEBFM/index.php
twitter: #NEBFM16 @NEBFM



1

July 11-14, West Lafayette, IN
2016 Purdue Conferences Compressor Engineering, Refrigeration and Air Conditioning, High Performance Buildings
https://engineering.purdue.edu/Herrick/Events/Conferences

2

July 11-14, San Francisco,CA
Intersolar North America
https://www.intersolar.us/en/home.html
twitter: #Intersolar @Intersolar

3

July 13-14, Houston, TX
Build Expo 2016
http://buildexpousa.com/index.html
twitter: @BuildExpoUSA

4

July 16-19, Chicago,IL
IFT16 - Institute of Food Technologists
http://am-fe.ift.org/cms/
twitter: #IFT @IFT

5

July 29-31, Monterey, CA
PMA Foodservice Conference and Expo
http://www.pma.com/events/foodservice

SHORT TAKES

— By Michael Garry and Klara Skacanova

DR PEPPER SNAPPLE TO PURCHASE R290 COOLERS

Plano, Texas-based beverage manufacturer Dr Pepper Snapple Group will begin purchasing vending machines and coolers that use propane (R290) as the refrigerant, according to spokesman Chris Barnes.

"We will move to R290 units as they become more widely available," he said. "By the middle of this year we will start purchasing them."

Dr Pepper Snapple "recognizes the benefits of R290 in terms of the ozone layer and climate, and that it has excellent thermodynamic properties," added Barnes. "It will give us a more environmental fleet of equipment."

The company, which also markets such major beverage brands as 7 Up, Canada Dry and Hawaiian Punch, replaced 60,000 vending machines and coolers in 2013 with equipment meeting the U.S. Environmental Protection Agency's Energy Star requirements. It replaced an additional 20,000 in 2014. "Each unit represents an energy savings of up to 30%," the company reported. MG

HANNAFORD BUYS CREDITS FOR HFC RECYCLING

Hannaford Supermarkets, a Scarborough, Maine-based pioneer in the use of CO_2 transcritical refrigeration, has participated as a buyer in the first project to generate Verified Emission Reductions (VERs), also known as carbon credits, from the reclamation and re-use of HFC refrigerants.

The project was orchestrated by San Francisco-based EOS Climate; EOS is the author of the VERs program's methodology, which was approved by the American Carbon Registry. Earlier this month, the American Carbon Registry awarded EOS Climate its Innovation Award for the VERs methodology.


Harrison Horning, Hannaford Supermarkets

Buying or selling HFC credits provide a new option for companies who use large commercial refrigeration equipment to take immediate action on HFC emissions while transitioning equipment to lower GWP alternatives. Hannaford was the first U.S. food retailer to install a low-GWP CO_2 transcritical system in 2013. The chain installed its second transcritical system last year.

"Reclaimed HFC VERs are a promising instrument to assist our efforts to mitigate HFC emissions from our refrigeration equipment while phase-down plans are completed," said Harrison Horning, director of energy and facilities for Hannaford Supermarkets.

Credits created from this methodology represent carbon emission reductions from the displacement of virgin HFCs with reclaimed and reused HFCs. MG

MAYEKAWA TO LAUNCH UPGRADED NEWTONS

Japan-based manufacturer Mayekawa will launch four new models of its natural refrigerant-based cooling system, the NewTon, on July 21, 2016.

The NewTon is a low-charge ammonia system that pumps CO_2 to cool loads. Mayekawa is partnering with Toronto-based Cimco Refrigeration to market the NewTon in North America. (See "Coming to America," *Accelerate America*, February 2016.)

The NewTon R-3000 and R-6000 for cold storage, and F-300 and F-600 for frozen storage, will feature reduced refrigerant charge, system size and weight compared to previous models, as well as improved maintainability. For example, the NH_3 refrigerant charge is being cut by 16% from 25 kg down 21kg for R-3000 and F-300.

Mayekawa introduced the NewTon to the market in 2008. In 2012, Mayekawa launched the NewTon series, comprising NewTon R, NewTon C (for chilled storage), NewTon F, and NewTon S (for ice rinks). The four new models to be launched in July are upgraded versions of 2012 R and F models.

Sales of the NewTon have reached over 850 units to date. KS


The NewTon's semi-hermetic ammonia compressor

ATMOSPHERE AMERICA HEADS TO WINDY CITY

The NatRefs conference in Chicago will address CO_2, hydrocarbon and ammonia trends in a gathering of end users, technical experts and policy makers

– By Elke Milner

It's that time of year again: warm weather, afternoons by the pool, beach trips. But first there's ATMOsphere America, North America's leading conference on environmentally sustainable natural refrigerants.

Hosted by shecco, publisher of *Accelerate America*, ATMOsphere America will take place in Chicago, the Windy City (also known as the Second City, and the City of Broad Shoulders), on June 16-17 at the Westin Michigan Avenue. It promises to be a major gathering, with more than 35 sponsors and organizations like RETA and IIAR on board as partners, as well as more than 350 participants.

The global ATMOsphere conference series, which also has events in Europe, Japan and Australia, has been known since 2009 for bringing together a comprehensive selection of policy makers, market experts, industry suppliers, end users and consumer brands.

This year's conference comprises three major themes: scaling CO_2 refrigeration, hydrocarbons for America, and reinventing ammonia refrigeration. It will also feature the presentation of the first annual *Accelerate America* Natural Refrigerant Awards, given to a food retailer, industrial end user, and foodservice brand, as well as to a "person of the year."

ATMOsphere America will feature end users and industry suppliers describing their experiences with natural refrigerants. This year, small grocer pioneer DeCicco's will discuss its new CO_2 transcritical system while other leading retailers will outline their commitments to natural refrigerants.

Industrial end users, including Western Gateway, Port Newark Refrigerated Warehouse, LA Cold Storage Company and Shepard's Egg, will explore practical application of low-charge ammonia systems. End users, in conjunction with other industry stakeholders, will also be present in a panel to discuss new and emerging opportunities for natural refrigerants, such as the integration of HVAC requirements.

The popular session on regulations and standards – which are increasingly important to the adoption of natural refrigerants -- will include representatives of the Environmental Protection Agency, the California Air Resources Board (CARB), IIAR and Underwriters Laboratories.

CARB will explore its latest Proposed Strategy to reduce short-lived climate pollutants, including HFCs. (See story, page 40.) With the latest EPA proposal to expand the use of hydrocarbons in some commercial refrigeration applications, UL will highlight safety and charge limitations in hydrocarbon-cooled equipment. The IIAR will discuss changes to the regulatory and standards environment impacting the adoption of low-charge ammonia systems.

The conference will also feature a session on utilities and incentives, which are often necessary to overcome cost barriers and support the initial adoption of natural refrigerant systems.

Another session will tackle the growing role of contractors in helping end users, both industrial and commercial, to transition to natural refrigerants. A key part of that is training, which will have its own dedicated session featuring leading authorities RSES and RETA, as well as Professor Pega Hrnjak of the University of Illinois and Rusty Walker of HIllphoenix's Learning Center.

For a complete look at the agenda for ATMOsphere America 2016, go to: http://www.atmo.org/events.details.php?eventid=44.
EM

THE FORGOTTEN NATURAL REFRIGERANT SYSTEM

A hit in Japan, CO_2 heat pump water heaters are poised to wake up the North American home and commercial water heating market

– By John Miles

> "Everyone in the developed world uses hot water."

Most people who are asked to name applications for natural refrigerants would immediately think about cold storage, supermarket systems, convenience stores or merchandisers, depending on their specific area of interest and expertise.

There is, however, a natural refrigerant application lurking in our home, our place of work and all around us that most of us are unaware of: making hot water.

It is a fact of life that everyone in the developed world uses hot water. Period. At home, at work or at play, someone has a faucet, shower or dishwasher running, all using hot water in various quantities.

However, very rarely do we think about the root source of that hot water, how efficient or how "green" it is. Does that hot water I use daily have any connection with the world of natural refrigerants?

Typically in North America, hot-water making has fallen into two schools of thought. First it is a combustion process, combining a fuel source, (natural gas, propane or fuel oil) with air and a spark in a controlled explosion; or second it uses an immersion element to convert electrons in heat. Neither has anything to do with natural refrigerants.

The two main fuel sources, gas and electricity, have split the U.S. water-heating market for both residential and commercial applications pretty much straight down the middle, selling approximately 52% gas units and 48% electric.

> "The Japanese Eco Cute market has grown to approximately 500,000 systems.

This split is not always about what is it the best or most efficient energy source. It boils down simply to the geography of the U.S. and the energy infrastructure in place. For example, in the South, electric water heaters have a two-thirds market share, but in the Midwest the opposite occurs and gas water heaters enjoy that two-thirds majority.

A typical American household uses approximately 18% of its total utility spending just to heat hot water; in a commercial application this falls to just below 10% of the utility spend.

Considering that across the U.S. and Canada we have approximately 148 million homes and close to 6 million commercial buildings using hot water, we can see that a lot of energy and money is being expended just to keep our water hot. In fact that dollar value, just in the U.S., exceeds $35 billion annually.

But how does this particular application apply to natural refrigerants?

To find an answer we have to go back in time and look to the East, specifically to Japan.

AN EARLY FAILURE

As early as 1949, patents were filed for the use of a compressor-driven heat pump to heat water, but for at least the next four decades this technology mostly lay dormant.

From the 1970's onwards the U.S. Department of Energy looked at various methods for reducing water heater energy usage. It was not until the early 90's that attention to heat pump water heaters moved into high gear with a joint effort between the Department of Energy, various national labs and industry stakeholders. This led to a new type of design where the tank and the refrigeration system were integrated.

continued on p.14

It was postulated that this design would reduce the cost of the unit, make it easy to install and at least double the efficiency of the water heater. These units were based on HFC R134a, as R410a was not yet invented.

Despite being named an R&D Top 100 product, that product proved to be a commercial failure.

But across the rest of the world similar efforts were being made. In Europe and Japan some natural refrigerant seeds were being sown, mostly by Gustav Lorentzen, with a tip of the hat to shecco.

These new products employed CO_2, and, instead of the normal refrigerant cycle, took advantage of the transcritical nature of CO_2 to increase the heat transfer between the refrigerant and water, increasing the temperature of the water delivered.

These seeds would finally bear fruit in the next century, as the first CO_2 heat pump water heater would hit the market in Japan in 2001 with the name "Eco Cute."

The name Eco Cute is derived from the Japanese phrase Shizen Reibai Hīto Ponpu Kyūtō-ki, which literally means "natural refrigerant heat pump water heater" – a cute nickname for one of the first products in a new wave of natural refrigerant applications.

> "These new products employed CO_2, and took advantage of the transcritical nature of CO_2 to increase the heat transfer between the refrigerant and water."

VERY HOT WATER

Very quickly the market in Japan for the Eco Cute expanded, as customers loved its ability to produce lots of very hot water. That's thanks to the transcritical CO_2 cycle being able to take water from ground temperature to over 150°F in a single pass. Moreover, the efficiency of the system is considerably higher than any other method of heating hot water, resulting in lower utility bills.

Currently the Japanese Eco Cute market has grown to approximately 500,000 systems, or 16% of the overall water heater market, and the product has passed from revolutionary technology into an accepted "normal" method of water heating.

Meanwhile in North America it was business as usual for the hot water market, with the heat pump product virtually non-existent in terms of availability and market share.

Heat pump water heaters did not appear in the U.S. in any viable numbers until the start of this decade, with General Electric launching an HFC product in late 2009, followed by the other main players in that market. Heat pump water heaters still command just a sliver of the overall market; they are still "revolutionary technology" to most of North America, with no sign of a product using natural refrigerants … until now.

Two companies with deep ties to the development of natural refrigerant products, Sanden and Mayekawa, now offer natural refrigerant hot water solutions in North America for both home and commercial applications; they use the technology of the Eco Cute products from Japan, but with a U.S. slant -- like getting a Big Mac in Tokyo!

So the next time you are thinking about water heaters, perhaps in the shower, remember there is now a natural refrigerant solution, one where everybody in the family or company can feel the benefits of CO_2 hot water, or as we like to say at Sanden: Hot Water, Naturally. JM

A 25-year veteran of the HVAC industry John Miles is general manager of the Eco Systems division for Sanden International USA. He is currently overseeing the sale and support network for the first residential CO_2 refrigerant heat pump water heater sold in North America. Prior to joining Sanden he was most recently chief product officer at Quietside/Samsung.

Natural Refrigerant Equipment Solutions

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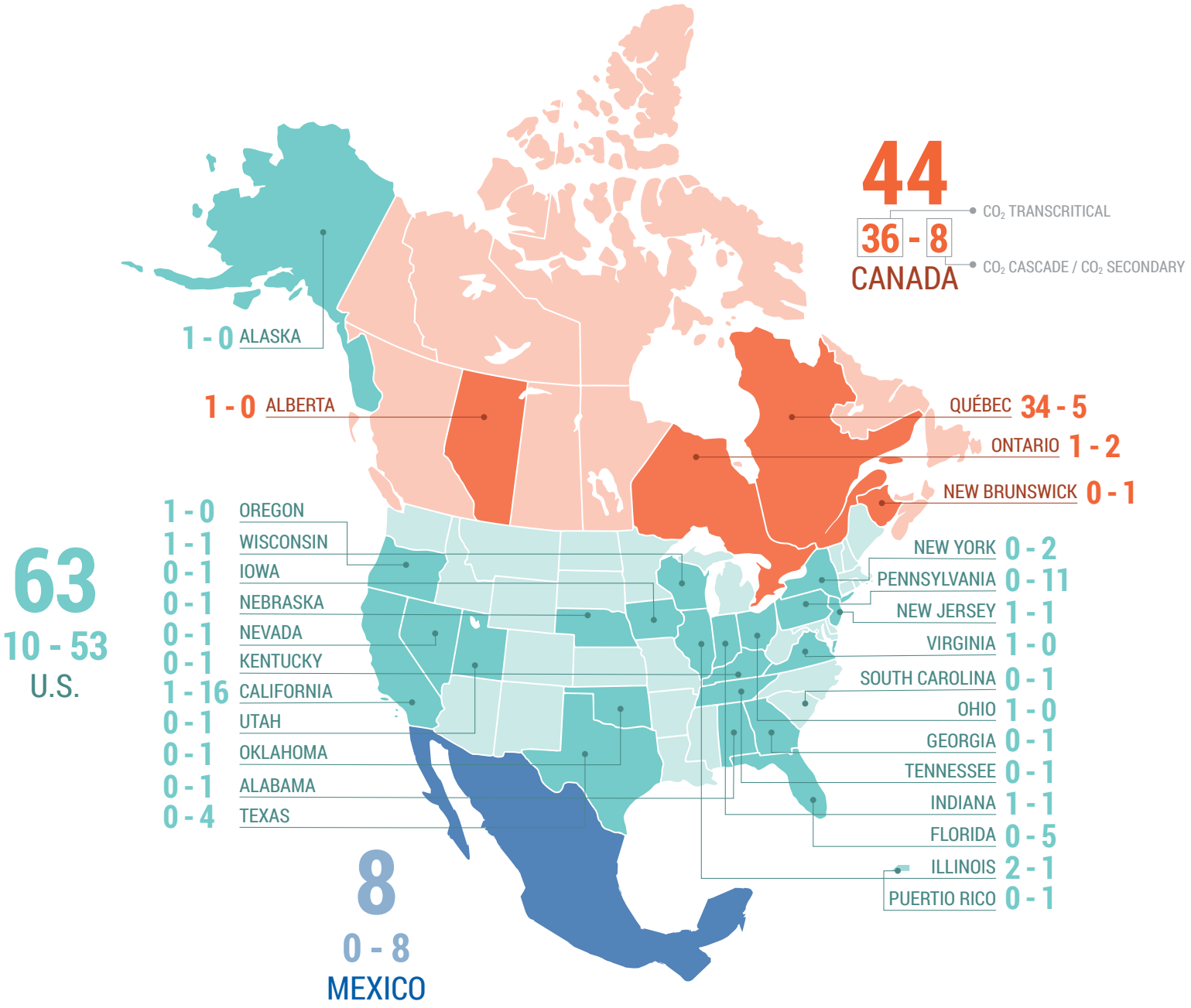

As of September 2015.
Source: Guide to Natural Refrigerants in North America, published by shecco.

THE POWER OF BRAINS

A machine is only as good as the engineer who built it

THE FLAGSHIP SOLUTIONS FOR CO2 TRANSCRITICAL APPLICATIONS

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AN ALTERNATIVE TO VAPOR-COMPRESSION COOLING?

The Ames Laboratory at Iowa State will be leading a major effort to develop a commercial application for caloric cooling, said to be more efficient and quieter than conventional cooling

– By Michael Garry


Joseph Sebranek, Iowa State University

While natural refrigerants offer an efficient and environmentally beneficial alternative to conventional halocarbon refrigerants in conventional vapor-compression refrigeration, a totally different kind of cooling technology may ultimately prove to be even more efficient and friendly to the environment.

That technology is called magneto-caloric cooling, in which certain solid materials heat up when placed in a magnetic field and cool down when they are removed from the field.

Magneto-caloric cooling is the most developed form of what is called caloric cooling, a process that was discovered in the 1800s and includes mechano-caloric cooling and electro-caloric cooling. The technology has undergone development over the decades, but not to the point of commercialization.

However, starting July 1, the Ames Laboratory at Iowa State will be leading an effort called CaloriCool to develop a commercial application for magneto-caloric cooling and other forms of caloric cooling. The Ames Laboratory, which operates under the U.S. Department of Energy, has previously done important research into magneto-caloric cooling.

The Ames Laboratory will be collaborating with eight other national labs in the CaloriCool program. "This is truly a major effort – a multimillion-dollar program to develop caloric cooling to the point of commercial application," said Dr. Joseph Sebranek, distinguished professor of animal science at Iowa State University, at a "Scientists Speak" session at the IARW-WFLO Convention, held April 16-19 in Las Vegas.

"This may well lead to something very interesting in terms of changes in the way we accomplish cooling and freezing," he added.

Technology based on caloric cooling is estimated to save 20% to 35% in energy consumption compared to a standard vapor-compression system, said Sebranek. And by eliminating compressors, caloric cooling reduces noise, vibration and mechanical maintenance, as well as the risks of refrigerant leaks, he added.

Over the past 40 years, "several systems have been built to show that the concept [of caloric cooling] is functional," said Sebranek. But the concept is still not practical, he added. "There are some barriers to development at the commercial [level]. But it can be done – and that's the critical first step."

FIVE GOALS

The objectives of the CaloriCool program include:

- Creating acceptable materials to overcome the limitations in currently available commercial products, such as corrosion.
- Designing a demonstration facility to show the performance of materials.
- Determining the economics of developing this material on a production basis.
- Developing a technology transfer process for commercial applications. "Substituting for vapor compression technology is going to take some significant transfer," said Sebranek.
- Producing appropriate economic and environmental impact statements.

Some progress has already been made toward the commercialization of magneto-caloric cooling. Materials capable of producing the magneto-caloric effect (heating and cooling) include an alloy of lanthanum, iron and silicon (Calorivac, from Vacuumschmelze in Germany), and an alloy of manganese, iron, phosphorus and silicon (Quice, from BASF in Germany).

BASF, Haier and Astronautics Corp. of America, displayed a wine cooler using a magneto-caloric heat pump at the Consumer Electronics Show in 2015, while Cooltech showcased a medical fridge employing magnetic refrigeration at the MEDICA show last November. Cooltech recently discussed the technology at ATMOsphere Europe in Barcelona, Spain. MG

TAPPING CO_2 AND SEAWATER IN THE LAST FRONTIER

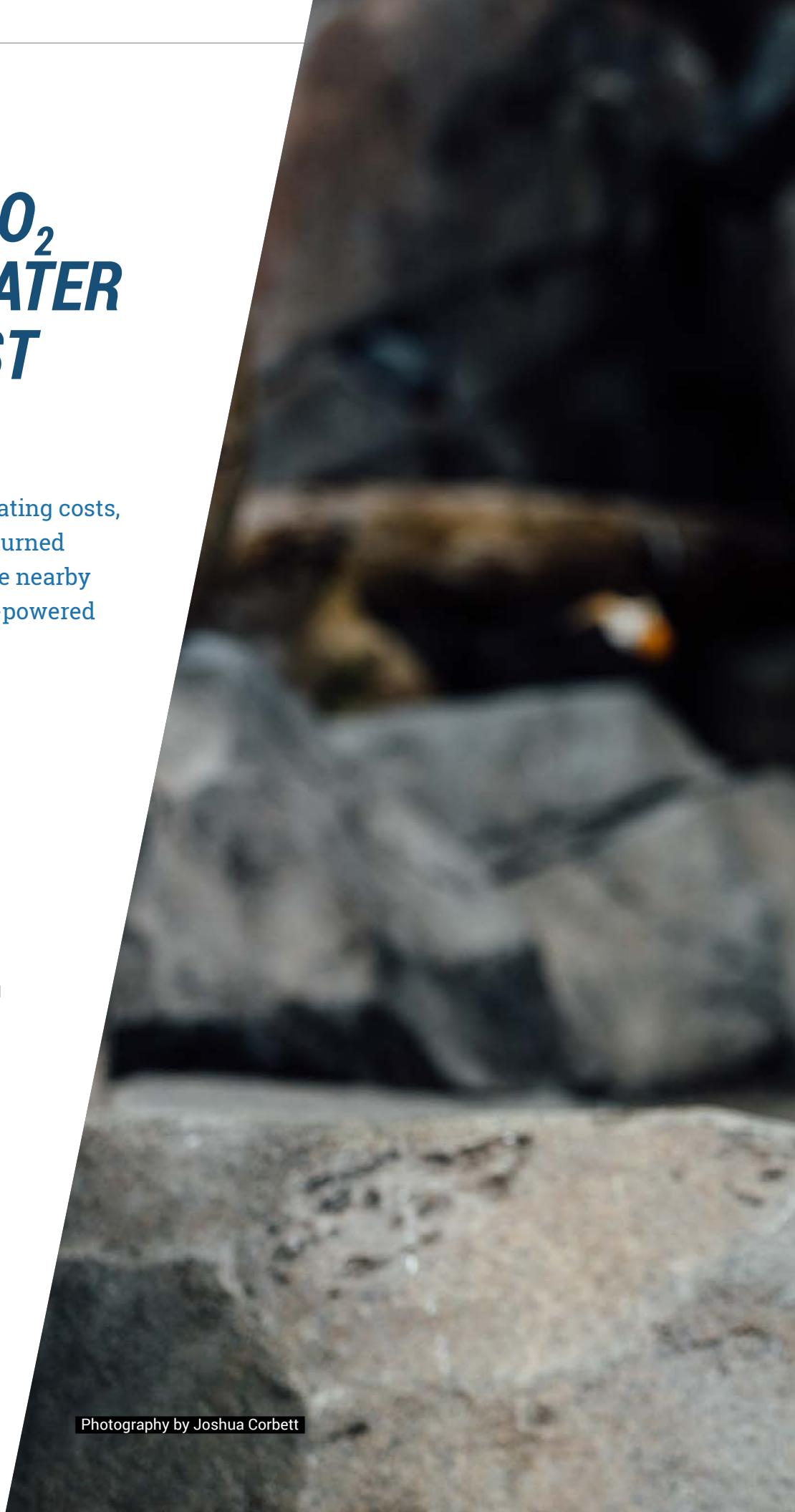
Facing astronomical oil heating costs, the Alaska SeaLife Center turned to heat pumps that leverage nearby seawater, including a high-powered CO_2 system

– By Michael Garry

On March 24, 1989, the supertanker Exxon Valdez spilled 11 million gallons of oil into Prince William Sound on the southern coast of Alaska, damaging nearly 1,500 miles of shoreline and killing thousands of marine animals like sea otters and harbor seals as well as some 250,000 seabirds.

In an effort to understand and alleviate the impact of the oil spill on its eco-system, the Alaska legislature in 1993 appropriated $12.5 million from the criminal settlement with Exxon to the southern Alaska city of Seward for the development of what became the Alaska SeaLife Center.

Located on the northern shores of Resurrection Bay, west of Prince William Sound, the 120,000-square-foot SeaLife Center opened on May 2, 1998, the only institution in Alaska authorized to care for live stranded marine animals victimized by natural or man-made disasters. It also serves as a public aquarium and a research and education facility, attracting over 150,000 visitors annually to see marine life from the subarctic ecosystem of Alaska.



Photography by Joshua Corbett

Darryl Schaefermeyer, Alaska SeaLife Center

continued on p.22

But in 2008, as the price of oil soared to almost $5 per gallon and its oil heating bills became unsustainable, the SeaLife Center, a nonprofit organization, found itself in need of rescue. "We had to figure out a way to get [the Center] off oil," said Andy Baker, PE, owner of Anchorage-based YourCleanEnergy engineering consulting firm. "If we did not succeed, it could go under."

Baker, in concert with Darryl Schaefermeyer, the SeaLife Center's special projects director, embarked on a seven-year journey to reinvent the heating and cooling systems at the facility with the help of government and private grants. This ultimately resulted in shifting 98% of the SeaLife Center's annual heating needs from fossil fuel to ocean water as a heat source, and using heat pumps – including CO_2 units -- in place of oil-burning and electric boilers.

The SeaLife Center estimates that its combined heat pump systems save $15,000 per month at current oil and electricity rates, with an annual reduction 1.24 million lbs. of carbon-equivalent emissions by not operating oil-fired boilers. The complex $1.5 million project absent grants would have an ROI of less than nine years, according to the Center.

The SeaLife Center's project represents the first installation of CO_2 refrigerant heat pumps to replace oil or electrical boilers in a conventional heating system in the United States. It shows how CO_2 heat pumps, linked to an innovative water-piping design, can be a viable heating and cooling source for a large, multi-faceted facility, especially when heat from natural resources like seawater can be leveraged.

It is also the story of how the fierce determination of a small group of individuals in a rural Alaska town overcame significant financial and technical obstacles to create a sustainable heating solution for an important public institution.

PHASE ONE: ELIMINATING OIL HEAT

A 64-year resident of Alaska, Schaefermeyer began his career working for legendary Alaska Senator Ted Stevens in Washington, D.C., and later served as city manager for the city of Seward. He has been involved with the SeaLife Center since its creation in 1990, first on its board, and then as an employee of the Center, which opened in May 1998.

In 2008, when the SeaLife Center's heating and electric bills swelled to $1.3 million, Schaefermeyer began assessing alternatives to its three Cleaver Brooks oil-fired boilers (two 80-HP units and one 125-HP unit). The boilers generated heat for the inside of the building and outside pavements, as well as for heating domestic hot water.

Schaefermeyer's first move was to purchase, with operating funds, a 500-kW Sussman electric boiler to replace the 125-HP oil boiler in April 2009. The electric boiler was then used to supply all heating from April to October, when demand was low.

With two oil boilers still operating during the cold winter months, the SeaLife Center was left with considerable energy costs. But then a staffer for Schaefermeyer noticed an article about a Japanese aquarium employing heat pumps supported by ocean-water heat. Would such a scheme work at the SeaLife Center? Having met Baker at a local advisory board meeting in 2006, Schaefermeyer recruited him to do a feasibility study funded by the Center.


At the Alaska SeaLife Center: Horned Puffin


Harbor Seal


Steller Sea Lion

Baker, who has lived in Alaska since 1998, "has a real passion for what he does," said Schaefermeyer. A civil engineer by training (Penn State), Baker spent 15 years designing municipal water systems, including four years in Zambia. He also worked as a guide on a safari camp in the Lower Zambezi National Park for the 1997 season – an experience that led him to Alaska.

"I got used to a lot of adventure in Africa," he said. "When I came back to the U.S., I wanted to live in a place where it was still possible to go out in the wilderness and explore things."

In Alaska, he also found a place that offered "a lot of room to create a business, be competitive and innovate," and in 2006, he started his YourCleanEnergy consulting business, which does renewable energy assessments and system design, along with designing sea-water heat pump systems.

The SeaLife Center project was "my first real deep encounter with heat pumps," said Baker.

In gathering data on the temperature of the seawater in Resurrection Bay from the University of Alaska, Baker found that it was warm enough to serve as a source of heat for the SeaLife Center.

Meanwhile, the Ted Stevens Marine Research Institute in Juneau, Alaska, had installed two Trane heat pumps that use seawater heat. After a successful simulation test, Baker concluded that these heat pumps, importing heat from the Bay, could replace the two remaining oil-fired boilers. But how would the Center pay for the heat pumps?

The SeaLife Center applied for a $426,720 grant from the Denali Commission Emerging Energy Technology Program, a federal entity. "It was quite a competition, including oral presentations," said Schaefermeyer.

Baker saw the grant process as a race against time. "It became a game of, can we move quickly enough with grants such that we'll be able to move off fossil fuels before the grants run out?"

The SeaLife Center won that grant, and then another offered by Alaska Energy Authority Renewable Energy & Emerging Energy Technology Fund for $286,580, for a total of $713,300. That almost covered the cost of the two Trane RTWD heat pumps and infrastructure ($766,265). To keep costs down, the SeaLife Center installed the heat pumps (apart from the control system) with its own employees for a labor contribution of $52,965.

The Center fired up the two 90TR RTWD heat pumps (which use R134a as a refrigerant) in July 2011. The heat pump system initially preheated domestic hot water in a 600-gallon tank – topped off by a 7TR WaterFurnace R134a heat pump -- and supplied heat to five air-handling units, delivering water temperatures up to 130°F and raising the temperature of outside air to between 55°F and 75°F.

With the help of a $115,000 grant from the M.J. Murdock Charitable Trust, the SeaLife Center connected the RTWD heat pumps to outside pavements in December 2012. "Once we did that, we were able to totally get off heating oil," said Schaefermeyer.

The pavements represent one of the biggest heating loads at the SeaLife Center. "The animals splash water, and you have to keep the sidewalks and habitat concrete from freezing," said Baker. "There's 12,000 linear feet of glycol tubing under the pavement slabs. When the pavement heating is running, it's half the load of the SeaLife Center."

At this point, the Center met 60% of its heating requirements with the heat pumps and 40% with the electric boiler. Because the top temperature reached by the RTWD units

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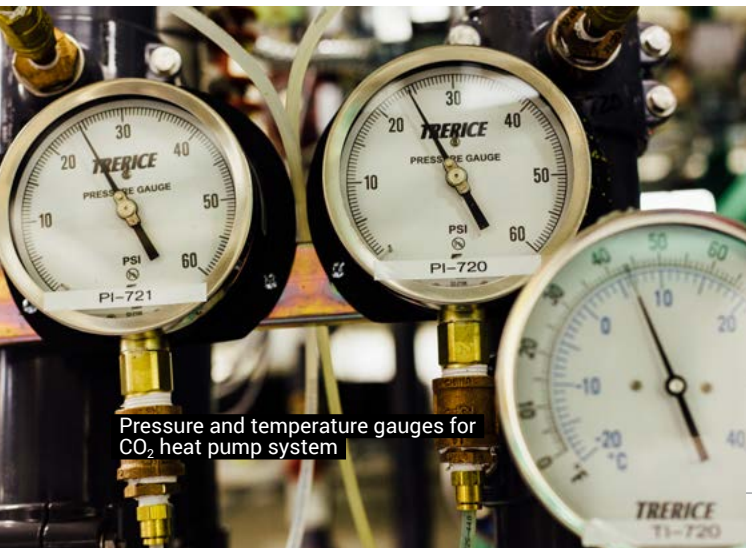
From left: John Underwood and Darryl Schaefermeyer, Alaska SeaLife Center

is 130°F, they were limited to serving the lower temperature loads in the facility. Medium temperature heat loads including baseboards and unit heaters in the office and lab space remained served by the electric boiler, which delivered the 160°F water required during the winter months.

However, with the electric boiler, which has a COP of only 1, the SeaLife Center was paying for both grid electricity and monthly demand charges that come with such a large resistance heater, said Baker.

"The question was, 'Could we serve the remaining loads with a higher-temperature heat pump system?'" said Baker.

Baker was able get an answer to that question – a CO_2 heat pump – from Troy Davis, energy manager, utility business, Mayekawa USA. Mayekawa's UNIMO CO_2 heat pumps have a considerable track record around the world, though there are only 15 units now installed in the U.S. (See story, page 29.)



Pressure and temperature gauges for CO_2 heat pump system

PHASE TWO: ENTER CO_2

In phase two of its project, the SeaLife Center decided to purchase four UNIMO ww 20TR CO_2 heat pumps from Mayekawa. The units cost $50,000 apiece, a more expensive proposition than the RTWD heat pumps, which cost $88,000 each but have a capacity of 90TR per unit. With some of the piping infrastructure in place, the complete CO_2 heat pump system cost $655,000 to design and install.

Once again, the SeaLife Center faced the challenge of obtaining grant money. But the Center was able to secure a $537,560 grant from the Alaska Energy Authority, followed by a $50,000 grant from the Rasmuson Foundation.

In its grant application to the Alaska Energy Authority, the SeaLife Center "stressed the novelty and the advantage of the transcritical CO_2 process," said Baker.

One asset that the SeaLife Center had in getting the grant for the CO_2 heat pumps was that it had already demonstrated it could capably install heat pumps fueled by seawater. "We showed that if you gave us money, we would make good use of it," said Baker. "We had to make believers out of conservative people who believe that if state money is spent, it should deliver a return."

Once again, the SeaLife Center team prevailed, and the CO_2 heat pumps went live in January 2016.

Schaefermeyer noted that with the precipitous drop in the price of oil in the recent past, the Alaska government's financial resources have dried up, resulting in a $4 billion deficit; this has made grants like the kind the SeaLife Center obtained for its heat pumps unavailable "for the foreseeable future," he said.

The electric boiler now only accounts for 2% of the annual heating load, the rest supplied by the heat pumps. In effect it serves as the "fifth CO_2 heat pump" if they "can't maintain the set point for perimeter heating," said Schaefermeyer.

Complementing the RTWD heat pumps, the CO_2 heat pumps provide heating for baseboards in offices and labs, for some heating coils in public areas, for pre-heating domestic hot water, and for pavement in the Center's animal-habitat observation decks. The CO_2 heat pumps also provide air conditioning from the evaporator side, via a loop of chilled water to two fan coil units, one in a mechanical room and one in an electrical room.

The CO_2 heat pumps run through the long Alaska winter. In the spring, summer and fall, when the temperature exceeds 65°F, the RTWD heat pumps shut off, and the CO_2 heat pumps are used as needed, such as for preheating water and preventing condensation in the basement.

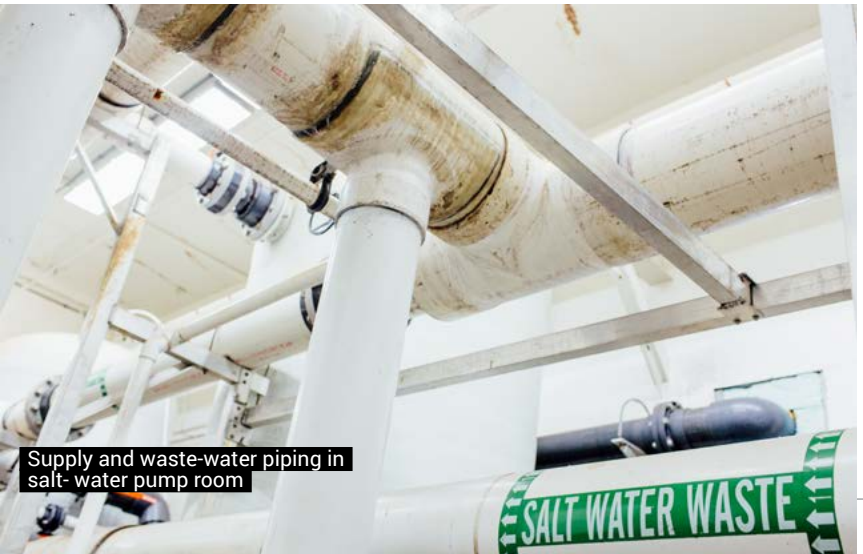
TAKING THE ESCALATOR UP

Baker compared the CO_2 heat pump to a "really nice Toyota – it's well built, super quiet, and designed for power." It works in several stages. First, seawater from Resurrection Bay is channeled through a titanium-plate heat exchanger, returning cooled seawater to the Bay and heating a 10% propylene glycol water solution.

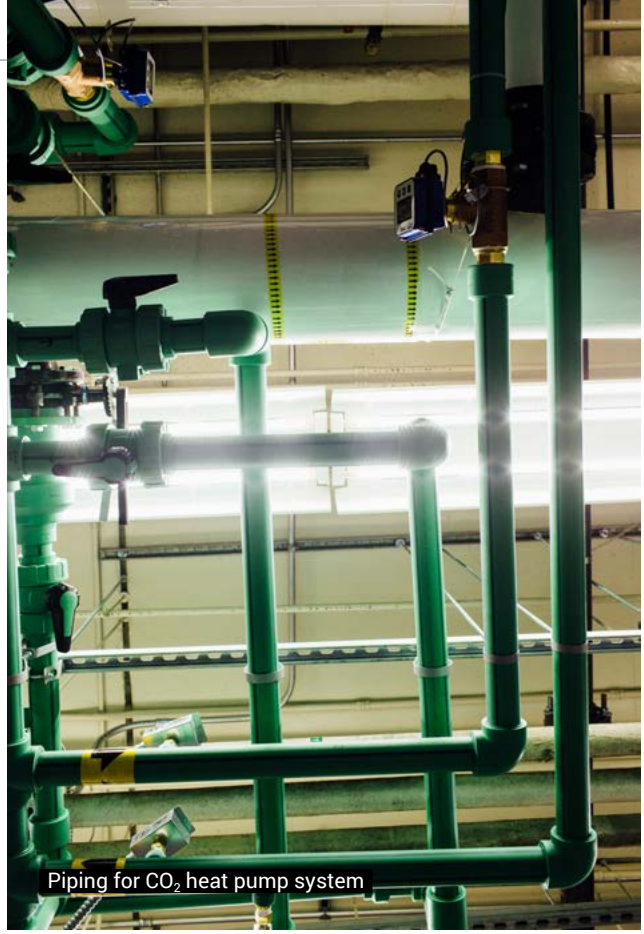
The glycol solution passes through the four CO_2 heat pumps at 30 gallons/minute, though the heat pumps are piped in parallel so that the number used depends on the load.

The glycol solution mixes in the evaporators with liquid CO_2, which boils. CO_2 vapor is then compressed above its critical point to 2,000 psi and a temperature higher than 194°F. The hot, high-pressure CO_2 then passes through a gas cooler, heating hydronic water to 194°F.

Finally, the hot water is blended into the main building heat loop, ultimately circulating through the Center between 120°F and 160°F on the coldest winter day.



Supply and waste-water piping in salt- water pump room


Piping for CO_2 heat pump system

The overall COP of the heating system at the SeaLife Center is between 2.4 and 3.0, said Baker. The initial COP of the CO_2 heat pump system, based on April heating and cooling production, was 2.25, but Baker is working on boosting the number up to around 3.0.

The biggest factor affecting the efficiency of a transcritical CO_2 heat pump is the temperature of the water returning to it on the load (hot) side. The lower the temperature, the higher the COP of the unit, because each heat pump "cranks out six gallons per minute at 194°F, no matter what you throw at it," said Baker. He compared it to an escalator, "which doesn't care where you get on, it always takes you to the top for about the same price. It's amazing."

Currently the load-side water comes into the CO_2 units at about 130°F and has its temperature elevated to 194°F, consuming 20 kW. But if it were to come in at 100°F, it would still go up to 194°F, at just 21kW. "So there's very little penalty for getting the extra ride from a lower temperature," explained Baker. "But there's a big improvement in COP, because you're getting an extra BTU lift with very little extra electrical energy. That's one of the magic facts about the transcritical heat pump cycle."

By contrast, the RTWD units raise the temperature of the returning water from 100°F to 120°F.

In order to bring the return water temperature down to 100°F and the COP of the CO_2 units up to three, Baker is expanding the design to add low-temperature loads to the return line, he said.

The latest heating load being added to the CO_2 system is a heating coil connecting an air-handling unit to a basement that has condensation issues in

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OCEAN HEAT

The Alaska SeaLife Center derives heat for its heat pumps from seawater imported from nearby Resurrection Bay.

The seawater – also used in the SeaLife Center's aquariums – is brought in through two 24-inch-diameter pipelines, which extend out 750 feet to a depth of 300 feet.

Andy Baker, PE, owner of Anchorage-based YourCleanEnergy engineering consulting firm, who designed the SeaLife Center's heat pump system, found the temperature of the seawater in Resurrection Bay to vary from 37°F to 52°F.

The heat in the Bay, which is 1,000-feet deep, three miles wide and 11 miles long, originates at the equator and travels north through the North Pacific gyre; it is picked up by the Alaska gyre, and moves up the Alaska coast, filling into bays and rendering them ice-free. "Right before winter, Resurrection Bay is charged with 52°F seawater," said Baker. "It's perfect solar storage. We're bringing in enough heat capacity with seawater to heat the entire facility on the coldest day."

The SeaLife Center's heat pumps are designed to work with seawater that has a temperature as low as 36°F, which the Bay would historically reach in the spring. More recently the effects of global warming have driven up the temperature of the seawater arriving from the gyres. "We're at 43°F-44°F now, when the water should be at its coldest," noted Darryl Schaefermeyer, the Center's special projects director, adding, "The Arctic area is ground zero for the effects of climate change."


Andy Baker, YourCleanEnergy

warmer months. "The idea is to hook up a loop from the CO_2 system to supply 140°F heat to this basement corridor and defeat the condensation problem," said Schaefermeyer. Baker expected the new equipment to be installed by mid-June. "We now have a heat load for the CO_2 system on the warmest summer days," he said.

The new load will lower the temperature of the return water to the CO_2 heat pump by 15°F, to 125°F, and boost the COP by 10%.

Another way to boost the COP is to further leverage the cooling capacity of the CO_2 heat pump. Baker and Schaefermeyer are targeting two overheated rooms in the SeaLife Center, one a server room, the other containing freezers. "We're going to put fan coils in each room and send our cold source water there, warm it up and send it to the source side of the heat pump at about 50°F, which will push the COP up," said Baker.

In fact, the existing waste heat available to the CO_2 heat pump system may become sufficient to turn off the seawater supply pumps during most of the year, Baker said.

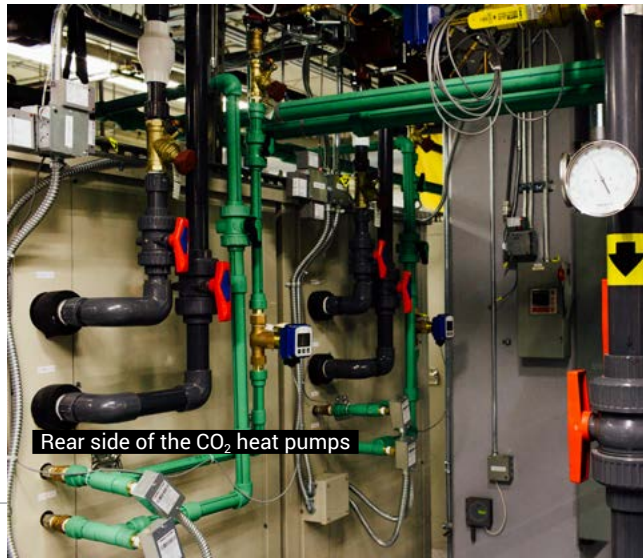
One last piece of Baker's COP-improvement program – assuming the funding is available -- will be to install coils in two large exhaust fans on the roof that are expelling inside air. "In my mind, we have three to four more steps to go to optimize the system," he said, adding, "I look at the [SeaLife Center] as a living thing, with hot places and cold places, where we can move energy around."

APPLYING LOOPSAMETRICS

Perhaps the defining feature of the SeaLife Center's CO_2 heat pump system is Baker's design of the water-pipe loops conveying hot water to the heating loads and back to the heat pump. It is what will enable the system to add loads and ultimately return water at 100°F.

In the configuration of the water-pipe loops lies "the magic of how we've been able to make this work," said Schaefermeyer. He also credits John Underwood, the Center's life support system manager, who built and installed the heat pumps and the accompanying piping loops with his crew.

Because of its transcritical vapor-compressions cycle, the CO_2 heat pump could not simply be dropped into the water loop. "Its integration was not self-evident," said Baker. "We had to do a lot of branching and re-joining of loops to make it work."


Rear side of the CO_2 heat pumps

Baker got the idea for his loop design from the principle of fractal branching, which involves repeating patterns of self-similarity often found in nature. It explains how energy and fluids optimally move in the veins of leaves, blood vessels and tree roots.

"One of the great inspirations came from looking at the branching and looping veins in the leaf of a giant live oak tree in the Ocala National Forest in Florida in 2012," Baker said. "That opened up the door to understanding how to branch water loops in a different way, which led to the solution we have. I think it's the optimal solution." He has even coined a word to represent the design of interconnected fluid loops: "loopsametrics."

As Baker explained it, the loopsametric design of the CO_2 heat pump incorporates cooling and heating loops "that branch multiple times" into split flows, add or subtract heat, and reconnect in order to "meet temperature and flow targets for the project."

Another challenge the SeaLife Center faces with its heat pump technology is the high cost of bringing in technicians from outside of Alaska to make repairs, though the Center's own personnel handles most maintenance issues. "I'm hoping the CO_2 system is pretty robust," Schaefermeyer said, adding, "Maintenance costs are something we have to watch."

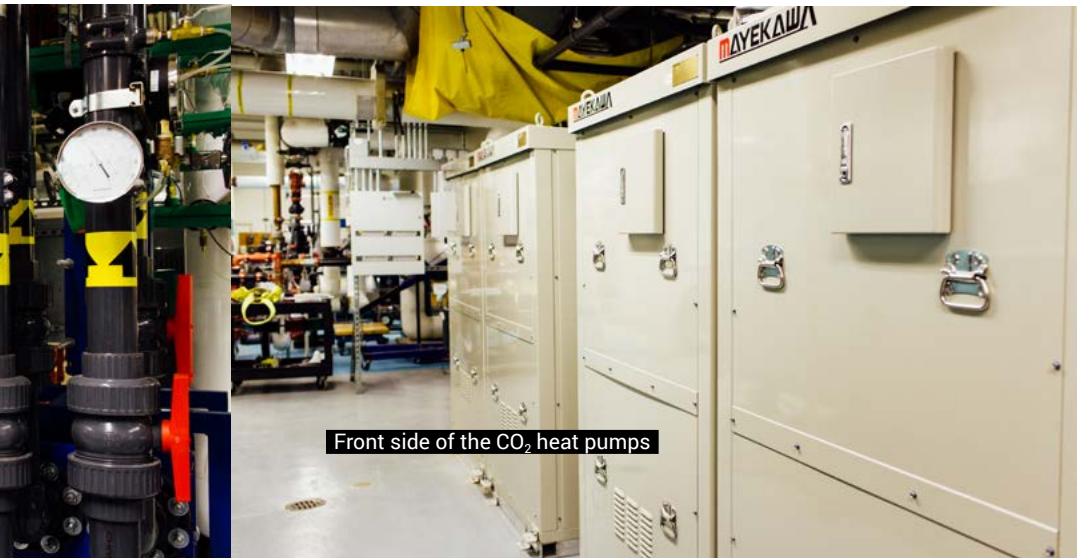
Perhaps the SeaLife Center's biggest challenge is the cost of energy. Currently, the Center has a special electricity contract with the city of Seward, but the city plans to eliminate that rate in nine years, which would more than double the Center's utility costs, said Schaefermeyer. "As fast as we make improvements to reduce our energy costs, the city takes some of the savings back in higher grid electricity rates."

Can the CO_2 heat pump system used at the SeaLife Center be similarly employed in other venues? Baker said it could be used on a smaller scale, though "you may be better off having a fresh water or ground heat source." It would also need custom engineering as well as maintenance know-how. "The biggest obstacle to more CO_2 heat pumps is simply the integration engineering – understanding the heat loads and how to serve them." This might require other heating generators besides the heat pumps in a hybrid system.

"You can't just throw in a couple of heat pumps to directly replace a boiler," Baker said. "That would be very unrealistic."

But Baker believes that CO_2 was the right refrigerant to add to this project. "It has a great future," he said. "People are mesmerized by it."

The irony, he noted, is that CO_2 is both the primary greenhouse gas in the atmosphere causing global warming "and the gas that can help us to eliminate the problem." MG



Front side of the CO_2 heat pumps

VERSATILE HEAT PUMP

Japanese manufacturer Mayekawa introduced its UNIMO CO_2 commercial/industrial heat pumps in Japan around 2003 "after we developed a small-size CO_2 high-pressure reciprocating compressor specifically for this product line," said Troy Davis, energy manager, utility business, Mayekawa USA.

The UNIMO CO_2 heat pumps are now installed all over the world, including approximately 500 UNIMO ww units, over 750 UNIMO aw units, and a few UNIMO aww units.

Outside of North America, the heat pumps are used "in Japan, Korea and Taiwan for data and processing facilities, Vietnam, India, many in Australia, several in Europe, several in South America at wineries in Chile and Peru, and one in Central America at a hotel," said Davis.

There are 15 installations in the U.S., including four CO_2 heat pumps at the Alaska SeaLife Center, and 11 others at wineries, a dairy, hotel and two food processors. All of the U.S. installations have ROI's in the three-to-five year range, said Davis. "We are targeting some utility incentives to be offered in the U.S. in the future to help decrease this ROI even further."

Davis stressed that the UNIMO heat pump, due to its size, can fit well with commercial as well as industrial applications. "I am working on a hospital right now for a cooling/heating application and we have several hotel sites upcoming, as well as a mixed use large apartment building with retail on the ground floor, where simultaneous cooling and hot water heating is needed."

Mayekawa also makes ammonia heat pumps for food/beverage processors and other applications.

SKATING ON CO_2-MADE ICE

Anchorage, Alaska, continues rollout of CO_2 transcritical cooling systems at its municipal ice rinks, in a phase out of R22 equipment

- By Mark Hamstra

Ice Rink at the Sullivan Arena, Anchorage, Alaska

In Alaska, where ice skating is a favorite pastime, the municipality of Anchorage operates four public ice rinks. By next year all four will use a natural refrigerant (CO_2) in a transcritical system to keep the ice frozen – the first in the U.S. to do so.

Anchorage, through its Parks and Recreation Department, finished installation of the first transcritical system at the Harry J. McDonald Recreational Center in December 2014, and will complete the second at Sullivan Arena in October 2016. This year, it is also putting the system in its Ben Boeke Ice Rink, with completion planned this September. The CO_2 system will be implemented at the Dempsey-Anderson Arena next year.

The CO_2 systems were provided by Hillphoenix, based in Conyers, Ga., Hillphoenix has submitted an application to the Environmental Protection Agency asking the agency to list CO_2 as an acceptable refrigerant for ice rinks under its SNAP (Significant New Alternative Policy) program. The EPA has approved the application, and will announce its decision in a future SNAP rule; meanwhile, Hillphoenix has been able to install the first Anchorage ice rink and move forward with the next three.

John Rodda, director of the Parks and Recreation Department, said he launched a thorough assessment of the Department's options in 2013 before opting to go with a transcritical CO_2 system to replace the R22 cooling systems that had been operating for decades at all of its facilities.

The ongoing phase out of R22 as a refrigerant under the Montreal Protocol — the global agreement calling for a reduction in the use of ozone-depleting chemicals — along with the aging of the facilities, prompted Rodda to replace all of the existing R22 systems.

> "We took into account everything we could possibly imagine, and ultimately it came down to efficiencies, and how we could utilize waste heat."

"We had an opportunity through state grant funding to receive enough money to do these four facilities," Rodda told *Accelerate America*. "Sooner or later we were going to be dealing with it."

All of the facilities were built in the 1970s and '80s, and were using R22 systems to freeze and maintain the temperature of their ice sheets.

"Every building is a minimum of 30-plus years old, and over the course of time, gradually we had a few more problems," Rodda explained. "We had a couple of leaks, and you just have to do something at some stage."

In addition, repair was becoming more difficult for the R22 systems as parts became harder to come by, Rodda said.

Under the Montreal Protocol, the production and import of R22 will be banned in 2020, after which only recycled R22 will be available. The price of R22 had already been increasing significantly, up from about $1 per pound in the early 1990s to about $15-$18 per pound recently, according to reports.

Rodda said Anchorage considered a variety of options, including ammonia-based cooling systems, indirect systems and industrial direct systems, before settling on the Advansor Transcritical Direct CO_2 System from Hillphoenix.

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He said he decided against an ammonia system because there would be some additional costs involved for added safety and isolation requirements.

HIGH EFFICIENCY

The system chosen by Anchorage will deliver high efficiency, said Tim Henderson, industrial program manager, Hillphoenix.

"If they didn't use CO_2 as a replacement for R22, an alternative would be a chiller that uses an HFC, ammonia or CO_2 as a primary refrigerant to chill glycol or brine, which would be pumped under the ice," he said. "But this is inefficient compared to the all-CO_2 transcritical system because the pumping power is up to 90% greater, and there is an extra heat exchange process between the primary refrigerant and the secondary fluid."

The ability to capture as much of the excess heat as possible generated by the cooling system factored into the decision to go with direct CO_2, Rodda explained. The heat will be deployed for other purposes in the facility, thus lowering overall energy consumption.

"We took into account everything we could possibly imagine, and ultimately it came down to efficiencies, and how we could utilize waste heat for additional savings in a system that is able to produce what we need in the facility, and that's ice

Rodda said energy use at the first installation has been "trending in the right direction," although he's waiting for full-year reports from local energy companies to draw specific conclusions about total energy consumption at the McDonald Rec Center.

"It's been pretty consistent with what we expected," he said. "We have noticed a fairly consistent pattern in which our energy consumption has not really increased all that much, as opposed to what it would have been with the R22 system. And we are seeing the ability to keep [heating] gas costs down."

Harry J. McDonald Recreational Center, Anchorage, Alaska

John Rodda, Anchorage Parks & Recreation Department

The excess heat can be used for a variety of purposes in the facilities, Rodda explained, including for locker rooms, floor heating, and hot water.

In addition, Anchorage is located in a northern climate favorable to the efficient operation of CO_2 transcritical technology.

LARGER CHARGE

The CO_2 system used at the Ben Boeke Arena will be similar to the ones at the two other installations, although the Ben Boeke installation will include a larger CO_2 charge because the system will be used to cool two ice sheets rather than one (which will also be the case for the Dempsey-Anderson Arena next year).

The systems at the first two installations required CO_2 charges of 4,500 lbs. at the McDonald Center and 5,000 lbs. at the Sullivan Arena, which is a slightly larger facility. The new system at the Ben Boeke Arena will likely require a charge of about 9,000-10,000 lbs., Rodda estimated. Although each of the two ice sheets is slightly smaller than the individual sheets at the first two facilities, the overall surface area of the ice is larger at Ben Boeke.

The system will give the Ben Boeke arena managers the ability to set the temperatures independently for each of the two ice sheets — hockey calls for harder ice than figure skating, for example — or to shut one of the ice sheets down during the summer for other activities, such as basketball.

continued on p.34

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Transcritical rack at Harry J. McDonald Recreational Center

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- Direct air cooling.

Another consideration in using CO_2 systems is that the higher pressure can create perceived challenges for technicians more familiar with low-pressure systems, but Rodda said that this has not been an issue. He said Hillphoenix sent a team of people to train the technicians in Anchorage on how to work with the high-pressure systems, which are also much more computerized than the previous R22 systems, and can also be monitored and operated remotely.

The closed-loop system works by pumping liquid CO_2 under the ice first to freeze it, then to remove residual heat. When the liquid CO_2 along with some vapor comes back, it goes into a separator vessel, where the gas is sent to the compressor to be liquefied before being pumped back under the ice again. The vapor also goes through an oil separation system to remove any oil.

Some of the heated vapor, as well as the heat removed from the ice, goes through a heat reclamation system to be used elsewhere in the arena, or rejected to the atmosphere.

Rodda said the system has been well-received by customers who have skated on it at the McDonald and Sullivan facilities.

"Does it achieve what it needs to achieve for the best skating experience for the end user? Absolutely," he said. "Whatever you need to do in terms of a set point, it does whatever you want, and the quality of the ice is excellent."

Henderson of Hillphoenix said the Anchorage Parks and Recreation Department has been a standout in the industry in its effort to switch to alternative refrigerants.

"Even as slow to change [to new refrigeration technology] as the industrial refrigeration industry is, the ice rinks industry is even slower," he said. "But they [the Alaska Parks and Rec Department] are committed to the CO_2 technology. They love the technology."

He said Hillphoenix has been working toward adoption of CO_2 by other ice rinks in the Continental U.S., "but there's no commitment yet." CO_2 cooling systems have also been used in several ice rinks in Canada and Europe, the latter since the late 90s. MH

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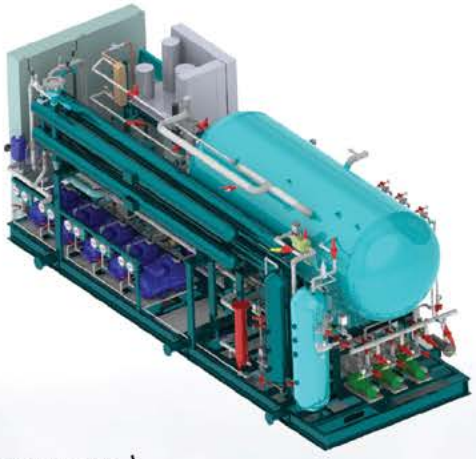

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Stuart Saville, Coles

COLES CUTS ITS TEETH ON CO_2 TRANSCRITICAL

The Australian retailer's first transcritical installation, which encompasses refrigeration, air conditioning and heating, is recording promising efficiency numbers, setting the stage for more installations of the technology

- by James Ranson and Jan Dusek

Stuart Saville is a man of purpose. Charged with driving the sustainability agenda for Coles – one of the two dominant food retailers in Australia with Woolworths – Saville, national engineering refrigeration manager, is measured in his thoughts but knows he is onto something good.

Decked out with "all the bells and whistles," Coles' first CO_2 transcritical booster installation at its recently opened flagship store in North Coburg, Melbourne, has so far performed above expectations. Management was hoping for energy reductions of 10%. But since the store opened in August 2015 the refrigeration system has so far seen an impressive 15% efficiency improvement (with a maximum of 22%) during the cooler months, compared to its baseline CO_2/R134a systems.

It's little wonder industry figures and rival retailers have been keeping their ears close to the ground for news on one of Australia's five commercial transcritical installations, which include three at competitor Metcash IGA stores.

The transcritical installation is the result of Coles' longtime use of subcritical CO_2 systems at 120 of its 780 supermarkets. The chain is also testing other natural refrigerants, including propane in display cases at a Liquorland outlet adjacent to the North Coburg store, and one ammonia/CO_2 cascade test.

Accelerate Australia, a sister publication to *Accelerate America*, was invited to see the bustling North Coburg store with Saville and Brian Toulson, senior project engineer for U.K.-based City Refrigeration Holdings, whose Australian arm, City Facilities Management, partners with Coles on all of its installations.

Described as a "concept store," the 39,826-square-foot supermarket is Cole's first attempt at an almost-all-natural solution. (Only one back-up compressor is running on HFC R134a.)

Coles is eager to implement CO_2 transcritical systems in two more stores as early as this year and is all but convinced that ejector technology will accompany one or both. "At Coles we think, from an efficiency and emissions point of view, that it [transcritical] is the right way to go but there are just a couple of steps we need to take before we make a blanket commitment to the technology."

Meanwhile, the North Coburg installation encompasses not only refrigeration but also air conditioning and heating, making it one of the most versatile transcritical installations in the world. The booster system includes two Bitzer CO_2 centralized racks supplying a load of 610kW; parallel compression; adiabatic cooling; hot gas defrost, 250kW of chilled water capacity to supply store air conditioning; heat reclaim supplying store hot water and heating; and four solar inverters generating up to 100kW.

OPTIMIZING ENERGY

The transcritical system has performed well so far, even in warmer temperatures. Toulson, who has been in the engine room and seen the system under stable operation on a 109°F day, said no stone had been left unturned in ensuring the store was as advanced as possible. "We looked at everything that would help the energy profile and we really wanted to get rid of synthetic refrigerants and also to hit the optimum energy savings that we could."

Recalling the efficiency monitoring that started last autumn, Toulson noted the collective interest from his technical staff, who would scurry to the plant room to monitor the operation of the system on the first 86°F and 90°F days. "That's no longer the case and in fact on the 109°F day the operation of the [CO_2 transcritical] system was very stable. We've got to the stage now where our mechanics and technicians don't even bother coming here on the hot days; they go to the stores which have heat issues."

Coles has measured the transcritical system against one of its benchmark stores fitted with a CO_2/R134a cascade system, using all the key metrics considered to be pertinent to get a true measure: overall refrigeration capacity, sales floor area, climatic region, and case length. "We were expecting to see in the vicinity of a 10% reduction in power consumption but after a full six-month period (August-January) we found that the consumption has actually come in at about 15% under one of our benchmark stores," Saville said.

The next step is to measure the system's efficiency during the upcoming summer months "so that we can clearly demonstrate what the savings have been," Toulson said. "Hopefully then we can seek endorsement for two further stores."

TEMPLATE SOUGHT

Avoiding the intricacies involved with installing any HVAC&R system is imperative for end users like Coles. The company ideally wants to use the technology as a template. "We'll trial another couple of stores with transcritical, we'll take the learnings that we've had, take some of the complexity out of what we've done here, and try to simplify it and drive down the capital cost," Toulson said.

The entire process from design to delivery at the North Coburg store took roughly six months. "We spent a lot of time on the fixtures in the [store] so that it could essentially be 'dropped in' to avoid installation time and hassles" said Toulson, adding that installation time still took an additional 14-16 weeks.

Bitzer and Danfoss were chosen as key suppliers due to their "experience and excellent track record in Europe," Saville said. Bitzer and Danfoss helped both Coles and City Facilities Management with the design and installation. "We had buy-in from both of them [Bitzer and Danfoss] to ask for their assistance to ensure our technicians were fluent in installation, servicing and maintenance of the system."

continued on p.38

From left: Brian Toulson, City Facilities Management; and Stuart Saville, Coles

Even though Saville and Toulson are restrained in their appraisal of the transcritical system's performance, there is an undeniable sense of achievement so far. Reigning in higher capital costs remains the major barrier to tackle as well as ensuring the technology is transferrable to Coles' more remote stores in higher ambient temperatures. The addition of ejector technology will no doubt help in that regard.

"Probably if [the installation] had been six months later we would've run ejectors in unison with parallel compression in this store but we'll definitely be looking at ejectors in our next iteration of a transcritical system," Saville said. "We've had initial discussions with quite a few primary producers who are saying that they could look at this for us if we're to take the next step."

Although the southern city of Melbourne can reach temperatures of 113°F in the summer, the other seasons are typically much cooler than in the northern states, which pose CO_2 transcritical a more consistent challenge in terms of high ambient temperatures.

The team estimates that initial capital costs of the first CO_2 transcritical store were around 27%-28% higher than their "business as usual" cascade CO_2/R134a system, adding that it took Coles around two years when it installed its first cascade system in 2005 to reach cost parity with its now obsolete all-HFC model. "We would expect to see the same kind of timeline for the transition to transcritical once it's up and running," Saville said. "[In 2005] we were able to simplify the systems and saw the added interest in CO_2 in retail in Australia, with more end users actually using the technology. The market penetration of CO_2 in Australia is really quite deep.

"With some of the global suppliers entering the Australian market, we'll definitely see, and we're already starting to see, costs come down. If [ejectors] enable us to simplify the design and maybe drop some compressors off the rack, there's big capital savings."
JR & JD

SYSTEM SPECS

Coles' transcritical CO_2 Booster system in North Coburg, Melbourne, Australia, has the following specifications:

- 39,826-square-foot sales floor
- Total fixture load of 610kW
- Two centralized CO_2 Bitzer racks supplying three temperature ranges: LT, MT and HT
- Booster system with parallel compression into the flash gas bypass
- 320kW MT display cases and rooms
- 40kW LT fixtures (-17.5°F and -31°F)
- Bitzer compressors: 4 MT, 3 HT and 2 LT compressors per rack
- Hot gas defrost for all LT fixtures
- Two 90kW Alfa Laval heat exchangers for heat reclaim used for potable water and store heating
- 250kW chilled water from racks recirculated to power 100% of store AC through plate heat exchanger
- ARNEG hydrocarbon (R290) display cases
- 108 evaporators connected to MT, LT
- Four solar inverters generating 100kW power capacity
- Two Alfa Laval (Bitzer/Buffalo Trident supplier) roof-mounted adiabatic gas coolers
- Gas coolers fitted with K65 copper/steel heat exchanger

COLES' NATURAL REFRIGERANT INSTALLATIONS

- Types of natural refrigerant equipment: R134a/CO_2 Hybrid DX, R134a/CO_2 hybrid liquid Recirculation, R717/CO_2 cascade, hydrocarbon display cases, transcritical
- Number of subcritical CO_2 stores: 120
- Number of transcritical CO_2 stores: 1
- Number of hydrocarbon display cases: 20+ (North Coburg store)
- Number of ammonia stores: 1 (R717/CO_2 cascade supermarket)
- Number of stores converted to natural refrigerants/year: 25-30

ONE STEP CLOSER

The California Air Resources Board unveils its Proposed Strategy to crack down on HFCs, paving a path to natural refrigerants.

– By Klara Skacanova

In April, the California Air Resources Board (CARB) took another step towards curbing emissions of high-GWP HFCs with the publication of its Proposed Strategy to reduce short-lived climate pollutants, which also include methane and black carbon (soot).

While HFCs account currently for 4% of California's GHG emissions, their amount is expected to double in the next few decades if no additional measures are taken. "Fluorinated gases, and in particular HFCs, are the fastest-growing source of GHG emissions in California and globally," reads the proposal.

The Air Resources Board is putting forward actions to cut HFC emissions by 40% by 2030, compared to 2013 levels. Meeting these targets will help to achieve the Governor's goal to cut all greenhouse gas emissions in California by 40% below 1990 levels by 2030 and help to meet federal air quality standards for 2031 and beyond.

California Environmental Protection Agency

Air Resources Board

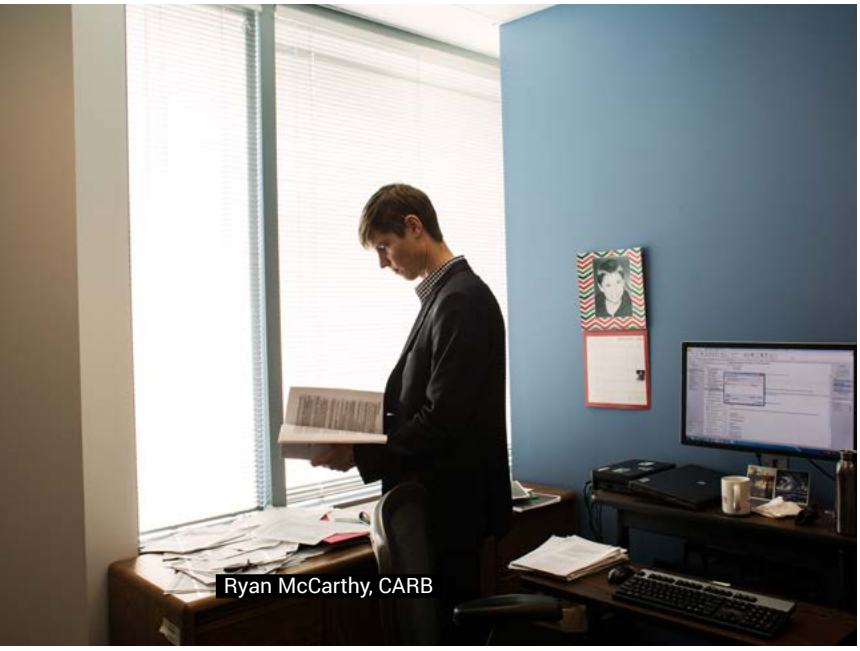
"The impact of these super pollutants is real and the fight against climate change must include a strategy to aggressively reduce them," said California Governor Edmund G. Brown.

The suggested measures to reduce HFC emissions were first outlined in a Concept Paper that CARB published in May 2015. Following consultations with industry experts, the agency released a Draft Strategy later in 2015. Now, with the Proposed Strategy, the measures that will influence the refrigeration and air conditioning business in California are taking more concrete shape.

The Proposed Strategy notes that "early action, ahead of some of the phase-down schedules being proposed internationally, can avoid locking in the use of high-GWP refrigerants in new or retrofitted systems in the coming years."

"Without early action to reduce unnecessary emissions now and into the future, the State [of California] would need to take additional — likely more costly — steps to meet its 2030 climate targets," the document reads.

The proposal further notes that although low-GWP technologies are assumed to have at least 10% higher initial cost, "in many cases, the added initial cost is offset or reversed through energy savings of low-GWP refrigeration and AC. Additionally, low-GWP refrigerants such as carbon dioxide refrigerant, ammonia, and hydrocarbons are less expensive than HFCs."


Ryan McCarthy, CARB

HFC BANS

Similar to HFC policies adopted in other regions and countries, such as the EU F-Gas Regulation or Japan's F-Gas law, CARB is proposing a combination of measures to reduce HFC emissions. In the EU and some of the countries that had adopted restrictions on the use of fluorinated refrigerants even before the revised F-Gas Regulation, bans on HFCs in new equipment have proven to be the most effective tool to shift away from fluorinated refrigerants and invest in HFC-free technologies.

In the U.S., the Environmental Protection Agency has started imposing restrictions on the use of certain high-GWP HFCs for specific end-uses, an action that is already having an impact in the market.

The recommended bans for new equipment in CARB's Proposed Strategy would go beyond the EPA restrictions and even the EU F-Gas Regulation, potentially making California one of the most advanced regions in terms of HFC legislation. A ban on HFCs with GWPs greater than 150 in new commercial and industrial refrigeration is proposed to start as of 2020. Such a ban would be in line with the deadline for phasing out R22, thereby enabling technology end-users to go directly to the most climate-friendly solution, avoiding intermediary HFC refrigerants.

In case of residential refrigeration, CARB suggests a ban on HFCs with GWPs greater than 150 in new equipment to start in 2021, aligning it with the recent EPA SNAP proposal to delist R134a and other high-GWP refrigerants in this sector.

New stationary air-conditioning equipment (residential, commercial and industrial) is also targeted for prohibitions starting in 2021 for HFCs with GWPs greater than 750. Nevertheless, the paper notes that GWP limits might be subject to change when evidence about availability of HFC alternatives is proven. "For example, low and medium-pressure chillers used for air-conditioning may be able to use refrigerants with a GWP less than 150."

Another key measure proposed to reduce the use of high-GWP refrigerants is a prohibition in the sale of new refrigerants with GWPs greater than 2,500, beginning in 2020. Reclaimed or recycled refrigerants would be exempt from the sales ban.

"A sales ban on very high-GWP refrigerants is enforceable and provides immediate reductions," explains the Proposed Strategy. "Such a ban facilitates a much faster transition from very high-GWP refrigerants to lower-GWP alternatives in existing equipment (thus avoiding the ongoing high-GWP emissions from equipment that typically lasts for 15 years or longer)."

continued on p.42

FINANCIAL INCENTIVES

Developing an incentive program is particularly important to help the industry transition towards low-GWP refrigeration technology, such as CO_2, ammonia and hydrocarbons. The Governor's proposed 2016-2017 budget includes $20 million for incentives to reduce HFC emissions from refrigerants.

The report notes that substantial progress has already been made regarding the safe use of natural refrigerants in North America and other parts of the world. For example, at least 300,000 HFC-free light commercial refrigeration units have been deployed in North America, with more than 250 stores using CO_2 systems and over 250 "next-generation" small-charge ammonia industrial refrigeration systems.

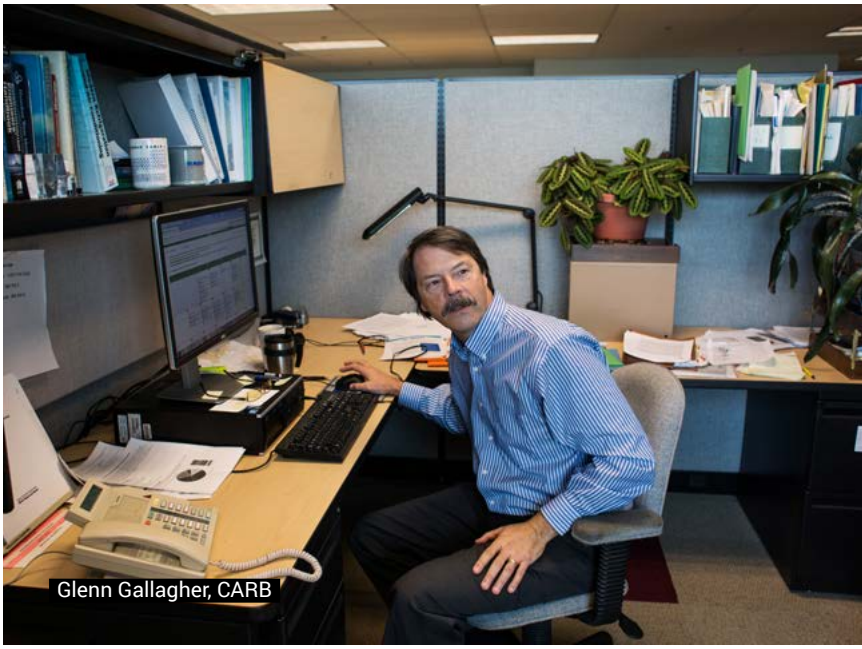
The report also states that California reserves the right to put forward a proposal to phase down the use of HFCs in the absence of an agreement this year for a global HFC phase down within the Montreal Protocol, where ongoing discussions are taking place.

"If a national or international HFC phasedown agreement cannot be reached in 2016, ARB may pursue a California HFC phasedown schedule that will help meet the State GHG emission reduction goals. California would seek a partnership with the EU, Canada, Japan, and Australia, all of which are currently pursuing their own separate HFC phasedown programs," outlines the Proposed Strategy.

CARB will present the Proposed Strategy to its Board on May 19. Comments by interested stakeholders will be accepted until May 26. The Final Strategy will be presented to the Board for a vote in autumn 2016. KS

CARB'S HFC EMISSION-REDUCTION TARGET (IN MILLIONS OF METRIC TONS OF CO_2-EQUIVALENTS)

2013	2030 (business as usual)	2030 (Proposed Strategy)
40	65	24


Glenn Gallagher, CARB

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AAA/Hillphoenix Symposium

SO FAR, SO GOOD

At the AAA/Hillphoenix Symposium, John DeCicco, Jr., reports that his four-month-old transcritical system is maintaining constant temperatures, saving energy at night, and providing great heat reclaim

– By Michael Garry

Last December, DeCicco & Sons, a six-store food retailer based in Pelham, N.Y., became one of a small but growing number of independent grocery operators to install a transcritical CO_2 refrigeration at an 18,000-square-foot store in Larchmont, N.Y. (See "DeCicco's Bold Move," *Accelerate America*, October, 2015.)

Almost four months later, John DeCicco, Jr., president of the company and the driving force behind the transcritical project, spoke favorably about it at the 7th annual AAA/Hillphoenix Spring Symposium 2016, which took place on April 6 in Tarrytown, N.Y.

The event was co-hosted by AAA Refrigeration Service, DeCicco's Bronx, N.Y.-based contractor, which installed and is maintaining the transcritical system; and Conyers, Ga.-based Hillphoenix, which manufactured the system and trained AAA technicians on its proper maintenance (See "Shifting Gears," *Accelerate America*, November 2015.)

One of the most striking advantages of the CO_2 system, said DeCicco, has been its ability to maintain a consistent temperature. For example, the system, combined with electronic expansion valves in the cases, held a frozen case at the Larchmont store at -8°F "essentially the entire day and night," he said. "That's really good." By contrast, a reach-in cooler at another DeCicco's store in Armonk, N.Y., which uses R404A refrigerant and EPR valves, showed a much bigger variation in temperature.

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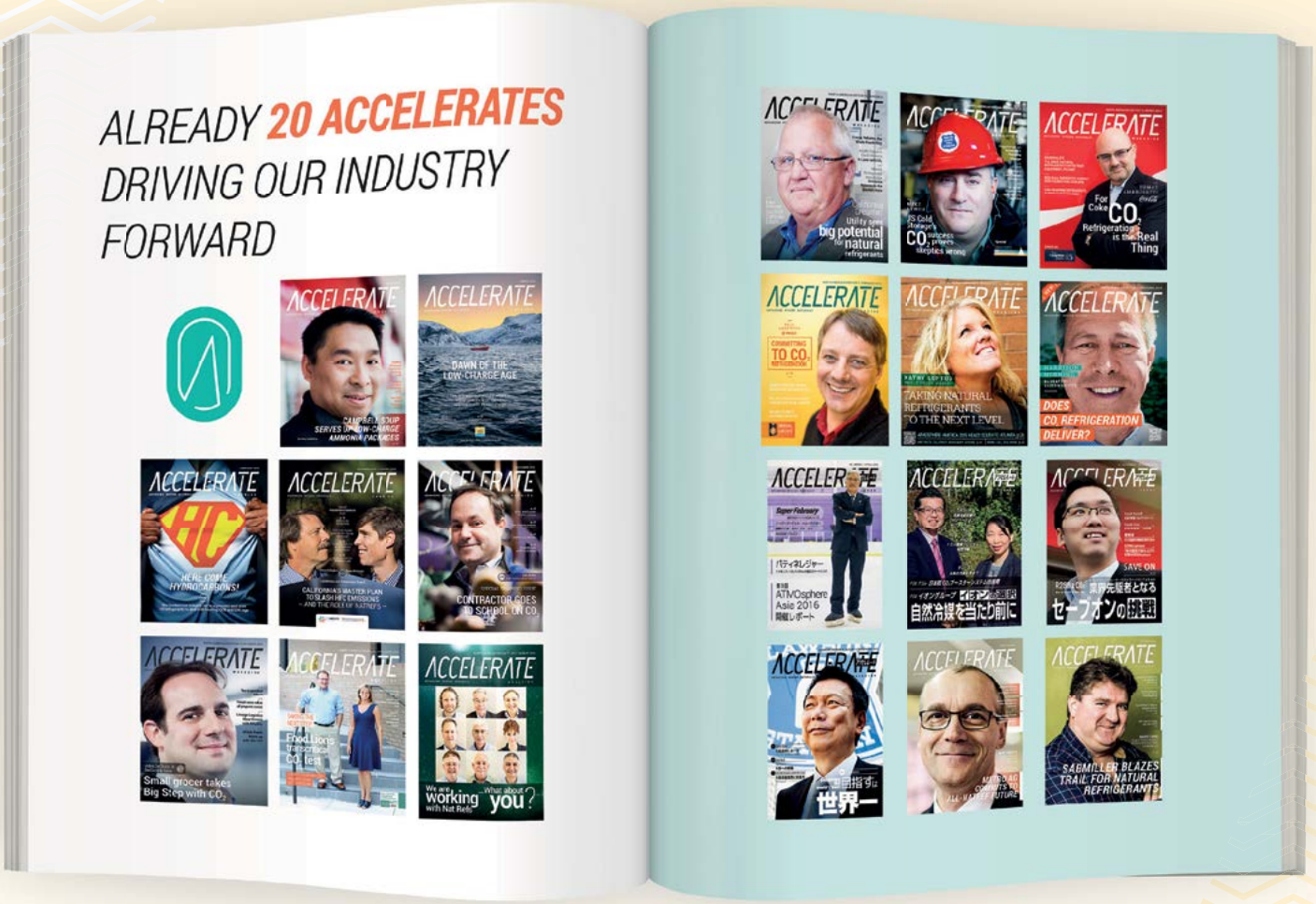

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> "The product integrity is much better."

Similarly, a multi-deck dairy case at the Larchmont store, set at 34°F, maintained that temperature throughout the day while an R404A case showed "much greater fluctuation."

DeCicco's policy is to remove meat from the case when it starts turning dark, but that doesn't occur as fast with the CO_2 system; instead meat is pulled based on sell-by dates. "The product integrity is much better and we're getting a better product life," said DeCicco. Again, he attributed that to the consistent product temperature of the meat case (28°F), which "does hold up a lot better than traditional systems," as well as to the case controllers, the variable speed compressor, and the use of CO_2 as a refrigerant.

DeCicco also pointed to the electrical savings the CO_2 system offers at night when the transcritical rack operates at 25% of capacity and the night curtains are drawn on cases. In the morning, the curtains go up and the rack jumps to 45% capacity throughout the day. The difference in electricity is 28kW at night and 50kW during the day, which translates to a savings of $25,000 annually. In addition, using a variable-speed lead compressor reduces electricity demand considerably.

The transcritical store is also able to generate 1 million BTUs for heat reclaim in the store, 250,000 to make hot water, and the rest to heat make-up air in the kitchen, and provide heat to air handlers at the store entrance and in the center-store area.

Eric Berman, field engineer for Hillphoenix, said at the Symposium that there have been very few issues with DeCicco's transcritical system, adding, "The rack's running great." The suction pressure has been around 400 psi, while the discharge pressure has ranged from 1,100 psi to 650 at night. The BAC Trillium condenser, which can help cool the CO_2 gas on warm days, has been used on just a few occasions so far.

AAA technicians, who were initially wary of the transcritical system's high pressures, have become accustomed to them, noted Berman. The technicians were trained on the technology, including case controllers, which Berman called "the heart of the system."

Buoyed by the results at the Larchmont store, DeCicco plans this year to install a transcritical system at an existing store in Pelham, N.Y., in place of an R22 system. MG

CERTIFYING FOR CO_2

In an effort to raise standards for training on CO_2 transcritical refrigeration systems, Hillphoenix has started a certification program at its Learning Center in Conyers, Ga.

The two-day program is a "mix of hands-on and classroom training," said Rusty Walker, Hillphoenix's chief trainer in a presentation at the 7th annual AAA/Hillphoenix Spring Symposium 2016. Most important: a 30-question test at the end that "they have to pass" to be certified. The scores are kept in a database and made available to customers on request.

The program covers everything from case and rack controllers to "how to calibrate the high-pressure control valve," Walker said. He emphasized that, though transcritical technology involves new valves and higher pressures, it still encompasses basic refrigeration. "So the first thing we say is, 'dude – relax, breathe. You understand more than you think you do.'" (See, "It's Not Rocket Science, It's Just Refrigeration," *Accelerate America*, February 2015.)

To assist the learning process, Hillphoenix is putting scannable QR codes linked to YouTube training videos in its manuals and on its equipment. "People are visual learners," said Walker.

Walker would like to see the HVAC&R industry develop a certification program and ongoing training for technicians working on transcritical refrigeration. "If you look at the quality of technicians, they're not the same as they used to be," he said. "We don't have schools that teach refrigeration. So we've got to be more active in training. We need industry certification to prove they've been through it."


Rusty Walker, Hillphoenix

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LET'S INNOVATE!

Emerson officially opens its Helix Innovation Center, designed to foster creative thinking in HVAC&R

By Michael Garry

Transcritical CO_2 rack at The Helix

In the Ohio city where the Wright Brothers invented the airplane, Emerson Climate Technologies last month officially opened its HVAC&R Innovation Center, The Helix.

Located on the sprawling campus of the University of Dayton in the city of Dayton, the Helix is the product of a partnership between Emerson Climate Technologies, based in nearby Sidney, and the University. The 40,000-square-foot, two-story, $35 million facility was designed to promote exploration and problem-solving in refrigeration, air conditioning, heating and related fields, with an array of real-world labs and high-tech collaboration spaces.

The Helix was built so that "a lot of innovation can be brought to bear to make a better world," said Dave Farr, chairman and CEO of Emerson Electric, St. Louis-based parent of Emerson Climate Technologies, in a presentation at the grand opening on April 27 in a tent outside the Helix.

Farr alluded to the role natural refrigerants would play at the Helix. With regulators restricting traditional refrigerants, the innovation center will address "how we do cooling and heating with CO_2 and propane" as well as "how to make CO_2 compressors smarter and easier to use," he said.

Daniel Curran, president of the University of Dayton, commented at the grand opening that the Helix was "a place to explore ideas and ask big questions," and he welcomed the opportunity for students to "interact with the professionals at Emerson."

Rajan Rajendran, vice president, systems innovation center and sustainability for Emerson Climate Technologies, who was instrumental in the development of The Helix, observed that the facility was unique for bringing all aspects of HVAC&R research "under one roof."

REAL-WORLD SCENARIOS

The Helix comprises several modules that emulate real-world refrigeration and HVAC scenarios, including a supermarket; working commercial kitchen; industrial refrigeration system; data center; and a two-story, 2,000-square-foot home, outside of which the temperature can be set between -20°F and 120°F. In addition, the facility comprises several video conferencing rooms designed to promote brainstorming and collaboration.

The 2,500-square-foot supermarket encompasses a transcritical CO_2 system from Systemes LMP, which features Emerson compressors and controls, including three semi-hermetic compressors for medium-temperature loads and three scroll compressors for low temperatures. The condenser/gas cooler is contained in an enclosed, outside environmental chamber where the temperature and humidity can be adjusted to test the efficiency of the system in warmer conditions when the ambient temperature exceeds 88°F, the critical point of CO_2. The system also has a parallel compressor to improve efficiency under warmer conditions.

The supermarket also features a raised floor, making it easy to alter plumbing and electrical lines to reconfigure case layout, and allowing Emerson to simulate refrigerant leaks and evaluate leak-prevention technology.

The Helix had a "soft opening" in December leading up to the grand opening on April 27. Since December, it has hosted more than 3,000 individuals, including Emerson employees (about half), end users, OEMs, component makers, academics and consultants. Emerson is also inviting experts from outside the HVAC&R industry who can offer a different perspective. MG

ATMOsphere Europe, in Barcelona

EUROPEANS BURNISH NATREF CREDENTIALS

At ATMOsphere Europe, Supermarket giants METRO AG, Delhaize and Sainsbury reveal plans to install even more CO_2 and hydrocarbon stores

– By Andrew Williams

In the global HVAC&R marketplace, European food retailers have pioneered the use of natural refrigerant systems. Now they are forging ahead with additional installations, which they discussed last month in Barcelona, Spain, at ATMOsphere Europe, hosted by shecco, publisher of *Accelerate America*.

Take, for example, German retail giant METRO AG, which has been using only natural refrigerants – where technically possible – since 2013 in new and remodeled stores,

METRO AG is aiming to reduce its greenhouse gas emissions by 50% by 2030 compared to 2011 levels, primarily by reducing energy demand in stores, introducing green energy sources, and reducing refrigerant leaks. Central to this mission is the company's F-Gas Exit Program for transitioning away from HFCs by 2030, which was the driving force behind the decision to begin adopting natural refrigerants in 2013.

METRO AG currently operates 40 CO_2 transcritical and 58 CO_2 subcritical stores, with an additional 52 CO_2 stores planned for 2016. "We hope to be able to say next year that we are introducing CO_2 transcritical to China, India and Russia," said Olaf Schulze, the German retailer's director of facility, energy and resource management.

continued on p.52

Let's make the switch

The natural next step in supermarket cooling

With its low global warming potential (GWP) and capability to recover heat at high temperature, CO_2 is the natural refrigerant for green supermarket cooling systems. What's more, the heat recovered by a transcritical CO_2 refrigeration system can be used for tap water and space heating. Equipment from Alfa Laval makes transcritical and cascading CO_2 systems greener, more efficient, reliable and safe.

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BELGIANS PURSUE CO_2, HYDROCARBONS

Belgian retailer Delhaize is putting natural refrigerants at the heart of its strategy to reduce the global warming potential of its stores and slash the company's CO_2 emissions by 20% by 2020 and by 40% to 70% by 2050. "Delhaize Group is committed to increasing the number of natural refrigerant systems where they are feasible and cost-effective," said David Schalenbourg, director of the Delhaize Group's technical department for Belgium and Luxembourg.

Delhaize's use of natural refrigerants fits with its broader corporate social responsibility objectives. "Our aim is to lead the way, help transform the marketplace and show others what is possible," said Schalenbourg.

In Belgium, Delhaize currently has eight CO_2 transcritical stores and nine R290 stores, with another three CO_2 transcritical stores in operation in the U.S. (two by Hannaford Supermarkets, one by Food Lion). In Romania, meanwhile, the group operates 93 R290 systems.

The company is working to optimize the efficiency of its CO_2 systems by, for example, testing new ejector technology. It is also planning to roll out more plug-in R290 systems in its stores, and is evaluating CO_2 refrigeration equipment for transport.

U.K. supermarket giant Sainsbury's recently installed its 200th CO_2 transcritical refrigeration system, at Abbey Wood in southeast London. Paul Arrowsmith, refrigeration design manager, said that adopting CO_2 refrigeration had already saved the firm 330,000 tons of CO_2-equivalent emissions, equal to lighting 1.7 million domestic buildings for a year.

Arrowsmith outlined how installing a CO_2 refrigeration system at its Olympic Way store in Wembley (part of London) had reduced average weekly electricity consumption for refrigeration by 37.8%, resulting in a payback period of 14-15 months and annual CO_2-equivalent emission savings of 70 tons.

Harnessed in partnership with other innovations like heat reclaim and destratification fans, the transcritical refrigeration system has become an integral part of a wider sustainability package capable of reducing average weekly electricity consumption by 56.8%. AW

A HOT TOPIC IN BARCELONA

"One final barrier limiting the full deployment of CO_2 transcritical systems is the question of efficiency and sustainability in warmer climates," said Diego Malimpensa, business unit manager - retail solutions at Carel Industries S.p.A., at ATMOsphere Europe in Barcelona last month.

But Malimpensa and other speakers pointed to progress in overcoming that barrier, known as the CO_2 equator, with high-efficiency CO_2 refrigeration systems, which are being used in higher ambient temperatures than had previously been considered technically and economically feasible. These systems incorporate technologies like ejectors, parallel compressors, adiabatic condensers and subcooling.

"CO_2 transcritical systems should operate in the same way, whether they are in a northern European climate or a southern one," declared Jonas Schönenberger, head of research and development at Frigo-Consulting.

A combination of liquid ejectors, vapor ejectors and heat exchangers led to an efficiency increase of between 15%-25% at Swiss retailer Migros' Mythencenter superstore, for example. The Mythencenter system demonstrates that, with site-specific customization, CO_2 transcritical systems can be very successful, Schönenberger noted.

Carel and Carrier Commercial Refrigeration Europe have joined forces to develop and industrialize a range of modulating ejectors to address the CO_2 equator. "We're now moving from concepts to real industrial sustainability solutions," Malimpensa said.

Presenting a new series of adjustable CO_2 ejectors for commercial refrigeration systems, Sascha Hellman, project leader for systems development at Carrier Commercial Refrigeration, said that the company's transcritical CO_2 system with the CO_2Oltec ejector rack was capable of reducing the average energy consumption of a total refrigeration system by 13%.

In addition, Torben Funder-Kristensen, Danfoss' head of public and industry affairs, showed how variable capacity ejectors improve the efficiency of CO_2 as a refrigerant in supermarket applications.

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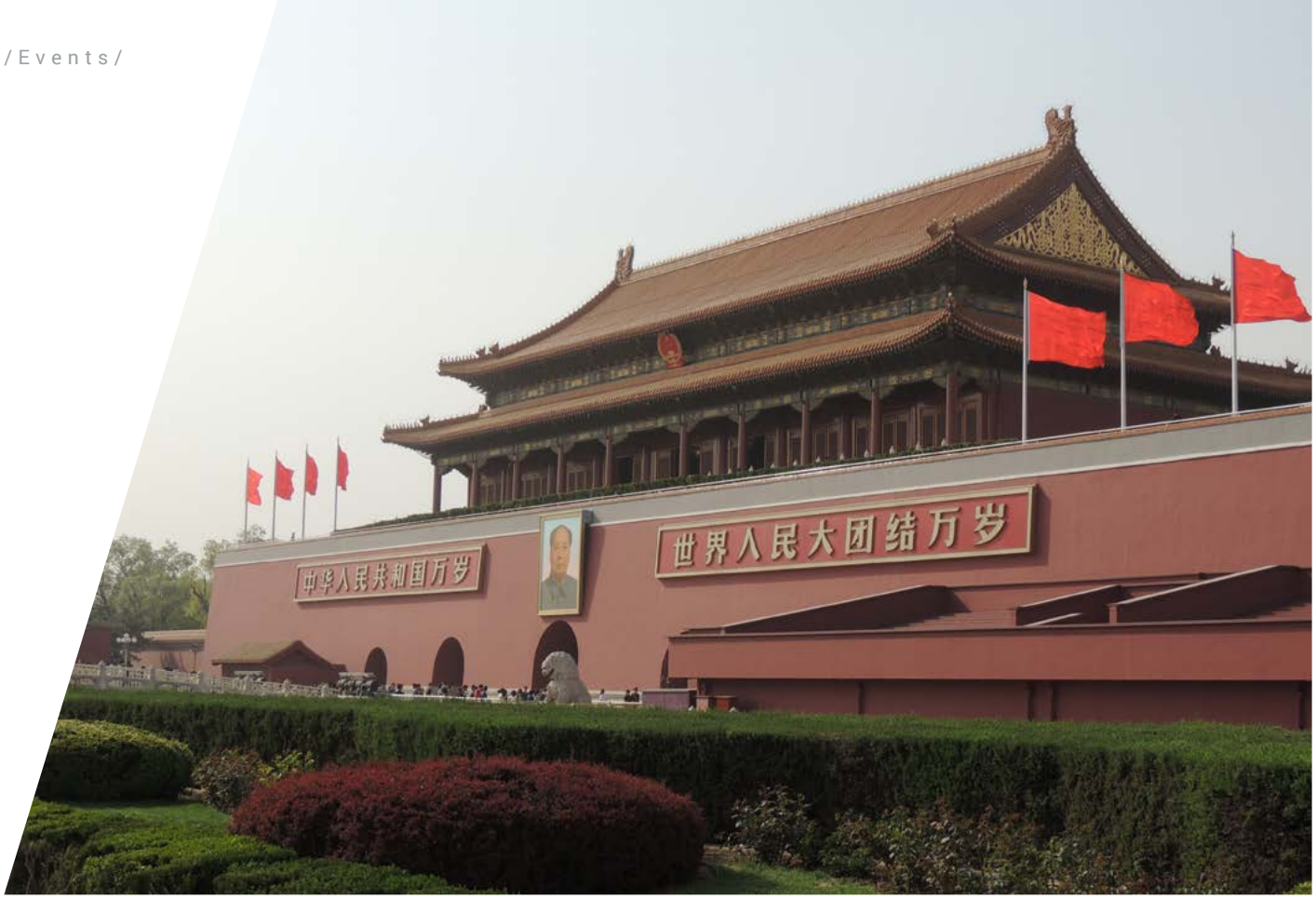


CHINA'S NATREFS MOMENT

The China Refrigeration conference highlighted progress with CO_2 and hydrocarbon adoption in a country phasing out HCFCs to help reduce air pollution

– By Andrew Williams

> "In China, natural refrigerants can contribute to reducing greenhouse gas emissions and lead to bluer skies."

China produces the vast majority (92%) of HCFCs for developing countries. No doubt, then, that the industrial powerhouse's move to completely eliminate their production and consumption of HCFCs by 2030, under the auspices of the Montreal Protocol, will have a major global impact, bolstering uptake of natural refrigerants.

At China Refrigeration, held in Beijing April 7-9, the importance of embracing natural refrigerant technology in the cold chain was a major theme, along with the need to welcome proven overseas natref manufacturers into the market, and subsidize new technology to accelerate the transition.

The Chinese government recognizes the role that natural refrigerants can play in putting the country on a sustainable footing. "In China, natural refrigerants can contribute to reducing greenhouse gas emissions and lead to bluer skies," said Xiao Xuezhi, deputy director-general of China's Foreign Economic Cooperation Office (FECO), at the conference's Ozone2Climate Industry Roundtable.

In 2015, FECO issued a list of recommended substitutes for HCFCs. It is currently finalizing proposals for Stage II of the "HCFC Phase-Out Management Plan" and the revision of national standards for natural refrigerants – both representing a significant shift in China's approach.

CO_2 FOR CHINA

For Rüdiger Rudischhauser, vice-president sales international at Snowkey (part of Chinese manufacturer Fujian Snowman Co. Ltd.), "food processing is the megatrend" not just in China but also globally, and natural refrigerants have a key role to play.

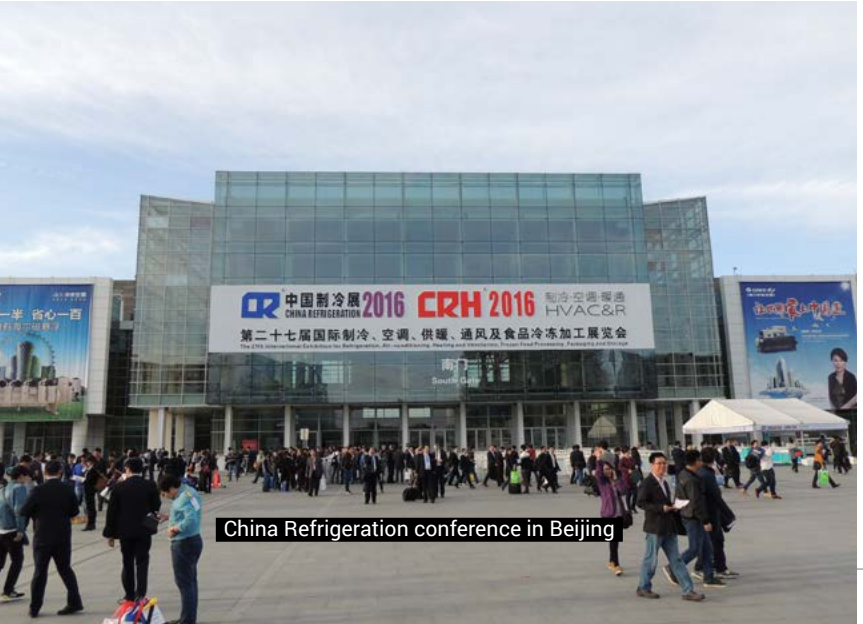
Rudischhauser believes natural refrigerants are needed to deliver more sustainable food processes in applications like food preservation, cold storage and blast freezing for a global population that is expected to hit nine billion people by 2050.

Snowkey plans to soon install a CO_2 transcritical system in a major supermarket in China. "I'm very positive about bringing CO_2 transcritical to China, because the ambient temperatures in the northern part of China are very favorable," Rudischhauser said.

This is leading manufacturers like Snowkey to offer complete technology packages to China. "We see the future not just in compressors, but in complete packages and solutions – on the industrial and commercial side," he explained. This "clearly shows that in China we have already made that step of forward integration from being a compressor manufacturer to a system provider,"

Major European manufacturers like German compressor manufacturer Bitzer also see opportunities in the Chinese market for their natural refrigerant technologies. Bitzer has supplied a subcritical CO_2 cascade system to a METRO China supermarket in the city of Weifang, and some CO_2 heat pumps.

"Globally, Bitzer is very strong in promoting CO_2 applications," said Bill Feng, general manager – sales and marketing, Great China Region at Bitzer. "We have [the] METRO store with CO_2 for refrigeration [and are] also starting on some heat pump applications in industrial segments, for instance in railway stations in the north."



China Refrigeration conference in Beijing

USHERING IN HYDROCARBONS

Transitioning end-of-cycle HCFC equipment to hydrocarbons is also necessary in a country still heavily reliant on R22 for domestic air conditioning and other light commercial applications, such as household freezers and beverage vending machines.

As part of its HCFC Phase-out Management Action Plan, the Chinese Ministry of Environmental Protection published a list of nine air conditioner makers eligible to receive the so-called Incremental Operating Cost (IOC) subsidy in 2015.

The subsidy is designed to help companies cover the cost of transitioning air conditioner production lines to R290 (propane) and the increased cost of producing R290 units in the first few years of production.

Central to the transition is Chinese appliance manufacturer Gree's demonstration project providing 243 R290 air conditioning units to Shenzhen University.

Meanwhile, German compressor manufacturer SECOP, which primarily supplies systems for household, light commercial and DC-powered refrigeration, plans to focus solely on hydrocarbons. "That's what we're good at," said Pieter Boink, head of business development and marketing at SECOP. "We have different dynamics in different markets. One thing we're really good at in China is looking at total cost. It's very easy to choose natural refrigerants, because propane gives you very high efficiency – bringing costs down – and it's green."

Danish component maker Danfoss also sees potential for hydrocarbon air conditioning in China. To that end Danfoss has made investments in compressor labs in order to deal with A3 and A2/A2L flammability and to investigate compressor solutions for both the residential and light commercial air conditioning and refrigeration applications, said Bonny Dai, senior regional marketing manager (China) at Danfoss Commercial Compressors.

Jan Dusek, business development manager, shecco Japan, said that there were already over 750,000 retail display cases, vending machines and bottle coolers using hydrocarbons or CO_2 in China. "The use of natural refrigerants in light commercial refrigeration is a strong trend in most major economies," said Dusek, adding, "And China is the fastest growing world market for commercial refrigeration." AW

Caleb Nelson, Azane

AZANE EYES THE MIDDLE GROUND

Maker of low-charge ammonia refrigeration units targets light industrial and commercial sectors.

– By Mark Hamstra and Michael Garry

When it comes to natural refrigeration, Caleb Nelson is leading the charge — the low charge, that is.

As the new vice president of business development at San Francisco-based Azane Inc., a division of global refrigeration manufacturer Star Refrigeration Group, Nelson is seeking opportunities for the installation of the company's low-charge ammonia Azanechillers and Azanefreezers in light industrial and commercial settings.

While Nelson believes low-charge ammonia refrigeration (incorporating CO_2) is beginning to gain ground in the supermarket sector via the four installations currently in place in the U.S., he sees the light industrial sector as particularly ripe for the implementation of the ammonia refrigeration units offered by Azane.

> "There's a lot of opportunity in the middle, where there are a lot of R22 users operating small ice rinks or small warehouses."

"There's a lot of opportunity in the middle, where there are a lot of R22 users operating small ice rinks or small warehouses, where they do not necessarily require a full-blown ammonia system, Nelson told *Accelerate America*. "Similarly, medium-sized facilities with traditional ammonia systems will most likely have an opportunity to reduce charge well below the [10,000-lb.] critical limit to avoid burdening regulation since none of our packages contain more than 500 lbs. of ammonia but can achieve large capacities."

As a natural refrigerant with no ozone depleting or global warming potential, ammonia is an option for businesses seeking to shift away from refrigerants that are being phased out, such as R-22, or those seeking to guard against the potential for future regulation of other synthetic refrigerants like HFCs.

Most of the inquiries so far have been for the company's Azanechiller systems, which can be used for process cooling, HVAC systems, cold storage and other uses in the above-freezing range, but their freezer business is expected to pick up very soon for cold storage warehouses and blast freezing.

Azane has recently sold its low-charge ammonia chillers into three facilities in North America: an installation at Hato Rey Plastics in Puerto Rico; a unit that is being built in Pennsylvania for installation in a Campbell's Soup facility in Ohio, and a unit in design/development for a ConAgra facility. In addition, Azane has provided quotes for other facilities, including breweries and temperature-controlled warehouses.

SUPERMARKET POTENTIAL

In his former role at design/engineering firm CTA Group, Nelson in 2012 helped design the nation's first ammonia/CO_2 refrigeration system for a supermarket at an Alberstons store in Carpinteria, Calif. That installation followed a research paper Nelson had written on the feasibility of using ammonia as a refrigerant for food retailing. Since then, three other supermarkets have installed ammonia/CO_2 refrigeration systems in the U.S.

The Carpinteria installation, which was built to demonstrate the feasibility, and primarily, the efficiency benefit of using ammonia in supermarkets, was constructed using readily available industrial parts, he explained. "Ironically, the newer technologies with ammonia like semi-hermetic compressors or ultra-low-charge, dry expansion options would've only dampened the energy performance of the ammonia system, which was against the goal of the project."

"We didn't want to reinvent the wheel," he said, "it was not the project to 'test' anything while risking the reliability of the system," although he added that the system did innovate with the use of an automatic oil return system to minimize the maintenance requirements.

In a comparison against an adjacent installation of a state-of-the-art HFC system, the ammonia/CO_2 system operated 25% more efficiently, Nelson said.

Nelson sees potential for the Azanechiller in the supermarket environment using a similar cascade ammonia/CO_2 rooftop system. Current Azane installations use a water/glycol mix as a secondary refrigerant but there's no reason they couldn't employ a CO_2 system, he said.

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> "I think the perception [of ammonia] is going to change over time."

"I think we'd have to make some tweaks to the system to make it long-term feasible for the retail customer," he added. "We make a true industrial product currently, and while some states may scrape up natural refrigerant incentive dollars, the system will need to become more 'commercial' if it's to become a fair comparison to the price of an HFC system."

Although ammonia had once been viewed as a controversial option for supermarket refrigeration systems because of the potential that a leak might send a worrisome odor into the store, the success of the current installations appears to have quieted some of those fears. Nelson said he was unaware of any reports of odor at the four supermarkets pioneering the technology in the U.S.

Asked if it might be possible to create an ammonia refrigeration system for supermarkets that could be guaranteed not to leak, Nelson was unsure.

"I don't know that you ever could due to operational 'human' factors that are many times out of our control as the manufacturer," he said. "If you did, the system wouldn't be feasible. But that's today. Taxation on HFCs could change the economic model completely, and penalties could change that equation." Nelson also noted that "our parent company, Star Refrigeration, has gone the last 20+ years installing systems like the Azane products without any real ammonia leaks in any of their systems. Although an open-drive compressor is known to leak through the shaft seal over time, a properly built and maintained system shouldn't operate with the smell of ammonia."

Among the other challenges involved in selling the systems into the supermarket space is the fact that not all retailers own their facilities; and in fact, many often carry short-term leases and don't necessarily have an interest in making longer term investments into the building's infrastructure. MH & MG

WIDENING AMMONIA'S APPEAL

The ammonia refrigeration industry needs to continue to do all it can to make ammonia a viable financial alternative beyond traditional industrial facilities for businesses such as supermarkets, said Caleb Nelson, vice president of business development, during a presentation at the IIAR Industrial Refrigeration Conference in March.

That includes stressing ammonia's beneficial environmental impact and energy performance. Decision makers need to look at both when selecting a refrigeration system, he said. Moreover, the two are interrelated, and can be measured together in TEWI (total equivalent warming impact), which takes into account the greenhouse gas emissions caused by energy use and by direct emissions through leaks.

"If you look at selecting a refrigerant that's natural and has zero ozone depletion and zero GWP, then that effectively eliminates any fear you might have about refrigerants leaking into the atmosphere," Nelson said. "When you look at energy performance, that's where the indirect global warming impact comes into play, and thinking about how natural refrigerants impact the environment has both of these in that equation."

Another factor to consider as the ammonia refrigeration industry seeks a bigger slice of the natural refrigeration market is the cost of installation and maintenance, including contractor know-how, he said.

An end user can ruin a payback by hiring a contractor who "doesn't know how to handle the ammonia system, or isn't willing to learn, or nobody's willing to teach him," Nelson said. "That's going to be an important piece to focus on, as well as the system cost."

Nelson said he believes transcritical CO_2 systems will likely continue to be a popular option for commercial end users seeking a fully natural option in northern climes where CO_2 functions more efficiently, while ammonia will be explored as a potential option where temperatures are likely to push a CO_2 system into the supercritical range for longer durations throughout the year.

If the industry can focus on curbing system costs while increasing the population of qualified service technicians, "I think the perception [of ammonia] is going to change over time, as we see more of this technology being used where HFCs currently dominate," he said.

From left: Marc-Andre Lesmerises, Ann-Sophie Hamel-Boisvert, and Thierry Vasseur, Carnot Refrigeration, at Data Center World

CO_2 FOR SERVER ROOMS

At Data Center World, Carnot's Marc-André Lesmerises explained the advantages of CO_2 cooling units for server rooms, including free cooling

– By Michael Garry

> "We get free cooling 80%-85% of the time in Montreal."

Since its founding in 2008, Quebec-based Carnot Refrigeration has been one of the most versatile OEMs in the HVAC&R industry when it comes to marketing transcritical CO_2 refrigeration systems.

Carnot's greatest success has been as a provider of transcritical CO_2 systems to Sobeys, Canada's second largest food retailer, and the North American leader in transcritical installations, with more than 80 stores using the technology, including over 50 Carnot units. But Carnot has not stopped there, building transcritical units for industrial warehouses, ice rinks and data centers as well.

It was the data-center market that Carnot's founder, CEO and president, Marc-André Lesmerises, was targeting in March in a presentation at Data Center World in Las Vegas. The explosive growth of server farms and cloud computing in the IT and telecommunications sectors to support the digital economy makes this one of the most potential-rich marketplaces for advanced cooling systems like Carnot's.

A study by market research firm BSRIA predicts that, over the next five to 10 years, the use of traditional computer room air conditioning (CRAC) units will drop as end users opt for other technologies like free cooling, liquid cooling and chilled water cooling, opening up opportunities for CO_2 systems.


Marc-Andre Lesmerises, Carnot Refrigeration

Another factor is federal regulation. Lesmerises pointed out that the Environmental Protection Agency has taken steps to delist refrigerants like R134a and R410 in the food retail sector by 2019. Those refrigerants are used in CRAC units and, though the current delisting does not apply to the data center sector, "you need to have a plan," Lesmerises suggested at his presentation, noting that CO_2 would be a regulation-proof alternative.

PROBLEM WITH R22

In September 2014, Bell Canada, the country's largest telecommunications provider, became one of the first companies to install a CO_2 transcritical cooling system for data centers -- Carnot's Aquilon unit -- at its Ottawa facility.

Bell Canada initially approached Lesmerises after finding out what he was able to accomplish with Sobeys. "They said, 'We have the same problem with 3,000 sites that have CRAC units with R22 and we need to replace the refrigerant or the unit,'" he said at Data Center World.

Bell Canada's 105kW system, which features Carnot's patented Rain Cycle free cooling technology, replaced an R22 system. The UL-approved Aquilon system, which costs about the same as HFC CRAC units with free cooling, ranges from 52kW (15TR) to 158kW (45TR).

Free cooling uses outdoor air for cooling when its temperature drops below that needed by the server room. (In its 2011 thermal guidelines for data centers, ASHRAE recommended temperatures between 64.4°F and 80.6°F for server rooms.) Bell Canada's system functioned 95% of the time in free cooling mode during its first six months of operation, helping to cut energy use in the server room by about 70%.

Transcritical systems lose efficiency in warmer temperatures (above 88°F) but in northern climates, Carnot's target for the Aquilon, that does not happen frequently. Free cooling is a far more common occurrence. "We get free cooling 80%-85% of the time in Montreal," said Lesmerises. "San Francisco looks like paradise for free cooling; New York and Seattle, too. It's not necessarily appropriate for Las Vegas."

Bell Canada is now running the Aquilon system at two sites, as is Rogers Communications, the second largest telecommunications company in Canada. "Both are impressed with the efficiency of the unit," said Lesmerises.

EASY RETROFITS

CO_2's advantageous thermodynamic properties make it a useful refrigerant for data centers, Lesmerises said. For example, its high volumetric capacity results in smaller piping sizes. This compensates for the higher price of stainless steel piping and also enables "a more compact system or more capacity for the same size," he said.

A data center can take advantage of the ability of the CO_2 system to offer more capacity if it needs more cooling capacity in the same space. "You can take out the existing unit, put ours in, and you have more capacity for the same footprint," said Lesmerises. "We can easily retrofit an existing data center."

In addition, a CO_2 system can achieve free cooling with just 1°F of temperature difference (TD) between the refrigerant and air in the evaporator, compared with a much greater TD for synthetic refrigerants like R134a. Also, the CO_2 CRAC unit, unlike HFC units, uses a fan rather than a pump to save energy.

Heat recovery, which is not always easy to do in a data center, is possible with the CO_2 system. "We have a system that can generate megawatts of heat recovery," said Lesmerises.

To calm any end user concerns about technicians' familiarity with CO_2 systems, Carnot maintains a 24-hour remote communication help desk at its headquarters to assist technicians on site. "We get rapid feedback from the site to make sure it is set up properly," said Lesmerises. MG

A shipping container using the NaturalLine CO_2 transcritical refrigeratipn system, being hauled to its final destination by truck.

NATURAL REFRIGERATION SETS SAIL

World's first shipping containers cooled by CO_2 are in test stage; maker Carrier Transicold touts advanced technology

– By Mark Hamstra and Michael Garry

Anyone who has ever seen a container ship sailing into port must wonder what's inside those thousands of massive metal boxes.

Currently, some are making history, not because of the cargo they carry, but because they contain the world's first natural refrigerant system designed for shipping containers.

Carrier Transicold, a global provider of transport refrigeration systems, has developed a transcritical CO_2 container refrigeration unit specifically engineered for the rigors of ocean travel. The NaturaLINE unit replicates — and exceeds, under certain conditions — the efficiency of Carrier Transicold's PrimeLINE refrigeration unit, heretofore its most efficient refrigeration system for shipping containers. Both are used to transport perishable items at a range of temperatures, from frozen foods to fresh fruits and vegetables.

> "The NaturaLINE system is groundbreaking in the sense that it was designed for our shipping customers."

Several shipping companies of various sizes are in the early stages of testing the highly efficient and environmentally sustainable CO_2-refrigerant system.

"The NaturaLINE system is groundbreaking in the sense that it was designed for our shipping customers," said Edward Goh, director of marketing, Global Container Refrigeration, Carrier Transicold in an interview with *Accelerate America*. "It was designed to handle the increased vibrations, temperature variations, and corrosion from being exposed to salt spray, and the impact that typically comes when you move containers from ships to land, and from port terminals to the ship."

Carrier Transicold's road transport refrigeration business unit is also developing a transcritical CO_2-refrigerant system for trailers, a new frontier in the trucking space; U.K. grocer Sainsbury's is the first to test the unit. Previously, Sainsbury's employed NaturaLINE CO_2 systems on two trailers adapted to accommodate the marine units. (See story, page 66.). In addition, trucks (as well as rail cars) can be used to haul refrigerated maritime containers, after they are off-loaded from a ship, to their final destination.

The predominant refrigerant used in the maritime container business for more than 20 years is R134a, an HFC that today represents about 75%-80% of the refrigerant used in temperature-controlled shipping containers, according to Goh. Systems using R404A comprise much of the rest of the market.

REGULATION COMING

Although end users pay a premium for the NaturaLINE unit over the price of Carrier Transicold's R134a-refrigerant PrimeLINE system, those Carrier Transicold customers who invest in the NaturaLINE systems would be hedging against the potential for future regulations that could restrict or penalize use of HFC refrigerants.

"Not only is it highly efficient, it is also environmentally sustainable," said Goh of the NaturaLINE unit. "Its sustainability — particularly its minimal global warming potential (GWP) — is especially important, because both in the U.S. and the European Union, there [are regulations] in place to phase down the global warming potential of refrigerants in the next 10-15 years."

Effective last year, the European Union's F-gas Regulation (EU517/2014) imposed tight restrictions on the use of high-GWP HFC refrigerants. The HFC phase down will require reducing the average GWP of refrigerants from 2,000 to 400 by 2030.

In the U.S., the Environmental Protection Agency has been heading in a similar direction, and in April announced its latest proposed rule prohibiting certain high-GWP HFC refrigerants under its Significant New Alternatives Policy (SNAP).

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Although regulations have not yet targeted the maritime container industry, the evolving regulations make CO_2 — a natural refrigerant gas with a GWP of one — an attractive alternative for shipping companies to consider, Goh explained.

"When you look at the HFCs in use today, R134a has a GWP of 1,430, so to be able to go from that straight to one [CO_2's GWP] takes away any operational issues or phase-down regulations that you might have over the next several years," he said. "I think we're on the cusp of a major change in refrigeration technology."

One of the calculations shipping companies have to make when they evaluate a potential investment in the transcritical CO_2 NaturaLINE system is the relatively long lifecycle — about 15 years — of shipping containers. Not only does this long lifecycle prompt the need for thorough testing under a range of conditions, but it also requires end users to think carefully about what the future may bring in terms of regulation before they make such a commitment.

New investments made now in HFC-based systems could prove to be costlier down the road as regulations take shape, Goh explained. Thus the initially more expensive NaturaLINE units could become the more financially attractive option over time.

"The fact that we have a NaturaLINE CO_2 unit available today essentially means that shipping lines can protect themselves from higher refrigerant costs down the road that might result from a potential refrigerant phase down," said Goh.

Carrier Transicold's transcritical CO_2 refrigeration system for shipping containers.

> "I think we're on the cusp of a major change in refrigeration technology."

ADVANCED TECHNOLOGY

Carrier, which shares innovation across its divisions through its research and development center, engineered the NaturaLINE refrigeration unit not only to withstand the rigors of shipping, but also to operate under the higher pressures inherent in transcritical CO_2 systems and to provide high levels of energy efficiency. It is particularly efficient under perishable "part load" conditions, when it is maintaining cooler temperatures rather than reducing the temperature at "full load."

In addition, the NaturaLINE system was built to operate efficiently when ambient temperatures exceed 88 °F the critical temperature for CO_2 refrigerant. Transcritical CO_2 systems have been criticized for drawing too much power under such conditions.

"We engineered our system to minimize the power draw over the full range of operating parameters," said Goh, "so when its performance is weighted for real-world shipping conditions, the NaturaLINE unit ranks among the most efficient units on the market today."

Among the innovations and advanced technologies included in the system:

- A multistage compressor that maximizes capacity while minimizing power consumption;
- A custom variable-speed drive that adjusts cooling capacity as needed;
- A compact and lightweight gas cooler coil;
- A flash tank that manages the flow and phase change of the refrigerant after leaving the cooler;
- Two-speed fans on the evaporator and gas cooler for versatility and energy savings;
- Advanced operating software that features the same control interface as other Carrier Transicold containers; and
- Zero-GWP polyurethane foam blowing agent technology that has high insulation properties.

"When you add that all together, there's a lot of new technology in our NaturaLINE system," said Goh. "The good news for the industry is that Carrier thoroughly tested these new technologies over two years with several shipping lines in a variety of climates, carrying everything from ice cream to meat, cheese, bananas, cookie dough and Belgian beer."

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Report on Natural Refrigerants Training in **North America**

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Transitioning to higher-pressure CO_2 systems has been known to present some challenges for technicians in other industries. However, Carrier Transicold said the NaturaLINE system, which operates with pressures of up to about 800-1,800 psi compared with 100-200 psi for R134a systems, has not presented such problems for operators, thanks to its user-friendly design.

After conducting some customer training classes for technicians and operating personnel, "we got really good feedback," James Taeckens, senior product manager – Global Container Refrigeration, Carrier Transicold, told *Accelerate America.*

"They were pleased with how well this system works within the existing fleet," he said, noting that the NaturaLINE system pressures are significantly less than the operating pressures of many other systems in the shipping container environment, such as straddle carriers, ship fuel systems and forklifts.

The NaturaLINE system was designed so that it could be serviced much like an HFC unit, Taeckens explained.

The NaturaLINE system employs a series of both software-based and mechanical pressure-relief valves. The higher pressure "has not been an issue," Taeckens said.

Asked if Carrier Transicold had considered creating a system that used a low-GWP synthetic refrigerant, such as hydrofluoroolefins (HFOs), Goh said the company was confident that CO_2 refrigerant offers the better solution for its customers.

"We looked at several [alternative refrigerants], but we have an end-state product," he said. "When you factor in the unique set of performance indicators that we worry about in our space — you've got environmental impact, energy efficiency, cost and safety, in a tightly packed shipping container situation where you could have up to a couple thousand reefer units in the hold of a large container ship — CO_2 refrigerant, which is rated A1 for low flammability and low toxicity, just seems like the natural choice," he said. MG & MH

SAINSBURY'S DEBUTS TRUCK-TRAILER CO_2 PROTOTYPE

U.K.-based supermarket operator Sainsbury's is preparing to deploy its third refrigerated trailer cooled by a CO_2-based system from Carrier Transicold.

Unlike the first two, which used modified versions of Carrier Transicold's NaturaLINE marine container transcritical refrigeration units in 2013 and 2014, the newest trailer employs a prototype system developed by Carrier Transicold specifically for use on refrigerated trailers. It is the first of three slated to join Sainsbury's fleet in 2016.

The prototype is a proof-of-concept system and will be "studied, refined and further tested" by Carrier Transicold engineers before it becomes commercially available, said Jon Shaw, director sustainability & communications, UTC Climate, Controls & Security. (Carrier is a brand of UTC Climate, Controls & Security.)

The new prototype system also uses technology from the NaturaLINE refrigeration system, placed inside Carrier's Vector trailer refrigeration platform. The technology that Carrier Transicold uses in its NaturaLINE system was itself adapted from Carrier's commercial refrigeration division, which supplies CO_2 refrigeration units to more than 1,900 supermarkets across Europe.

The new prototype CO_2 trailer "will be in action in the next couple of months," a Sainsbury's spokesman told *Accelerate America.*

The trailer was displayed in late April at the Commercial Vehicle Show in Birmingham, U.K., the spokesman said.

"Delivering the first dedicated natural refrigerant trailer prototype into service marks a huge milestone in the development of over-the-road refrigeration using CO_2," said David Appel, president, Carrier Transicold & Refrigeration Systems in a release. "Our ultimate vision is to see temperature-controlled units running on natural refrigerant in mainstream production."

To help facilitate greater adoption of CO_2 in the U.S., Carrier successfully petitioned the U.S. Environmental Protection Agency in 2015 to recognize CO_2 as acceptable for transport refrigeration applications.

By 2020, Carrier is committed to commercializing CO_2 in road transport refrigeration, said Shaw. MH

Sainsbury is testing a CO_2 transcritical CO_2 refrigeration system designed for refrigerated trailers.

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ACCELERATE AMERICA

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Issue #16
June 2016

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Supplement to Issue #18
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Nov. - Dec. 2016

Publication date: Nov. 15

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Additional Topics:

- Ice Rinks
- Data Centers
- New Technology
- Mobile Air Conditioning
- Buildings (residential)
- Buildings (hospitals, universities, offices, government, hotels, sports, shopping centers, airports)
- Research

*Publisher reserves the right to modify the calendar.