

SEPTEMBER 2016

ACCELERATE

ADVANCING HVAC&R NATURALLY

A M E R I C A

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Rooftop Units

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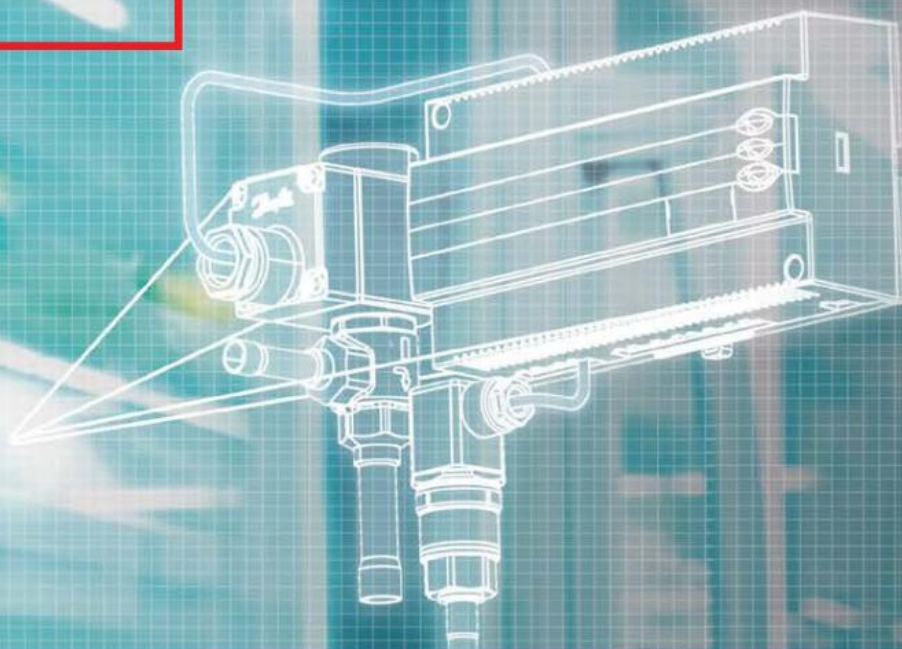
Keith Milligan,
JTM Corp.
(Piggly Wiggly)

p. 32

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Editor's note by Michael Garry

CHALLENGING THE STATUS QUO

There are many reasons why I enjoy covering the natural refrigerants industry. First and foremost, I believe natural refrigerant HVAC&R technology is the best replacement for halocarbon refrigerant systems that harm the ozone layer and/or contribute significantly to global warming.

But another very exciting aspect of this industry is the almost non-stop development of innovative natural refrigerant systems that are disrupting the marketplace and offering a myriad of new options to end users.

In this issue, we have several examples of eye-catching innovation. For example, our cover story ([page 32](#)) tells the story of JTM Corp., a Piggly Wiggly franchise operator, that installed an ammonia/CO₂ cascade refrigeration system in a store in Columbus, Ga., last year – only the fourth supermarket in the U.S. to implement such a system. It has a tremendous upside, saving the store on average 22% in energy over a four-month period this year compared to an HFC system installed in the same building. The big question is whether the ammonia – just 53 pounds and confined to the roof – will prove to be a safe and unobtrusive refrigerant over the long term; so far it has.

Last month, another highly unusual system – a propane/CO₂ cascade system, at a store in Santa Clara, Calif. – was announced by Whole Foods Market ([page 10](#)). Here, too, the high-side refrigerant, propane, is confined to the roof. This is believed to be the first such installation in the U.S.

Another novel refrigeration design, believed to be unique in the world, is the low-charge ammonia system that is just about installed on the rooftop of a 248,000-square-foot Baker Cold Storage warehouse in Long Beach, Calif. ([page 42](#)). This system, which is being managed by another cold-storage operator, Lineage Logistics, comprises no less than 46 NXCOLD low-charge units, which will serve applications ranging from cold storage and blast freezers to railroad/truck docks and produce repacking. Rather than the 22,000 lbs. of ammonia originally slated for this building, the system contains just 496 pounds for 1,015 TR.

Also in this issue we have articles on two refrigeration systems that have yet to hit the marketplace. What is particularly notable about them is that they both depart from using vapor compression in favor of a totally different technology.

One of these systems, marketed by Cooltech Applications, employs the magneto-caloric effect, whereby certain materials heat up in a magnetic field, and cool off outside it ([page 60](#)). Based in France, Cooltech is starting to market the system in the U.S. as a refrigeration option for beverage coolers. The other system, called IcePoint (from Rebound Technologies), uses ammonia to freeze water below its freezing point, and waste heat to separate the two and restart the cycle ([page 10](#)).

How all of these innovative technologies are going to play out remains to be seen. What is certain is they are challenging the status quo and offering end users new ways to run their businesses and help the environment. **MG**

VOLUME 2, ISSUE #18, SEPTEMBER 2016

ACCELERATE

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AMERICA



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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://acceleratenas.com>



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Guest column by Chris Vallis



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Guest column by Keilly Witman



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The Pig's NH_3 / CO_2 Experiment

JTM Corp.'s year-old Piggly Wiggly store in Columbus, Ga., saved an average of 28.5% in energy usage over a seven-month period, thanks mainly to its NH_3 / CO_2 refrigeration system. But will ammonia prove viable for supermarkets?

Up on the Roof

In a first for industrial refrigeration, Lineage Logistics is managing a cold-storage facility next to the Port of Long Beach, Calif., with 46 NXCOLD low-charge ammonia units, cutting the charge from 22,000 lbs. to 496 lbs.

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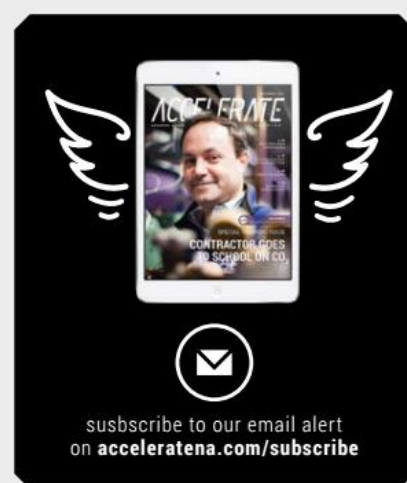


The Next Refrigeration System?



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- 1** September 7-9, Austin, TX
CONSTRUCT 2016
<https://constructshow.com/>
- 2** September 11-14, New Orleans, LA
FMI's Energy & Store Development Conference
<http://www.fmi.org/forms/meeting/Microsite/ESD2016.0>
twitter: @FMI_ORG #FMIEnergySD
- 3** September 12-14, Alexandria, VA
IAQ 2016 Defining Indoor Air Quality
<https://www.ashrae.org/membership-conferences/conferences/ashrae-conferences/iaq-2016>
- 4** September 13-15, Charlotte, NC
21st Century Building Expo & Conference
<http://21buildingexpo.com/>
twitter: #21CBEC @21CBEC
- 5** September 14-15, Indianapolis, IN
The New Consumer Conference, a Supermarket News Event
<http://www.snconsumerconference.com/sn16/Public/Enter>
twitter: #TheNewConsumer @Snnewconsumer
- 6** September 14-15, Newport Beach, CA
NAFA Annual Convention
<http://www.nafahq.org/event/2016-nafa-annual-convention/>
- 7** September 20, Online at 2pm EDT
GreenChill Webinar: Carbon Credits from Reclaimed HFC Refrigerants and Advanced Refrigeration Systems
<https://epawebconferencing.acms.com/carboncredits/>
- 8** September 20-22, Monterrey, Mexico
AHR Expo Mexico
<http://www.ahrexpomexico.com/>
twitter: @ahrexpomexico
- 9** September 20-22, Philadelphia, PA
Comfortech 2016
<http://www.comfortechshow.com/ct16/Public/Enter.aspx>
twitter: @comfortechshow
- 10** September 21-22, Santa Clara, CA
Northern California Facilities Expo 2016
<http://www.fenc.facilitiesexpo.com/>
twitter: @Facilities_Expo
- 11** September 21-22, San Jose, CA
Bay Area Build Expo 2016
<http://buildexpousa.com>
twitter: @BuildExpoUSA
- 12** September 21-22, Atlanta, Georgia
Supermarket Sense 2016
<http://www.supermarketsense.com/>
- 13** September 21-23, Washington, DC
39th World Energy Engineering Congress
<http://www.energycongress.com/>
- 14** September 27-29, 2016, Frisco, TX
EEBA Excellence in Building Conference & Expo
<http://www.conference.eeba.org/conference>
- 15** September 27-29, Orlando, FL
2016 Florida Restaurant & Lodging Show
<http://www.flrestaurantandlodgingshow.com/>



- | | |
|--|---|
| <p>1 October 3-5, Charlotte, NC
 Critical Facilities Summit 2016
 http://www.criticalfacilitiessummit.com/
 twitter: #CFS16 @CFSummit</p> | <p>8 October 11-12, Long Beach, CA
 Cargo Logistics America (CLA) 2016
 http://cargologisticsamerica.com/
 twitter: #cargo2016 @CargoLogistics</p> |
| <p>2 October 4, Online at 2pm EDT
 GreenChill Webinar: Using the Internet of Things to Manage Refrigerants
 http://epawebconferencing.acms.com/internetofthings/
 twitter: @EPAGreenchill</p> | <p>9 October 16-19, Phoenix, AZ
 2016 SMACNA Annual Convention
 https://www.smacna.org/events-education/events/calendar-of-events/event-details/2016/10/16/default-calendar/2016-smacna-annual-convention
 twitter: #SMACNA16 @SMACNA</p> |
| <p>3 October 4-7, Las Vegas, NV
 RETA Annual Conference
 http://reta.com/</p> | <p>10 October 18, Online at 2pm EDT
 GreenChill Webinar: Ongoing Efforts to Evaluate Alternative Refrigerants
 http://epawebconferencing.acms.com/evaluatingrefrigerants/
 twitter: @EPAGreenchill</p> |
| <p>4 October 4-8, Madison, WI
 2016 World Dairy Expo
 http://worlddairyexpo.com/
 twitter: @WDExpo</p> | <p>11 October 18-21, Atlanta, GA
 NACS Show
 http://www.nacsonline.com/NACSShow/Pages/default.aspx
 twitter: #NACSShow @NACSONline</p> |
| <p>5 October 5-7, Los Angeles, CA
 2016 Greenbuild International Conference & Expo
 https://greenbuildexpo.com/
 twitter: #Greenbuild16 @Greenbuild</p> | <p>12 October 19-21, San Antonio, TX
 CONNECT 2016 - Plumbing-Heating-Cooling Contractors
 http://www.phccweb.org/EducationEvents/content.cfm?ItemNumber=6714</p> |
| <p>6 October 8-11, Las Vegas, NV
 IBIE 2016
 http://www.ibie2016.com/
 twitter: #IBIELive #IBIE2016 @BakingExpo</p> | <p>13 October 22-25, Washington, DC
 2016 NFRA Convention
 https://nfraconvention.org/</p> |
| <p>7 October 11-12, Washington, DC
 Beverage Business Expo
 http://eventegg.com/bb-expo/</p> | <p>14 October 26-28, Mexico City
 The GREEN Exhibition and Congress 2016
 http://thegreenexpo.com.mx/en/
 twitter: #experienciagreen #thegreenexpo2016 @thegreenexpomx</p> |



1 November 1, Online at 2pm EDT
GreenChill Webinar: Transcritical CO₂ Operations in Warm Ambient Conditions
<http://epawebconferencing.acms.com/warmtranscriticalco2/>

2 November 1-2, Las Vegas, NV
NFMT Vegas 2016
<http://www.nfmt.com/vegas/>

3 November 2-3, Vancouver, BC
CIPHEX West 2016
<http://www.ciphwest.ca/west2016/public/enter.aspx>
 twitter: #CIPH @CIPHEXwest

4 November 3-4, Orlando, FL
Central Florida Ammonia Refrigeration Regional Conference
<https://eventgrid.com/Events/20665>
 twitter: #NFMTVegas @nfmt_conference

5 November 9-11, Calgary, CA
Buildex Calgary
<http://buildexcalgary.com/>
 twitter: @BUILDEXshows

6 November 13-14, Scottsdale, AZ
AHRI 2016 Annual Meeting
<http://www.ahrinet.org/News-Events/Meetings-and-Events/AHRI-2016-Annual-Meeting.aspx>

7 November 16, Pasadena, CA
IHACI's 37th Annual Trade Show
<http://www.ihaci.org/trade-show/>

8 November 29-30, Phoenix, AZ
ICSC RetailGreen Conference & Sustainability Showcase 2016
<http://www.icsc.org/events-and-programs/details/retailgreen-conference-sustainability-showcase/>

9 November 30- December 2, Toronto, ON
The Buildings Show
<http://www.thebuildingsshow.com/>

Shaping Refrigeration Systems for Tomorrow

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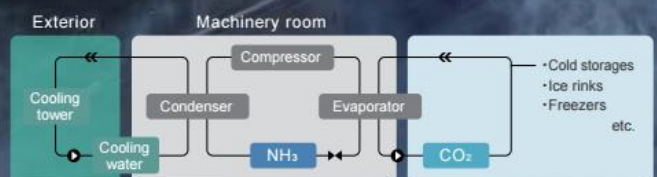
Energy-Saving

- ▶ Semi-hermetic screw compressor equipped with a high performance IPM motor
- ▶ Use of screw rotors with a new type of more efficient profile, "J-profile".



Safety

- ▶ Ammonia / CO₂ indirect cooling method, Minimizing the risk of ammonia leak



- ▶ Support via remote monitoring system

SHORT TAKES

— By Michael Garry and Charlotte McLaughlin

AHRI CHAGRINED AT RULING ON DOE RULES

The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) responded strongly last month to ruling by the U.S. Court of Appeals for the Seventh Circuit that manufacturers of commercial refrigeration equipment must comply with U.S. Department of Energy (DOE) energy efficiency standards by March 2017.

Arlington, Va.-based AHRI filed a lawsuit in 2014 with manufacturer Zero Zone challenging DOE's 2014 efficiency standard and test procedure rulemakings for commercial refrigeration equipment. The standards call for an energy-reduction of between 30% and 50% in kWh/day for closed-door reach-ins (self-contained) and for other display cases (including remote).

"We are disappointed in the Court's ruling, as well as the Court taking nearly a year after oral argument to issue a decision," said Stephen Yurek, president and CEO of AHRI. "Our members must now comply with the efficiency standard by March 27, 2017."

AHRI argued that DOE failed to follow its procedures and that its analysis was flawed. AHRI also raised concerns regarding DOE issuing test procedure amendments after amending efficiency standards. **MG**



WHOLE FOODS FIRST WITH R290/CO₂ SYSTEM

Whole Foods Market, Austin Texas, last month opened a store in Santa Clara, Calif., that is the first in the U.S. to employ a propane/CO₂ cascade refrigeration system.

"There is precedent for this type of system in North America and Europe, but this is the first installation of the technology in the U.S.," said Tristram Coffin, sustainable

facilities coordinator for Whole Foods Market Northern California.

"Ultimately, the system uses the least possible amount of the most climate-friendly refrigerants in a format that both reduces the energy it takes to operate it and re-uses the heat its operation generates," he added.

The system includes seven rooftop condensing units, each containing "around 50 pounds of propane," said Marc-André Lesmerises, CEO of Carnot Refrigeration, which supplied the system. The propane condenses CO₂, which is piped through refrigeration cases to keep products cool, via direct expansion for low-temperature units and pump recirculation for medium-temperature units. **MG & CM**



NEW SUB-COOLING SYSTEM BEING VETTED BY UTILITY

A new energy-saving sub-cooling technology called IcePoint, which has attracted the attention of major industry end users, is starting to undergo testing and validation by Southern California Edison's Thermal Test Centers this month.

"This is a great opportunity to produce more data and get continuing attention from the sector," said Kevin Davis, CEO of Rebound Technologies, developer of IcePoint.

Rebound is in talks with cold-storage operator Lineage Logistics to pilot the

system. In addition, Whole Foods Market "sees IcePoint as potentially providing an important boost in efficiency for transcritical CO₂ systems deployed in warm climates," said Davis.

Rather than vapor compression, IcePoint employs a "freeze point suppression cycle" to generate cooling. The cycle includes: freezing ice; mixing a freeze suppressant (ammonia) with the ice to create a -25°F refrigerant; using the refrigerant mix in a commercial or industrial refrigeration freezer system in the liquid sub-cooling process before the expansion valve; employing waste heat to separate water from the freeze suppressant and restart the cycle.

By leveraging waste heat, IcePoint is able to improve the energy efficiency of the commercial or industrial freezer by 40%, said Davis. Another 20% energy gain is possible via energy load shifting during the freezing process. **MG**





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From left: Andy Baker, YourCleanEnergy; Jeff Cohen, EOS Climate; John Scherer, LA Cold Storage/NXTCOLD; Tom Land, EPA; Paul Delaney, Southern California Edison; Richard Reeves Red Bull.

MARKET OPPORTUNITIES FOR NATURAL REFRIGERANTS

At ATMOsphere America in June in Chicago, six industry experts offered their perspectives on the prospects for natural refrigerant technologies and incentives

— By Michael Garry

HYDROCARBON BEVERAGE COOLERS

Richard Reeves, director of fleet/purchasing/safety & compliance, Red Bull:

In the U.S. today we have more than 200,000 [R600a] coolers, which will double in two years. (See, ["Best in Sector/Foodservice: Red Bull," Accelerate America, July-August 2016.](#)) Not only is the technology solid, it helps us get into the retail market. Everybody's fighting for retail space, and we've been able to tell a good story to retailers: not only is the cooler safe but it delivers a lot of energy savings. We're seeing more interest from the retail market in energy consumption.



When you open the door of the cooler, you see a label that says "This is a hydrocarbon cooler." The label has a QR code linked to an online explanation of the efficiency of hydrocarbon coolers. We did this to bring visibility to consumers, and we made retailers aware of it. Now retailers are insisting on getting hydrocarbon coolers.

LOW-CHARGE AMMONIA SYSTEMS

John Scherer, manager of engineering for Los Angeles Cold Storage; chief technology officer, NXTCOLD:

The market for low-charge ammonia units is huge for industrial and commercial applications. In California, up to 40,000 HFC and HCFC units are regulated; some percentage of those – like a produce operation or a cold storage warehouse – are prime candidates to be switched to low-charge ammonia. There is a component of food retail where low-charge ammonia or ammonia/CO₂ is the most economical system. And large ammonia facilities with 50,000 to 100,000 lbs. of ammonia can be converted to a low-charge system with a payback of four to five years. (See [story, page 42.](#))



It's happening fairly quickly, but there is education needed because people are afraid of ammonia. But it's not the ammonia, it's the amount of it, and this is a tiny quantity. Over the next four to five years we'll see a complete change.

CO₂ INDUSTRIAL HEAT PUMPS

Andy Baker, owner of Anchorage, Alaska-based YourCleanEnergy engineering consulting firm:

I worked with [the Alaska SeaLife Center] to get it off fossil fuels, using sea water as a heat source. (See ["Tapping CO₂ and Seawater in the Last Frontier," Accelerate America, May 2016.](#)) We got it 60% off fossil fuels with R134a heat pumps from Trane. With CO₂ heat pumps from Mayekawa we covered the remaining 40%; we received a \$500,000 grant to put in four units.

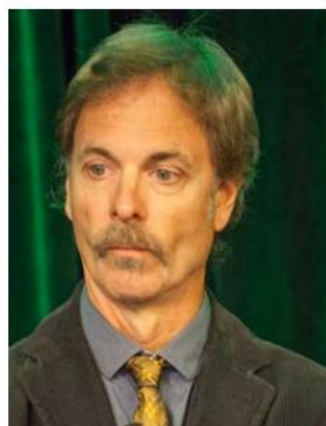


In Alaska, we're stuck with existing buildings with hydronic infrastructure requiring higher temperatures. The West Coast is full of these buildings, so CO₂ heat pumps could go big. But U.S. manufacturers need to get on board with CO₂ heat pumps so the price can come down.

CARBON CREDITS FOR LOW-GWP SYSTEMS

Jeff Cohen, co-founder, senior vice president for science and policy, EOS Climate:

Since 2009, we've generated 4 million carbon offsets for North American greenhouse gas markets, including the California cap-and-trade system. Our initial focus was the collection and destruction of CFC refrigerants from older equipment. Recently we've developed new protocols and methodology that enables carbon crediting for two activities related to [the natural refrigerants] community.



One is for the installation of low-GWP refrigeration systems, commercial or industrial. The crediting is based on charge size and alternative refrigerant used. This creates another incentive, not to pay for a new system, but to offset some of the costs. Any new installation or retrofit with natural refrigerants would qualify. The other protocol enables crediting for the use of reclaimed HFC refrigerant.

When HFCs are reclaimed and reused, that displaces new production of HFCs and prevents significant greenhouse gas emissions.

INCENTIVES FOR NATURAL REFRIGERANT SYSTEMS

Paul Delaney, senior engineer, Southern California Edison:

Natural refrigerants – low-charge ammonia, CO₂ and hydrocarbons – are truly the end game. We see ammonia as an opportunity to attack greenhouse gas emissions. In California, 40% of electricity is used on HVAC, so low-charge ammonia to cool office buildings – that's the next step.



We're collaborating with other utilities and EPRI [Electric Power Research Institute] to figure out incentives for demand and consumption. Utilities in California can always do custom incentives, but where we'd like to go is, "Can I give you \$1 per ton for a specific application in a specific climate zone?"

PUBLICIZING GREENCHILL CERTIFICATION

Tom Land, manager Environmental Protection Agency's GreenChill Partnership:

Food retail is on a huge path toward change and experimentation with natural refrigerants, principally with new stores, but it's working its way to retrofits. Of the 10 supermarkets currently certified as GreenChill platinum, all but two use only natural refrigerants.



We are going to launch a program to allow a store that is GreenChill certified to communicate that distinction to customers. So customers in a store will see the plaque, hear a public address announcement, see the decal on the cabinet door, and make the connection – this is a green store that has an advanced refrigeration system, and it's not leaking. **MG**

NATREFS IN ABUNDANCE AT GERMAN TRADE SHOW

Chillventa will feature 181 companies showcasing natural refrigerant technology, more than any other event in the world

— By Alvaro de Oña

Next month, in Nuremberg, Germany, the every-other-year Chillventa trade show will be the epicenter of the natural refrigerants world, featuring 181 exhibitors showing natural refrigerant-based HVAC&R systems and components, up from 120 companies in 2014.

This greater-than-50% increase reflects the rapid evolution of natural refrigerants over the last two years globally.

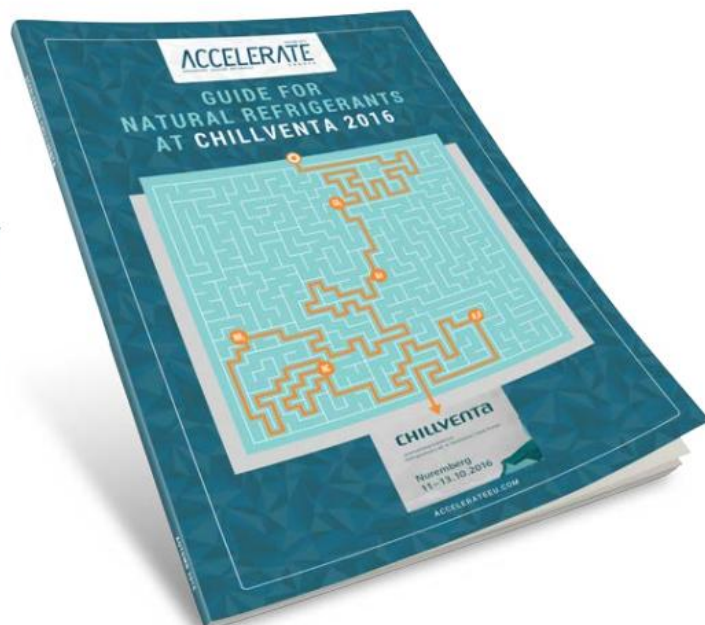
Overall, Chillventa, scheduled from October 11 to 13 at the Nuremberg Exhibition Center, will have around 1,000 exhibitors and over 30,000 visitors from all over the world, surpassing previous records. Even though the trade show has a German flair, nearly 70% of exhibitors and 55% of the visitors are of international origin.

More than 200 presentations will be offered at the Chillventa Congress (scheduled for October 10, the day before Chillventa), the specialist forums and the special presentation areas. Among the 30 educational sessions dedicated to natural refrigerants are presentations and case studies from Colombia, South Africa, Romania and China.

In general, this year's presentations will focus on topics such as current climate targets, eco-design, refrigerants, efficiency through control systems, innovation in heat transfer, limits of refrigeration technology and climate control at data centers.

Daniela Heinkel, director of Chillventa, describes the event as "the international hub for refrigeration, air-conditioning, ventilation and heat pump technology, for advances and optimizations as well as current trends, new paths and innovative products."

On October 11, the Chillventa Awards will be presented for the first time, recognizing expert teams (planners, plant engineers, owners and operators) in four categories: commercial refrigeration, industrial refrigeration, air-conditioning technology and heat pumps.



INNOVATIONS ON DISPLAY

CO₂ will be a major trend at Chillventa, with several product launches lined up:

- Bitzer reciprocating CO₂ compressors.
- Danfoss capacity controller for CO₂ systems.
- Carel updated HEOS system for controlling temperature in supermarkets.
- Günter adiabatic gas cooler for transcritical CO₂ plants.
- Baltimore Air Coil CO₂ hybrid transcritical condenser.
- Henry Technologies CO₂ safety devices, including electronic oil controllers and levels sensors.

In addition, visitors can expect to come across a number of ejectors, which is the solution set to attract the largest amount of attention for its potential to improve performance of CO₂ systems in warm climates.

In regards to hydrocarbons, Secop is ready to announce a new line of variable-speed compressors, including propane-based units for light-commercial applications and those suitable for household applications.

Ammonia solutions will also be on display at Chillventa, with Alfa Laval being especially active with new products. Its new series of industrial air coolers will include a single and a dual discharge industrial air cooler. The Swedish manufacturer will also present a new generation of plate heat exchangers, with one model specifically designed for different pressure levels, making it suitable for low-charge ammonia in food retail applications.

Chillventa will also show how water (R718) is used as a refrigerant; one example is ILK Dresden's vacuum ice slurry technology, which won first place at the German Refrigeration Awards 2016.

For a complete rundown of natural refrigerant-related products and educational sessions at Chillventa, a "Guide for Natural Refrigerants at Chillventa, 2016" published by shecco (publisher of *Accelerate America*), will be distributed at the event and available at <http://publications.shecco.com>. 



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BEYOND HEAT PUMPS

Having built a booming CO₂ hot-water heat pump market, Japan is bringing natural refrigerants to the commercial, industrial and vending machine sectors, according to shecco's new GUIDE Japan

– By Justina Tamasiunaite

The Japanese market has some of the greatest natural refrigerant success stories in the world, as well as key sectors with large potential for growth in the use of this technology.

Japan's biggest success has come in the widespread adoption of CO₂ hot-water heat pumps. But other sectors are beginning to attract attention, especially the accelerated uptake of CO₂ transcritical solutions by convenience stores.

These and other market trends are delineated in "GUIDE to Natural Refrigerants in Japan - State of the Industry 2016," published in June by shecco, publisher of *Accelerate America*.

CO₂ PLAYS ACROSS SECTORS

GUIDE Japan focuses on four key sectors: commercial, light commercial, industrial refrigeration, and heat pumps:

- The growth of CO₂ transcritical condensing systems in commercial refrigeration is the strongest trend in Japan in the last three years, almost exclusively within convenience stores. From only 190 units in March 2014, the convenience store market – primarily Lawson but also 7-Eleven and Family Mart – now has over 1,500 stores using CO₂ systems. Lawson made CO₂ transcritical its standard refrigeration technology in 2014.
- In the light-commercial market, vending machines continue to embrace natural refrigerants, with 1.35 million beverage vending machines in Japan using either hydrocarbons or CO₂. This represents over 50% of the Japanese beverage vending-machine market. Coca-Cola is the primary user of CO₂, while other vendors are employing isobutane (R600a), which is the standard in domestic refrigeration.

- Industrial refrigeration is beginning to turn a corner in Japan with a growing number of "next generation" installations. In particular, NH₃/CO₂ systems have emerged, addressing safety concerns while offering efficiency. Government subsidies have supported 113 out of 300 NH₃/CO₂ deployments, which in total encompass more than 1,000 units.
- Japan remains the world leader in CO₂ heat pumps used in domestic water heating, with 400,000-500,000 EcoCute units sold annually. As of February 2016, there were approximately five million units in operation, 90% of them marketed by Panasonic, Daikin, Mitsubishi Electric and Corona. Virtually all (98%) residential hot-water heat pumps use CO₂.

MAIN MARKET DRIVERS

The primary drivers of natural refrigerant adoption in Japan are: the government's financial subsidies; a revised F-Gas law that covers the lifecycle of f-gases; and the dissemination of information.

While the government has been supportive, gaps remain that must be addressed to allow for the full proliferation of natural refrigerant solutions in Japan. In particular, the High Pressure Gas Safety Act imposes major limitations on the use of CO₂ in the larger-capacity transcritical rack systems used by supermarkets, which have consequently been slow to adopt CO₂.

An industry-wide survey also identified the environmental friendliness and energy efficiency of natural refrigerant-based equipment as key drivers for the uptake of this equipment in Japan. **© JT**

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LESSONS FROM ACROSS THE POND

Led by F-gas regulations, many retailers in the U.K. have made the transition to CO₂ refrigeration systems, but there were hard-earned lessons learned along the way

— By Chris Vallis

As a designer by trade, I think simplicity is always of paramount importance. And the argument for natural refrigerants like CO₂ over synthetic refrigerants is quite simple: Naturals don't deplete the ozone layer and make a negligible (or zero) contribution to global warming; they are sustainable and energy-efficient solutions; and if adopted now, they are future-proof.

The future-proof point is becoming increasingly compelling with the movement toward more regional regulations of HFCs, and the possibility that a global HFC phase-down amendment will be enacted next month in Kigali, Rwanda, at the 28th Meeting of the Parties (MOP) to the Montreal Protocol. An amendment to the Montreal Protocol would have the force of law in almost every country, which could give it more potency than the Paris Climate Accord, a legal hybrid that lacks the binding force of a treaty.

"Amending the Montreal Protocol to phase down HFCs is one of the single most important unitary steps that we could possibly take at this moment to stave off the worst impacts of climate change and to protect the future for people in every single corner of the globe," said U.S. Secretary of State John Kerry at the Montreal Protocol meeting in Vienna in July.

I share the view that regulations are driving innovation in our sector, as opposed to stifling it. Regulations have had a clear and positive impact on the speed and rate of the adoption of natural refrigerant technologies in the U.K., where our consultancy business, the AB Group, is based. The investment and evolution



Chris Vallis, AB Group

of CO₂, for example, would not have happened at today's level without the driving force of the EU's F-Gas Regulation.

At AB Group, we've worked with several U.K. food retailers to help in their transition to low-GWP refrigeration. Retailers have found natural refrigerants have played a key role in advancing environmental sustainability objectives while impressing their environmentally aware consumers. Moreover, the energy-efficiency of natural refrigerant systems translate into lower energy costs, which mean a lower total cost of ownership (TCO) for retailers as well as lower prices for consumers.

CO₂ centralized systems, in particular, have emerged as an industry-standard natural solution in the U.K., where many retailers have adopted CO₂ refrigeration as business-as-usual equipment. Pushing the envelope further, we have worked on integrating a transcritical CO₂ system for a 100,000-square-foot supermarket with a geothermal ground-source heat pump (GSHP) system, as well as integrating HVAC and refrigeration in a 3,000-square-foot convenience store.

continued on p.22 →



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→ THE NEW NORMAL

There have been, of course, many challenges in making this transition in the U.K. Our biggest challenge was changing the perception of CO₂ refrigeration from “new technology” to “business-as-usual,” or even “the new normal.”

We have achieved this through a deep understanding of the technology as well as our client and their estate, supply chain and workforce. We have applied quality management processes, auditing, training programs, collaboration, and continual improvement, along with a good bit of patience, perseverance and determination. The lessons we’ve learned have been hard-earned and have now become powerful tools to help guide our consultancy.

For example, what makes any refrigerant dangerous is a lack of understanding. So the early skepticism about CO₂ pressures has been largely overcome through engagement, education and training. In addition, the skepticism about CO₂ efficiency in warmer climates is now being overcome through technological innovations such as ejectors, parallel compression, sub-cooling and the use of water to improve heat rejection conditions.

Another major challenge is the perception of higher upfront costs being a deal breaker. What we have found helpful is using an iceberg, the internationally recognized symbol of climate change,

as a metaphor for overall lifetime costs ([see diagram on this page](#)). The tip of the iceberg represents only the upfront costs (CAPEX), while the much larger (and mostly unseen) portion of the iceberg beneath the water stands for ongoing costs (OPEX).

What is easily seen in the iceberg visual is that although a natural refrigerant system comes with potentially higher upfront costs by comparison to HFCs, the ongoing costs can be much lower over its lifetime due to a combination of energy efficiencies and integration options.

If carbon impact is also factored into the equation of ownership, then the strength of naturals obviously grows further, and significantly, by way of the Total Equivalent Warming Impact (TEWI) and/or Life Cycle Climate Performance (LCCP).

In sum, it’s an exciting time for the industry. Here’s for a successful outcome in Rwanda next month – an HFC phase-down agreement that drives us in an environmentally sustainable direction. 🇰🇪 CV

Chris Vallis is head of design & consultancy at AB Group (www.abgroup.com), an independent U.K.-based business in science & technology for the built environment, with a specialization in refrigeration.



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TIME FOR MANUFACTURERS TO STEP UP

If equipment and component manufacturers want systems using natural refrigerants – hydrocarbons, CO₂ or ammonia – to thrive, they need to support end users in the supermarket industry every step of the way

– By Keilly Witman



From left: Patrick Gareau, Sobeys; Tom Land, EPA; Keilly Witman

Food retailers are facing an increasing number of natural refrigerant options. Some of these technologies are gaining momentum, while others are in need of a jump-start. Equipment and component manufacturers will be playing a key role, in either case.

Propane is clearly in the first camp. In fact, I believe that 2017 will be the year of propane refrigeration in supermarkets.

End users are very eager to explore hydrocarbon self-contained systems because they see these systems clearing a lot of hurdles in one fell swoop; one of these is the lack of experienced service technicians. If end-users can't find people to install and maintain natural refrigerant rack systems, they are likely to ask themselves whether they can avoid rack systems. Self-contained propane systems are "wheel-in and plug-in." There's nothing simpler than that. And that huge problem of the lack of qualified technicians that is a barrier to the adoption of natural refrigerants vanishes in one fell swoop.

Target is a retailer that is incorporating propane self-contained cases as part of its overall refrigeration strategy. Paul Anderson, Target's director of engineering, went to a White House meeting last year and made a commitment that all new, self-contained units in Target stores will use propane refrigeration technology.

How Target got to this point is an interesting story. While it's easy for many of us to step up and readily embrace natural refrigerants, Target's experience shows that there is a process involved for companies as they start along this path.

First, Target sent out notifications to all of its refrigeration technology suppliers outlining its plans for implementing propane self-contained systems, seeking feedback and offering to work together to realize its goals. What Target found was that many of its suppliers were already moving in that direction and were ready to get on board.

Next, Target talked to its contractors — the people who might be maintaining this equipment. Despite what we've heard about the hurdles involving the training of service contractors, as it turns out, when Target says, "This is where we are going, and we expect you to be able to handle it," lo and behold, people get trained. It's a big business opportunity for contractors.

That's why Target feels very comfortable moving forward. The retailer is planning to have several stores come online in the next eighteen months that will use self-contained propane systems.

Whole Foods just opened the first store in the United States that uses a propane-CO₂ cascade system. The store, which is located in Northern California, will use seven individual propane modules that each use 30-40 pounds of propane.

At the beginning of the planning process for this store, when Whole Foods brought in several systems manufacturers to discuss ideas for this type of system, the results were interesting - and not always in a good way. Even though the only criterion was that the system be a propane system, some manufacturers spent their time with the design group trying to talk Whole Foods out of what the company wanted to design and into what the equipment manufacturer preferred to sell.

If equipment manufacturers want to be able to give their customers what they want, they will need to offer systems that use the whole range of natural refrigerants. As much as I hear from equipment manufacturers that their goal is to meet their customers' needs, it seems that equipment manufacturers' interpretation of that motto often includes them first telling the retailer what those needs are. Just as Henry Ford was willing to sell you any color car, as long as it was black, at the dawn of the age of automobile manufacturing, it may have worked well at the beginning of the natural refrigerant revolution to offer CO₂ to everyone. But manufacturers that offer a limited selection in natural refrigerant solutions are going to find their customers going elsewhere to get what they want.

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→ There are still some hurdles to overcome with propane systems, especially in terms of building codes, but the industry is starting to make some progress on these fronts through the North American Sustainable Refrigeration Council.

AFTER-SALES CHALLENGES

CO₂ transcritical systems have come a long way in the supermarket industry. End users are no longer talking about this in theory – they are deep into the details, and they are talking about some of the challenges they have faced.

Again, Whole Foods has been at the leading edge of this technology, gaining experience with multiple CO₂ transcritical stores. But Whole Foods and other retailers that have piloted CO₂ transcritical systems report very high leak rates – sometimes even within the first two weeks of operation. When these issues come up, we've seen the manufacturer blame the installer, and the installer blame the manufacturer. That leaves the end user in a very bad position.

Whether manufacturers believe it or not, when retailers are having problems with a system within the first few months, no matter what the cause, it's a big problem for the manufacturer. End users know who is piloting the various technology options, and many wait to jump on board with a particular technology until they receive feedback from retailers who pilot that technology. When the news about the pilot project isn't good, for whatever reason, guess what? Those who are sitting back and waiting decide to wait a little longer.

Another area where manufacturers need to jump in and help early adopters is with the retailers' return on investment calculations. About 12 months after installation, retailers start calculating their numbers and compare them to manufacturers' return on investment claims that were made during the sales process. If those numbers don't match, that news gets around pretty quickly. For instance, there can be many reasons why a store's energy use does not match the manufacturers' claims, but when the end users

I believe that 2017 will be the year of propane refrigeration in supermarkets.

When retailers are having problems with a system within the first few months, no matter what the cause, it's a big problem for the manufacturer.

talk amongst themselves, the only message that gets conveyed is that the system "didn't do what it was supposed to do." It doesn't matter whether that's true from the manufacturer's perspective or not – it is the perception of the end user that matters.

WANTED: AN AMMONIA ADVOCATE

Ammonia's rate of adoption in retail food is turning out to be much slower than expected. Unlike CO₂ transcritical and hydrocarbons, there's not really a vocal champion out there among the manufacturers for ammonia systems. Until someone steps up to champion ammonia, we are going to see it lag behind.

A Whole Foods store in Dublin, Calif., that installed an ammonia/CO₂ cascade system in May 2015 is still not where it needs to be in terms of results. They have found it is a lengthy process to get it up and running as promised. But everyone at Whole Foods is very committed to the NH₃/CO₂ system, and they understand that the first time you do something, it is always going to be a bit challenging. They feel strongly that is important to have a good ammonia option out there.

No matter which type of natural refrigeration system end users select, equipment manufacturers need to step up and take responsibility for helping them succeed. Manufacturers can't just step back and say, "We trained you, now you are on your own."

Manufacturers need more end users to adopt the various technology options, if they want their business to grow. You can only rely on first movers for so long. **KW**

Keilly Witman is the founder of KW Refrigerant Management Strategy, which specializes in supporting supermarkets in their refrigeration systems and planning. Previously, she had launched the Environmental Protection Agency's GreenChill Partnership in 2007, and oversaw it until she left the EPA in 2013.



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Oak Ridge National Laboratory researcher Brian Fricke with the Advansor transcritical CO₂ booster system.

FROM R&D, MARKETABLE TECHNOLOGY

Oak Ridge National Laboratory helped OEM Hillphoenix bring the Advansor transcritical CO₂ refrigeration system to the North American market.

— By Marlene Taylor

Global calls have been heard to replace inefficient HVAC&R technologies as well as refrigerants that contribute to global warming, and the search for better alternatives is in full swing.

To that end, Oak Ridge National Laboratory (ORNL), Oak Ridge, Tenn., working on behalf of the Department of Energy's (DOE) Building Technologies Office, is helping to deliver marketable HVAC&R technologies that address energy consumption in existing and new buildings. Specifically targeted are equipment categories that have high greenhouse gas emissions, such as commercial refrigeration.

A good example of these technologies is Hillphoenix's Advansor transcritical CO₂ booster refrigeration system, which uses only CO₂ as a refrigerant, in food retail and industrial applications.

In 2011, Hillphoenix purchased Advansor A/S, a Denmark-based company that makes transcritical CO₂ systems and continues to sell thousands of these systems to food retailers in Europe. Following this acquisition, Hillphoenix modified the design of the system for the North American market; this means complying with safety regulations, providing equivalent or better energy performance in southern climates, and doing all of that at costs that provide a lower total cost of ownership than the traditional synthetic-refrigerant-based systems it was replacing.

Hillphoenix also began a partnership with ORNL whereby the lab tested the new design to make sure it met these criteria. Hillphoenix and ORNL collaborated through a Cooperative Research and Development Agreement (CRADA). A CRADA is formed between a national laboratory and a non-federal entity,

such as industry, a university, or a non-profit, to collaborate on research and development projects in which the creation of intellectual property (inventions and data) is possible. CRADAs support technology transfer by spelling out in advance how intellectual property that is generated will be handled.

Regardless of whether research results in an invention, CRADAs allow non-government partners to gain access to the unique technologies, facilities and expertise available at national labs. For example, through the R&D collaboration, the non-government partner may discover and license previously invented ORNL technologies or manufacturing techniques for integration into its products or processes. Or the partner may benefit from modeling guidance or experimental performance characterization during prototype development. Through CRADAs, science can be translated more quickly into products on the market, creating jobs and saving energy.

Through the ORNL-Hillphoenix CRADA, ORNL researchers Brian Fricke and Vishaldeep Sharma worked on the team that tested the redesigned Advansor refrigeration system. Their primary goal was to ensure that the system emits 75% less greenhouse gas (from energy use and refrigerant leakage over service life), consumes 25% to 30% less energy than existing systems, and has refrigerant leak rates of less than 5% annually. In addition to the collaboration between Hillphoenix and ORNL, contributions made by industry partners Danfoss, Luvata and SWEP contributed greatly to the success of the project.

It's understandable that targeting commercial refrigeration for environmentally friendly alternatives is a priority for DOE and ORNL. There are approximately 35,000 supermarkets and over 150,000 convenience stores in the U.S. Traditional HFC-based multiplex direct expansion (DX) systems have large refrigerant inventories and high annual leakage rates. Refrigeration systems in supermarkets account for approximately 50% of their energy use, placing this class of equipment among the highest energy consumers in the commercial building domain. High energy consumption equates to high greenhouse gas emissions, as does the high amount of refrigerant leakage.

"Each supermarket has a lot of refrigerant in its system – two to four thousand pounds – and about 20 to 25% of that leaks out every year," said Fricke.



Advansor transcritical CO₂ compressor rack.

USING LCCP METHODOLOGY

The research team performed analyses on a variety of supermarket refrigeration systems and refrigerant options, looking for a system configuration and refrigerant that reduced both energy consumption and life-cycle carbon-equivalent emissions. The team used the Life Cycle Climate Performance (LCCP) methodology to determine the environmental impact of a refrigeration system design during its service life. This methodology has become the international standard for such assessments.

For energy consumption analyses, the team used DOE's flagship modeling tool EnergyPlus to calculate the hourly energy consumption of the alternate refrigeration systems in different U.S. climate zones. The researchers evaluated standard- and high-efficiency refrigerated display cases, walk-in coolers and freezers, and various refrigeration systems, including traditional multiplex DX rack systems, cascade systems with secondary loops, and transcritical CO₂ systems.

Their results demonstrated that a transcritical CO₂ booster refrigeration system, coupled with high-efficiency display cases and walk-ins, can achieve energy reductions of up to 39% (depending on ambient temperature), compared to the standard-efficiency R-404A multiplex DX system, with 76% lower emissions.

These findings accompanied Hillphoenix's Second Nature Advansor System's birth into the North American market. Early this year, Hillphoenix introduced the AdvansorFlex CO₂ refrigeration system, a smaller format version of the Advansor system.

"While it's not perfect, CO₂ is only going to get more popular as time goes by," Fricke said.

ORNL has nearly 20 CRADAs in the works, including assessments of other refrigerants and systems that are targeted for market introduction within the next few years. **MT**

Marlene Taylor is a technical writer at CSRA, a U.S. government contractor that provides IT and professional support. It is based in Falls Church, Virginia.

Key Natural Refrigerant Installations In North American Supermarkets

2017:

Roundy's (Mariano's), Chicago area; five stores to use transcritical CO₂ refrigeration

October 2015:

Target, Minneapolis; declares self-contained units will be HFC-free (using propane)

June 2016:

DeCicco & Sons, Pelham, N.Y.; retrofitting store with transcritical CO₂

August 2016:

Whole Foods Market, Santa Clara, Calif.; first propane/CO₂ cascade system in U.S.

October 2015:

Food Lion, Southport, N.C.; transcritical CO₂ system

September 2015:

JTM Corp. (Piggly Wiggly), Columbus, Ga; NH₃/CO₂ cascade system

June 2015:

Ahold USA (Giant Food), Springfield, Va.; transcritical CO₂

January 2015:

Lowe's Market, Lubbock, Texas; propane freezer units

January 2015:

Kroger, Holland, Ohio; transcritical CO₂ system

February 2015:

Whole Foods Market, Dublin, Calif.; NH₃/CO₂ cascade system

December 2014:

Lackland Air Force Base Commissary, San Antonio, Texas; NH₃/CO₂ cascade system

September 2014:

Angelo Caputo's Fresh Markets, Carol Stream, Ill.; transcritical CO₂ system for combined warehouse/commissary/store

July 2014:

Sprouts Farmers Market, Dunwoody, Ga; first transcritical CO₂ in high ambient

December 2013:

Whole Foods Market, Brooklyn, N.Y.; CO₂ transcritical refrigeration and CHP system; no HFCs in store

January 2014:

Roundy's (Pick 'n Save), Menomonee Falls, Wis.; transcritical CO₂ system

June 2014:

Target, Minneapolis; announces hybrid cascade prototype with CO₂ DX for low-temperature cases

July 2013:

H.E. Butt Grocery, Austin, Texas; all-propane refrigeration in self-contained cases

July 2013:

Hannaford Supermarkets, Turner, Maine; first transcritical CO₂ system in a U.S. supermarket

May 2012:

Albertsons, Carpinteria, Calif.; first NH₃/CO₂ cascade system in U.S.

December 2006:

Food Lion, Montpelier, Va.; CO₂ as secondary coolant for low-temperature cases

2009:

Sobeys, Canada's second largest food retailer, begins installing transcritical CO₂ system

2011:

Sobeys makes transcritical CO₂ standard for all new stores and remodels

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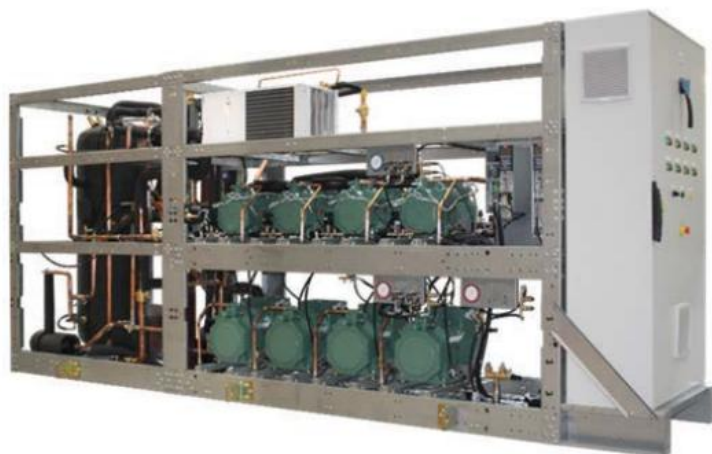
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THE PIG'S NH₃/CO₂ EXPERIMENT

JTM Corp.'s year-old Piggly Wiggly store in Columbus, Ga., saved an average of 28.5% in energy usage over a seven-month period, thanks mainly to its NH₃/CO₂ refrigeration system. But will ammonia prove viable for supermarkets?

— By Michael Garry



Keith Milligan, JTM Corp. (Piggly Wiggly)

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Keith Milligan, JTM Corp. (Piggly Wiggly)

When Keith Milligan received the first utility bill for his new 36,000-square-foot Piggly Wiggly store in Columbus, Ga., last year, he was flabbergasted at how low it was.

"I called the lady at the power company [Georgia Power] and said, 'I just want to make sure you got this right,'" said Milligan, CIO for JTM Corp., Phenix City, Ala., a family-owned retailer that operates 19 Piggly Wiggly stores along the border separating central Alabama and Georgia. He chuckled at the memory. "I didn't want her to come back in two years and say, 'I billed you wrong and you owe us \$200,000.' But she checked it, and it was correct."

The linchpin of this Piggly Wiggly – and the biggest contributor to its energy-saving capacity – is an ammonia/carbon dioxide cascade system made by Heatcraft Worldwide Refrigeration (under the Kysor/Warren brand) at its plant in Columbus, about 1.5 miles from the store.

The store, opened in September 2015, is just the fourth in the U.S. to use an NH_3/CO_2 refrigeration system, along with some installations at European supermarkets. (See story, page 52.) But its superior energy efficiency, even in a warm climate like central Georgia, makes NH_3/CO_2 one of the more promising natural refrigerant technologies in the world. "We're excited about being one of the first stores to do this," said Milligan.



Masood Ali, Heatcraft

The Piggly Wiggly store is also one of just 10 supermarkets in the U.S. to receive the highest certification level – platinum – from the Environmental Protection Agency's GreenChill Partnership, in this case for using refrigerants with a global warming potential (GWP) of under 150.

The Piggly Wiggly store uses an ultra-low charge (53 pounds) of ammonia – less than any of the other U.S. NH_3/CO_2 stores – which is confined to the roof in the ammonia rack. The ammonia condenses the CO_2 , which circulates throughout the store, cooling low-temperature cases via direct expansion and medium-temperature cases through pumped liquid overfeed. For energy comparison purposes, an HFC (R407A) rack alternates every few weeks with the ammonia rack in condensing the CO_2 .

At the ATMOsphere America conference in June (organized by shecco, publisher of *Accelerate America*), Milligan presented data on the Columbus store's power consumption compared with one of his company's R407A stores in LaGrange, Ga., normalized for store size. For the period ranging from October 2015 to April 2016, the new Piggly Wiggly consumed 23% to 33% less energy than the conventional outlet, for an average energy savings of 28.5% (\$33,170 in total).

The new store was equipped with a number of other energy-saving elements, including LED lights, skylights, occupancy and daylight controls, doors on display cases, Lennox rooftop HVAC units, external Dryvit insulation and white roof, and heat reclaim for hot water. But the NH_3/CO_2 system, which accounts for 60% of the store's electricity consumption, was by far the most impactful on efficiency. "What Heatcraft provided dovetailed with JTM's requirement to reduce its operating costs and carbon footprint," said Masood Ali, global leader for alternative systems center for excellence, Heatcraft.

At the ATMOsphere America conference, Ali offered energy data on the ammonia rack used by the NH_3/CO_2 system, compared with that of the HFC rack installed in the store; the two “top-side” racks have been analyzed side-by-side under the same loads, weather and shopping patterns as they individually operate. Each works in tandem with the CO_2 rack, and each is cooled via a glycol loop connected to an evaporative fluid cooler.

Between February 2, 2016, and May 22, 2016, the NH_3 rack consumed 22% less energy on average than the HFC rack, ranging between 18% and 25% depending on ambient temperature.

“This was done with the intent of taking the ambiguity out of the energy comparison and getting really good numbers,” said Robert Delventura, vice president of global innovation for Heatcraft. An independent firm is in the process of compiling a white paper on the energy consumption of the two systems, which are monitored remotely by Heatcraft.

A LOWER TCO

While the NH_3/CO_2 system has demonstrated significant energy savings – crucial in a small-margin business like food retailing – it does, at present, come with a higher price tag than a conventional HFC system. Would its total cost of ownership (TCO), factoring in operating costs, make it a worthwhile investment for Piggly Wiggly?

Time will tell, though Milligan is optimistic. In addition to the energy savings, he points to the rising costs of synthetic refrigerants like R407A and R22, used in his other stores. “We really feel like natural refrigerants are the end game,” he said. “We won’t have to worry about their costs going up.” Nor will there be any concern about regulations banning or phasing out high-GWP refrigerants.

continued on p.38 →



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→ At ATMosphere America, Ali presented a slide on the estimated total cost of ownership (TCO) of an NH_3/CO_2 system modeled for a store in San Diego, Calif. Again using a traditional HFC store as a baseline, Heatcraft found a 15% to 20% lower TCO for the ammonia system. This calculation factored in a 15%–23% lower energy cost, a 50%–70% higher first (capital) cost, and a 0–5% higher maintenance cost. All of the costs for the San Diego store are comparable to those of the Piggly Wiggly store in Columbus, Ga., said Delventura (except for JTM Corp.'s first cost, which was lower).

JTM Corp. was able to secure a "sizable" energy-efficiency incentive for the Columbus store from the Georgia Power Co., though not for the refrigeration system. The incentive covered other standard energy savers like LED lighting and glass case doors. With the NH_3/CO_2 in place, and proving to be energy efficient, future stores in Georgia would be eligible for incentives for this equipment.

Beyond its impact on energy consumption, the NH_3/CO_2 system offers a tremendous reduction in direct greenhouse gas emissions stemming from refrigerant leaks. That's due to the virtually non-existent combined GWP of ammonia (zero) and CO_2 (one). Based on a 15-year life, a 15% leak rate, a refrigeration load of 535 kW, among other factors, an NH_3/CO_2 system in San Diego would cut direct emissions by 99% compared to an HFC DX system; including indirect emissions from power consumption, the NH_3/CO_2 system's life cycle climate performance (LCCP) would be reduced by 64%, according to Heatcraft.

The environmental benefits of his Columbus store are aligned with Milligan's values. "We wish all of our stores were like that," he said. "I have grandkids and I want to leave a good place for them. As a nation and a world we are making progress, but we still have a long way to go."

Now he would like to see more supermarkets follow his lead. "Every store you change makes a big difference." To that end, he invites other retailers, including competitors, to tour his Columbus store.

Milligan intends to use an NH_3/CO_2 system in future stores. As for existing outlets, he is hoping Heatcraft will come up with a retrofit solution that encompasses natural refrigerants.



The iconic Mr. Pig mascot

THE BIGGEST XMAS EVER

The Piggly Wiggly store brand, carried by more than 600 stores franchised by independent operators like JTM Corp. in 17 states, is celebrating its 100th year in 2016. A grocery institution, Piggly Wiggly stores were the first to provide checkout stands and price mark every item in the store, use refrigerated cases, and franchise independent grocers to operate under a self-service method of food merchandising.

JTM Corp. is a third-generation business founded in 1966 by Milligan's father, Tommy, now retired. Milligan, who earned his first paycheck in the business at age 14 in 1970, shares responsibility for it with two brothers, Gil and Mike, as well as with his two sons, Justin and Drew, and Gil's son Brian. As CIO, Milligan's tasks include IT, pricing and store development (including new refrigeration). Gil oversees two store maintenance employees, who take care of the company's older, stand-alone refrigeration systems. The NH_3/CO_2 system and rack systems in other stores are maintained by Archie's Service Co., Cusseta, Ga., which also installed the NH_3/CO_2 equipment.

"When I asked [owner Archie Worrell] if he'd be interested in installing the NH_3/CO_2 system, it was like he had the biggest Christmas ever," said Milligan. "I had no doubt he'd do a great job."

JTM Corp. has had a long relationship with Heatcraft, its neighbor in Columbus, which has supplied some of its refrigeration systems and used its Piggly Wiggly stores to test new display-case designs. When JTM decided to build a new store in Columbus – its first in two decades – “we called them and tried to get a good deal on a refrigeration system,” said Milligan. “They called back a few weeks later and said, ‘We’ve got something we think you can’t turn down.’”

That turned out to be the NH_3/CO_2 system, which Heatcraft was originally going to test in a lab that would be built for that purpose. Instead the Columbus store became the test lab, equipped not only with the NH_3/CO_2 system (racks, evaporative fluid cooler, cases, piping, etc.) but also the HFC rack used for energy comparisons (and provided at no cost to JTM). Because of that arrangement, “they gave us a really good deal,” though the cost was still 30%–40% greater than that of a traditional HFC DX system, Milligan said. “It’s been a really good partnership with Heatcraft.”

For its part, Heatcraft appreciates the opportunity JTM Corp. offered to test the NH_3/CO_2 technology. “A lot of times, smaller independents like JTM are more available to try unique designs,” said Delventura. “Larger retailers are a little tougher to get that level of flexibility. [JTM Corp.] gave us poetic license in that store.”

One of the unique features of the NH_3/CO_2 system is its automatic oil recovery system. Because it is immiscible in ammonia, oil does not suction back to the compressor from the case evaporators as it does in a conventional HFC system. Normally that means a technician has to periodically recover the oil from the evaporators, but Heatcraft’s patented the oil recovery system eliminates that task. In fact, the oil never reaches the evaporators, as it is captured in the receiver and channeled back to the compressors.

“With no oil in the evaporators, you improve their efficiency,” said Ali. The energy saved, he added, helps to defray the additional cost of the oil recovery system.

However, Joe Sanchez, engineering manager for Bitzer US, believes that manual draining of oil is manageable for supermarket technicians. “It’s maybe every six months to a year, a gallon of oil – not a big deal,” he said. “That might simplify the system.” ([See story, page 52.](#))

Milligan said he considered installing a transcritical CO_2 system, offered by Heatcraft, Hillphoenix and other OEMs, instead of the NH_3/CO_2 system, but decided not to because of central Georgia’s warm climate. “The [transcritical] technology is improving [for warm climates] but at the time it would have increased my power bill.”

By contrast, ammonia systems are unaffected by high ambient temperatures. “The ammonia system has worked very well,” Milligan said. “Ammonia has been around forever as a refrigerant, though not in such tiny quantities.” Ali added that in warmer climates, the NH_3/CO_2 systems offers “the biggest bang for the buck.”

Heatcraft is working on enabling transcritical systems to operate efficiently in high-temperature environments. “We want to provide our customers choices,” said Delventura.

QUESTIONS ABOUT AMMONIA

Ammonia poses its own challenges, notably its toxicity in certain concentrations and its pungent odor. “I asked a lot of questions about that,” said Milligan. “But because there is such a small amount [53 lbs.], I didn’t see much danger. I’m very comfortable with it.” The Piggly Wiggly distribution center in Bessemer, Ala., he noted, uses thousands of pounds of ammonia.

In the first year of operation, there have been no ammonia leaks. If there were a leak, “ammonia is lighter than air, and it’s above the store,” said Milligan. “So it stays outside.” In the event of a cold day with temperature inversion, leaked ammonia could move toward the ground, but “normally it would rise,” he noted. And with its self-alarming odor, “ammonia lets you know you have a leak and you have to leave the area. So I don’t think there’s any danger at all for our techs.”

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The NH_3/CO_2 system’s CO_2 rack.

LEARNING ABOUT NH₃/CO₂

For an innovative and unusual set of equipment like an NH₃/CO₂ system, training installers and technicians is one of the most critical and challenging requirements.

Heatcraft Worldwide Refrigeration, maker of the NH₃/CO₂ system installed at JTM Corp.'s Columbus, Ga., store, provided "complete training" in its Columbus factory and in the store to Archie's Service Co., Cusseta, Ga., said Masood Ali, global leader for alternative systems center for excellence, Heatcraft. This covered installation and maintenance best practices for the NH₃/CO₂ system.

The training included ammonia rack charging and start-up; ammonia pump-down and recovery; replacement of coalescing filter element in oil separator; oil charging, balancing and monitoring; and replacement of oil regulator float, check valves and liquid-level sensors.

Owner Archie Worrell acknowledged that the initial start-up of the NH₃/CO₂ system was "a huge challenge for us – and for Heatcraft, too – because it was a new system." After the start-up, four or five CO₂ valves leaked and had to be replaced, he noted.

Another big challenge was the abundance of new electronics, sensors and controls. "There was a learning curve to get to know that," said Keith Milligan, CIO of JTM Corp. Danfoss has proved very helpful in answering any questions. "If you have a holistic understanding of controls, you will be successful," said Robert Delventura, vice president of global innovation for Heatcraft.

A year after start-up, Worrell and his staff are comfortable with the NH₃/CO₂ system. "We haven't used [Heatcraft] in the last six months," he said. "There have been a few calls, but it's surprising to me that we haven't had more issues than we have."

But Heatcraft is keeping a close eye on the system via remote monitoring. "They tell me, 'if there is a problem, we will know before you do,'" said Milligan. The OEM has already learned a few lessons from this initial installation, including the need to better balance the flow of CO₂ to the cascade evaporators, and the ability to use a larger oil filter.

→ The ammonia system, which is designed in conformance with all major ammonia safety standards (IIAR-2, IBC, IMC, IFC, EPA and ASHRAE-15), easily passed muster with the local fire marshal. Because of the small ammonia charge (under 100 lbs.), the store does not fall under the Emergency Planning and Community Right to Know Act's reporting requirements, nor does it require an on-site engineer to monitor it.

Heatcraft designed the system to mitigate against any ammonia exposure. The rack is enclosed by removable panels; in the piping, valves use seal caps, and as a safety precaution in abnormal high pressure situations the pressure release valves would discharge ammonia into a water diffusion tank rather than the atmosphere, "so nobody can smell it," said Ali.

The company conducted a plume study at the store that assessed the risk in the event of a "catastrophic leak" of the 53 lbs. of ammonia in 10 minutes, and found "there would be no impact to personnel in the surrounding area," said Delventura. In the event the catastrophic leak occurred with a downdraft wind, assumed in the study, "there would be no significant level other than in a very short period around the store you may be able to smell it." Overall, he added, "there was no identified risk."

Still, even a small amount of ammonia can cause injuries, warned Jim Price, former president of RETA (Refrigerating Engineers & Technicians Association), at the ATMosphere America conference in June. "When we become lackadaisical about safety, that's when the accidents occur." The odor might also pose a "perception" problem if a customer smells it, he added.

To shed further light on this topic, the International Institute of Ammonia Refrigeration (IIAR) is conducting research on ammonia releases in urban settings to determine the relative risk to the public, said Eric Smith, technical director for the IIAR. **MG**



The NH₃/CO₂ system's rooftop ammonia rack.



Joe Sanchez, Bitzer US

WILL NH₃/CO₂ CATCH ON?

Supermarkets using ammonia/CO₂ systems are very rare, with only four in the U.S., and a small number in other countries. But now that the grocery marketplace is testing these systems, what are the chances they will catch on?

One of the main detriments to NH₃ in supermarkets is that it is probably a higher cost system due to the need for steel and the fact that many components are designed for industrial applications at a lower quantity and premium price, said Joe Sanchez, engineering manager for Bitzer US.

Still, he said, "this could be something that takes off. And if ammonia in supermarkets is going to take off, the U.S. might be the country to blaze the trail."

Here's why, according to Sanchez:

- In comparison to other climates searching for all-natural solutions (Europe for example), the climate is warmer in the U.S. and this means the efficiency advantage of NH₃ or hydrocarbons over CO₂ is more attractive, with a better payback.
- The U.S. generally has larger stores and this again works in the favor of higher initial cost and better payback for NH₃ vs. CO₂.
- Low-charge ammonia is becoming popular in the U.S., which is a trend not found in other parts of the world. This plays directly into one of the goals that a supermarket would want to have in their system, which is to mitigate risk. In supermarkets, there is even a "retail" aspect of having a low charge because a major leak could literally drive shoppers away.
- The other high-side solutions besides CO₂ or NH₃ are hydrocarbons. However, the flammability aspect probably makes NH₃ preferable to some extent over hydrocarbons (for now) due to lack of safety and buildings standards that address flammable refrigerants. Also, the U.S. leads the world in lawyers, which could further encourage the industry to overly manage when to really focus on hydrocarbons.

SYSTEM SPECS

The NH₃/CO₂ cascade refrigeration system at the Piggly Wiggly store in Columbus, Ga., has the following characteristics:

- » Refrigeration capacity, medium temperature cases: 462.1 MBH (38.5 TR)
- » Refrigeration capacity, low temperature cases: 221.7 MBH (18.5 TR)
- » Total capacity of the ammonia cycle: 70 TR
- » NH₃ rack: three Bitzer open-drive reciprocating compressors
- » CO₂ rack: two Bitzer reciprocating compressors
- » HFC rack (for energy comparison with NH₃ rack): five Copeland semi-hermetic compressors
- » NH₃ charge: 53 lbs. (0.75 lbs./TR)
- » CO₂ charge: 1,400 lbs.
- » HFC (R407A) charge: 300 lbs.
- » Automatic oil recovery system
- » Water diffusion tank
- » Stratus display cases with electronic expansion valves
- » Danfoss case and rack controls
- » BAC evaporative fluid cooler
- » Variable frequency drives
- » Heat reclaim for hot water
- » Defrost, low temperature: electric
- » Defrost, medium temperature: off-cycle



Ammonia electrical panel (left) and VFDs for ammonia compressors.

UP ON THE ROOF

In a first for industrial refrigeration, Lineage Logistics is managing a cold-storage facility next to the Port of Long Beach, Calif., with 46 NXTCOLD low-charge ammonia units, cutting the charge from 22,000 lbs. to 496 lbs.

— By Michael Garry



From left, John Dittrick, Lineage Logistics; John Scherer, NXTCOLD

On March 10, 1933 at 5:54 PST, a magnitude 6.4 earthquake struck Southern California. The epicenter was offshore, southeast of Long Beach, on the Newport-Inglewood Fault. More than 100 people died, and damage to buildings was extensive.

The vulnerability of California to earthquakes calls for buildings to be constructed to withstand sudden shocks. And it is also causing some owners of cold-storage facilities in the Golden State to rethink how much ammonia refrigerant they should have on premises.

For its new 248,000-square-foot cold-storage warehouse adjacent to the Port of Long Beach — the largest of its kind near a Southern California port — Baker Cold Storage, Vernon, Calif., a division of Baker Commodities, decided to use as little ammonia as possible. Its proximity to the container port, the second-busiest in the U.S., underscored the need to minimize the ammonia charge in the event of a natural disaster or accidental leak.

Originally, Baker Cold Storage designed the 12.6-acre facility, a former wood treatment plant, to employ a standard liquid overfeed ammonia system with a central engine room and an ammonia charge of 22,000 lbs. But Baker switched to a low-charge option in the form of packaged rooftop ammonia units from Los Angeles-based NXTCOLD. Each NXTCOLD unit has its own compressor, evaporator (except in the blast-freezing areas) and condenser, and is paired with a small adjacent water tower.

The Long Beach facility, set to open late next month, will employ 46 of the NXTCOLD units — likely the most low-charge units in one facility in the world — none holding more than 30 lbs. of ammonia, for a total of just 496 lbs. Its charge-to-capacity ratio is only 0.5 lbs./TR, compared to 20-25 lbs./TR for a conventional system. With its use of a natural refrigerant, the low-charge system makes a good fit at the Port of Long Beach, which touts itself as “the Green Port.”



Baker's Long Beach facility will be operated by Lineage Logistics, Irvine, Calif., the second-largest cold-storage company in the world, with several port facilities of its own. ([See story, page 45.](#)) The NXTCOLD units were designed by Controlled Environments Construction, Tustin, Calif., the general contractor and developer of the facility.

Lineage already has experience with one NXTCOLD unit running at its facility in Oxnard, Calif., 85 miles up the coast from Long Beach. ([See story, page 46.](#)) Lineage operates some systems with very large charges at its other locations, including a 500,000-square-foot building that uses 150,000 lbs. of ammonia.

"Safety was a big motivator for choosing the low-charge scenario," said John Dittrick, senior vice president of engineering for Lineage, during an interview with *Accelerate America* on July 28 at the Long Beach facility (where a minor earthquake was detected

that day). "We certainly don't want to disrupt the day-to-day operation of the port due to a potential ammonia leak."

A leak from more than one NXTCOLD unit at the same time would be extremely improbable. And a leak from one unit, a third-party analysis showed, would effectively have no impact on the area, said John Scherer, chief technology officer and co-founder of NXTCOLD, inventor of the NXTCOLD system, and longtime manager of engineering for Los Angeles Cold Storage, during the same interview. When California's Division of Occupational Safety & Health evaluates the facility, "the worst case is a 30-lb. ammonia leak," he noted.

The low charge of the NXTCOLD system made it easy to gain approval from the local fire chief, said Gary Guesman, president, Controlled Environments Construction, during a tour of the site.

Not that the fire department isn't sensitive to ammonia used near the Port of Long Beach. A cold-storage operator located a mile away was shut down following two ammonia leaks, one of which closed the highway to the port. "It was all over the local news," said Dittrick. "That's my fear in having a big ammonia charge in a facility like this."

In an industry known for the glacial pace of change, a facility with 46 separate refrigeration units represents a remarkable departure from the status quo. "This building is probably the first of its kind," said Dittrick.

It will be closely watched as a case study in whether a large industrial facility can cost effectively transition from a large-charge, centralized ammonia system to a distributed system with multiple units that drastically reduces the amount of ammonia.

Low-charge ammonia systems, still relatively new to the North American marketplace, are attracting considerable interest in the industrial refrigeration sector. In addition to reducing the risks associated with ammonia leaks, the low-charge systems enable cold-storage operators and food processing plants to lower the regulatory burdens that apply to systems with more than 10,000 pounds of ammonia.

[continued on p.44](#)



A NXTCOLD unit and cooling tower, on the roof of the Baker Cold Storage facility in Long Beach, Calif.

→ The small-charge units can also be used in place of industrial systems that employ R22, which is being phased out of circulation, or high-GWP HFCs, which are being targeted for removal by the Environmental Protection Agency.

NXTCOLD is one of several companies marketing low-charge packaged units; the others include Evapco, Azane and Stellar. Some larger operators are taking a different approach to lowering the ammonia charge, such as using a NH_3/CO_2 system that confines ammonia to the machine room, or an ammonia DX system that employs a DX evaporator. In April, Lineage opened a facility in Charleston, S.C., that uses an NH_3/CO_2 system. (See [“Seizing the \$\text{NH}_3/\text{CO}_2\$ Opportunity,” *Accelerate America*, October 2015.](#))

In addition to its two Lineage installations, NXTCOLD has installed two low-charge freezer units at a Neptune Foods seafood storage facility in San Pedro, Calif., seven miles west of Long Beach, as well as one at Los Angeles Cold Storage near downtown Los Angeles. (See [“Embarking on a New Voyage,” *Accelerate America*, March 2016.](#))

But the 46-unit Long Beach facility is by far NXTCOLD's most audacious project to date. “This is John [Scherer's] dream coming true,” said Guesman. “Look at it. It's beautiful.”

FAIL-SAFE OPERATION

With its port location, the Long Beach cold-storage warehouse will import fruits and vegetables while exporting beef, pork and chicken products. It comprises 14 cold-storage rooms (from 8,000-55,000 square feet), six blast-freezer areas, three railroad docks and two truck docks (one a cross-dock area), as well as a produce repacking area leased by an independent processor. “This is the most flexible building either of us has ever seen in the cold-storage industry,” said Scherer.

The 46 low-charge ammonia units range in capacity from 10 to 60 TR. Baker opted to go with twice as many units as absolutely needed in order to ensure a fail-safe operation, said Scherer. “If one stops, you run another one.”

Ten of the NXTCOLD units were installed on the day of *Accelerate America's* interview with Dittrick and Scherer over the course of eight hours, for a total of 40 at that point, with the remaining six blast-freezer units still to go in before the facility's October start date.

Another big factor in the decision to employ low-charge ammonia units is the considerable documentation associated with complying with OSHA's PSM (process safety management) program for large-charge ammonia facilities. Federal PSM rules apply to facilities with 10,000 lbs. or more of ammonia, while California's PSM rules apply to just 500 lbs. or more. “That costs a lot of money and [Baker] would like to reduce their compliance costs,” said Dittrick. The low-charge units, which are evaluated individually for their charge under federal and state rules, “virtually eliminate the onerous requirements that have been burdening this industry.”

Added Scherer: “We have plants where the people who do maintenance work spend more time on codes and regulations than they do in the plant. The tail's been wagging the dog lately.”

The small charge and relative simplicity of the low-charge ammonia units thus enable cold-storage operators to spend less time dealing with their refrigeration systems and more time taking care of their core business, said Scherer. “We like to blast-freeze product, and ship it in and out. That's our business – not running ammonia systems.”

As an added bonus, the room that would have been an engine room in the original design is another revenue-generating storage area, with 700 pallet positions. “People forget that,” said Dittrick.

NXTCOLD is not the only type of low-charge ammonia technology Lineage is using. In April, the company opened a 180,000-square-foot facility in Charleston, S.C., that employs an NH_3/CO_2 cascade system. The system contains just under 8,000 lbs. of ammonia, confined to the machine room, and 60,000 lbs. of CO_2 , which is condensed by the ammonia and circulates through the refrigerated areas, accommodating 2,291 TR of capacity. The ammonia charge is thus 3.6 lbs./TR.

Dittrick pointed out that the Charleston facility differs from the Long Beach warehouse in having a large quick-freeze room (647,160 cu. ft.) at very low temperatures (-20 to -25°F). "There are places with low temperatures and big loads where ammonia/ CO_2 is the system to put in," added Scherer.

But the NXTCOLD units give Lineage more options and flexibility than a centralized system, noted Dittrick. For example, Lineage intends to initially operate the largest freezer in the facility – a 55,000-square-foot room with more than 10,000 pallet positions (more than a third of the operation) – in mid-September, while other parts of the building, such as the blast freezers, are being constructed. By contrast, in a building with an engine room, "if the contractor doesn't have the engine room done, it holds up everything," he said.

Moreover, the temperature reduction for each room can be staged slowly and independently. "So our start-up costs should be very favorable," said Dittrick.

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Gary Guesman, Controlled Environments Construction

THE LINEAGE STORY

Through a series of acquisitions, Lineage Logistics, Irvine, Calif., in four short years, has become the second largest cold-storage provider in the world, following only Americold Logistics, according to the International Association of Refrigerated Warehouses.

Lineage currently operates 113 facilities encompassing 609,276,428 cubic feet across 22 U.S. states.

Lineage was formed in 2012 by Bay Grove Capital, San Francisco, a principal investment firm, which acquired and consolidated the following companies under the Lineage name: Richmond Cold Storage, Terminal Freezers, Flint River Services, CityIce and Seafreeze, as well as other individual locations.

In July 2012, Lineage acquired Castle & Cook Cold Storage, doubling its size. Castle & Cook's CEO, Bill Hendrickson, and president, Paul Hendrickson, became CEO and COO of Lineage, respectively. (Greg Lehmkuhl is Lineage's current CEO and president.) The following month it purchased Stanford Refrigerated Warehouses.

In April 2013, Lineage bought Seattle Cold Storage, and in May 2014, it expanded further, acquiring Loop Cold Storage, Oneida Cold Storage and Millard Refrigeration Services. Lineage added Columbia Colstor in January 2015. Last month, it acquired Consolidated Distribution Corp.

Lineage's Castle & Cook acquisition led it into the warehouse management business. Castle & Cook was formed in 2008 through the merger of Inland Cold Storage and Madison Warehousing. Inland Cold Storage had operated two facilities owned by Baker Commodities prior to being acquired by Castle & Cook – contracts that continued under Castle & Cook and continue now under Lineage. Lineage will also manage Baker's new Long Beach, Calif., warehouse (see main story), along with one other third-party facility; Lineage either owns or leases the rest of its warehouses.



Inside NXTCOLD's low-charge ammonia unit: from left, ammonia compressor package; Danfoss valves, including electronic liquid injection.

→ COMPARABLE FIRST COSTS

While offering significant advantages with its small amount of ammonia, the Long Beach facility's 46-unit NXTCOLD system must also pass muster on a total-cost-of-ownership (TCO) basis.

The capital and installation cost of the system is "comparable" to that of a traditional two-stage ammonia system, said Dittrick, who expects the cost of low-charge units to come down as demand grows. "It's still early, only under two years" that the systems have been available, he noted. One added cost with rooftop units is the heavy steel needed to support them.

Scherer acknowledged that the maintenance work required for 46 independent low-charge units will probably be more than that of a standard ammonia plant. "We need to run the units to see," he said, adding that the compressors used in the units are much smaller and less costly to maintain than central machine room compressors,

In addition, having all of the units on the roof means that maintenance workers "won't disrupt general business in the warehouse," said Dittrick. "One guy goes up to the roof and does one unit by himself."

Lineage plans to employ CIRO (certified industrial refrigeration operator) technicians at the facility who will inspect the units daily. The 46 units will also be networked together under a refrigeration control system that will enable Lineage to track them from a laptop or iPhone.

As for energy costs, Lineage's NXTCOLD unit at its Oxnard facility has been found to save 9% to 13% in energy consumption. ([See story, this page.](#))

Given its first-of-its kind status, the Long Beach facility refrigeration system has been carefully scrutinized and will continue to be for some time. "We've walked out on the plank on this, all of us together, to make sure it would work," said Guesman. "We're feeling pretty good about it." **OMG**

OXNARD'S ENERGY-SAVING UNIT

Lineage Logistics installed its first low-charge ammonia unit from NXTCOLD at its facility in Oxnard, Calif., in May 2015, only the second ever deployed.

The unit supplements the facility's blast-freezing needs by "hardening" strawberries at -10°F, freezing them to the core, after they emerge from blast freezing, said John Dittrick, senior vice president, engineering for Lineage.

The 50-TR NXTCOLD unit, located on the ground outside the hardening room, uses 25 lbs. of ammonia, or 0.5 lbs./TR. Had Lineage not purchased the unit, "I would have had to purchase another evaporator coil or two, and run a whole new suction liquid and hot gas pipe to the coils," said Dittrick.

Southern California Edison (SCE) has determined that the energy savings of the unit is between 9% and 13%, based on total building utility data. The utility plans to offer custom incentives for low-charge units of \$0.08 per kWh of energy saved, and \$150 per kW of demand reduction, according to Paul Delaney, senior engineer for SCE.

SYSTEM SPECS

The low-charge ammonia system at Baker Cold Storage's Long Beach, Calif., facility has the following characteristics:

- Provider: NXTCOLD
- No. of units: 46 (on rooftop)
- Total capacity: 1,015 TR
- Total ammonia charge: 496 lbs. (.5 lbs./TR)
- One RSD fiberglass cooling tower/unit
- Loads: 14 cold-storage rooms, six blast-freezer areas, three railroad docks and two truck docks and a produce repacking area.
- Temperature ranges: freezers, 0°F to -5°F; docks, 36°F to 40°F; produce areas, 40°F to 50°F
- Four water-treatment sumps

Each unit has:

- Evaporator (except blast freezer units)
- Evaporator fans
- Ductwork into refrigerated space
- Return-air grates
- Bitzer compressor
- Plate-and-frame condenser
- Danfoss controls, including electronic liquid injection
- Plate-and-frame oil cooler
- Two NH₃ detectors
- VFD for screw compressor and evaporator fans

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From left, Keith Milligan, JTM Corp. (Piggly Wiggly); David Schalenbourg, Delhaize; James Hyland, Roundy's

SHOWING WHAT IS POSSIBLE

Delhaize, now merged with Ahold, is spearheading CO₂, propane and ammonia projects in Europe as well as CO₂ and ammonia installations in the U.S. through its Food Lion and Hannaford divisions

— By Mark Hamstra

Ahold Delhaize, the newly formed company consisting of global food retailers Ahold and Delhaize, is leveraging the learnings it has gleaned from operating natural refrigerant-based systems in Belgium to expand implementation into other markets in Europe and the U.S.

"In Belgium we are quite advanced, and we are sharing the knowledge we have with our other operating partners," David Schalenbourg, director, technical department, for Delhaize Belgium, told attendees during a presentation at the ATMosphere America conference in Chicago in June. "We have as a goal to lead the way, to help transform the marketplace, and to show others what is possible."

In July, Brussels, Belgium, based-Delhaize Group, which operates the Food Lion and Hannaford Bros. chains in the U.S., completed its merger with Zaandam, the Netherlands-based Ahold, which operates the Stop & Shop and Giant Food chains in the U.S. Both also have holdings in Europe and other regions.

Delhaize will continue with the same approach to refrigeration and greenhouse gas reduction while "aligning with the Ahold team," said Schalenbourg.

Delhaize has been rolling out a variety of cooling systems for its stores, including CO₂ transcritical refrigeration racks, hybrid systems and self-contained plug-in propane coolers, and has

installed ammonia refrigeration systems in several warehouses, including ammonia/CO₂ systems. It also has deployed CO₂ cooling systems in 25 refrigerated trailers in Belgium.

"We are committed to increasing the number of natural refrigerant systems wherever feasible," said Schalenbourg.

In some markets, however, the lack of trained contractors who can install and maintain the equipment presents a barrier to implementation, he said.

Delhaize's corporate goals include reducing its greenhouse gas emissions by 20% by 2020 (from 2008 levels), while also reducing the average global warming potential (GWP) of the refrigerants it uses.

It continues to focus on efficiency optimization for its CO₂ systems (including tests of ejector technology), systems integration, and the ongoing rollout of self-contained propane coolers.

In the U.S., Delhaize has three CO₂ transcritical installations (two at Hannaford, one at Food Lion), three CO₂ hybrid installations at Food Lion, and five distribution centers that use ammonia refrigeration technology (large charge). One additional CO₂ transcritical project, in a Hannaford Bros. store remodel, is scheduled to be completed by the summer of 2017.

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→ In Belgium, where the company's green refrigeration efforts are the most well-established, Delhaize has eight CO₂ transcritical installations, 48 hybrid installations, and three DCs with ammonia/CO₂ systems. It also uses R290 (high-grade propane) in self-contained systems at nine locations.

Delhaize has already achieved a 31% reduction in greenhouse gas emissions in Belgium, Schalenbourg noted. In an effort to increase efficiency, the company has installed covers on its low-temperature refrigeration cases and doors on its mid-temperature coolers. It has also installed inverters on racks.

"This led to a capacity reduction, and when you combine it with active leak management by continuously monitoring the installations, you can really outperform and achieve good results," said Schalenbourg.

VARIETY OF CO₂ APPLICATIONS

As the company continues to convert its legacy, high-GWP refrigeration systems to natural refrigeration technologies, all new installations in Belgium will feature CO₂ transcritical refrigeration systems, he said.

At three remodeled locations in Belgium where the company has switched from R404A to CO₂ transcritical refrigeration, greenhouse gas emissions have dropped from 20% to as much as 40% in one award-winning store that was completely rebuilt to replace a much older facility.

Schalenbourg also described some of the significant progress it has achieved in energy savings at a warehouse complex near Brussels that contains three generations of ammonia technologies.

The oldest installation used a hybrid system of ammonia and

glycol, but Delhaize was able to achieve much more efficiency with ammonia-CO₂ systems in the other two buildings.

The first ammonia-CO₂ installation helped reduce energy use by 64%. The second achieved a 90% reduction, despite the increased height and volume of the building; that was accomplished through improved condenser design and better building insulation, Schalenbourg explained.

Delhaize is also a leader in the testing of CO₂ refrigerated transport technology in its trailers. It has 25 refrigerated trailers in Belgium cooled by CryoTech CO₂ systems. This open-loop technology uses CO₂ from industrial waste, so that no new CO₂ is released into the atmosphere.

Trailers can travel about 250 miles on each CO₂ charge, which Schalenbourg said is enough for the company's needs in Belgium. The trailers reduce emissions by 90%, he said, and also operate more quietly than traditional trailers — an advantage for overnight deliveries in residential areas.

In Greece, Delhaize's efforts to install natural refrigerant technology are ramping up. Delhaize already has 12 hybrid systems, two DCs with ammonia technology and 15 locations featuring propane refrigeration.

In Romania, Delhaize has one distribution center that uses ammonia refrigeration and also has 93 locations using propane refrigeration technology, and in Serbia, Delhaize has one DC featuring ammonia refrigeration.

In Indonesia, where Delhaize operates 128 stores with a joint-venture partner, Schalenbourg said the company was hopeful that upcoming tests of systems in warmer climates will yield natural-refrigerant solutions for that region as well. **MH**

Delhaize's Natural Refrigerant Locations

	TRANSCRITICAL CO ₂	HYBRID CO ₂	R290	NH ₃ DISTRIBUTION CENTERS
U.S	3 stores	3 stores		5
Belgium	8 stores	48 stores	9 stores	3
Greece		12 stores	15 stores	2
Romania			93 stores	1
Serbia				1

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NH₃, PROPANE JOIN CO₂ IN NORTH AMERICAN STORES

Ammonia/CO₂ cascade systems and self-contained propane cases are starting to gain a foothold as natural refrigerant solutions, alongside transcritical CO₂

- By Michael Garry.

While CO₂ transcritical refrigeration systems are slowly being adopted in the U.S. food retail industry, two other natural refrigerants — ammonia and propane — are beginning to attract interest as well among food retailers.

All three refrigerants were addressed in "Commercial Refrigeration Case Studies, Part 2," a session at ATMOsphere America in Chicago in June.



From left, Marc-André Lesmerises, Carnot Refrigeration; Dan O'Brien, Zero Zone; Daniel Clark, Hamilton-Clark Refrigeration Design & Management; Paul Delaney, Southern California Edison; Howard Feig, AHT Cooling Systems USA; Joe Sanchez, Bitzer US.

AMMONIA/CO₂ AT FOUR U.S. STORES

Whole Foods Market's store in Dublin, Calif., has one of four supermarket deployments in the U.S. of an ammonia/CO₂ cascade system, which uses ammonia as the primary refrigerant and CO₂ as the secondary cooling agent. In this application, recirculated CO₂ goes to (750 KBTU) medium-temperature cases while DX CO₂ is employed in (120 KBTU) low-temperature cases, noted Dan O'Brien, national sales manager for Zero Zone, which supplied the system. Total load is 70 TR.

O'Brien described the year-old project as "overall successful," though data on energy consumption has not yet been collected.

Environmental and regulatory changes, especially in California, were a driver of the project, he noted.

Among the challenges posed by the NH₃/CO₂ system: isolating ammonia from occupied areas, and keeping costs justifiable "in markets accustomed to cheaper systems using synthetic refrigerants," said O'Brien.

The Whole Foods store has the ammonia equipment, including 200 pounds of ammonia, on the roof, with controlled access to the equipment area and leak detection with local and remote alarms. DC Engineering, which worked on the project, and Whole Foods "dealt with the local municipality" to gain approval for the system, said O'Brien.

In the "worst-case" event that all 200 pounds of the ammonia leaked, it would be contained on the roof, according to an Environmental Protection Agency study. Calculations like this are needed to educate retailers and overcome "misconceptions of ammonia leak potential," O'Brien said.

At the Whole Foods store, shaft-seal leaks released "minute amounts of ammonia" to no effect, and the seals were replaced, he said.

To compensate for the absence of an on-site operator and to minimize service, the system incorporates near-total automation, including extra sensors for monitoring, automatic shut-down/restart, remote monitoring, and an automatic oil recovery and return system.

“There’s no clear winner – and there will be no perfect system in the future,”

The Whole Foods NH₃/CO₂ system also employs a BAC Trillium condenser, which increases operating efficiency and improves life cycle costs, while capturing compressor heat for facility heating and hot water.

Joe Sanchez, engineering manager for Bitzer U.S., pointed out that the four U.S. supermarket installations of NH₃/CO₂ – Whole Foods, Piggly Wiggly ([see page 32](#)), Defense Commissary Agency (DeCA) and Albertsons – are "extremely different," with varied approaches to ammonia charge, efficiency, cost and maintenance. "There's no clear winner – and there will be no perfect system in the future," he said.

One difference is the compressor configuration. The Albertsons store in Carpinteria, Calif., uses a single pack, whereas the Piggly Wiggly and Whole Foods stores employ multi-compressor parallel racks, and the DeCA commissary has a modular design with nine rooftop units.

Though the Whole Foods store uses an automatic oil recovery and return system, Sanchez said the cost of that system "is one of the cost drivers hampering the success of ammonia/CO₂ [installations]." He noted that in industrial refrigeration, manual oil draining is a longtime practice. "Why not consider draining oil in supermarkets?" he said. He suggested having grocery technicians drain the oil once every six-12 months.

Sanchez described the danger of ammonia in a supermarket setting "very, very low." But he acknowledged that in a supermarket even the smell of ammonia presents a "social" issue. But it doesn't have to be perceived as scary, he said. "Maybe one day we will smell ammonia in a supermarket and say that's not a big deal; it's probably something with the refrigeration."

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→ MORE THAN 1,000 PROPANE CASES

According to Howell Feig, sales director for strategic accounts, AHT Cooling Systems USA, AHT's self-contained propane (R290) cases, including spot bunker units and narrow, wide and jumbo island cases, have been installed in more than 1,000 locations in the U.S. In addition, a number of retailers are exploring AHT's R290 self-contained units as a "full-store solution," with some projects to be completed "in the near term," he said.

Though R290 cases are approximately 10% more expensive than HFC cases, utility rebates, based on superior energy efficiency, are available to offset that initial premium, Feig said. Thirteen-foot R290 cases with lids were found to be much more efficient than open cases, consuming 4,672 annual kWh compared to 7,640 kWh (remote 12-foot) and 10,741 kWh (self-contained 10-foot).

All propane cases contain a maximum charge of 150 g, but "maybe it can get up to 300-500" with regulatory changes, said Feig.

Technician training and getting permission from local authorities were barriers when AHT introduced self-contained R290 units in the U.S. in 2010-2011. However, there are now many certified technicians and no issues with local authorities, said Feig.

Paul Delaney, senior engineer for Southern California Edison (SCE) described a study of propane-case efficiency that the utility conducted in its labs. The propane "coffin" cases were found to offer 20% energy savings compared to R404A cases, with an annual savings of about 500-600 kWh. "The propane and variable-speed drives contributed to the efficiency," he said.

SCE is offering a custom incentive to a new group of 39 stores entering Southern California for these R290 cases. In addition, the utility will be monitoring the efficiency of the new stores in an effort to develop a deemed (prescriptive) incentive that is easier to implement, said Delaney.

“CO₂ is the ‘New Normal’ in Europe.”

CO₂ IN SUPERMARKETS AND ICE RINKS

Carnot Refrigeration has brought energy-efficient CO₂ refrigeration to a range of applications. At ATMOSphere America, CEO Marc-André Lesmerises, described two types of applications – ice rinks and supermarkets.

Two ice rink installations of Carnot's CO₂ systems using glycol as a secondary fluid saved 29% and 18% in energy compared to previous systems, he said. The energy expended in pumping glycol is recovered in heat recovery from the system. The facility with 29% savings – the Cynthia-Coull Arena, Greenfield Park, Quebec – received an ASHRAE Best Technology Award in 2015.

Carnot has installed CO₂ transcritical systems in 65 supermarkets, including 15 retrofits. In two examples, the stores were found to save 23% and 14% in energy compared to prior systems. To enhance energy savings at these stores, Carnot deployed software to improve heat reclaim capabilities.

Daniel Clark, founder of U.K.-based Hamilton-Clark Refrigeration Design & Management, described the implementation of CO₂ transcritical systems by Booths, a 28-store grocery chain in Northwest England. Starting in 2010, Booths now has these systems in 40% of its stores. "Transcritical CO₂ is the new norm," said Clark.

Each Booths store uses two independent transcritical booster CO₂ systems encompassing Advansor racks, Bitzer compressors, Hauser cabinets, Wieland tubing and Resource Data Management controls.

The CO₂ racks offer 12% energy savings, and in Booths' northern climate, can take advantage of free cooling. Doors on the multi-deck cases add 38% savings, while heat recovery contributes 5% savings, said Clark.

Cost of the system is "getting nearer" to that of HFC systems. But because of CO₂'s higher pressures, which require more metal, "you are never going to get to cost parity," he said. However, capital cost uplift is "dwarfed by life cycle savings."

Clark also noted that the total equivalent warming impact (TEWI) of Booths' CO₂ system is 82% less than that of an R404A system with open multi-decks and no heat recovery.

U.S. food retailers installing CO₂ transcritical systems can benefit from the "intensive development of CO₂ refrigeration technology over the past 10 years," said Clark. "CO₂ is the 'New Normal' in Europe." **MG**



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SIZING UP NATREFS IN THE PACIFIC NORTHWEST

Utility wholesaler Bonneville Power Administration is collecting energy data on baseline and natural refrigerant systems as part of its incentive program

— By Michael Garry



EPRI's 2016 Energy Efficiency & Demand Response Symposium

The Bonneville Power Administration (BPA), responsible for about 28% of the electric power used in the Northwest, has its eye on energy-efficient refrigeration technology, including that using natural refrigerants.

"We think GWP [global warming potential] limits on refrigerants will cause the refrigeration equipment market to shift," said Jamie Anthony, contract staff engineer and grocery subject-matter expert for Portland, Ore.-based BPA, in a presentation at the Electric Power Research Institute (EPRI) 2016 Energy Efficiency & Demand Response Symposium, held in Long Beach, Calif., July 25-28. "We see this as an opportunity to influence equipment choice and want to prepare to promote efficient equipment."

Natural refrigerant systems fall into the category of energy-efficient equipment, and the BPA is in the process of investigating the efficiency of different refrigeration options at supermarkets, including a transcritical CO₂ system, in advance of providing food retailers with incentives to implement them.

Established in 1937, BPA is a non-profit federal utility wholesaler that sells and transmits carbon-free power (generated by hydro and nuclear sources) to retail utilities in the Pacific Northwest. Its 142 customers include electric cooperatives, municipalities, public utility districts, investor-owned utilities and tribal utilities. BPA develops "very precise, personalized plans for our 142 different customers," said Anthony.

continued on p.58 →

A wind of change is coming...



Frick
INDUSTRIAL REFRIGERATION

Johnson
Controls

→ BPA is among a growing number of utilities looking into offering incentives to end users for using natural refrigerant HVAC&R technology as an energy-saving and environmentally friendly alternative to traditional high-GWP systems. ([See "Putting Money on the Table," Accelerate America, July-August 2016.](#))

Anthony described several potential new incentive mechanisms for natural refrigerant equipment, notably custom projects and deemed measures.

Custom projects offer the most flexibility and early opportunities. "We do a lot of custom projects and this is how we're going to do our first natural refrigerant changeover projects," said Anthony. Though it takes time to estimate and document the energy savings achieved in custom projects, "you can do whatever you want for the most part; so natural refrigerants fit into this category."

To that end, Anthony encouraged end users in BPA's territory to contact BPA "if you've got a really good idea that is going to save energy by going from a traditional refrigerant to an alternative or natural refrigerant. We can work with you now."

Deemed incentives, by contrast, are fixed amounts attached to specific pieces of equipment, such as an electronic commutated motor in an evaporator coil. "You claim a certain amount of energy saved per motor, and you're paid per motor installed," he said. "It's simple." BPA is evaluating deemed incentives for integrated stand-alone display cases that use propane refrigerant.

In general, deemed measures are the hardest to establish because they require the most research; so it may take a long time before more complex refrigeration systems can attain deemed status.

BPA is also developing a "strategic energy management" program based on annual energy savings at the whole building level whereby the incentive would be paid "year after year," Anthony said.

“We see this as an opportunity to influence equipment choice.”

BASELINE AND TRANSCRITICAL PROJECTS

In order to move forward with natural refrigerant incentives, BPA is working to establish a baseline against which to measure efficiency gains. "We need to know the baseline system that you're going to upgrade," said Anthony. "How much energy does the baseline system use compared to the more efficient system you're going to install. The delta is the savings."

He provided some hypothetical examples with different potential GWP limits: a baseline multiplex system with an EER (energy efficiency ratio) of 11 using a refrigerant with a maximum GWP of 500, compared with a more efficient glycol cascade system with an EER of 13 using the same refrigerant; and a baseline multiplex system with an EER of 10 using a refrigerant with a maximum GWP of 250, compared with a transcritical CO₂ system with heat reclaim and an EER of 12.

To help it gain information on available refrigerants and the cost for switching to natural refrigerants, BPA is collaborating with EPRI. BPA is also working with the Pacific Northwest's Regional Technical Forum on deemed measures, as well as grocery chains in the region to assess the EER of existing systems and of a transcritical CO₂ system over one year.

"We will do field research, compile data, and analyze and share the results," said Anthony.

Currently, BPA is using a ClimaCheck device to collect a year's worth of baseline data on a medium-temperature system and low-temperature system at four stores in the Pacific Northwest. The data includes temperature, pressure, EER, power and cooling loads.

BPA has also entered into "contract work" to install a ClimaCheck system on a transcritical CO₂ system. "I'm pretty excited about that," said Anthony. "I want to know all the temperatures and pressures." **MG**



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Cooltech booth at FMI Connect in June.

THE NEXT REFRIGERATION SYSTEM?

Cooltech brings its gas-free, magnetic refrigeration technology to U.S. supermarket industry

— By Mark Hamstra and Michael Garry

What could be better for the environment than using a natural refrigerant that changes phase between gas and liquid?

Using no refrigerant at all, according to executives from Cooltech Applications, a pioneer of commercial magnetic refrigeration systems that recently formed a partnership to bring its eco-friendly technology to the U.S. for installation in supermarket coolers.

Strasbourg, France-based Cooltech in June unveiled an agreement with Structural Concepts, a refrigerated display-case manufacturer based in Muskegon, Mich., by which Structural Solutions will incorporate Cooltech's novel magnetic refrigeration system in some of its cases.

Both companies exhibited at the Food Marketing Institute (FMI) Connect conference in June in Chicago, where *Accelerate America* spoke with Michael Hittinger, engineering manager at Cooltech, and Vincent Delecourt, director of sales and marketing, about their plans to introduce magnetic refrigeration to the U.S. grocery industry.

"We can offer something with no gas, less pressure, better safety and 30% to 40% energy savings," Delecourt said of his company's refrigeration systems for supermarket coolers, comparing them to the commonly used R404A cooling systems.

Cooltech has deployed magnetic refrigeration systems for uses other than supermarket coolers, including some medical applications, but the technology has not yet been rolled out in a supermarket environment. The company owns a portfolio of more than 300 patents in 40 countries.

Delecourt said Cooltech expects to complete the first supermarket installation in Europe by the end of this year, and he said the company is targeting the first U.S. supermarket deployment within the next 12 months.

HOW IT WORKS

Magnetic refrigeration leverages a phenomenon called the magneto-caloric effect, in which materials heat up when subjected to a magnetic field, and cool down when removed from it. This process replaces the vapor-compression technology commonly used in both conventional and natural refrigerant systems. Because no gas is used in the magnetic system, it does not require a compressor or an evaporator.

Cooltech's MR400 system uses a proprietary blend of solids, including a gadolinium alloy, as the material that is influenced by the magnetic field. That material in turn cools a water/glycol mixture, which becomes the secondary refrigerant that cools a display case.

The unit operates at low pressure with low rotational speed, which reduces vibrations to a minimum and cuts noise to less than 35 decibels. The system has a "quasi-indefinite lifespan" with minimal maintenance required, according to Cooltech.

The system is relatively small, with cooling power of 200 W-700 W, and is designed for individual, self-contained coolers. It can cool to a range of temperatures for both mid-temperature refrigeration units (32°F) and low-temperature freezers (19.4°F) as well as high-temperature applications (about 4°F above ambient room temperature). The system can also be customized to suit specific case sizes.

In addition to functioning without gas, Cooltech's magnetic refrigeration system also operates with relatively low pressure (about 30 psi) compared to vapor-compression systems and draws less electricity.

Delecourt said he sees the potential for the system to eventually account for 10% to 20% of the cooler market in the supermarket industry. In addition to its partnership with Structural Concepts in the U.S., Cooltech also has agreements with high-end equipment manufacturers in Europe for the potential rollout of the product there, and is seeking to expand in the Asia-Pacific market in the same way.

Hittinger said the company hopes to have one installation in each of the commercial segments it is targeting in each of three global regions within the next year.

A larger magnetic refrigeration system with 20 kW or more of cooling power for commercial rack and industrial applications is in the planning stages, and could take about two years to develop, Delecourt said. Cooltech is currently seeking an equipment manufacturer to partner with on that initiative.

"Right now we're looking at medical equipment, display cases, beverage coolers and foodservice equipment" for the MR400 rollout, Delecourt said.

Cooltech and Kirsch, its German partner for medical applications of the technology, presented the first magneto-caloric refrigerator system for medical refrigeration installations at the Medica 2015 conference in Dusseldorf, Germany, last December.



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→ COMPETING WITH PROPANE

Delecourt said the company views self-contained propane refrigeration systems as the primary competitor in the market for naturally refrigerated display cases.

"It is more expensive than propane, but more efficient," he said, adding that he expects costs to decline as the company gains scale.

Although Cooltech has not compared its energy use side-by-side with propane systems, Delecourt said the Cooltech system achieves energy savings of 30% to 40% when compared to R404A refrigeration units. The magnetic system needs to outperform propane by at least 20% to be competitive, he said.

The system also discharges warm air that can be reclaimed for other uses.

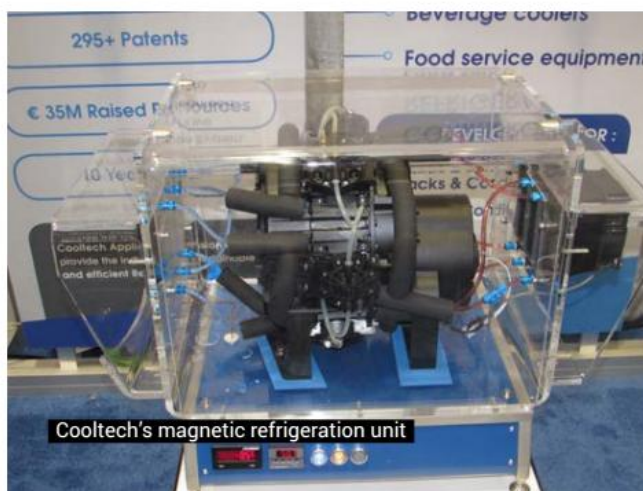
Magnetic refrigeration technology is already widely known among supermarket companies in Europe, where stringent environmental regulations have forced operators to explore various natural refrigerant options.

"In Europe, most supermarkets know this technology, but in the U.S., I would say they have just started thinking about it," Delecourt said, citing the evolving regulatory landscape around refrigerant use.

Magnetic refrigeration may be less familiar to U.S. supermarket operators, but Cooltech is working to change that by promoting it to end users at events such as FMI Connect. While at the conference, Delecourt said he showed the technology to some leading supermarket operators, including Whole Foods Market, Publix Super Markets and Target Corp.

Part of the process of educating U.S. supermarket operators about the technology will be convincing them of its cost-effectiveness. Although the Cooltech systems currently are more expensive than propane alternatives, Delecourt said he expects the technology to eventually yield a payback for those who invest in it.

"The final target when it is mature is to reach a return on investment within two to three years," he said, referring to the ROI in relation to the additional cost of the technology over the cost of propane systems.



The cost saving attributed to magnetic refrigeration systems stems from their reduced energy use and relatively low maintenance costs, Delecourt explained.

In Europe, the cost has not been a significant barrier for operators, he said.

"The big supermarket chains in France don't care as much about the price; they care that they are doing something green," Delecourt said. "In Europe, they are very enthusiastic about this technology."

UNIVERSITY RESEARCH

While Cooltech describes itself as the world leader in commercial magnetic refrigeration technology, others have also been seeking to refine its use for commercial and domestic applications as well.

As reported in the May 2016 issue of *Accelerate America*, researchers at the Ames Laboratory at Iowa State University have been working toward a commercial application of their research on magnetic refrigeration. The Ames Laboratory, which operates under the U.S. Department of Energy, is partnering with eight other labs around the country on a project called CaloriCool that is seeking to lay the groundwork for potential commercial use of the technology.

Other private firms have also been working on marketable magnetic refrigeration systems. Boston-based General Electric, for example, is developing a home refrigerator that uses magnetism rather than vapor compression, aiming to introduce it in the next three years. In addition, two German companies (BASF and Vacuumschmelze), the Chinese firm Haier and Astronautics Corp. of America have all made progress toward commercialization of magneto-caloric cooling. **MH & MG**

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- Issue #19 October 2016

Issue #18

September 2016

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Ad submission deadline: Sep. 30

Additional Topics:

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- » Data Centers
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VOLUME #3

- Issue #20 Nov.-Dec. 2016
- Issue #21 January 2017
- Issue #22 February 2017
- Issue #23 March 2017
- Issue #24 April 2017
- Issue #25 May 2017
- Issue #26 June 2017
- Issue #27 July-Aug. 2017
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Focus: Foodservice, Industrial Refrigeration (Cold Storage)

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