

JUNE 2019

ACCELERATE

ADVANCING HVAC&R SUSTAINABLY

MAGAZINE

NORTH AMERICA - EUROPE - AUSTRALIA - JAPAN - CHINA

**WELCOME TO OUR
FIRST GLOBAL EDITION!**

Daimler CO₂ MAC: 1998



NATREFS

Montreal Protocol: 1987

EU F-Gas Regulation: 2006

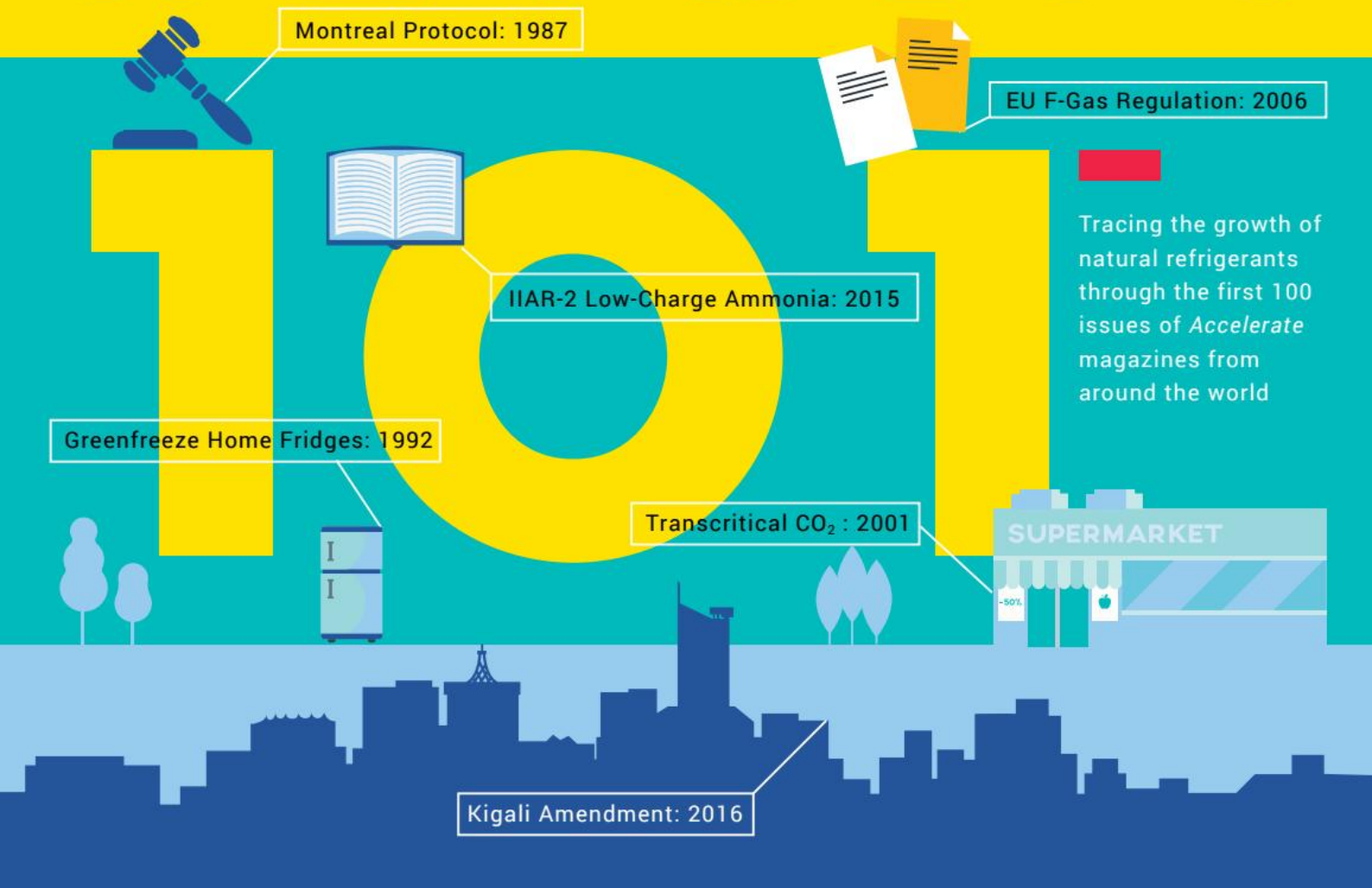
IIAR-2 Low-Charge Ammonia: 2015

Greenfreeze Home Fridges: 1992

Transcritical CO₂ : 2001

Tracing the growth of natural refrigerants through the first 100 issues of *Accelerate* magazines from around the world

Kigali Amendment: 2016



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ADVANCED NATURAL REFRIGERANT TECHNOLOGY RESULTS IN:

- Less energy consumption
- Reduced operating costs
- Improved eco-balance

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A Quick Look at This Issue

END USERS

Whole Foods Market's Tristram Coffin says he would install a second R290/CO₂ cascade system, after finding its initial performance promising and overcoming permitting challenges in California. (Page 40) ... **Mega Image** has opened three supermarkets fitted with CO₂ transcritical systems, which are uncommon in Romania. (Page 52) ... Aiming for 100 transcritical CO₂ stores by 2025, **ALDI Australia** is developing a system that would not rely on adiabatic water usage, despite Australia's warm climate. (Page 62) ... **SNØ**, Norway's first year-round indoor ski arena, will feature snow made by the country's largest transcritical CO₂ system. (Page 56) ... **Yoshio Ice's** three transcritical CO₂ systems at a cold storage facility exceeded energy expectations in one of Japan's hottest regions. (Page 74)

TECHNOLOGY

Taking advantage of the rising cost of HFCs, a bevy of OEMs introduce **propane heat pumps** at ISH, a German trade show. (Page 58) ... Rising gas costs in Australia are driving hotels and wineries to re-evaluate their space heating and hot water systems, opening up opportunities for **CO₂ heat pumps**. (Page 66) ... The Japanese CO₂ leader Panasonic is testing an **80-HP transcritical CO₂ rack** for the industrial sector, moving beyond its stronghold in food retail. (Page 76) ... China's high-speed rail network is set to become greener with the implementation of a **CO₂-based air-conditioning system**. (Page 80) ... Growing interest in **propane water-loop systems** in the Philippines – such as Royal Duty Free's all-R290 store – is driven by 25%-30% energy savings. (Page 86) ... Rebound Technologies' **on-demand subcooler** at an ammonia plant provides bursts of cooling that boost throughput and save energy in blast freezing. (Page 90)

MARKET

As it takes on North America, newly formed **Kysor Warren Epta US** will bring **Epta's** energy-saving systems from Europe, while **Kysor Warren** will continue to offer transcritical and ammonia/CO₂ systems. (Page 48) ... The **TAFE South Australia** vocational school has been using virtual reality for instruction on natural refrigerants – and is seeking industry input to improve the program. (Page 72) ... **China** is revising its ammonia safety standards, focusing on training and considering new technology to overcome concerns stemming from major accidents. (Page 84)

POLICY

Stakeholders in Australia, Europe and U.S. see lower costs resulting from the **IEC's** approval of a 500-g charge limit for flammable refrigerants. (Page 24) ... The **U.S. Climate Alliance's** 24 state members have made reducing short-lived climate pollutants like HFCs, one of their top priorities. (Page 46)



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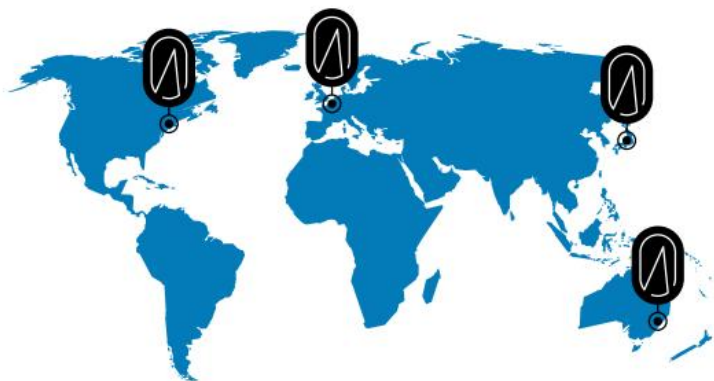
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ACCELERATE

ADVANCING HVAC&R SUSTAINABLY
MAGAZINE



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

About Accelerate Magazine

Brought to you by the worldwide experts in natural refrigerant news, *Accelerate* Magazine is the first global news magazine written for and about the most progressive business leaders working with natural refrigerant solutions in all HVAC&R sectors. It builds on the legacies of five regional magazines: *Accelerate* America, *Accelerate* Europe, *Accelerate* Australia/New Zealand, *Accelerate* China and *Accelerate* Asia, and is published in coordination with the Japanese language magazine, *Accelerate* Japan

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June 2019
// Volume 1, Issue #101

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Editorial Calendar, 2019-2020, Volume 1

// ISSUE #101

June 2019

Cover Story:

NatRefs 101: Tracing the growth of natural refrigerants through the first 100 issues of *Accelerate* magazines from around the world.

Publication Date: June 11

Ad Deadline: May 29

Print distribution: ATMosphere America (Atlanta, June 17-18)

// ISSUE #102

July/August 2019

Cover Story:

Impact of IEC's new 500-g charge limit for hydrocarbons. What are the next steps?

Publication Date: July 29

Ad Deadline: July 19

// ISSUE #103

September 2019

FOCUS:

Cover Story:

HFOs: What Environmental Impact?

Publication Date: September 3

Ad Deadline: August 23

Print Distribution: FMI Energy & Store Development Conference (Dallas, September 8-11); ATMosphere Asia (Bangkok, Thailand, September 24)

// ISSUE #104

October 2019

Cover Story:

NatRefs: Are they making a difference? What is their potential?

Publication Date: October 2

Ad Deadline: September 20

Print Distribution: ATMosphere Europe (Warsaw, Poland, October 16-17)

// ISSUE #105

**November/
December 2019**

Cover Story:

Year One of Kigali: Where do we stand?

Publication Date: October 28

Ad Deadline: October 21

Print Distribution: The 31st Meeting of the Parties to the Montreal Protocol (Rome, November 4-8)

// ISSUE #106

January 2020

Cover Story:

How do NatRefs stack up in first cost, efficiency, maintenance – and TCO?

Publication Date: January 8

Ad Deadline: December 20

Print Distribution:

AHR Expo (Orlando, Fla., February 3-5)

// ISSUE #107

February 2020

Cover Story:

How are NatRefs transforming heating and cooling of buildings?

Publication Date: February 6

Ad Deadline: January 27

// ISSUE #108

March 2020

Cover Story:

Which NatRef is Best: CO₂, Ammonia or Hydrocarbons?

Publication Date: March 5

Ad Deadline: February 21

Print Distribution: IIAR Natural Refrigeration Conference and Heavy Equipment Expo (Orlando, Fla., March 15-18)

// ISSUE #109

April 2020

Cover Story:

How CO₂ heat pumps make electric cars go further

Publication Date: April 8

Ad Deadline: March 27

// ISSUE #110

May 2020

Cover Story:

The Training Revolution: How IoT, AI, virtual reality and robotics will fill the technician void

Publication Date: May 6

Ad Deadline: April 24

The editorial calendar is subject to change by the publisher.

Sustainable Cooling Matters

— By Marc Chasserot



Marc Chasserot
Founder & Publisher

Systems that use refrigerants to provide cooling, refrigeration and heating are typically taken for granted, yet their importance, reach and impact are massive.

Consider this: according to the University of Birmingham in the U.K. there are about 4 billion cooling units (refrigerators and air conditioners) in the world. Including refrigerant leakage and electricity consumption, these units account for 10%-15% of all the greenhouse gas emissions in the world, says GIZ, the German development association.

That's just today. By 2050, the number of cooling units is expected to grow to nearly 10 billion, increasing at about 19 installations every second! Not only is all this cooling a significant factor in climate change, it plays a key role in all of the other sustainable development goals (17 in all) identified by the United Nations, such as zero hunger and good health and well being.

It's clear that cooling matters; and making sure that it develops in a sustainable way throughout the world is a big deal. And that's where this magazine comes in.

Since the need for sustainable cooling is a global issue, we have decided to make *Accelerate* a global magazine, drawing from our experience publishing several regional magazines over the past five years, including *Accelerate America*, *Accelerate Europe* and *Accelerate Australia & New Zealand*, for a total of 100 issues.

In *Accelerate Magazine* our global network of journalists and analysts will showcase in a single 10X-per-year publication the best sustainable HVAC&R solutions from every part of the world, covering all natural refrigerants and other climate-friendly technologies, and including all applications and sectors. It will be your go-to source for news, insights and best practices about how to move forward to a more sustainable future.

In doing this we are responding to our readers, who in a survey told us they want to learn about what is happening not just in their own market but also in other parts of the world, where often the most innovative work is being done. Moreover, creative solutions to universal problems like recruiting and training can come from anywhere, and be applied anywhere.

While many of our readers are senior executives, we feel it is important to connect with up-and-coming members of the industry and help them learn about the untold opportunities that exist for sustainable HVAC&R technologies. To that end we will continue to offer articles that, while technically astute, are also clear, engaging and thought-provoking.

In sum, we feel our global approach in *Accelerate Magazine* will help us achieve our core mission, which is to accelerate adoption of natural refrigerants and sustainable HVAC&R everywhere on earth.

Enjoy this inaugural issue, and I welcome your feedback at marc.chasserot@shecco.com.

■ MC



Cooling with natural refrigerants

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As a technology partner for refrigeration, air-conditioning and heating applications GEA offers comprehensive knowledge and equipment for the natural refrigerants ammonia (NH_3), carbon dioxide (CO_2 subcritical and transcritical), and hydrocarbons (HC/R290). For commercial requirements our CO_2 and HC compressors provide economically efficient solutions. For industrial applications our successful range of compressors includes long-proven ammonia systems.

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One Global Industry

— By Michael Garry



Though we live in a world of growing nationalism, where countries are focused on regional interests, shecco has chosen to take a different path with the publication of this inaugural issue of *Accelerate Magazine*.

As longtime readers of *Accelerate America* (of which I was founding editor), *Accelerate Europe* and *Accelerate Australia & NZ* know, our magazines previously had a regional orientation, for the most part looking at natural refrigerant developments in each of those parts of the world. That was the right approach initially as we endeavored to spark interest in what was happening in our reader's own backyards.

However, to take the next step in our coverage, we realized that it would benefit readers in each region to become more aware of innovations and trends taking place outside of their home markets. So we created the magazine you are now reading, which treats sustainable HVAC&R as the global phenomenon that it is.

We have retained individual regional sections so readers mostly interested in local developments can learn about what's happening there. But now readers in, for example, Australia or North America, where progress in natural refrigerant adoption has been measured, can easily learn about the exciting innovations happening in Europe, Japan and other places around the world. They will see what the true potential for sustainable cooling and heating systems is, across a wide variety of sectors, unencumbered by regional limitations.

Each of our regional sections showcases the best that each region has to offer in natural refrigerant adoption. In this issue that ranges from the retailer Whole Foods Market and the contractor South-Town Refrigeration & Mechanical in North America, to the retailer Mega Image and SNØ indoor ski arena in Europe, to aquatic centers, a winery, a hotel and retailer ALDI in Australia, to cold-storage operator Yoshio Ice in Japan, to CRRC Changchun Railway in China, to Royal Duty Free stores in the Philippines.

When you look at natural refrigerants on a global basis, what an amazing array of applications and sectors! Moreover, readers will see that while each region approaches natural refrigerants differently, they all have common concerns about regulations, training, costs – and more.

At the same time, *Accelerate Magazine* gives us the perfect platform to address global phenomena like the Kigali Amendment (for which we will provide an ongoing list of country ratifications), World Refrigeration Day and the new IEC standard for hydrocarbon charge.

We will also be delving outside of natural refrigerant vapor compression systems to look at alternative technologies and other ways to save energy, using examples from around the world.

Finally, our cover story, "NatRefs 101," straddles the regional and the global, showing the evolution of natural refrigerant technologies and how different regions have impacted each other.

That is the ultimate goal of the magazine – demonstrating that, while each region has its own interests and priorities, natural refrigerants encompass one global industry where ultimately there are no boundaries. ■ MG

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Higher Hydrocarbon Charge Limits: A Long and Winding Road

The charge sizes and safety requirements for flammable refrigerants went through years of heated review before the IEC's recent approval of 500g for A3 and 1.2 kg for A2 and A2L. But is there a new twist in the road?

— By Daniel Colbourne

Use of hydrocarbon refrigerants in commercial refrigeration systems has steadily developed over the past decade or so, but the technology has been held back by the limitations on refrigerant charge size in the product standard, IEC (International Electrotechnical Commission) 60335-2-89.

That recently changed when the IEC approved a revision including a charge limit increase from 150 g to 500 g for A3 (hydrocarbon) refrigerants, and up to 1.2 kg for A2 and A2L refrigerants, used in self-contained cabinets.

But the road to the new standard was long and winding. It began in July 2014 when the British National Committee circulated a draft for comment (61C/581/DC), which was a proposal to increase the flammable refrigerant charge to above 150 g. This was motivated by a substantial number of commercial appliance manufacturers wanting to use larger R290 (propane) charge amounts.

The proposal included a number of protective measures intended to minimize the potential increase in flammability risk arising from the greater charge amount. These included:

- ▶ Releasable charge test
- ▶ Surrounding concentration test
- ▶ Additional construction features
- ▶ Minimum height of refrigerant-containing parts
- ▶ Minimum airflow

These were in conjunction with other measures intended to demonstrate the resilience of the system tightness.

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Originally the target was flammable refrigerants, but with a focus on A3 (specifically hydrocarbon) refrigerants. However, some manufacturers interested in flammable fluorinated refrigerants requested inclusion of A2L (and presumably A2) refrigerants, but in quantities proportional to the refrigerants' lower flammability limit (LFL).

Numerous working group meetings were convened and during this period significant experimental and computational work was generated and analyzed in order to assess the various proposed requirements.

One of the major issues that arose was the maximum charge sizes for A2L refrigerants. While in other refrigeration, air-conditioning and heat pump safety standards the permissible charge had been adjusted in proportion to the refrigerants' LFL, there was major concern over the validity of applying this approach. Other options were discussed, including adjusting the mass according to the refrigerants' heat of combustion (HoC), but in the end it was decided to take the precautionary principle and adjust the mass according to cooling capacity.

Specifically, it was estimated that 500 g of R290 could offer about 4 kW of cooling (at certain conditions) and so in order to achieve the same cooling capacity with A2L refrigerant it would be necessary to use approximately 1.2 kg. In the end, that was the charge selected.

A 'PROOF' TEST

While the original Great Britain National Committee proposal included a host of different preventative measures to enable a larger refrigerant charge, it appeared increasingly complicated to integrate all these measures, since each influences the effectiveness of others.

So one of the options considered was simply a "proof" test where refrigerant is released and the concentration surrounding the appliance is monitored to ensure it does not exceed 50% of the LFL. If this threshold is exceeded then additional protective measures (such as airflow) could be applied. Such a "surrounding concentration test" is thus a reasonable performance test and enables the level or strength of preventative measures to be selected and adjusted as necessary to achieve the result.

Once Working Group 4 agreed to this concept, the remaining work was primarily to refine the text to a suitable form.

In July 2018 the text was circulated as a committee draft for vote (CDV), where both participating and observing member National Committees are expected to submit a vote (positive, negative or abstention) along with any supporting comments. The outcome was an approval of the CDV, and a final draft international standard (FDIS) was issued.

The vote on the FDIS – "yes", "no" or "abstain" – was concluded in mid-April, sadly with a rejection. However, it was noticed that at least one country had only submitted editorial comments along with their negative vote. According to the IEC directives, any vote not accompanied with a technical justification shall be excluded from the count. Once IEC corrected the count it reissued the result as an "approval" of the FDIS on May 9.

However, this is not the end of the story! It transpired on May 27 that one country submitted an appeal against the decision to approve the FDIS, presumably on the basis that its comments should instead

have been treated as technical (rather than editorial). It may be another two or three months until a final (final) decision is made on the FDIS.

While the companies involved in orchestrating the majority of the negative votes did so on the basis of "safety," they also argued that it was done to ensure a higher upper charge limit of A2L refrigerants.

However, subsequent discussions have indicated the main driver was in fact the intention to block hydrocarbon refrigerants entirely from such larger systems. The commercial refrigeration sector represents about one-quarter of refrigerant consumption and were it to switch to HCs and R744, there would be a huge gap in A2L sales.

In the meantime many companies have begun developing commercial refrigeration appliances that use the larger R290 charge limit.

Dr Daniel Colbourne, a consultant for GIZ Proklima, has done extensive scientific and analytical work on environmental safety and efficiency-related aspects of refrigerants and refrigeration systems. He is a member of the UNEP Refrigeration Technical Options Committee (RTOC) for the Montreal Protocol as well as a number of European and international standardization committees.



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JUNE

JUNE 10-12

Global Cold Chain Expo, Chicago, Ill., USA

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



<https://bit.ly/1PQyRFQ>



@gccaorg

JUNE 17-18

ATMOsphere America, Atlanta, Ga., USA

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



<https://bit.ly/20OPdro>



@ATMOEvents

JUNE 17-18

4th World Summit on Climate Change & Global Warming, Osaka, Japan

This event brings together scientists, educators, researchers and students in the fields of meteorology and climatology. The theme of this year's conference is: "Change Scenarios: Slow, Rapid, Abrupt, or Episodic."



<https://bit.ly/2sHzdwW>



@MeetingsInt

JUNE 22-26

ASHRAE Annual Conference, Kansas City, Mo., USA

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



<https://bit.ly/2KPf5QW>



@ashraenews

JUNE 25-26

The Temperature Controlled Storage & Distribution Exhibition (TCS&D), Peterborough, U.K.

This event, in its 5th year, includes an exhibition and conference for the frozen and chilled foods and pharmaceutical sectors.



<https://bit.ly/2PaYPfg>



#TCS&D19



JUL – AUG



JULY 1-5

Forty-First Meeting of the Open-Ended Working Group of the Parties to the Montreal Protocol (OEWG41), Bangkok, Thailand

The Montreal Protocol is an international treaty designed to protect the ozone layer by arranging for the phase out of CFCs and HCFCs. Its Kigali Amendment is organizing the phase down of HFCs.



<https://bit.ly/2Ja53Nr>



@UNEnvironment

JULY 9-12

FOOMA Japan International Food Machinery & Technology Exhibition 2019, Tokyo, Japan

FOOMA JAPAN is a showcase of products, technologies, and services for food processing and related operations.



<https://bit.ly/2JbCvTS>

JULY 11-13

Mega Clima Expo, Lagos, Nigeria

This event is an international exhibition platform for the air-conditioning, refrigeration, ventilation and heating sector in West and East Africa.



<https://bit.ly/305aT7T>



@ExpoMegaClima

JULY 17-19

Indo Renergy 2019 Expo, Jakarta, Indonesia

This event will bring together businesses, sustainable energy industry trade associations, government agencies, and energy policy research organizations to showcase the status and near-term potential of a cross-section of renewable energy (bio fuels/ biomass, geothermal, solar, water, wind) and energy efficiency technologies.



<https://bit.ly/2VSFLcp>



@IndoWater

AUGUST 24-30

ICR 2019, The 25th IIR International Conference of Refrigeration, Montreal, Canada

Held every four years, the ICR 2019 Congress will have the theme, "Refrigeration for Human Health and Future Prosperity." It will focus on energy saving and energy efficiency, food supply, health, reduction of global warming and the protection of the ozone layer.

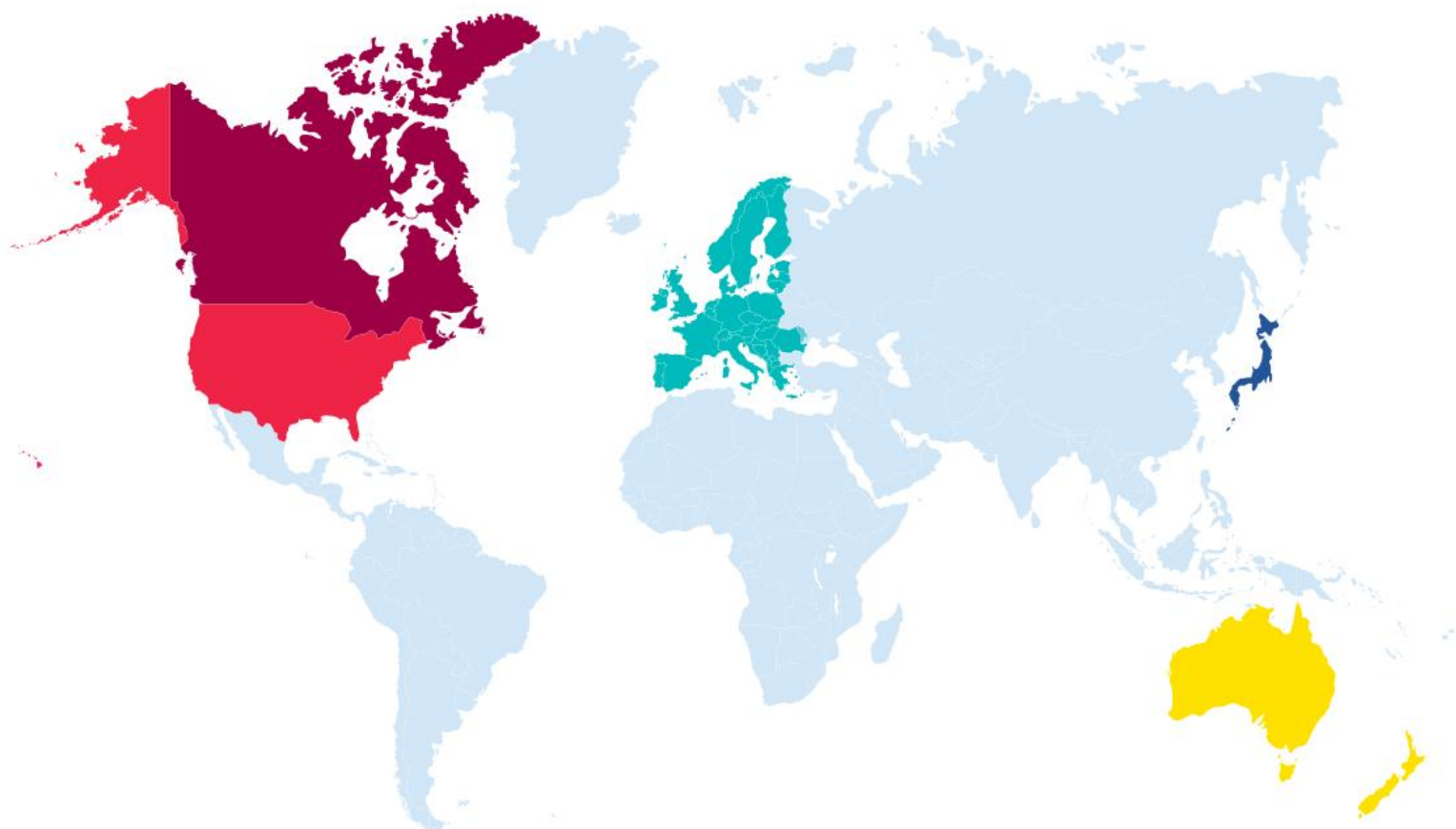


<https://bit.ly/2YhYax0>



@IIFIR

Leading Food Retailers in Major Markets Using Natural Refrigerants



Number of Stores with Natural Refrigerants, By Refrigerant, As of Date

Europe	U.S.	Australia & NZ	Japan
Migros: 302 transcritical CO₂; 149 cascade CO₂; about 20 R290 water-loop (May 2019) Colruyt: 92 R290 compact chillers; 30 compact chillers with heat reclaim (January 2020) METRO AG Cash & Carry: 95 transcritical CO₂; 108 cascade CO₂ (May 2019) Sainsbury's: 274 transcritical CO₂, including 30 convenience stores (May 2019) Albert Heijn: 346 transcritical CO₂ (May 2019) Mega Image: 170 R290 (chest freezers); 3 transcritical CO₂ (May 2019)	ALDI US: 320+ transcritical CO₂; 900+ R290 (January 2020) Whole Foods Market: 500 R290; 30 CO₂ (transcritical or cascade/sec-ondary); 1 NH₃/CO₂ cascade; 1 R290/CO₂ cascade (April 2019) Target: 1,000+ R290; 2 transcritical CO₂ (April 2019) Roundy's: 12 transcritical CO₂ (May 2019) DeCA: 4 transcritical CO₂; 1 NH₃/CO₂ cascade (May 2019) DeCicco & Sons: 4 transcritical CO₂ (June 2019)	Woolworths: 250+ R134a/CO₂ cascade, 3 transcritical CO₂ (May 2019) Coles: 10 transcritical CO₂ (March 2019) ALDI: 300+ R134a/CO₂ cascade, 7 transcritical CO₂ (May 2019) Countdown: 20+ transcritical CO₂ (May 2018)	Lawson: 3,400+ transcritical CO₂ convenience stores (February 2019) AEON: 45+ CO₂ transcritical, including 16 convenience stores (2016) Japanese Consumers' Co-operative Union: 47 CO₂ transcritical (February 2019)
		Canada	
		Sobeys: 140 transcritical CO₂ (estimate May 2019) Longo's: 12 transcritical CO₂ (May 2019)	

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R744

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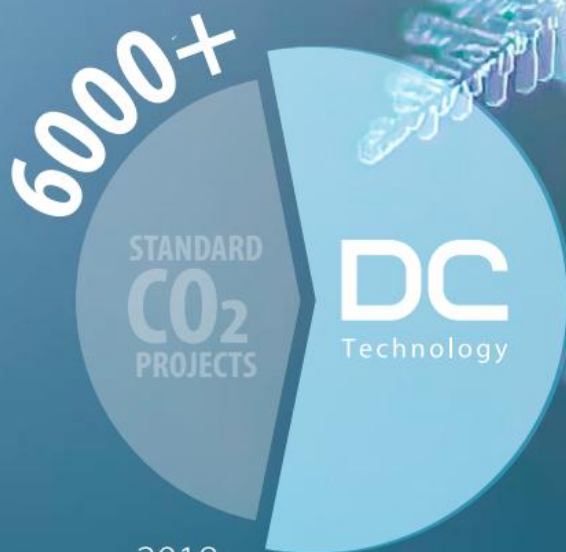
Over the last years, CAREL CO₂ refrigeration
projects have grown exponentially.
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natural refrigeration applications made
possible by CAREL technologies.



2016



2017



2018

Kigali Update

Seventy-two countries (including the European Union) have accepted, ratified or approved the Kigali Amendment to the Montreal Protocol as of June 5, 2019*

The Kigali Amendment to the Montreal Protocol was enacted on October 15, 2016 by 197 countries (parties) in Kigali, Rwanda; it took effect on January 1, 2019.

The Amendment calls for the phase down of the production and use of HFCs by developed and developing countries following the acceptance, ratification or approval of the amendment by each country.

Fifty developed (Non-Article 5) countries start with a 10% HFC phase down in 2019 (compared to a baseline of average HFC production/use in 2011-2013), except for Belarus, the Russian Federation, Kazakhstan, Tajikistan and Uzbekistan, which start with a 5% phase down in 2020. All developed countries end with an 85% HFC phase down by 2036. Thirty have so far accepted, ratified or approved the Amendment.

The 147 developing (Article 5) countries fall into two groups. The majority starts a freeze in 2024 at a baseline of average HFC production/use in 2020-2022; those countries end with an 80% HFC phase down by 2045. The other Article 5 countries (Bahrain, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, and the United Arab Emirates) start a freeze in 2028 at a baseline of average HFC production/use in 2024-2026; those countries end with an 85% HFC phase down by 2047. So far 42 Article 5 countries (both groups) have accepted, ratified or approved the Amendment.

Here is a list of the 72 countries that have accepted, ratified or approved the Kigali Amendment as of June 5:

* Based on data from United Nations Treaty Collection (<https://bit.ly/2pg0sgF>)

** With territorial exclusion in respect of Greenland

*** For the European part of the Netherlands

Developed (Non-Article 5) Countries

Participant	Acceptance(A), Ratification, Approval(AA)
Andorra	Jan 23, 2019 A
Australia	Oct 27, 2017 A
Austria	Sep 27, 2018
Belgium	Jun 4, 2018
Bulgaria	May 1, 2018
Canada	Nov 3, 2017
Croatia	Dec 6, 2018
Czech Republic	Sep 27, 2018 A
Denmark**	Dec 6, 2018 AA
Estonia	Sep 27, 2018
European Union	Sep 27, 2018 AA
Finland	Nov 14, 2017 A
France	Mar 29, 2018 AA
Germany	Nov 14, 2017 A
Greece	Oct 5, 2018
Hungary	Sep 14, 2018 AA
Ireland	Mar 12, 2018
Japan	Dec 18, 2018 A
Latvia	Aug 17, 2018
Lithuania	Jul 24, 2018
Luxembourg	Nov 16, 2017
Netherlands***	Feb 8, 2018 A
Norway	Sep 6, 2017
Poland	Jan 7, 2019
Portugal	Jul 17, 2018 AA
Slovakia	Nov 16, 2017
Slovenia	Dec 7, 2018
Sweden	Nov 17, 2017
Switzerland	Nov 7, 2018
United Kingdom of Great Britain and Northern Ireland	Nov 14, 2017

Developing Countries

Participant	Acceptance(A), Ratification, Approval(AA)
Albania	Jan 18, 2019
Armenia	May 2, 2019 A
Barbados	Apr 19, 2018
Benin	Mar 19, 2018
Burkina Faso	Jul 26, 2018
Chile	Sep 19, 2017
Comoros	Nov 16, 2017
Costa Rica	May 23, 2018
Côte d'Ivoire	Nov 29, 2017 A
Democratic People's Republic of Korea	Sep 21, 2017
Ecuador	Jan 22, 2018
Gabon	Feb 28, 2018 A
Grenada	May 29, 2018
Guinea-Bissau	Oct 22, 2018
Honduras	Jan 28, 2019
Kiribati	Oct 26, 2018
Lao People's Democratic Republic	Nov 16, 2017 A
Malawi	Nov 21, 2017
Maldives	Nov 13, 2017
Mali	Mar 31, 2017 A
Marshall Islands	May 15, 2017
Mexico	Sep 25, 2018 A
Micronesia (Federated States of)	May 12, 2017
Montenegro	Apr 23, 2019
Namibia	May 16, 2019 A
Niger	Aug 29, 2018
Nigeria	Dec 20, 2018
Niue	Apr 24, 2018
Norway	Sep 6, 2017
Palau	Aug 29, 2017

Participant	Acceptance(A), Ratification, Approval(AA)
Panama	Sep 28, 2018
Paraguay	Nov 1, 2018 A
Rwanda	May 23, 2017
Samoa	Mar 23, 2018
Senegal	Aug 31, 2018
Sri Lanka	Sep 28, 2018
Sweden	Nov 17, 2017
Togo	Mar 8, 2018 A
Tonga	Sep 17, 2018
Trinidad and Tobago	Nov 17, 2017
Tuvalu	Sep 21, 2017
Uganda	Jun 21, 2018
Uruguay	Sep 12, 2018
Vanuatu	Apr 20, 2018



World Refrigeration Day: Shining a Light on a Hidden Industry

Stephen Gill



On June 26, Lord Kelvin's birthday, more than 100 industry groups around the world will showcase the importance of refrigeration in our daily lives, as consultant Steve Gill's vision comes to life

— By Michael Garry

As an extraordinarily successful refrigeration engineer and consultant, and leader of trade associations, U.K.-based Stephen Gill knows the value of refrigeration. But he wants the wider world to know about it, too.

And on June 26, 2019, Gill's ambition to spread the word about refrigeration will be realized in the first-ever World Refrigeration Day, a global celebration with more than 100 trade groups supporting it from around the world.

"I, and others, have been trying to think of ways to promote our industry for a long time," he said. "It is considered a hidden industry in that it is all around us but so few people know what it is or how it impacts their daily lives."

In 2014, Gill created special posters on refrigeration that he disseminated to great fanfare on LinkedIn. One of them pointed out the myriad ways that refrigeration supports humanity: "Surgeons operate in air-conditioned hospitals. Chilled vaccines are delivered safely to millions in need. Artists perform in air-conditioned theaters. Low carbon heating solutions keep people warm through heat-pump technology. Food is produced and delivered to billions in hygienically safe conditions. Man traveled to the moon in a temperature controlled rocket."

On World Refrigeration Day, those ideas and more will be disseminated at international events and via social media campaigns, such as @worldrefday and #wrefd19 on Twitter.

The Institute of Refrigeration (IOR), of which Gill was president from April 2016 to November 2018, will hold several events, including a live viewing of an IOR video about the contribution of refrigeration and air conditioning to modern society. (See it at <https://bit.ly/2WvKJMG>.)

Other industry groups supporting World Refrigeration Day include AIRAH in Australia, ASHRAE, AHRI and IIAR in the U.S., and ASRAE and SHASE in Japan.

The United Nations Environment OzonAction Programme will be promoting responsible use of refrigeration in 147 developing economies via seminars and workshops, technical brochures, leaflets and posters in different languages, and public awareness programs. A UNEP-led webinar, hosted by Gill, will cover "Refrigerants for Life."

A list of other events can be found here: <https://bit.ly/2XjHqFL>

What will Gill be doing on World Refrigeration Day? "Apart from hosting the UNEP webinar, I have nothing else planned for the day as my work will be largely done by then," he said. "The more that mark it, the better, and the indications are that many organizations and individuals are rising to the occasion." ■ MG

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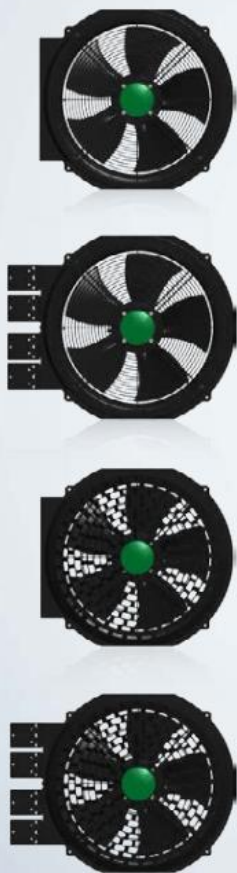
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Higher HC Charge Limit Gets Global Thumbs Up

Stakeholders in Australia, Europe and U.S. see lower costs resulting from the IEC's approval of a 500-g charge cap for flammable refrigerants

— By Michael Garry, Marie Battesti and Devin Yoshimoto

Global reaction to the International Electrotechnical Commission's approval of a 500 g charge limit for A3 (flammable) refrigerants has been widely favorable.

Stakeholders from Australia, Europe and North America generally found the news a boost to the prospects for lower costs and further adoption of propane (R290) in stand-alone commercial display cases, though approval of the new standard would still need to go forward at the regional level.

On May 9, IEC approved the increase in the charge limit for A3 refrigerants to 500 g from 150 g – as well as a rise in the charge limit for A2 and A2L (low flammable) refrigerants to 1,200 g from 150 g – in self-contained commercial refrigeration cabinets under IEC standard 60335-2-89.

In approving the higher charge limit, IEC reversed the original vote by its national committees, which had narrowly rejected the charge increase. The reversal resulted from a procedural error in the vote cast by Malaysia. (More details on the recount can be found at <https://bit.ly/2WkbP9x>.)

Reaction Down Under

Participants in the ATMOSphere Australia 2019 conference, held May 8-9 in Melbourne, were among the first to hear the news that IEC planned to increase the charge limit for A3 refrigerants. (The conference is organized by shecco, publisher of *Accelerate Magazine*.)

Jan Dusek – shecco's business development manager in the Asia Pacific – informed participants. "Today, at four in the morning, I got the confirmation that this update will go ahead," said Dusek. "This is going to have a big impact on our industry."

Conference participants – which included several of Australia's leading HVAC&R end users, suppliers, policymakers and educators – reacted with immediate applause.



Ricky Gatti, general manager at Coolphase, a refrigeration, air-conditioning and electrical contractor based in Queensland, said that the decision would have a big impact on the cost of technology and its adoption in the Australian market.

"For us and our little part of the world, it means that the [R290] cases become more affordable," Gatti said.

"One of the R290 freezer cabinets that we are bringing in has two circuits. So instead of two, now, that potentially will go to one, and then the cost would dramatically go down."

Dario Ferlin, Woolworths' sustainable innovations engineer, also said that the increased charge limit could potentially reduce the number of condensing units needed for larger multi-deck refrigerated cabinets.

"Wearing a retailer's cap," said Ferlin, "and thinking about the potential maintenance implications of having so many condensing units in the store, reducing that number would be much more attractive."

Ferlin asked Esequias Pereira Jr., senior sales manager for Asia Pacific for compressor manufacturer Embraco, the following question: "In light of recent developments, have you been working on or do you already have market-ready solutions which can go up to 500 g and therefore reduce the number of condensing units?"

"Yes," Pereira Jr. replied. "Very soon we are going to present solutions even bigger than what we are currently offering."

Emerson is another company that had already been anticipating the charge-limit change. Shannon Lovett, Emerson's senior business manager for cold chain solutions, highlighted the company's recently released horizontal scroll compressor for R290. The product was developed in anticipation of the rise in charge limits for R290, according to Lovett.

Regarding availability in Australia, he said that "at the moment, it is not commercially released here. But with yesterday's news, I think that opens up a lot of opportunities."

Shift to hydrocarbons

In Europe, Collin Bootsvelde, project engineer for the Belgian retailer Colruyt Group – which operates in Belgium, France, Luxembourg and the Netherlands with more than 200 stores – also welcomed the increase but noted that the shift to hydrocarbons was already driving the market.

"The 150-g limit was hardly a barrier for the operations of Colruyt Group, because in new food shops we use centralized propane chillers with glycol as a secondary refrigerant," Bootsvelde said.

He observed that, while IEC-60335-2-89 is a product standard, suppliers can still do their own risk analysis based on EN 378, which allows up to 1.5 kg of hydrocarbons or more under certain circumstances.

Lithuanian OEM Freor has been preparing for the charge limit increase. "We are fully prepared to supply propane-based refrigeration equipment with higher charges than the ones currently allowed on the market, as soon as the new standard IEC-60335-2-89 update will be [published]," said Jūratė Mizarė, marketing manager.

Opening up the market

In the U.S., Gary Cooper, director of refrigeration for Lowe's Markets, a Texas-based grocery chain, sees the new global standard "opening up the market considerably" and making it easier for R290 [propane] "to get a foothold, especially on the medium-temperature side. There will be lots of opportunity, even with open cabinets."

Richard Gilles, senior product leader – distributed solutions for OEM Hussmann, said the charge-limit increase "will help the industry uptake on hydrocarbons as the country regulations are changed." Hussmann, which supplied Lowe's with its R290 equipment, last year introduced a line of R290 cases called MicroDS.

"The IEC decision will help provide cover and support for a U.S. increase," said Gilles. But "wide adoption would only be possible with federal building code support, which has the next revision in 2024."

Even then, local fire marshals would have to weigh in before a permit could be granted. "Fire marshals can be problematic," said Cooper. At his Lubbock store, he had to "jump through some hoops" to get approval for the R290 units. "But they were a lot more comfortable once it was up and running" and saw the units could be safely operated.

Added Cooper: "Getting the fire marshals on board is key." That should be easier now that there are more R290 self-contained cases in the marketplace, he said.

In the U.S., there has been talk that standards bodies may only approve a charge-limit increase to 300 g for hydrocarbons in commercial cases.

"It may be that ASHRAE and UL take a more conservative approach and have no increase, or 300g, or some other variation based on closed versus open-case designs," said Gilles. ■ MG, MB & DY

World in Brief

COOP Opens Hydroloop Propane Store

Swiss food retailer COOP opened a propane-refrigerated store in early May in Delft, a city in southern Netherlands, according to OEM Freor.

Freor equipped the store with a hydroloop glycol refrigeration system with propane-based cases and cabinets. The system uses single-circuit integral R290 refrigerators and freezers. The installation of inverter compressors allows additional energy savings.

The R290-based freezers are optimized for small stores with a limited trading area.

Energy efficiency and sustainability were two key priorities for the design of the refrigeration system in the COOP store, said Freor. The equipment works with Carel's local monitoring system to supervise access to mobile devices through a Wi-Fi connection, further reducing energy consumption.

■ MB

Vermont Latest State to Regulate HFCs

In the latest example of a U.S. state incorporating HFC regulations previously used by the U.S. Environmental Protection Agency (EPA), Vermont's legislature in May passed legislation limiting the use of HFCs in new equipment.

The legislation, S.30, stipulates that products containing certain high-GWP HFCs prohibited by the EPA in SNAP (Significant New Alternatives Policy) Rules 20 and 21 would not be allowed in Vermont in new equipment for specific applications as of specific dates. A 2017 U.S. Court of Appeals ruling partially vacated the SNAP rules.

Baker Refrigeration Building CO₂ Training Site

Baker Refrigeration, one of Australia's leading commercial refrigeration contractors, is stepping up efforts to train its staff to use transcritical CO₂ refrigeration systems.

"We're going to make a transcritical CO₂ training facility that we are going to build ourselves in-house," said Mike Baker, managing director at Baker Refrigeration, at the ATMOsphere Australia 2019 conference, held on May 8-9 in Melbourne.

Baker said the new facility was being built as the company relocates its technical training center to Melbourne from its headquarters in Perth.

Baker stressed that the CO₂ training is urgently needed because the company has another four transcritical CO₂ systems scheduled to be commissioned this year.

■ DY

Epta Installs First TC CO₂ System in Gulf

Italian manufacturer Epta has been chosen to install a transcritical CO₂ refrigeration system incorporating its Full Transcritical Efficiency (FTE) technology at a 7,000-m² (75,347-ft²) supermarket in the brand new My City Centre Masdar shopping mall in Masdar City, Abu Dhabi (United Arab Emirates).

This is the first installation using transcritical CO₂ in an Arabian Gulf country, according to EPTA.

The FTE solution, launched at the Euroshop trade show in March 2017, helps to improve the efficiency of CO₂ refrigeration systems and overcome the challenge of an installation in a desert climate like Abu Dhabi, where temperatures reach up to 51°C (123.8°F).

According to Epta, its FTE technology will allow for up to 25% energy savings compared to a R404a system.

My City Centre Masdar is one of the most eco-friendly regional shopping malls, so sustainability and energy efficiency played a big role in the selection of a CO₂ system. The mall has set a goal of recycling 80% of waste, and also employs a photovoltaic system and LED lighting.

Masdar City as a whole is one of the world's most sustainable urban communities. Each building in Masdar City is constructed with low-carbon cement, utilizes 90% recycled aluminum, and is designed to reduce energy and water consumption by at least 40% compared with ASHRAE standards.

■ PA

The Vermont legislation takes effect on July 1, 2019 ■ MG

Azaneefreezer 2.0 Beats U.K. Energy Standard

Star Refrigeration's Azaneefreezer 2.0, an industrial freezer using ammonia at low charges, is delivering energy cost savings of up to 66% vs. U.K. benchmark figures according to Star.

The Azaneefreezer 2.0 is a new iteration of Star's air-cooled industrial freezer package designed for cold storage and food processing applications, such as blast and spiral freezing. It can be charged with as little as 0.52 kg/kW (4.1 lbs/TR) of ammonia.

Average energy consumption figures for chilled and frozen storage facilities across Europe are about 50% higher than the figure declared to be best practice by the U.K. government, according to research conducted by Judith Evans and others for the International Institute of Refrigeration.

But recent energy performance data analysis for the Azaneefreezer 2.0 indicates that its annual energy usage is one third that of the U.K.'s best-practice guidelines – or a 66% saving.

"We're really excited about the launch of Azaneefreezer 2.0, because the stunning improvement in energy consumption sets a new benchmark landscape for freezer performance," said Rob Lamb, group sales and marketing director at Star Refrigeration.

"As a pre-packaged low-charge ammonia freezer, the Azaneefreezer 2.0 is completely unique in the industry," Lamb said.

According to Star, the low-charge ammonia design of the Azaneefreezer 2.0 reduces refrigerant charge by up to 96% compared to traditional ammonia systems and avoids the need for complex valve stations. This removes the requirement for leak detection and ventilation, minimizing health and safety concerns.

■ AW

Italian Discounter Chooses CO₂

Gruppo Maxi Di Srl, a discount retailer operating across northern Italy, has equipped its new Famila store in Lonigo, Vincenza province, with a transcritical CO₂ compressor rack – complete with electronic modulating ejectors – to support over 50 refrigerated cabinets. The store opened in 2018.

Italian firm Arneg supplied the CO₂ rack, which is equipped with eight compressors. The rack features electronic controls and ejectors supplied by CAREL, another Italian company. The system serves a 2,300-m² (24,757-ft²) supermarket.

CAREL's pRack pR300T (a controller for managing centralized CO₂ refrigerating units) and three electronic modulating ejectors (EmJ) control the CO₂ compressor rack, which delivers a total cooling capacity of 185 kW (52.6 TR).

■ MB

Dutch Flower Maker Installing R290 Chiller

Steenwijk Flowers, a large-scale summer flower producer located in Abbenes, Netherlands, will soon deploy a propane chiller with secondary glycol for cold storage.

The installation, which will be completed this year, is custom-designed and produced by Celtic Cooling, a Netherlands-based manufacturer.

The system will be used mainly during the summer, and partly during the winter, said Siebe Duivenvoorden, account manager for Celtic Cooling.

"For each circumstance we try to find the most suitable solution based on the demands of the project in combination with the current financial situation and regulation," said Duivenvoorden. "More and more customers want to operate socially and be environmentally responsible." ■ EI

OPTEMUS Tests R290 Heat Pump in EVs

Extending driving range is one of the most crucial challenges for electric vehicles, which consume a significant portion of their energy in heating and cooling. A propane-based (R290) heat pump may help to increase their range, according to an EU project.

The European Union-funded "Optimized Energy Management and Use" project or OPTEMUS (www.optemus.eu) has been looking at improving the driving range of electric vehicles, with a particular focus on thermal management systems.

OPTEMUS developed a prototype R290 heat pump for electric vehicles, which was tested in a Fiat 500e against a similar car running with an R134a-based air-conditioning system.

Simulation results show that with the heat pump the driving range can be increased by 15%-30% at low outside temperatures. To validate these results a Fiat500e equipped with the unit is currently being tested in a climatic wind tunnel.

Together, all technologies under OPTEMUS are predicted to increase the range of electric vehicles by more than 40% in extreme weather conditions.

The OPTEMUS project received funding from the European Union's Horizon 2020 research and innovation program. ■ CM

NATREFS

101

Tracing the growth of natural refrigerants through the first 100 issues of *Accelerate* magazines from around the world

— By Michael Garry, Andrew Williams and Devin Yoshimoto

2016

Kigali Amendment to the Montreal Protocol developed to phase down high-GWP HFC refrigerants.

1987

Montreal Protocol established to phase out ozone-depleting CFC and HCFC refrigerants.



Shecco launched its first *Accelerate* publication, *Accelerate America*, in November 2014 with the visage of Harrison Horning, director of energy and facility services for Delhaize America, on the cover. Horning had overseen the installation of the first U.S. transcritical CO₂ system at a Hannaford store in Turner, Maine, the previous year.

Accelerate America was followed with *Accelerate* editions in Europe, Japan and Australia/New Zealand, as well as two issues of *Accelerate China* and one of *Accelerate Asia*. All told, 100 issues of the regional magazines were published through May 2019.

The *Accelerate* concept has now evolved to become a global magazine replacing the regional editions (*Accelerate Japan* will continue to be published in Japanese.) *Accelerate Magazine* will cover natural refrigerant developments in all parts of the world, with a particular focus on Europe, North America, Australia, Japan and China, though it will leave no region where natural refrigerants are being used uncovered.

In this inaugural issue, we look back over the major natural refrigerant developments described in the regional editions. Each region has its own particular historical narrative, though Europe's leading role has had a strong effect on other major markets in the world.

Beyond individual regions, natural refrigerants are a worldwide phenomenon, and have thus been impacted by the Montreal Protocol, the global treaty that in 1987 orchestrated the elimination of ozone-depleting refrigerants, and in 2016 set the stage for the phase down of high-GWP refrigerants via the Kigali Amendment. Both have paved the way for the emergence of the regional natural refrigerant alternatives detailed in the following pages. ■ MG

EUROPE

Leading the World

Europe has long been a major source of natural refrigerant innovation in the HVAC&R sector. It can be said that Norwegian scientist Gustav Lorentzen created the modern age of natural refrigerants in the late 1980s when he developed the modern transcritical cycle for CO₂.

Following in Lorentzen's footsteps, other Europeans have played a crucial role in extending the boundaries of what natural refrigerants can achieve and creating new markets for technologies that harness them.

Sergio Girotto, president of Italian OEM enEX (which he founded in 2004), has worked tirelessly to bring CO₂ to new applications. Among his achievements, Girotto is perhaps best known for installing the first-ever CO₂ transcritical system in a Bingo supermarket (now owned by Coop Group), in Cornuda, Italy, in 2001 – the culmination of a natural refrigerants adventure that began in 1996, when he asked Italian manufacturer Dorin to produce a CO₂ compressor.

Girotto has patented a number of refrigeration products and system designs. Among his personal favorites is a liquid ejector for overfeeding evaporators produced in 2012. (See "[The restless innovator](#)," *Accelerate Italy*, February 2018.) enEX developed its first systems with parallel compressors in 2008, and its first gas ejectors in 2013.

Another influential European, Menno van der Hoff, is one of the continent's leading HVAC innovators. He was the driving force behind the development of the TripleAqua, an energy-efficient heat pump that employs propane (R290).

Van der Hoff is head of R&D and HVAC manager at Uniechemie, a division of

Swedish HVAC&R distributor Beijer Ref, which is marketing TripleAqua.

According to Beijer Ref, TripleAqua can save up to 50% in heating and cooling costs in commercial buildings compared to traditional heat pumps, with a COP (coefficient of performance) between 4 and 10.

Europe's natural refrigerant development took off in the wake of the EU's F-Gas Regulation, first announced in 2006. The latest iteration, which took effect in 2015, aims to reduce the EU's HFC use by 79% by 2030, compared to a baseline of average levels in 2009-2012. To help deliver this target, it is progressively banning the use of certain HFCs in different types of new equipment. In 2022, for example, bans on using certain HFCs (with GWPs greater than or equal to 150) in new centralized and plug-in commercial refrigeration equipment will come into effect.

In 2006 the EU also announced its MAC (mobile air conditioning) directive, which put a cap of 150 on the GWP of refrigerants allowed in new car air conditioning systems. This led to the adoption of CO₂ MAC systems by Daimler and Volkswagen.

Spurred by the EU directives, European system manufacturers have been at the forefront of developing natural refrigerant technologies – and exporting them around the world.

In April, Carrier Commercial Refrigeration – part of UTC Climate, Controls & Security, a unit of United Technologies Corp., announced that it had delivered 10,000 CO₂ systems to commercial and industrial customers worldwide. It achieved this largely thanks to the combined effort of the Carrier, Profroid, Green & Cool and Celsior brands in Europe.

EUROPE TIMELINE:

1986:

Nestlé begins replacing CFC and HCFC plants with ammonia systems in production sites.

1988-1991:

Gustav Lorentzen develops the modern transcritical cycle for CO₂.

1992:

Greenpeace introduces Greenfreeze isobutane home fridge.

1997:

Sergio Girotto installs first subcritical CO₂ cascade system at a supermarket in Conegliano, Italy

1998:

Daimler installs first MAC CO₂ system

2001:

Sergio Girotto installs first transcritical CO₂ multicompressor system at a Bingo supermarket in Cornuda, Italy

2001:

Nestlé opens first large NH₃/CO₂ cascade system to use compressed CO₂, in Hayes, U.K.

2004:

Carrier installs its first CO₂ transcritical system, at a Migros supermarket in Switzerland.

Advansor, founded in 2007 (and sold to Hillphoenix in 2011), has been another market leader, with its website now reporting 4,815 CO₂ installations. On its website, SCN Frigo says it has 2,303 CO₂ installations. Other OEMs with more than 1,000 CO₂ installations include enEX, TEKNO and Epta.

RETAIL LEADERS

Some of Europe's biggest retailers – including the Schwarz Group (which operates the Lidl and Kaufland brands), Sainsbury's, Carrefour S.A., METRO AG and Ahold Delhaize – are turning to CO₂ and hydrocarbon systems to comply with the F-Gas Regulation and to benefit from the efficiency savings these systems offer. According to shecco, publisher of *Accelerate Magazine*, there were about 16,000 supermarkets in Europe using transcritical CO₂ systems as of last October, or 14% of the total number of outlets (about 115,000). The biggest European retailers are also helping to bring natural refrigerant technology to other parts of the world.

Germany-based METRO AG, an international wholesale and food retail company, has committed to reducing overall greenhouse gas emissions across the company by 50% by 2030 (vs. 2011 levels). The company's F-Gas Exit Program is helping the company achieve this target. In place since 2013, the program aims to phase out f-gases in all METRO stores worldwide by 2030, replacing them with natural refrigerant systems where it is technically and economically feasible to do so. (See "[An irreversible stand on natural refrigerants](#)," *Accelerate Europe*, winter 2015.)

METRO has a reputation for bringing natural refrigerant technology to different parts of the world. The company has opened three CO₂ transcritical stores in Russia and three in China. In April

2019, it opened its first CO₂ transcritical store in Croatia (in Dubrovnik). In total, the cash and carry giant operates 95 CO₂ transcritical and 108 CO₂ subcritical stores worldwide.

Carrefour, another Europe-headquartered multinational, is phasing out HFCs and replacing them with CO₂ for commercial refrigeration. In smaller stores; it is also investing in hydrocarbons. As of September 2017, Carrefour operated about 418 stores using natural refrigerants, about 90% of which used CO₂ (170 with transcritical CO₂). Factors ultimately influencing the decision to go with CO₂ vs. hydrocarbons include store size, equipment cost, and legislation in each country. (See "[Crossing the CO2 equator: Carrefour leads the march south](#)," *Accelerate Europe*, summer 2016.)

Amsterdam-headquartered retail group Ahold Delhaize is aiming to reduce its greenhouse gas emissions by 40%-70% compared to 2010 levels. By the end of 2017, 13% of the group's sites were already using natural refrigerant-based installations worldwide. In Europe the figure was 33%, with the Netherlands' Albert Heijn, which has 346 transcritical CO₂ stores, showing an impressive commitment. (See "[All the fun of the playground](#)," *Accelerate Europe*, spring 2017.)

Other major European natural refrigerant retailers include German retailer ALDI Sud, which was running 1,496 transcritical stores by the end of 2017, including 1,324 in Germany. The Swiss retailer Migros operates 302 transcritical and 149 subcritical CO₂ stores and about 20 using an R290 water-loop system (in total, 66% of all stores), while U.K. retailer Sainsbury has 244 supermarkets and 30 convenience stores using transcritical CO₂.

Several European chains, including Colruyt and Lidl, have rolled out large numbers of stores that use only R290-supported display cases. By the end of the 2019 calendar year, Colruyt will have 92 supermarkets using R290 compact chillers, and another 30 using

compact chillers with heat recovery. In 2016, Lidl, based in Germany, said it planned to roll out R290 systems in all future European installations; its French division expects to have 250 R290 stores by February 2020 out of 1,500 outlets in total, and plans to retrofit 100 stores per year.

On the domestic front, Europe was also the first market to widely adopt another hydrocarbon refrigerant, isobutane (R600a), in home fridges – the so-called Greenfreeze system introduced by the NGO Greenpeace in 1992.

ROCHE PRESCRIBES NATREFS

Europe is also a leader in other sectors. For example, F. Hoffmann-La Roche Ltd. (a multinational biotechnology company commonly referred to as Roche) understands the responsibility it shares to help put the world on a more sustainable environmental path.

The Roche Group is phasing out halogenated refrigerants across its cooling portfolio of laboratory refrigerators, cold-storage facilities, walk-in research coolers, stability chambers for product testing, cafeteria equipment, heating, air conditioning, centrifuges, freeze drying, fire suppression systems, packaging foam and data centers.

Roche applies the policy of adopting natural refrigerants where reasonably possible to all the above applications. (See *"The natural refrigerant treatment"* *Accelerate Europe*, spring 2019.) In so doing the company has become an incubator for new technologies – something it urges potential new suppliers to capitalize on. "When companies as big as Roche ask for something, they see that there is a clear incentive for them to develop it," said Thomas Wolf, Roche's chief environmental sustainability officer.

Brewers are also getting in on the act. Convinced of the role that natural refrigerants can play in reducing its

carbon footprint, Dutch multinational brewing giant Heineken is adopting hydrocarbons for all its new beer fridges worldwide. (See *"Cheers to a greener world!"* *Accelerate Europe*, spring 2018.)

Targeting 50% lower emissions from fridges by 2020, Heineken provides "green" units whenever one needs replacing and tests fridges against the Heineken Energy Efficiency Index (HEEI).

The brewer defines green fridges according to the following four principles: the use of hydrocarbon refrigerant, LED illumination, an energy management system, and energy-efficient fans.

"We adopted hydrocarbons for two reasons – one, because they help to deliver the energy efficiency that we want; and two, because of their significantly lower GWP compared to the existing refrigerants we used in our fridges," said Graeme Houghton, Global Category Leader – Commercial Equipment & Servicing, Heineken Global Procurement.

The company started to use fridges based on hydrocarbons in 2010. "We expect that by 2020, the majority if not all of our fridge population will be green, with natural refrigerants," Houghton said.

Swiss multinational Nestlé began replacing its CFC and HCFC systems with natural refrigerants in 1986. Today, its commitment to adopting natural refrigerants for HVAC&R applications wherever possible is helping to bring the technology to new parts of the world.

With industrial refrigeration systems with NH₃/CO₂ at key production sites in Switzerland, ammonia-cooled data centers, and the worldwide deployment of hydrocarbons-based display cabinets, Nestlé's commitment to natural refrigerants is consistent and firm. ■AW

2006:

EU introduces F-Gas Regulation and MAC Directive, both calling for HFC phase down.

2006:

enEX installs its first CO₂ transcritical system.

2006:

Green & Cool founded.

2007:

Advansor founded.

2015:

Menno van der Hoff develops TripleAqua hydrocarbon-based heat pump.

2015:

Revised EU F-Gas Regulation enters into force, mandating 79% HFC cut by 2030.

2016:

Lidl announces plans to roll out R290 systems in all future European installations.

2016:

Mercedes-Benz offers CO₂ MAC in S-Class model.

2018:

EU approves Kigali Amendment to Montreal Protocol

2019:

Carrier announces delivery of 10,000th CO₂ system.

NORTH AMERICA

Steady Growth, Despite Policy Setbacks

Given Europe's pre-eminence in the field of natural refrigerant systems, it's no surprise that a transplanted European, — Predrag (Pega) Hrnjak, research professor at the University of Illinois at Urbana-Champaign — laid the foundation for the technology in North America.

Inspired by CO₂ visionary Gustav Lorentzen (see page 92), whom he met in the early 1980s, Hrnjak and his team have written papers on virtually every technical aspect of CO₂ technology.

But transcritical CO₂ refrigeration did not become a commercial entity in North America until 2008, when a French Canadian, Marc-André Lesmerises, launched Carnot Refrigeration in Trois-Rivières, Quebec with two partners in order to supply the Sobeys supermarket chain with its first transcritical CO₂ system.

Sobeys went on to become one of the leading users of transcritical CO₂ refrigeration in North America, with an estimated 140 stores now equipped with the technology, many supplied by Carnot. Other Canadian chains, like Loblaw and Longo's, have followed suit, adopting transcritical in numerous stores.

It took a while for transcritical CO₂ refrigeration to reach the U.S. Finally, in July 2013, Hannaford, a Scarborough, Maine-based chain (now owned by Ahold-Delhaize), opened a store in Turner, Maine, that was the first U.S. supermarket to use the technology. Its supplier: Carnot, whose factory is 240 miles away.

In December 2013, Whole Foods Market opened the second U.S. store to use a transcritical CO₂ system (from Hillphoenix) in Brooklyn, N.Y. This store had the additional distinction of being the first in the nation to be completely HFC-free, from HVAC systems to break-room refrigerators to juice and beer dispensers.

Since then, Whole Foods has continued to install transcritical CO₂ systems in the U.S., and has also experimented with CO₂ cascade systems, which it began installing in 2009 (along with secondary CO₂ systems). In 2015, the chain opened a store in Dublin, Calif., that uses an ammonia/CO₂ cascade system — one of only four stores in the U.S. with this technology. The next year, Whole Foods opened the first, and so far only, U.S. store to employ a propane/CO₂ cascade system. (See page 40.)

The U.S. grocery chain that has become by far the leading user of transcritical CO₂ systems is ALDI U.S. The chain, an independently operated member of the German retailer ALDI South (Süd), expects to have more than 320 stores using transcritical CO₂ refrigeration by the end of the year, according to data published online in April by the Environmental Investigation Agency (see <https://www.climatefriendlysupermarkets.org>).

ALDI's main transcritical system supplier has been Conyers, Ga.-based Hillphoenix, which has been a leading provider of CO₂ technology to U.S. food retailers.

R290 IN SELF-CONTAINED CASES

In addition to transcritical and cascade/secondary CO₂ systems, the other natural refrigerant used by North American grocers in significant numbers is propane (R290), largely in self-contained display cases at the checkout or in spot merchandising locations (with a maximum charge of 150 g). Target has deployed such cases in more than 1,000 of its 1,800 U.S. stores, while Whole Foods has them in 500 stores, according to EIA.

More recently, some U.S. supermarkets have begun installing R290 cases in partial or whole-store configurations, creating an alternative to centralized rack systems. One example is Hannaford, which is testing R290 in complete frozen-food lineups in some new stores, with heat removed by a glycol loop. Hannaford took its inspiration from H.E. Butt Grocery, a Texas chain that in 2013 became the first U.S. grocer to install R290-based self-contained cases throughout a store. (See "[R290: The Future of Retail Refrigeration?](#)" *Accelerate America*, January 2018.)

Hannaford and H.E. Butt are using R290 cases from Hussmann, which last year unveiled a new line of R290 self-contained, glycol-cooled cases called MicroDS.

NORTH AMERICA TIMELINE

1999:

Pega Hrnjak presents first low-charge ammonia paper at IIAR conference.

2007:

Environmental Protection Agency launches voluntary GreenChill Partnership with food retailers.

2008:

Carnot Refrigeration is founded, and starts supplying Sobey's with first transcritical CO₂ systems

2012:

Supervalu installs first all-natural, NH₃/CO₂ cascade refrigeration system at an Albertsons store in Carpinteria, Calif.

2013:

H.E. Butt Grocery (HEB) opens first U.S. store to use only R290 self-contained cases for refrigeration in Austin, Texas.

2013:

Hannaford installs first U.S. transcritical system at a store in Turner, Maine.

2015:

IIAR-2 standard addresses low-charge ammonia packaged systems.

2016:

Whole Foods Market opens store in Santa Clara, Calif., with propane/CO₂ cascade system.

2017:

Department of Energy raises efficiency requirements for commercial refrigeration cases.

Hydrocarbons, notably R290, have also become prevalent in the foodservice sector, adopted by chains like McDonald's and Starbucks, as well as brands like PepsiCo, Red Bull (using isobutane) and Coca-Cola (which switched gears from CO₂). OEMs like True Manufacturing, Welbilt and Beverage-Air converted to R290 systems, which helped them meet the Department of Energy's 2017 efficiency standards.

On the industrial side, low-charge ammonia packaged systems have become a marked trend in the U.S. since 2015. OEMs like Evapco, Azane and NXTCOLD (marketed by Hillphoenix), among others, have unveiled low-charge packaged systems and contractor/designers like CIMCO and Stellar have begun installing them.

Low-charge central systems have also emerged in the last few years, including ammonia DX systems enabled by Colmac Coil, ammonia/CO₂ cascade systems provided by M&M Refrigeration, and a remote condensing system developed by Frick. U.S. Cold Storage has become one of the leading users of ammonia/CO₂ technology with more than a dozen facilities employing the technology. In addition, cold-storage operators have started installing transcritical CO₂ systems, including Henningsen Cold Storage.

SWITCH AT THE EPA

For many years, the Environmental Protection Agency in the U.S. had the authority to phase out high-GWP HFCs, while at the same time a voluntary EPA program, the GreenChill Partnership, worked with supermarkets to reduce HFC leaks and find natural refrigerant alternatives.

But in August of 2017 a U.S. District Court ruled that the EPA could not compel companies that had used HFCs as a replacement for ozone-depleting gases to replace the

2017:

U.S. Court of Appeals for D.C. Circuit limits EPA's ability to regulate HFCs.

2018:

California Cooling Act becomes law, adopting EPA HFC regulations and establishing incentives for natural refrigerant systems.

2020:

ALDI US expects to have 320+ stores with transcritical CO₂ refrigeration, many provided by Hillphoenix.

HFCs with lower-GWP substances like natural refrigerants. The EPA took the ruling a step further, deciding to abandon HFC regulations in all circumstances while it undertook new rulemaking. (See *"The Policy Quagmire," Accelerate America*, June-July 2018.)

California reacted to federal backtracking by passing the California Cooling Act last year, which adopts most of the EPA's HFC regulations and establishing an incentive plan for natural refrigerant alternatives. Other states, including Washington, Connecticut, New York, Maryland and Vermont, are now following suit, as part of the U.S. Climate Alliance.

Meanwhile action on the federal level has continued to stagnate, as the Trump administration has so far declined to send the Kigali Amendment to the Montreal Protocol to the Senate for ratification, despite industry support for the amendment. By contrast, Canada and Mexico have both ratified Kigali, and Canada has launched an HFC-reduction plan.

Still, many U.S. end users see the wisdom of opting for future-proof natural refrigerant solutions that are immune to the vagaries of politics. ■ MG

AUSTRALIA + NEW ZEALAND

Cutting Costs Down Under

In Australia and New Zealand, HVAC&R industry leaders began to experiment with CO₂ systems in the 1990s and early 2000s, following Europe's lead. Australia's first transcritical CO₂ installation took place in 2007 at a Drakes Foodmarkets store in North Adelaide.

Since then, natural refrigerants progressed from pilot projects to HFC alternatives in these nations' commercial and industrial sectors.

As in other parts of the world, policy helps give companies in Australia and New Zealand an incentive to phase down f-gases and find alternatives.

In October 2017, Australia ratified the Kigali Amendment to the Montreal Protocol, which commits it to phasing down HFC imports. (No HFCs are manufactured in Australia itself.)

Australia had prepared itself for the Kigali commitment in June 2017, when it passed a bill amending its Ozone Protection and Synthetic Greenhouse Gas Management (OPSGGM) Act by adding an HFC phase-down plan. Under the bill, Australia would begin to phase down imports of HFCs in January 2018. The phase down is being managed through an annual import quota that will gradually be reduced over 18 years. The end point, 15% of the baseline level, will be reached in January 2036.

In New Zealand, the government has amended its Emission Trading Scheme to accelerate an HFC phase down. HFC importers and manufacturers are this year facing increased levies and must apply for permits.

For 2019 the emission unit price under the New Zealand Emission Trading Scheme (NZ ETS) increased by 17% for HFC importers and manufacturers compared to last year. Since January 2019, businesses must pay NZ \$25 (approximately \$16 US) per emission unit.

Participation in the NZ ETS is mandatory for importers and manufacturers of HFCs operating as of January 2013.

Regulatory change has helped to intensify the search for market-ready alternatives to HFCs. But from the beginning, it was clear that the higher cost of natural refrigerant-based systems was a barrier to their adoption. "What's enabled progress is that we saw from the first project that we needed to drive costs down," said Brian Toulson of City Holdings, which takes care of facilities management for Australian retailer Coles.

Engaging with overseas suppliers was crucial in reducing costs in the early days. "There was a perception that if we piggy-backed on bulk suppliers and leading manufacturers globally, then we could drive costs down and benefit from their high-volume supplies," Toulson said.

That is what City Holdings did for Coles, which installed its first transcritical CO₂ system in 2015. "We went over to see overseas manufacturers in their home countries, and sought commitments from them to bring staff over to help training and commissioning," Toulson said. "It worked really well."

On the other hand, Woolworths – another leading Australian retailer – took a more local approach. The company fully engaged local stakeholders in designing, installing and commissioning systems, which reduced installation time and standardized equipment.

Woolworths installed its first CO₂ transcritical system in July 2017, in a store in Colebee, New South Wales (NSW). As training of local industry picked up, familiarity and confidence with transcritical CO₂ systems began to grow (See "[Woolworths building NatRef momentum in Australia](#)," *Accelerate Australia & NZ*, winter 2017).

Standardizing equipment, meanwhile, has also reduced on-site costs. For example, Woolworths' second CO₂ transcritical system, installed in a store in Wadalba, NSW, in July 2018, was built to an e-specification system, helping to cut installation and on-site risk management costs.

Both Coles and Woolworths have helped pave the way for Australia's wider HVAC&R industry to adopt CO₂ transcritical systems by showing how to reduce costs, facilitating training, and familiarizing stakeholders with the technology.

SHIFTING MINDSET AMONG INDEPENDENTS

Not to be outdone by the two leading players, other food retailers active in Australia, including Aldi, Drakes and independent operators, have been moving towards natural refrigerants, too.

Smaller retailers are forced to be more cost-oriented than bigger players, which are often in a better position to invest in the future. Nonetheless, smaller firms are also mindful of how investing in certain types of equipment today can ultimately save costs in the long run. Discussions about future-proof technologies are therefore opening the door to natural refrigerants.

Petar Lujic, owner of IGA Market Central, summed up this sentiment in outlining his decision to go with natural refrigerants for a new store opened in November 2017. (See *"One man's vision," Accelerate Australia & NZ*, winter 2018).

"It means that we can focus far more on running our business as opposed to worrying about efficiency or replacing equipment and changing refrigerants," said Lujic. "That's it."

Bob Soang, general manager of Drakes, also seeks to take advantage of the long-term benefits of investing in natural refrigerant systems. (See *"The big comeback," Accelerate Australia & NZ*, summer 2018.)

"The technology is actually modern and likely to carry you through much longer than that cheap and nasty, low-cost-budget quick fix," Soang said.

PROGRESS IN THE INDUSTRIAL SECTOR

Commercial refrigeration is not the only promising growth area in Australia. Natural refrigerants are also progressing in the industrial sector.

Nowadays, efforts are underway to reduce ammonia charges in industrial systems without compromising on energy efficiency – which in turn is attracting new customers to ammonia.

Scantec Refrigeration Technologies has been a pioneer in this space, designing and building the first stick-built, centralized low-charge ammonia system of Australia's modern era in 2012-2013 for Bidford, a food service company, in Perth.

More recently, in October 2018, Scantec commissioned a central-type, two-stage, low-charge ammonia system in Mackay, North Queensland. The ammonia plant serves a cold storage and food service distribution facility and is, notably, "the smallest low-charge central system designed and constructed by Scantec so far," according to Stefan Jensen, the firm's managing director.

The Mackay system's low- and medium-temperature design capacities are each approximately 50 kW (14.2 TR), with a total ammonia charge of about 500 kg.

CO₂ transcritical is also beginning to penetrate the industrial sector as new technologies enable it to serve higher capacities. For example, in November 2017, Danish system manufacturer Advansor's first industrial transcritical CO₂ rack in Australia was commissioned at a United Food Express cold storage warehouse in Melbourne (see *"Up and running," Accelerate Australia & NZ*, summer 2018 edition).

Another option is to use ammonia and CO₂ in tandem. F. Mayer Imports Pty Ltd., a food importer and wholesaler, opted for a transcritical CO₂ plant with an ammonia chiller for its Melbourne distribution warehouse (see *"F. Mayer reaping rewards of innovation," Accelerate Australia & NZ*, summer 2017). ■ AW

AUSTRALIA TIMELINE

2007:

Australia's first transcritical CO₂ supermarket system at Drakes Foodmarkets store in Angle Vale, North Adelaide.

2012-2013:

Scantec Refrigeration Technologies designs and builds first stick-built, centralized low-charge ammonia system of the modern era for Bidford in Perth, Australia.

2013:

New Zealand compels HFC importers and manufacturers to participate in Emissions Trading Scheme.

2015:

Coles opens its first transcritical CO₂ supermarket, in North Coburg, Melbourne.

2017:

Australia amends Ozone Protection and Synthetic Greenhouse Gas Management Act by adding HFC phase-down plan.

2017:

Australia accepts Kigali Amendment to Montreal Protocol.

2017:

Woolworths installs its first transcritical CO₂ system, in a store in Colebee, New South Wales.

2017:

Advansor's first industrial transcritical CO₂ rack in Australia commissioned at United Food Express cold storage warehouse in Melbourne.

JAPAN

Eco Cute and C-Stores Lead NatRefs Growth

Like Europe, Japan played a key role in the early development of modern natural refrigerant-based technology.

In 1993, Japanese component maker Denso collaborated with Norwegian CO₂ pioneer Gustav Lorentzen to develop a CO₂-based mobile air conditioner (MAC), which led to the adoption of CO₂ MAC by companies like Daimler. It also resulted in the first widespread commercialization of a natural-refrigerant product, the Eco Cute heat pump water heater, introduced by Denso in Japan in 2001. The Eco Cute's success has spawned a host of CO₂ heat pumps marketed by several Japanese firms, including Mayekawa and Sanden. As of June 2018, total sales of Eco Cute units in Japan exceeded six million.

In the commercial sector, Japan has seen a remarkable uptake of CO₂ condensing units by convenience stores since 2010. Japanese convenience stores have continued to rapidly increase their use of these systems over the past few years, led by Lawson, the Japanese convenience store giant.

Starting in 2010, Lawson had 642 stores using CO₂-based refrigeration equipment (mostly condensing units supplied by Panasonic) by August of 2015, and continued a rapid rate of adoption. At the ATMOSphere Japan 2019 conference in February, Lawson announced that it operated more than 3,200 CO₂ stores and expected to exceed 4,000 by the end of February 2020.

COLD STORAGE PROGRESS

Though natural refrigerants have yet to make major inroads into the supermarket sector in Japan, the cold storage and food processing sectors have taken significant steps towards implementing the technology.

For example, Yokohama Reito — one of Japan's leading food distribution and cold storage companies — announced in 2001 that its new facilities would use only natural refrigerant systems.

In February of 2018, Yokohama Reito announced that it had installed both NH₃/CO₂ cascade systems and CO₂ condensing units at its new Tokyo Haneda Distribution Center located on Keihinjima island in Tokyo — Japan's single largest freight hub. The installation marked the first time the company installed a CO₂ direct expansion system.

"As a part of our corporate social responsibility strategy, we continue to promote the elimination of the use of f-gases in our business," a Yokohama Reito spokesperson said last year.

Japanese technology suppliers are also recognizing the potential for significant CO₂ adoption in industrial refrigeration applications, with several new CO₂ solutions debuting in the country over the past few years.

In September of 2017, Japanese OEM Nihon Netsugen Systems shook up the market by announcing its lineup of CO₂ transcritical condensing units aimed at the industrial refrigeration market. The company then publicly unveiled the systems at the International Food Machinery & Technology Exhibition (FOOMA JAPAN) exhibition in June 2018.

Most recently, Panasonic made a splash when it announced the development of an 80-HP transcritical CO₂ rack system aimed at the industrial sector.

The company unveiled the system at the China Refrigeration 2019 exhibition held in April and said that the unit was headed to Japan for field testing this summer.

RISE OF HYDROCARBON SYSTEMS

Hydrocarbon-based technology has long been thought of as too big a stretch for Japan's traditionally conservative industry, which has a strong focus on stringent safety standards.

“We already know that if the size and performance of natural refrigerant systems are the same compared to Freon systems – and if we can solve the initial cost barrier – we are ready to implement it.”

– Shigekatsu Koganemaru, Yoshio Ice Manufacturing & Refrigeration

Despite this, certain pioneers still see an opportunity for propane systems to win end users through R290's proven energy efficiency and flexibility.

One of the biggest developments in recent years was the entrance into the Japanese market by Freor, one of the largest European suppliers of hydrocarbon technology.

The Lithuania-based OEM partnered with Japanese firm Nihon Netsugen Systems to introduce hydrocarbon water-loop technology in Japan for the first time at this year's Supermarket Tradeshow 2019 exhibition, which was held in February.

The move, according to Katsuhiko Harada, president of Nihon Netsugen Systems, is just the first step towards educating the Japanese market about the potential for this technology to replace traditional systems in Japan.

"Once we explain the functionality of the water-loop system and the showcases with built-in R290 compressors, people are really surprised and think that it is a kind of revolutionary application," Harada said, explaining the reaction to the system by participants at the exhibition.

Harada said he hopes to have the first two-to-three stores install the system in Japan this year.

SUBSIDIES DRIVE ADOPTION

Subsidies, though not seen by the industry as a long-term solution, have played an important role in helping end users take their first steps toward installing natural refrigerant technology in Japan.

"We already know that if the size and performance of natural refrigerant systems are the same compared to Freon systems – and if we can solve the initial cost barrier – we are ready to implement it," said Shigekatsu Koganemaru, president of Yoshio Ice Manufacturing & Refrigeration, a cold storage operator, at ATMOSphere Japan in 2018.

The subsidies provided by Japan's Ministry of Environment for natural refrigerant installations in the commercial and industrial sectors will continue into the 2019 fiscal year (ending March 31, 2020) with a 7 billion yen (\$65 million) budget.

■ DY

JAPAN TIMELINE:

1993:

Denso and Gustav Lorentzen develop a CO₂-based mobile air conditioner

2001:

Denso introduces Eco Cute CO₂ heat pump water heater for residential use.

2005:

Ministry of Environment initiates subsidy scheme for natural refrigerants.

2008:

Mayekawa introduces NewTon NH₃/CO₂ system.

2010:

Panasonic launches CO₂ condensing unit.

2010:

Lawson installs CO₂ condensing unit at first store.

2017:

High Pressure Safety Institute of Japan lifts restrictions on CO₂ use in large refrigeration systems.

2017:

Nihon Netsugen debuts CO₂ condensing unit for industrial sector.

2018:

Lawson exceeds 3,200 stores using transcritical CO₂ systems.

2018:

Japan ratifies Kigali Amendment.

CHINA

NatRef Opportunities Abound

While China lags far behind Japan's aggressive adoption of natural refrigerant systems, it is increasingly recognizing the opportunities available today.

Technology advancements are being made by both overseas and local technology suppliers. For example, at China Refrigeration 2018, Japanese OEM Panasonic unveiled its first CO₂ transcritical rack for the Chinese commercial food retail market.

Panasonic's transcritical CO₂ system was installed in July 2018 at a new store in Beijing operated by local Chinese retailer CSF Market. The system was the second transcritical CO₂ system to be installed in China, following one at a METRO AG store in Beijing in 2017.

Last year, a number of transcritical CO₂ systems began to be exhibited at major exhibitions. At ChinaShop 2018, held last November in Kunming, China, Chinese OEM Zhejiang XingXing Refrigeration launched a transcritical CO₂ rack system aimed at the Chinese food retail market.

At the same time, Chinese OEM Kunming Dongqi Technology revealed its own newly developed transcritical CO₂ system for the Chinese market.

At China Refrigeration 2019, along with Beijer Ref's transcritical CO₂ rack and Panasonic's 80 HP CO₂ rack, transcritical CO₂ systems were displayed by local manufacturers Shenzhou and Cryotek.

China is also making progress on the hydrocarbons front. Last year, eight major Chinese room air-conditioner manufacturers committed to selling 220,000 R290 units in 2019.

RETURN TO AMMONIA?

But there are obstacles as well. In the industrial sector, ammonia has been shunned since major accidents took place in 2013. But recent developments point towards a return to the highly efficient natural refrigerant. (See Page 84.)

Industrial refrigeration expert Jin Ma, who is deputy director of the Cold Storage and Cold Processing Committee at the Chinese Association of Refrigeration, sees a resistant mindset on the part of the government as the biggest barrier to further adoption of ammonia and CO₂ technology in China's fast-growing cold chain sector.

CHINA TIMELINE:

2013:

Moon Tech completes first NH₃/CO₂ cascade system demonstration project for industrial refrigeration.

2017:

China installs first transcritical CO₂ system for commercial refrigeration at a METRO AG store in Beijing.

2018:

Local technology manufacturers debut several transcritical CO₂ racks at ChinaShop 2018.

2018:

Eight major Chinese room AC makers commit to selling 220,000 R290 units in 2019.

2019:

Ministry of Ecology and Environment announces phase out of 280,000 metric tons of ozone-depleting substances.

"I believe that the refrigeration and air conditioning industry will continue to grow in the future," said Ma in a recent interview. "Sustainable technology is really important for this industry. However, the main barrier in China, I believe, will not be with the technology but with the mindset."

"If end users can show the government that, though ammonia use does entail legitimate safety concerns, they can be easily managed with proper standards and training, then progress in China can be made." ■ DY



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'I Would Do It Again'

Whole Foods Market's Tristam Coffin would install a second R290/CO₂ cascade system, after finding its initial performance promising and overcoming permitting challenges

— By Michael Garry

Santa Clara, Calif., store with R290/CO₂ cascade system

Though small-charge propane (R290) self-contained cases have proliferated, in July 2016 Whole Foods Market became the first food retailer in North America to install a propane/CO₂ cascade refrigeration system. (See ["Whole Foods Pushes the Propane Envelope," Accelerate America](#), October 2016.)

Three years later, its 49,000-ft² Santa Clara, Calif., Whole Foods outlet remains the only store in North America known to use a propane/CO₂ system, which made it the object of considerable interest at the 2019 IAR Natural Refrigeration Conference & Expo, held in Phoenix in March.

At the conference, Tristam Coffin, director of sustainability & facilities for Whole Foods Market, shed light on the system's provenance and performance in a case-study presentation. (This is detailed in an IAR Technical Paper: "Case Study: The First Commercial Propane/Carbon Dioxide Cascade Refrigeration System in North

America," which can be purchased at <https://bit.ly/2WtvnIG>.) The presentation was part of a commercial refrigeration track organized by the North American Sustainable Refrigeration Council (NASRC).

As he concluded, Coffin divulged the answer to the question many in the audience were undoubtedly entertaining: Would Whole Foods choose to use this technology in another new store?

His answer: "I would absolutely explore this again. The system architecture and operation is more than worthy of further deployment."

But he added, with a smile, "I would encourage others to do it so I don't have to!"

For there were a number of hard lessons learned in deploying the first R290/CO₂ cascade system in North America (and a second deployment would offer lessons of its own, he said).

Perhaps the hardest lesson learned stemmed from Whole Foods' experience with the authority having jurisdiction (AHJ) in Santa Clara, responsible for providing permits for the store.

"We received a building permit in 2015 after the appropriate parties, including the fire department, reviewed the plans," recalled Coffin. "But, as we walked the building inspector [fire marshal] through the propane/CO₂ system weeks before the store opening, he said that was the first he had heard about it."

The discovery prompted some "pretty tough questions," which considerably delayed the final permit sign-off and resulted in a number of design changes for control, leak detection and response.

This clearly showed the need for earlier and closer engagement with the AHJ. "Let the AHJ know in no uncertain terms exactly what you are doing versus handing them the plans and expecting that they understand the concept," Coffin said.



Another step needed to deploy the R290/CO₂ cascade system called for the system supplier, Quebec-based Carnot Refrigeration, to apply for and receive test-market approval from the U.S. Environmental Protection Agency (EPA) under its SNAP (Significant New Alternatives Policy) program. Carnot did that, and was also able to get the system listed by the UL equivalent – CSA in Canada.

Cost and energy comparisons

The R290/CO₂ cascade system consists of three low-temperature rooftop chillers (each with 25 lbs of R290) and four medium-temperature rooftop chillers (each with 39 lbs of R290). A cascade CO₂ rack is used for the low-temperature cases, while liquid overfeed is used with medium-temperature cases. The CO₂ charge is 1,730 lbs.

Given the presence of flammable propane, “a lot of attention was paid to safety,” said Tom Wolgamot, principal, DC Engineering, who presented with Coffin at the IIR conference. The safety features include features to keep the amount of propane well below the 21,000 ppm LFL (lower flammability limit) in the event of a leak; for example, a notification is sent when a leak reaches 1,000 ppm; an email is sent at 2,500 ppm and the power is cut off at 5,000 ppm.

To date, no propane has leaked, and only 120 lbs of CO₂ leaked once into one of the propane chillers.

In studying the deployment of its R290/CO₂ cascade system, Whole Foods compared it to three other systems at other Northern California stores: a baseline (distributed R407A with scroll compressors and hybrid condensers); transcritical CO₂ with an air-cooled gas cooler; and an ammonia/CO₂ cascade system with hybrid condensers.

Experimental systems like an R290/CO₂ cascade system are known to be more expensive than traditional equipment, and in this case, it was 136% more costly than the baseline system.

Similarly, during 2018 the R290/CO₂ system was found to consume a little more energy



Medium-temperature propane chillers on the roof of Whole Foods' Santa Clara, Calif., store

than the baseline system, a highly efficient unit that has an inherent advantage in not using a cascade heat exchanger.

Normalized to weather and refrigeration load, the R290/CO₂ system consumed about 1.3 KWH/°F-MBH at 40°F, compared to 0.9 for baseline, a difference of 0.4. However the difference shrinks to 0.2 at 70°F and then to zero at 95°F.

The R290/CO₂ system generally performed better than the other natural refrigerant systems. The transcritical system outperformed it between 40°F and 55°F; thereafter R290/CO₂ consumed less energy, and by 80°F it consumed 0.5 KWH/°F-MBH less. R290/CO₂ consumed less than ammonia/CO₂ over the entire temperature range; at 60°F the difference was 0.5.

Coffin was pleased with the overall energy performance of the R290/CO₂ system. “We were told the energy penalty would be 50%-60% higher than baseline,” he said. “Getting so close to the HFC DX baseline in my mind is a success. If we did 100 more, we’d start to be neutral or better.”

In terms of TEWI (total equivalent warming impact), which combines direct refrigerant emissions and indirect electricity-driven emissions, all of the natural refrigerant systems far outperform the baseline system, which uses a high-GWP refrigerant (R407; GWP 2,107) and generates more than 400 tons of CO₂e. The R290/CO₂ system’s TEWI is about 160 tons of CO₂e.

“With regulatory implications and corporate sustainability goals, it’s important to look at TEWI vs. just indirect emissions from energy use,” said Coffin. In California, regulations are heading toward a 150 GWP cap in new commercial systems in 2022, offering further incentive to use R290 (GWP 3) and CO₂ (GWP 1). ■ MG



1 /

2 /

A VERSATILE CO₂ CONTRACTOR

South-Town/SCR has installed innovative transcritical CO₂ systems in three disparate Minnesota sites – a supermarket, a processing facility and an ice rink

— By Michael Garry

1 / Lunds & Byerlys has installed a transcritical CO₂ system
2 / Ryan Welty, South-Town Refrigeration & Mechanical

Transcritical CO₂ refrigeration has proven to be a versatile application that can be employed in a number of sectors, including supermarkets, industrial sites and ice rinks.

As contractors, Minneapolis-based South-Town Refrigeration & Mechanical and its sister company SCR (St. Cloud Refrigeration), which cover the Upper Midwest of the U.S., have been equally versatile, installing transcritical systems in all three sectors in Minnesota over the past two years.

"Now that we have systems in different settings, we have a good test of everything," said Ryan Welty, vice president of sales and operations for both companies, which are co-owned by Welty's father Pat and Mike Fitch. Fitch's father, Don, started SCR, a non-union shop, in 1957, and the families purchased unionized South-Town in 2009.

Importantly, with a few years of experience working on CO₂ systems, Welty's service technicians are "not scared" of them anymore," he said. "And manufacturers have a good base as well."

The first CO₂ project, handled two years ago by South-Town, was for a new innovation/technology center in Downtown Minneapolis where Jack Link's Beef Jerky tests new products. An Advansor transcritical CO₂ system (from Hillphoenix), is used in a 10,000-ft² processing area along with Colmac custom DX evaporator coils and Micro Thermo Controls (from Sporlan). The system delivers a low-temperature capacity of 36.4K BTUH and a medium-temperature capacity of 575.5K BTUH.

The transcritical system leverages heat reclaim to create hot water used to preheat the water required for the wash down of the processing area.

A unique aspect of the Jack Link's project is that the CO₂ discharge gas is cooled in a heat exchanger by chilled (40°F-50°F) water provided via underground pipes by Clearway Energy's Energy Center; the Energy Center supports cooling and heating in 100 buildings in downtown Minneapolis.

The cooled water prevents the CO₂ system from ever entering "transcritical

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MINNESOTA SCHOLARSHIP PROGRAM

South-Town Refrigeration & Mechanical and its sister company SCR (St. Cloud Refrigeration), both owned by the Welty-Fitch families, have been running a recruitment/apprentice program that has netted them several entry-level technicians per year over the last few years.

The Minnesota contractor works with local high schools and two-year technical schools with HVAC&R programs (where company officials sit on the advisory board) to sign up students for afternoon apprentice jobs while they are attending school. The company pays for "most or all" of tuition for students who commit to working for South-Town or SCR post-graduation, said Ryan Welty, vice president of sales and operations for both companies.

"This year we have five-to-six people finishing their first year of school and five to six finishing their second year, and we're recruiting for the fall," he said. "It's worked out great for us."

The 22-year-old program has grown considerably over the past decade, he noted, and helps the contractor maintain staffing, which includes 140-150 refrigeration technicians, about 35 air conditioning installers and 10-15 automation specialists.

"We don't take anybody" for the program, Welty said. "They need to get good grades in school."

mode," in which high ambient temperatures prevent the gas from condensing, said Welty, adding, "It's the perfect application for CO₂."

FIRST CO₂ RDM CONTROLS IN U.S.

Supermarkets are Welty's biggest area of focus. Last year, South-Town installed its third supermarket CO₂ system, a Advansor transcritical model with an adiabatic condenser at a new Lunds & Byerlys store in White Bear Lake, Minn., outside of Minneapolis. It is the first CO₂ system in the U.S. to use RDM (Resource Data Management) controls, said Welty. (RDM controls have been used in European stores.)

"RDM flew in people from Europe to make sure it was set up correctly," he said, noting that the unit had to be adjusted from metric to U.S. measurements. Lunds & Byerlys requested the RDM controls because the 27-store upscale chain uses them in its HFC systems.

The White Bear Lake store's transcritical system delivers a low-temperature capacity of 205.5K BTUH (-16°F) and medium-temperature capacity of 873.1L BTUH (19°F).

The CO₂ system has consumed less energy than an R407A system at a comparable nearby store, noted Welty. "They beat it every month," including warm periods in late summer-early fall, he said, though he could not provide consumption data.

Welty acknowledged a first-cost premium for CO₂ equipment, but said that installation costs were no higher than traditional systems. He attributed higher first costs to the greater use of electronic case controls.

South-Town has also installed CO₂ secondary systems at Target (for which it has also installed a transcritical CO₂ system) and Walmart stores, Welty said.

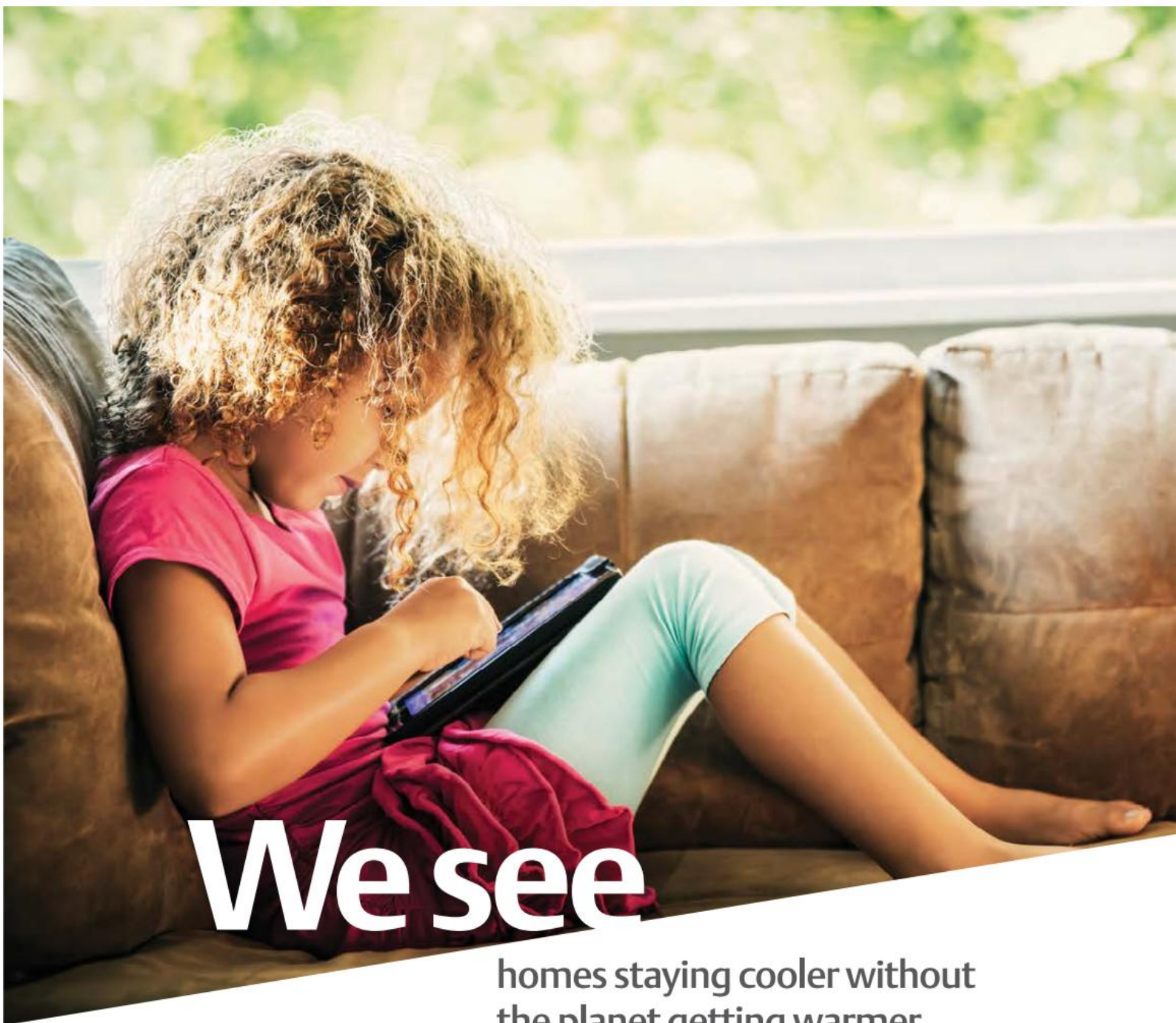
South-Town is also working with self-contained R290 cases at retailers like Target, though he doesn't see a major move to R290 until higher charge limits are adopted in the U.S. (The IEC has raised the global hydrocarbon charge-limit standard for stand-alone cases to 500 g; see page 24.)

Last year, SCR installed the first transcritical CO₂ system in an ice rink in the "lower 48" part of the U.S. (CO₂ ice rinks were previously deployed in Anchorage, Alaska.) The 170-TR chiller system, using glycol as a secondary fluid, serves an existing ice rink (replacing an R22 system) and a new rink at the St. Michael-Albertville Arena, Albertville, Minn. The system also employs a Guenter Cooling Tower and Micro Thermo Controls.

Welty is currently installing an ammonia refrigeration system for an ice rink, he said.

The biggest challenge Welty faced in his initial CO₂ projects was getting over the "fear factor" associated with new technology. "But we decided we were going to do this, and find good partners willing to take a chance with us," he said.

Another hurdle was supporting stores in remote regions of the Upper Midwest where there are scant supplies of refrigerant-grade CO₂. In one case a store in North Dakota had to purge its CO₂, and the closest supply was an eight-hour drive away. "We got it to them but they lost product," said Welty, who agreed that remote stores should invest in having extra CO₂ supplies on hand. ■ MG



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CONSIDER IT SOLVED™

States Coalition Making Progress on HFC Reduction

The U.S. Climate Alliance's 24 state members have made reducing short-lived climate pollutants like HFCs one of its top priorities

— By Michael Garry

In 2017, after the Trump administration announced that it planned to withdraw from the Paris accord on climate change, three governors — Jerry Brown of California, Andrew Cuomo of New York and Jay Inslee of Washington — decided to create a bipartisan group that would address climate change at the state level.

That group — the U.S. Climate Alliance — initially consisted of the governors of 16 U.S. states and Puerto Rico. It has since added governors from seven other states, the latest being Pennsylvania, which joined in late April.

The other states include Colorado, Connecticut, Delaware, Hawaii, Illinois, Maine, Maryland, Massachusetts, Michigan, Minnesota, Nevada, New Jersey, New Mexico, North Carolina, Oregon, Rhode Island, Vermont, Virginia and Wisconsin. (Three of the governors — from Massachusetts, Vermont and Maryland — are Republicans; the rest are Democrats.) Collectively, the states represent more than half the U.S. population and the third largest economy in the world.

In addressing climate change, states commit to implementing policies that aim to reduce greenhouse gas (GHG) emissions by at least 26%-28% below 2005 levels by 2025 — the goal set by the Obama administration for the Paris accord.

Joining the U.S. Climate Alliance is a serious commitment. “We want to make sure the Alliance is not used for ‘greenwashing,’” said Julie Cerqueira, its executive director. “The governors invited are those committed to doing what they can on climate change, and are willing to work together to be a unified voice and look for multi-state approaches that can be transformational.”

A BUSY SLCP WORKING GROUP

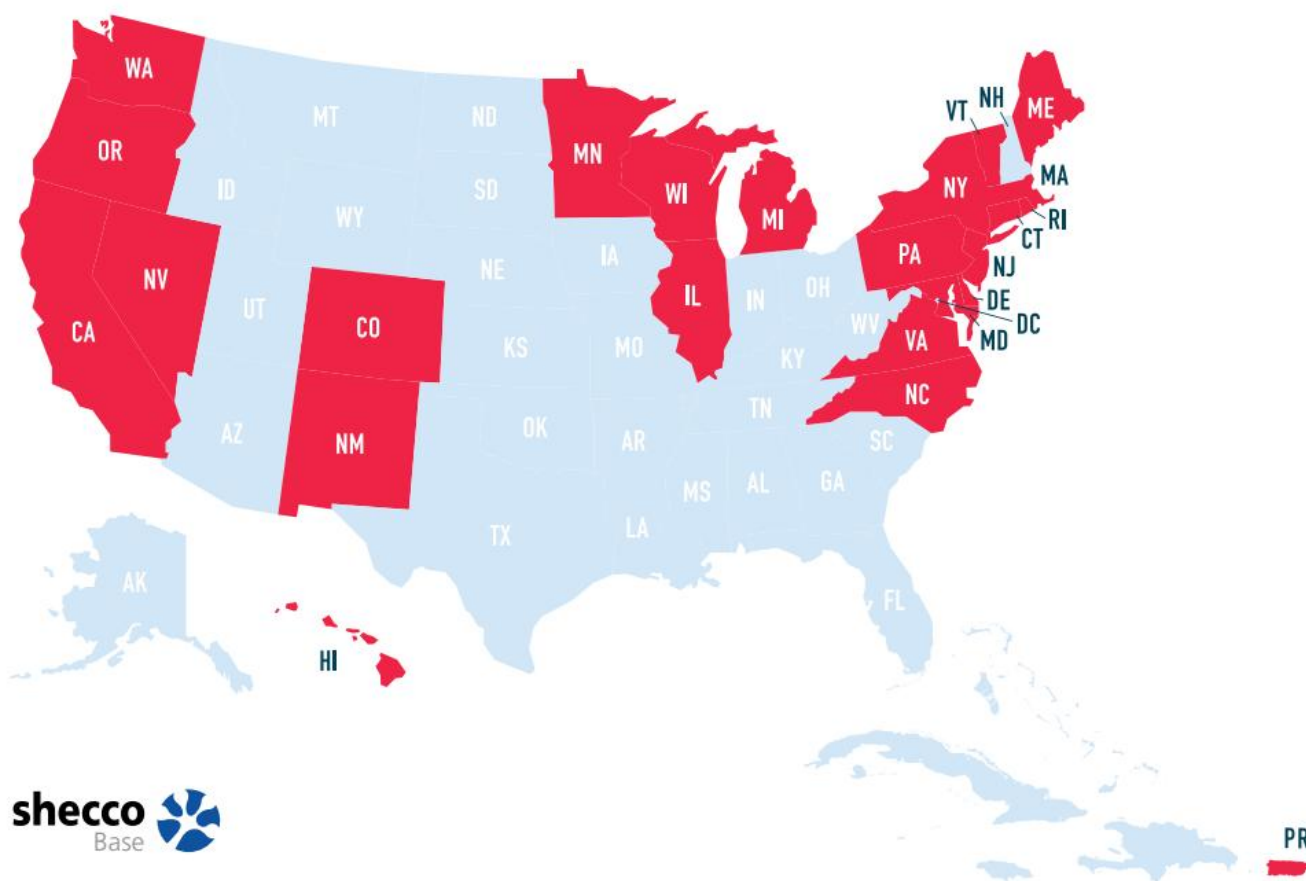
The Alliance runs nine working groups covering a range of climate issues. States share their experiences as they develop regulations and consult with stakeholders. One of the most active groups is focused on addressing short-lived climate pollutants (SLCPs), including HFCs and methane, which are powerful GHGs. These “non-CO₂” gases “are often forgotten in everybody’s quest for low-carbon energy and transportation,” said Cerqueira. “Yet methane is the second largest greenhouse gas and HFCs are really powerful.”

Last year, the Alliance issued an “SLCP Challenge” urging national and subnational jurisdictions, business and other actors to bring SLCP-reduction plans to the Global Climate Action Summit in San Francisco, Calif., in September. That month, the Alliance issued its own SLCP “Challenge to Action” roadmap filled with recommendations on how to reduce SLCP emissions by 40% below 2013 levels by 2030. For HFC reduction, the plan suggested that states could adopt regulations, limit use of high-GWP refrigerants, and develop incentive programs for new low-GWP systems, among other measures.

California, the leader of the SLCP Working Group, is the Alliance state that has done the most to reduce HFC emissions, having passed the California Cooling Act last September. The Act established incentives for low-GWP refrigerant systems and adopted many of the U.S. Environmental Protection Agency’s HFC restrictions that were partially revoked by a U.S. Court of Appeals decision in 2017.

At the Global Climate Action Summit, three states — New York, Maryland and Connecticut — announced they would follow California’s lead and adopt similar HFC regulations. Since then, Washington state passed legislation regulating HFCs and Vermont recently adopted HFC-reduction legislation patterned on the laws passed in California and Washington. ([See page 26.](#))

Member States of the U.S. Climate Alliance



"HFCs is where we've made the most progress," said Cerqueira, referring to the multiple state actions. "I think there's a lot of ambition on the HFC side, in particular." Additional states are expected to soon follow suit, she added. "As we see more states announcing, it has become easier for others to do it."

One of the key elements of state action, she noted, has been to "backstop" overturned EPA regulations "to make sure we're deterring backsliding as much as possible." States are also considering additional measures like adopting EPA Section 608 regulations on HFC leak repairs and addressing disposal issues, energy efficiency and car air conditioning.

States in the SLCP Working Group recognize the need to avoid a "patchwork regulatory framework" across states, said Cerqueira. "They're trying to have rules as consistent as possible to make it easy for industry to be in compliance."

What may limit further progress is a lack of familiarity with HFCs. The solution for that is educating policy makers that HFC reduction "is a near-term opportunity, and there's not a lot of opposition in the U.S. to doing more on HFCs, so it's a relatively easy win," said Cerqueira. ■ MG

HFC REGS IN THE NUTMEG STATE

Connecticut, one of the original state members of the U.S. Climate Alliance, has started developing regulations that will phase out the use of HFCs, as directed by its former governor, Dannel Malloy, last September.

A key player in this process is Keri Enright-Kato, director of the office of climate change technology and research in the Connecticut Department of Energy and Environmental Protection (DEEP). She expects final regulations to be ready in about a year.

Connecticut has worked with other states in the Alliance to develop a "model rule based on the California experience that we all feed off," said Keri Enright-Kato.

California last year enacted the California Cooling Act, which established incentives for low-GWP cooling systems and adopted federal HFC rules that had been rolled back by a U.S. Court of Appeals decision in 2017.

DEEP is starting to draft its own regulations with components that will "probably be similar" to those in the model rule, though timelines "might be slightly different," she said.

DEEP will solicit input from stakeholders who would be impacted by the legislation like food retailers, and then put together an economic impact analysis. The final step is for proposed regulations to be vetted by a regulatory review committee consisting of state legislators.

KYSOR WARREN EPTA US TAKES ON NORTH AMERICA

The newly formed company will bring from Europe Epta's energy-saving systems such as its FTE technology for transcritical CO₂ refrigeration and its R290 cases, while Kysor Warren will continue to offer transcritical and ammonia/CO₂ systems, explains Marketing Director Michael Lehtinen

— By Michael Garry



Michael Lehtinen,
Kysor Warren Epta US

On April 1, Italian OEM Epta S.p.A. announced the acquisition of Kysor Warren from U.S. conglomerate Lennox International in a \$49 million cash deal, and said the acquisition will result in the creation of a new company called Kysor Warren Epta US Corp.

Columbus, Ga.-based Kysor Warren, previously a division of Lennox subsidiary Heatcraft Worldwide Refrigeration, manufactures refrigerated display cases and commercial refrigeration systems – including transcritical CO₂ and ammonia/CO₂ cascade systems – for grocery and convenience stores.

Epta is a leading manufacturer of CO₂ refrigeration systems and cases as well as propane self-contained units in Europe, and has expanded its marketing to Australia, South America and Asia. It runs 12 manufacturing plants and a worldwide sales and technical service network; in 2018 it recorded sales of 921 million euros (\$1.027 billion). Epta's commercial refrigeration brands include Costan, Bonnet Névé, George Barker, Eurocryor, Misa, Iarp, Knudsen Kølring, and now Kysor Warren, which gives Epta a foothold in North and Central America.

Accelerate Magazine asked Michael Lehtinen, formerly director of marketing and business development for Kysor Warren, and now marketing director for Kysor Warren Epta US, about the direction the new company will take in North America.

// Accelerate Magazine: What is the market potential for natural refrigerant systems in North America?

Michael Lehtinen: The market potential in North America is substantial, and that's something that I've always believed in.

The one thing that makes it different here in the U.S. than what we're seeing in the rest of the world has to do with climate change. Climate change is occurring, there's data to support it, it's just a question of how does the user base interpret or believe that data. One of the contributors to the change in climate has been the refrigeration industry. If we see the North American population start to make the connection between climate change and the impact coming from refrigeration, and the need to really become sustainable long term, natural refrigerants will have to become standard.

Also, natural refrigerants offer an underlying risk mitigation strategy for businesses because the price of the synthetic gas continues to go up. And depending on what happens with these local and state regulations that we're starting to see in California and Washington state, you're seeing a whole other level of risk that your business is going to have to deal with.

// Accelerate Magazine: Where does Kysor Warren Epta US see the greatest opportunities in North America?

Michael Lehtinen: We still think that food retail is the biggest opportunity for natural refrigerants. Now our portfolio is even more well rounded as we become part of Epta. Kysor Warren has done a lot of work with CO₂ transcritical, and now we also have what the Epta Group has done, and they have some unique innovations.

One of them that we'll be talking about at ATMosphere America is called FTE [Full Transcritical Efficiency]. What's really great about this is it's not some new piece of equipment or technology that is difficult to understand; it's actually a fabulous simplification on some of the things people have been trying to do. It's extremely effective.

The other piece we get from Epta is the application of self-contained propane plug-in units. I'm not talking about point-of-sale bottle coolers that you see at the checkout; I'm talking about full-size display cabinets that utilize 150 grams or less of propane per circuit. One of the things that we just have to account for is the difference in power supply; Europe is 50 Hz and the U.S. is 60 Hz.

Kysor Warren also has a low-charge ammonia/CO₂ cascade system. We've done a lot of work publicizing the work we've done on that with Piggly Wiggly [JTM Corp.]. Whether or not the retail industry is ready to embrace ammonia as a primary refrigerant is still yet to be seen, but we believe in it and we will maintain the technology.

// Accelerate Magazine: Will Kysor Warren Epta U.S. look at other sectors?

Michael Lehtinen: Our core sector remains commercial refrigeration for food retail. Now that we are part of the Epta Group, we're also able to look into diversification strategies. Some of the areas we're looking at right now are foodservice-style products as well as some cold storage. As we see retailers working to solve delivery and pick up, we see that there's a lot more small- to medium-size warehousing going into place. On the foodservice side, if we look at the term "grocerant," food retailers are looking at ways to make their environment more engaging to retain shoppers.

// Accelerate Magazine: So you can offer grocers some of the propane equipment that foodservice people are starting to use? And for their cold storage, you can offer the ammonia/CO₂ product?



Michael Lehtinen: That's correct. We're well positioned right now.

// Accelerate Magazine: The FTE technology is beneficial in warm climates in North America.

Michael Lehtinen: I'd like to make a slight correction: FTE technology is beneficial for every climate. I'll use Rochester, N.Y.; the average temperatures there are a bit on the lower side, but it still gets really hot in the summer. Traditionally, when we've looked at CO₂ energy analysis, we've always accepted in a northern climate like that you're going to have maybe a month where transcritical CO₂ is less efficient, so on the average it nets out favorably. Now FTE is going to be able to cover that one month where you were not as efficient.

// Accelerate Magazine: What about the EptaBlue CO₂ condensing unit? There aren't many CO₂ condensing units in U.S. stores.

Michael Lehtinen: We're looking at those types of products and whether there is a demand for it. In North America, you don't see CO₂ condensing units, and there's a pretty logical reason behind it. When you're using CO₂ as a refrigerant, it's more efficient to have both low- and medium-temp offerings because you get the medium temperature almost for free if you have low temperature on the rack. There may be some retailers or other users where [CO₂ condensing units] make sense for certain applications, but right now the broader North American market is not asking for that.

// Accelerate Magazine: When will Kysor Warren Epta US start marketing in North America?

Michael Lehtinen: The marketing process has already begun. In that first month of April after the acquisition, we already started the process of changing our corporate image to incorporate Epta. We've also reached out to our strategic customers and potential customers to start discussing with them what the change means, and how does the organization look and function now, as well as giving future customers the opportunity to participate with us in how we start to interchange products across the entire Epta Group with Kysor Warren.

ATMOsphere America is going to be our first public display of the new branding, the new image and direction of the organization, so we see ATMOsphere as really the launching point to publicly show everybody how this is all going to look. First, we see FTE as a technology introduction, not a product introduction. At ATMOsphere, we'll be announcing FTE's availability and asking who wants to be the first FTE user in North America. Next will be the introduction of propane self-contained units. Finally, we see the complete transition concluding before the end of 2019.

// Accelerate Magazine: What is the biggest challenge Kysor Warren Epta US expects to face in North America?

Michael Lehtinen: The biggest challenge we've identified is incorporating two very different companies. If I look at Kysor Warren, it has 135 years of reliability. If I look at the Epta organization, it's extremely well established as an innovator and a technology leader. They develop technologies and they bring them to market and they bring them to life. So how do we put those two companies together?

Epta's got a global footprint. They have shown that new products and technologies work in different climates, and we have to find a way to show the North American user that these technologies can be a great fit also in this market. ■ MG



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Mega Image store in Straduintei district, Bucharest

Ahold Delhaize subsidiary Mega Image has opened three supermarkets fitted with CO₂ transcritical systems, which are uncommon in Romania

— By Andrew Williams

ROMANIAN GROCER ADOPTS CO₂ TRANSCRITICAL

As one of 22 local supermarket companies belonging to Ahold Delhaize, Mega Image SRL, the largest supermarket chain in Romania, shares its parent group's dedication to reducing the environmental footprint of its activities.

"Mega Image is part of the Ahold Delhaize group and all its actions are aligned to those of the group," said Vasile Casian, technical manager at Mega Image.

"Our commitment is to have as little an impact on the environment as possible, and to make our actions more sustainable."

Ahold Delhaize is aiming to reduce the conglomerate's greenhouse gas emissions by 40-70% by 2050 compared to 2010 levels. To that end, 13% of Ahold Delhaize sites were using natural refrigerant-based systems worldwide at the end of 2017; in Europe the figure was 33%.

"To reach [our] targets, natural refrigerants are the best choice and the long-term solution."

— Vasile Casian, Mega Image

For its part, Mega Image uses natural refrigerants in 170 of its more than 500 stores, including propane for chest freezers in all 170 stores, and CO₂ in condensing units and subcritical systems for selected cases in some stores, said Casian. And last year, Mega Image opened its first three stores that employ transcritical CO₂ systems for all refrigeration — one of the few Romanian stores equipped with this technology.

Mega Image is working with Frigo-Consulting, a Switzerland-headquartered multinational company that counts Romania among the countries in which it has opened branch offices. Frigo-Consulting has engineered and commissioned over 1,000 transcritical CO₂ systems.

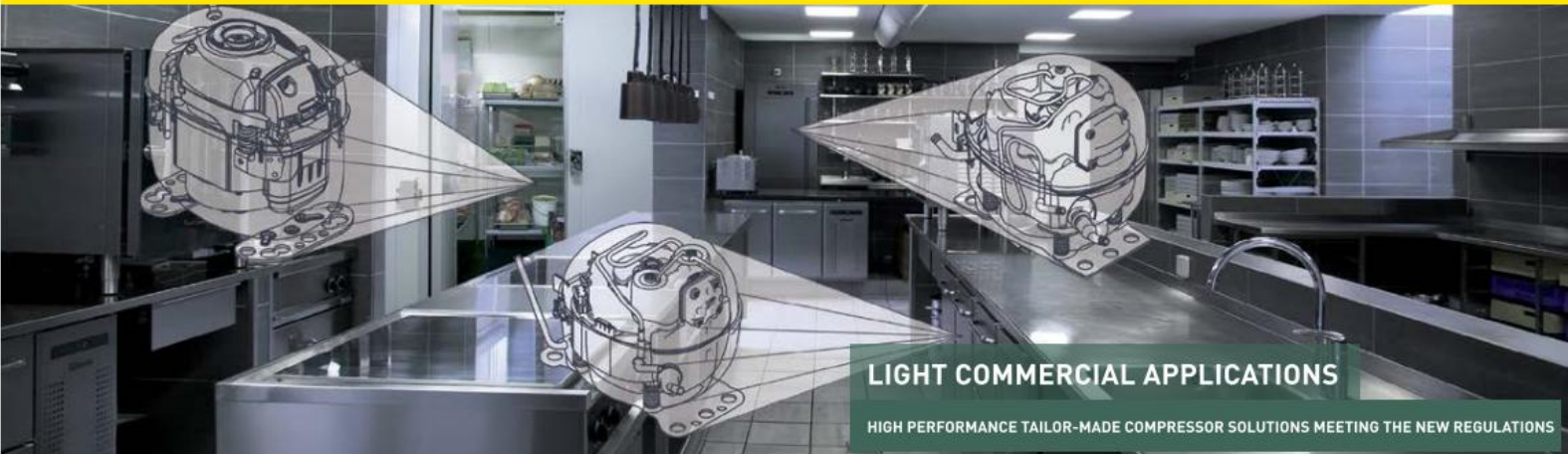
Casian also frequently reaches out to other colleagues in the Ahold Delhaize group on the topic of natural refrigerants.

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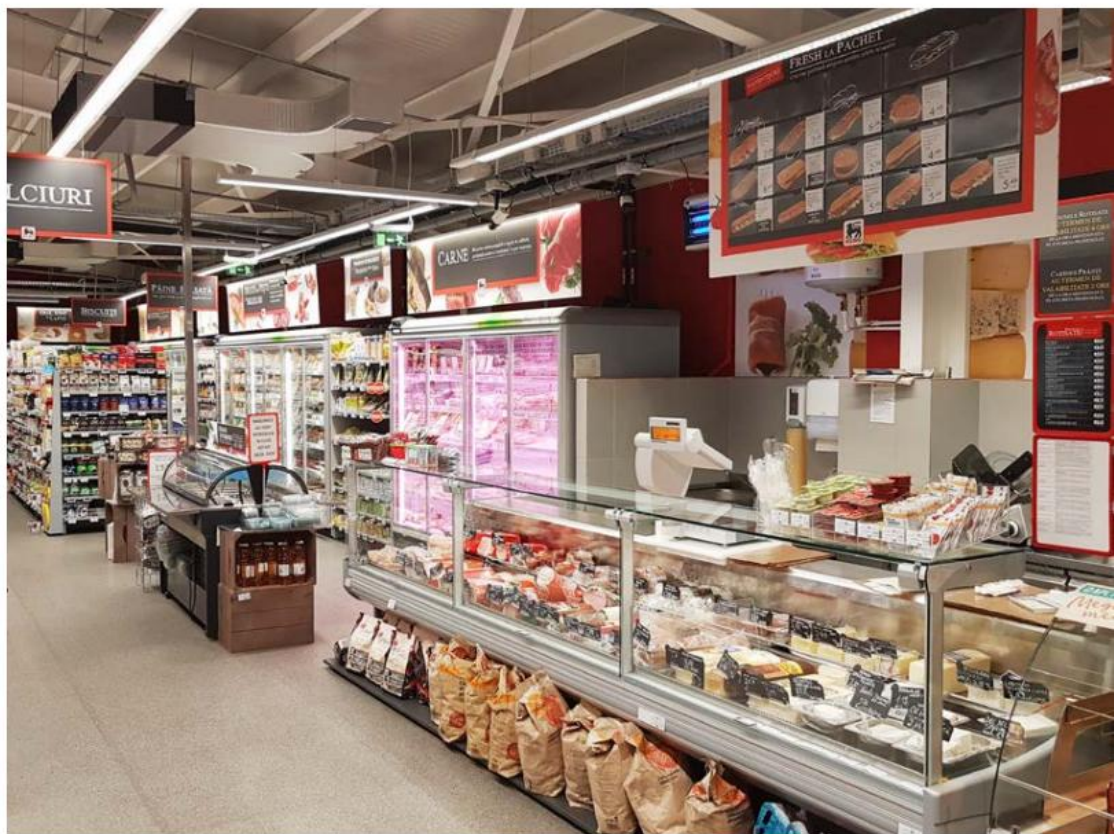


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“The CO₂ projects that we’ve implemented this year and last year have shown that in Romania, there are companies that know how to work with the requested CO₂ technology.”

— Vasile Casian, Mega Image



CO₂-cooled cabinets, Straduintei store

“We share and discuss information and experiences that ultimately lead to the harmonization of solutions and equipment used for HVAC&R technology,” he said.

“Our targets refer to reaching a certain level of GWP and reducing our CO₂ emissions,” he added. “To reach these targets, natural refrigerants are the best choice and the long-term solution.”

As a member state of the European Union, Romania is subject to the HFC phasedown that is taking place under the bloc’s F-Gas Regulation. Commercial refrigeration is one area in which the F-Gas Regulation, which regulates the EU’s f-gas use, is already beginning to bite. In 2022, bans on using certain HFCs with GWPs above 150 in new centralized and plug-in commercial refrigeration equipment will come into effect.

NEW STORES IN BUCHAREST AND CONSTANTA

Last year, Mega Image opened two new stores in Bucharest, Romania’s capital, that use CO₂ transcritical booster systems. The first, located in the Drumul Jilavei district, opened on in July 2018, and the second, in the Straduintei district, in September.

A third supermarket, in the Palazu Mare district of Constanta, Romania, debuted in April of this year. That store uses Epta’s Full Transcritical Efficiency concept, a CO₂ booster system with external sub-cooling that harnesses an intelligent liquid receiver.

“The CO₂ projects that we’ve implemented this year and last year have shown that in Romania, there are companies that know how to work with the requested CO₂ technology,” Casian said.

He acknowledged the higher cost of the transcritical systems. “So far, for HVAC&R, the CO₂ scenario has involved higher investment costs – 16%-45% higher than an old-fashioned synthetic refrigerant-based scenario,” he said.

To strengthen the business case for choosing CO₂, Casian recommends combining it with heat recovery.

Mega Image strives to ensure that its own staff members receive all the support they need to use advanced CO₂ installations, which can feature numerous electronic devices. Minimizing the risk of accidental system shutdowns is particularly important, as downtime “can affect the profitability of shops,” Casian noted.

“Our staff in the technical department and the people involved in choosing, designing and implementing the HVAC&R technology regularly attend dedicated training and seminars on using refrigeration plants with natural refrigerants,” he said. ■ AW

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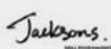
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SKIING ON CO₂-COOLED SNOW

SNØ, Norway's first year-round indoor ski arena, will feature snow made by the country's largest transcritical CO₂ system

— By Andrew Williams & Charlotte McLaughlin

In January 2020, Norway's first year-round indoor ski arena — aptly named SNØ — will open in Lørenskog, just east of capital city Oslo. The snow for the venue will be cooled by natural refrigerant CO₂.

The arena will be fitted with three PowerCO₂OL transcritical racks provided by Carrier Commercial Refrigeration, which celebrated delivery of its 10,000th CO₂ system in April. The system will deliver 3.1 MW (881 TR) of cooling in what will be the largest CO₂ transcritical installation in Norway.



"Carrier's CO₂ system meets our need for a long-term, cost-effective solution for Norway's first indoor ski arena that will allow visitors of all ages to enjoy winter year-round," said Ing. Petter Nome, CEO of Ipnas, consultants on the project for SNØ.

The PowerCO₂OL platform will maintain temperatures at -4°C (24.8°F) and be able to deliver temperatures as low as -12°C (10.4°F). It integrates Carrier's CO₂OLtec EVO modulating vapor ejector technology as a standard feature to improve energy efficiency. Carrier asserts that the PowerCO₂OL platform can deliver energy savings of up to 30% on an annual basis compared to standard transcritical CO₂ systems.

SKIING INDOORS

Visitors to SNØ will be able to enjoy Alpine and Nordic skiing in a year-round winter environment. The indoor arena's 36,000-m² snow area will have a 2-km cross-country trail, and three 500-m slalom slopes for beginners. SNØ hopes to attract 400,000 visitors in 2020, the first year of operation.

The snow for the arena will be 100% self-produced. Trym Klingenberg, operations manager at SNØ, is looking forward to the challenge of making snow for use year-round. He joined the company after a 25-year career working in outdoor ski resorts.



"We'll use the winter months to put the base in," Klingenberg explained. "Then we need small sprays daily or weekly to maintain perfect conditions throughout the summer."

Heat generated by the cooling systems will be recovered for use in local buildings via a district-heating network.

Rune Lorenzen, chairman of Røa Langrenn, a sports club near Oslo that offers cross-country skiing on the hills surrounding the capital, is following the development of the SNØ arena with interest.

This year, Røa had to produce over 10,000 m³ of snow for its own activities. The outdoor arena hosts 600 young people who are members of the club. It is also open to the public.

Natural snow can weigh between 50 and 125 kg per m³, depending on how wet it is. Manufactured snow is between 2.5 and 10 times as dense as natural snow, and this makes it resistant to mild temperatures and wear, Lorenzen explained.

There are also differences in snow made for indoor and outdoor uses, with the former process taking humidity into account. "Indoors, you have to add more air and use less water," he said Lorenzen. "And that means you can't make as [much] at a time compared to outdoors."

One major advantage of an indoor environment, however, is its constancy. "After the snow is first laid down, it will last a long time – we're talking months," he said. ■ AW & CM

“Carrier's CO₂ system meets our need for a long-term, cost-effective solution for Norway's first indoor ski arena that will allow visitors of all ages to enjoy winter year-round.”

— Ing. Petter Nome, Ipnas

Home Propane Heat Pumps Take Off at ISH

Capitalizing on the rising cost of HFCs, a bevy of OEMs introduce R290 units at the German trade show

— By Andrew Williams & Charlotte McLaughlin



Frankfurt-based ISH: the Bathroom Experience, Building, Energy, Air-Conditioning Technology and Renewable Energies trade show

Over 10.5 million heat pumps provide heating and sanitary hot water in Europe in domestic and commercial applications today, reports the European Heat Pump Association.

Of those, an estimated 200,000-220,000 heat pumps – about 2% of the installed base – use propane (R290) as the refrigerant, mostly for domestic applications, according to shecco, publisher of *Accelerate Magazine*. Most of the rest use HFCs, with some employing ammonia or CO₂.

But as HFCs continue to be regulated in Europe and around the globe, the market potential for heat pumps using propane to replace f-gases is huge.

This potential was reflected at this year's ISH: the Bathroom Experience, Building, Energy, Air-Conditioning Technology and Renewable Energies trade show,

held March 11-15 in Frankfurt, Germany, where a slew of companies launched new R290-based heat pumps targeting the residential market.

Propane has a good coefficient of performance (COP) compared to other refrigerants commonly used in heat pumps, which helps keep propane charges 40%-60% lower than average. In Europe, the charge limit for R290 heat pumps are generally 1 kg in a direct indoor system (depending upon room size) and 5 kg outside or in a special enclosure. Small, self-contained heat pumps limit charge size to 0.3 kg. Capacities range from 4 kW (1.1 TR) for small, self-contained units to 50 kw (14.2 TR) for space/hot water domestic heat pumps.

Europe is a particularly promising market, because propane performs well in providing space heating for mild climates. In Japan, where residential

heat pumps are well established, CO₂ tends to be used, providing the high temperatures required for the hot baths favored in Japanese culture.

But R290 heat pumps face a number of challenges as well. First, manufacturers are turning to R32 – an HFC with a GWP of 675 – in a big way. Economies of scale are driving down the initial purchase price of R32 units, and most homeowners consider cost to be a decisive factor in purchasing the equipment.

Moreover, according to a report written for the EU-funded LIFE FRONT project, standards limiting refrigerant charge sizes and a lack of trained technicians are slowing down the uptake in Europe of hydrocarbon-based refrigeration, air conditioning and heat pumps.

Yet policy can also help facilitate the market. The latest EU F-Gas Regulation – in force since 2015 – aims to reduce

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“R290 will be the future. It looks like generally the heat pump market will turn to propane.”

— Tarek Abdou, Hotjet

the European Union's HFC use by 79% by 2030. It is steadily banning the use of f-gases, with the scope and timing varying by sector. Under the regulation, HFC prices in Europe have been steadily increasing, according to data from Öko-Recherche, which does environmental research and monitoring. For example, average purchase prices of R134a, R410A and R404A were under €2 (\$2.40)/tCO₂e in 2014, but jumped to between €7 (\$8.30)/t CO₂e and €23 (\$27.20)/tCO₂e in the first quarter of 2018, the study said.

Some European governments, meanwhile, offer homeowners financial incentives to adopt renewable heat technologies – including heat pumps.

In the U.K., for example, the Renewable Heat Incentive (RHI) – launched in 2014 – provides financial support over seven years for owners of renewable heating systems such as heat pumps (which tap heat from the environment). And in France, heat pumps are often eligible for an Energy Saving Certificate (CEE) from the state thanks to the heat recovery offered by these technologies.

LAUNCHING AT ISH

As the business and environmental case for propane-based heat pumps grows, so too is the number of companies offering them on the European market, which stood at around 25 in 2017. That was certainly evident at ISH.

For example, Wolf GmbH, a German manufacturer of heating and air-handling systems, launched its first R290-based heat pump at the German trade show. “First we’ll start selling it in Germany, then in other [European] markets,” said Simon Reddig, responsible for training at Wolf.

Wolf’s residential heat pump comes in two heating capacity ranges: 1.6-6.82 kW (0.5-9.4 TR) and 2.0-9.8 kW (0.6-2.8 TR). According to Wolf, the unit offers a COP of 4.65, with a maximum propane charge of 3.4 kg. As an air-to-water split system, the heater is installed inside the house and the heat pump outside.

Vaillant, another German OEM, plans to use propane as the refrigerant across its heat pump range. “We don’t want to follow an intermediate solution,” said Elmar Zippel, Vaillant’s heat pump project manager. “Our aim is to step [by step] introduce R290 in all our products.”

In 2020, the company will launch the aroTHERM plus, a monoblock air-to-water heat pump with a modulating compressor. It will be available in heating capacities of 3, 5, 7, 10 and 12 kW (0.9, 1.4, 2, 2.8 and 3.4 TR). It is designed to produce hot water at temperatures of up to 75°C (167°F), for heating residential buildings of around 200 m² (2,153 ft²).

Czech manufacturer Hotjet says using propane in its new monoblock heat pump allowed it to meet the EU’s most efficient energy label rating (A+++), under the Ecodesign Directive, which regulates product design. Energy labels help European consumers make informed choices based on the energy efficiency of a wide range of products, including air conditioners, fridges and heat pumps.

Hotjet displayed the new air-to-water heat pump at ISH, having launched it in September 2018. “This will be the future – R290,” said Tarek Abdou, the firm’s export manager. “It looks like generally the heat pump market will turn to propane.”

Sweden’s NIBE also unveiled a new propane heat pump at ISH: an air-to-water system that integrates modulating compressor technology.

INVERTER-DRIVEN

German firms Roth GmbH and Alpha Innotec (a brand of ait-deutschland GmbH) both launched new propane-based heat pumps for the residential market at ISH.

Roth was pushing the ThermoAura F air-to-water R290-based heat pump, which uses an inverter. The unit heats and cools buildings using a water tank, and can be integrated with under-floor heating.

Heat pumps fitted with inverters give consumers the option of automatically shifting heating to when it is needed most, said Karl De Keyser, sales representative for Roth Belgium.

Alpha Innotec (part of the NIBE Group) has also invested in an inverter-driven R290 heat pump system. The alira LWDV has a small closed circuit, with less than 1.2 kg of charge, but it has to be installed outside. “It is more cost-efficient [but] more expensive than a regular R290 heat pump,” said Martin Lippold, who works in distribution at Alpha Innotec. ■ AW & CM

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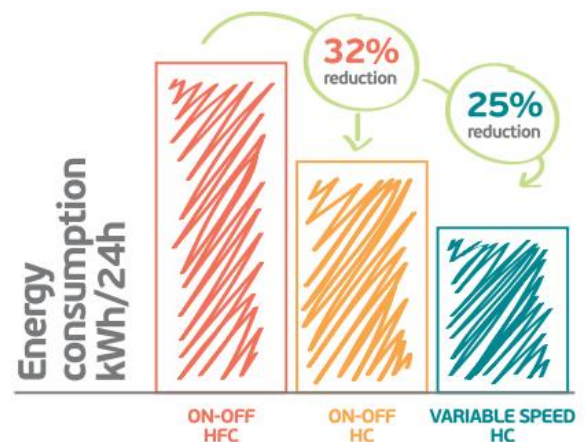
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To achieve that, the chain is developing a system that would not rely on adiabatic water usage, despite Australia's warm climate

— By Devin Yoshimoto

ALDI AUSTRALIA AIMS FOR 100 TRANSCRITICAL CO₂ STORES BY 2025

At ATMosphere Australia, held in Melbourne May 8-9, Jan Dusek, managing director for shecco Japan, posed a question to conference participants. (shecco, publisher of *Accelerate Magazine*, is the organizer of the conference.)

"How many transcritical CO₂ stores do you think we will have in Australia by 2025?" he asked. "Can we have 100?"

During his presentation, Marcus Meier, ALDI Australia's property director, replied to this inquiry.

"To Jan's question, do we achieve the 100 [transcritical CO₂] stores in 2025?

If I get that across the line," he said referring to a test ALDI is developing for its transcritical systems, "I would do 100 stores in 2025, just with ALDI."

The audience then erupted in spontaneous applause.

ALDI Australia is a division of ALDI Süd (South), based in Mülheim, Germany, which is one of the most proactive users of transcritical CO₂ refrigeration systems in the world.

ALDI Süd reported in 2018 that by the end of 2017, it had installed transcritical CO₂ systems in 1,496 stores worldwide, including 1,324 in Germany. It is installing them in all new stores in Germany.

In Australia, however, the extreme climate poses significant challenges to rolling out CO₂ transcritical systems as quickly as in Europe and North America. "Australia is quite a different beast," said Meier.

Still, Meier believes that ALDI Australia, which operates over 500 stores, could roll out 100 transcritical CO₂ stores by 2025 – under the right circumstances.

To date, the chain has installed transcritical systems at seven stores, including the first in Victoria in 2015, and one near Melbourne in 2018. It is using EptaBlue Natural CO₂ water-loop units in self-contained cases at a store in Melbourne since last year ([see story, page 64](#)).

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TEST RESULTS FOR SELF-CONTAINED CO₂ SYSTEM

In September 2018, ALDI Australia began testing the world's first EptaBlue Natural CO₂ water-loop refrigeration system, from Italian OEM Epta, at a central Melbourne supermarket. (See [*"ALDI turns to water-loop CO₂ in Melbourne," Accelerate Australia & NZ, Summer 2019.*](#))

The system is used in self-contained, plug-in cabinets, with heat withdrawn by the water loop.

After several months of operation, Marcus Meier, ALDI Australia's property director, revealed some conclusions from this test at ATMOSphere Australia 2019. The advantages of the system, Meier said, lay in three areas.

First, the CO₂ plug-in units "provided excellent case temperature control," he said.

Second, the solution makes sense for sites with engine-room space constraints — which was one of the original motivations to trial the system. "It's a good solution if you are in a mixed-use development where you don't have a plant room or you don't have a lot of space," Meier said.

In this case, the system was installed as a refurbishment in a multi-story high-rise building in Melbourne's space-constrained central business district.

Finally, the units are "ideal for sites with sensitive noise restrictions," he said.

With regard to energy efficiency, however, the units did not live up to expectations. "The energy usage," Meier said, "is definitely not what we would go forward with at this stage."

At ATMOSphere Australia, Meier provided energy-efficiency data on CO₂ transcritical systems at several stores using different configurations to boost efficiency, such as parallel compression and adiabatic cooling. He compared the energy use of those systems to that of R134a/CO₂ cascade systems running at comparable stores.

The results, he said, were a bit sobering. The transcritical CO₂ systems, on average, were only about 2% more energy efficient than the cascade systems over one year.

One of the reasons was the challenge of operating transcritical CO₂ efficiently during the summer. Though the systems were approximately 10% more efficient during winter months, they were 5% less efficient during the summer months, Meier said.

In the summer months, some of the systems use adiabatic water sprays on the condensers to help lower the gas temperature as it exits the condenser. However, this raises another concern for ALDI: Water usage is high during these months and represents a risk to the business.

ELIMINATING WATER

In order to mitigate this risk, ALDI is developing trials for a transcritical system that would eliminate the need for water sprays/adiabatics. Though still in the early stages, Meier said that the initial goals for the revised system include maintaining operational stability during summer months; completely eliminating water usage; and reducing operational costs. He did not disclose technical details about the system.

Meier was confident that if ALDI achieves these goals, it could roll out transcritical CO₂ Australia-wide. "This, I believe, is where our future lies," he said.

While it remains to be seen what results will be delivered by the trials, there is no doubt that ALDI Australia remains committed to natural refrigerants. "Here in Australia, we intend to innovate in the natural refrigerant space," said Meier. ■ DY



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CO₂ Heat Pumps Catching On in Australia

Rising gas costs are driving hotels and wineries to re-evaluate their space heating and hot water systems, opening up opportunities for natural refrigerant air-to-water heat pumps

— By Devin Yoshimoto



“Saving 75% on energy costs, along with the elimination of the need for LP gas, is, as they say, a 'no-brainer,'”

— Terry Plaisted,
Automatic Heating Global

At ARBS 2018, Australia's most important HVAC&R and building services exhibition, CO₂ heat pumps were all the rage.

Suppliers like Mayekawa, Mitsubishi Heavy Industries Air-Conditioners Australia, and Automatic Heating Global all had CO₂ heat pumps on display — and all remarked that interest in the technology was increasing from businesses looking to move away from gas-fired boiler systems. (The situation is similar in the U.S.; see *"NatRef Heat Pumps: A Key Piece in a Decarbonized Future," Accelerate America*, April-May 2019.)

One year and several installations later, suppliers have gained confidence that the technology has real commercial potential in a number of different sectors and applications.

Two case studies — at a winery and a small hotel — presented during the ATMOSphere Australia 2019 conference in May helped paint a picture of the businesses and applications where CO₂ air-to-water heat pumps have the most potential in the Australian market.

Free space heating and hot water

Halfway between Sydney and Brisbane is a city named Armidale, New South Wales.

Here temperatures often drop below -5°C (23°F) on winter nights due to the city's high elevation (1,110 m/3,641 ft) above sea level.

So for hotel owners in the area, a frequent question is, "Are the rooms heated?" In the FAQ section on City Centre Motor Inn's website, the answer is an emphatic "Absolutely!"

"We know how to keep the rooms warm," the website states.

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Not only does City Centre Motor Inn — a small family owned motel catering to tourists — know how to do this, but it has done so in a carbon-neutral way through the use of solar energy and CO₂ heat pumps.

In February, the hotel installed 30 kW of solar PV panels on the roof and connected it to a single Q-ton CO₂ air-to-water heat pump supplied by Mitsubishi Heavy Industries Air Conditioners Australia (MHIAA).

At the ATMOsphere Australia 2019 conference, Trent Miller MHIAA's Air-to-Water Manager, illustrated how the configuration has resulted in essentially free hot water and space heating for the hotel.

The Q-ton, he explained, runs for about two hours per day, generating 2,000 l (528 gal) of hot water storage, about 1,000 l (264 gal) more than necessary; the excess serves as thermal storage.

"So essentially now, whenever the PV is running, the Q-ton comes on first, then all the air conditioning comes on," said Miller. "Basically they've got no power bills." The payback period on the cost of the installation for the end user, he added, is about two-to-three years.

With solar PV technology continuing to rapidly develop, Miller sees hot-water heating headed in this direction — where all that is needed is a highly efficient piece of equipment running purely off solar energy. In fact, Miller said, "one of the people that resells our [Q-ton CO₂ heat pumps] used to be the largest commercial retailer of thermal solar systems."

The application has significant potential, Miller said, when scaled up to facilities such as large hotels and residential complexes. "There's big movement towards this within the industry now."

Winery saves 75% on energy costs

In January 2019, the Brown Brothers Milawa Winery — an Australian family-owned business located in central Victoria — decided to install a CO₂ heat pump to supply hot water for rinsing its wine filtration systems.

Originally, Brown Brothers used a liquid petroleum (LP) gas hot water boiler system, which cost \$13 per 1,000 l (264 gal) of hot water, said Terry Plaisted, national sales manager for Automatic Heating Global, a Melbourne-based hot-water heating solutions provider that supplied the CO₂ heat pump to the winery.



“Basically they've got no power bills.”

— Trent Miller,
Mitsubishi Heavy Industries Air
Conditioners Australia

With LP gas boilers known to run at low efficiencies compared to heat pumps, Automatic Heating Global showed the winery that it would cut its energy costs to \$2.70 per 1,000 l of hot water using a CO₂ air-to-water heat pump with a coefficient of performance (COP) of 3.6.

"Saving 75% on energy costs, along with the elimination of the need for LP gas, is, as they say, a 'no-brainer,'" said Plaisted.

The CO₂ heat pump at the winery is manufactured by Japanese OEM Nihon Itomic Co., Ltd., and sold and installed in Australia by Automatic Heating Global, which unveiled the system in Australia at the ARBS exhibition in May 2018.

According to Plaisted, interest in CO₂ heat pumps is not slowing down. The company is continuing to pursue opportunities in the winery sector, as well as in food processing and in residential and commercial hot-water heating applications.

In August 2018, the company installed a CO₂ hot-water heat pump at a residential apartment building in Melbourne's central business district. ■ DY



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SAVING ENERGY WHILE SWIMMING

Aquatics centers can cut their energy costs by replacing disparate heating and cooling systems with a water-to-water heat pump using a natural refrigerant

— By Andrew Williams & Devin Yoshimoto

Electricity prices across much of Australia's main grid hit record highs in the first quarter of 2019, according to data from AEMO, the Australian Energy Market Operator.

For local councils across Australia, which own energy-guzzling leisure and aquatics centers, this poses a problem. One solution may be an integrated energy system such as a water-to-water heat pump, which can dramatically reduce energy consumption.

"Water-to-water heat pumps are an almost perfect solution for aquatics centers," said Derek Harbison, a renewable energy consultant at SmartConsult, at ATMosphere Australia 2019, which took place on May 8-9 in Melbourne, Australia. (The conference was organized by shecco, publisher of *Accelerate Magazine*.)

Harbison illustrated how these systems can significantly reduce energy use in aquatics centers during the conference's policy and energy panel.

Water-to-water heat pumps often boast a coefficient of performance (COP) of up to 6.0, he said. Simultaneously adding the system's cooling capacity adds another 5.0 for a total COP of up to 11. In addition, using natural refrigerants — CO₂ or ammonia — in these systems contributes to superior energy efficiency performance compared to synthetic refrigerant-based counterparts, as well as providing low GWPs that protect against future regulations. Mayekawa is an example of a company that makes water-to-water CO₂ heat pumps.

Integrated energy systems that combine all the energy-consuming and energy-producing equipment into one package "fit very nicely into low-emissions regimes," Harbison said.

Yet despite the heat pumps' efficiency and environmental benefits, "it's very difficult to convince councils to use them, because they are expensive," Harbison said.

He has visited and evaluated aquatic centers in local councils throughout Australia over the past few years, making the case for the technology. He acknowledged that no installations have been completed yet.

One aquatics center used to account for 60% of a local council's entire costs. "So when you sit in the room with these people, it's a serious conversation — because people's jobs are at stake," he said.

Residents also take the facilities seriously. "People love their aquatic centers," said Harbison. "They pay their rates, and they're heavily subsidized by taxes." This means that if visitors think the water or air is too hot or too cold, they are likely to complain. "Councils are under a lot of pressure to get this right."



“As we move towards a renewable energy-supplied grid, we need to rethink our approach to high energy use in buildings.”

— Derek Harbison, SmartConsult



INTEGRATED HEATING AND COOLING

Illustrating the complex heating and cooling needs required, Harbison cited one facility where the pool water needs to be heated to 30°C (86°F), the pool air to 31°C (87.8°F), and the shower water to 55°C (131°F).

Meanwhile, there is also a significant demand for cooling – in the gym, cafeteria and office areas. The dry exercise areas need to be cooled to 19°C (66.2°F) and the office areas to 23°C (77.3°F). In the summer, cooling is also needed to maintain the pool air at 31°C (87.8°F).

“You also need to remove chlorinated air that is constantly evaporating off the surface of the pool, and eject all that heat from the building,” Harbison said. “This makes aquatic centers really hard to design,” he added.

It is here where a water-to-water heat pump would be an ideal solution, he said. The heat pump would have the ability to produce warm water at 40°C (104°F), hot water at 80°C (176°F), and cold water at 9°C (48.2°F). The hot and cold water would be circulated around the building via closed water loops.

Heat pumps help customers to avoid what Scantec Managing Director Stefan Jensen calls “the unitary equipment disease,” whereby customers buy different pieces of equipment to serve different functions, such as air conditioning or heating hot water.

For example, one facility Harbison visited had different “bits and pieces of unitary equipment producing both hot and cold,” and whose efficiency performance varied considerably: gas boilers (0.85 COP), air-to-water heat pumps (3.8 COP), and a pool air-exchange unit (3.8 COP). “Sometimes they are all in the same room and you scratch your head thinking, ‘who designed this?’” he said.

By choosing a natural refrigerant-based water-to-water heat pump, he said, aquatic centers have the potential to save significant amounts of energy by using future-proof, integrated systems. “As we move towards a renewable energy-supplied grid, we need to rethink our approach to high energy use in buildings,” said Harbison. ■ AW & DY

“Water-to-water heat pumps are an almost perfect solution for aquatic centers.”

— Derek Harbison,
SmartConsult

CAN VIRTUAL REALITY SOLVE THE TRAINING CHALLENGE?

One of the perennial challenges facing the HVAC&R industry is training and recruiting new technicians to replace aging employees as systems grow increasingly complex.

But a younger generation enamored of digital technology may find learning via virtual reality (VR) – an experience taking place within a simulated and immersive environment, typically facilitated by a headset – just the ticket.

TAFE (Technical and Further Education) South Australia, an Adelaide-based vocational school, launched its virtual reality pilot program on natural refrigerant safety training last year. The program has proved to be very successful in engaging students and improving learning outcomes.

"We get retention rates between 60% and 70% of the information given," said Shannon Baldock, TAFE SA's air conditioning and refrigeration lecturer, at the ATMOSphere Australia 2019 conference, held in Melbourne May 8-9.

TAFE SA is now reaching out to the natural refrigerant community to collaborate and contribute to the program, which the school believes has significant potential to help solve the training gap the industry is facing.

"[VR technology] has moved on from 'look we've got some shiny new hardware,'" said Baldock. "We've made it practical. What we need now is the content to give to our students."

Content, he said could come from "engineers that built the system," end users who want to "show us how they are being energy efficient," or contractors who want to "share what they are doing."

The TAFE South Australia vocational school has been using virtual reality for instruction on natural refrigerants – and is seeking industry input to improve the program

— By Devin Yoshimoto



“Immersive video for training is really, really powerful.”

— Shannon Baldock,
TAFE South Australia

Following his ATMOsphere Australia presentation, Baldock said he has received a significant amount of interest in contributing to the initiative from the natural refrigerant community. “Several people were very keen to open up their doors, collaborate, and share their content with us,” he said.

Discussions are already underway for major natural refrigerant end users, contractors and system manufacturers to begin delivering immersive video content to TAFE SA's virtual reality program.

A NATURAL FIT

Students in TAFE SA's Certificate III Air-Conditioning and Refrigeration program are using Lenovo Mirage Solo virtual reality headsets in elective classes teaching the safe use of CO₂, ammonia and hydrocarbons in refrigeration. An Adelaide-based startup, Lateral Vision, delivers immersive-video walk-through tours of natural refrigerant system plant rooms by TAFE SA lecturers.

Baldock attributes the improved retention rates partly to the use of immersive video. “Immersive video for training is really, really powerful,” he said.

He also credits VR technology's inherent advantage in being able to provide each student with a “one-on-one” training experience. “The delivery that the lecturer gives in the immersive video is not to a group of 16 students – it's to one bloke, the person in the headset,” he said. “That's a totally different interaction.” This can be particularly effective if the instructor “knows and is passionate about what they are talking about.”

The advanced nature of VR, Baldock added, makes it a “natural fit” with the natural refrigerant sector's innovation, leadership and excitement about the future. Moreover, industry stakeholders can do the instructing via VR.

Rather than speaking about what is happening in the natural refrigerant sector in front of a classroom, Baldock said, “wouldn't it be better if that was on site with a camera talking about your own plant?”

VR offers the opportunity to “infect people with your enthusiasm about it,” he said. “You want to be standing in front of your plant going, ‘How fantastic is this stuff!’”

Baldock reminded the audience at ATMOsphere Australia that VR is no longer a fad and will have a huge impact on training and the industry. “It is projected that by 2022 [VR] will be a 200 billion dollar industry,” Baldock said.

“We can start thinking now about what we are going to do for training,” he added. “How can we use this in the industry?”

“This is something we are looking to collaborate with the industry on,” he continued. “I'd like to see involvement from as many of you as we can in our project.” ■ DY



Shigekatsu Koganemaru, Yoshio Ice Manufacturing & Refrigeration

Yoshio Ice Goes With Transcritical CO₂ in Warm Climate

The cold storage operator's three CO₂ systems at a cold storage facility exceed energy expectations in one of Japan's hottest regions

— By Devin Yoshimoto, Rena Okabe, Tomoro Sato, Angie Tao



Inside Yoshio Ice's Fukuoka cold storage facility, where CO₂ transcritical systems were installed

Continuing the growth of CO₂ transcritical systems in Japan's cold storage industry, Fukuoka-based Yoshio Ice Manufacturing & Refrigeration (Yoshio Ice) installed three Japanese-manufactured CO₂ transcritical systems at one of its cold storage facilities in April 2018.

The plant's location: Fukuoka, Japan, on Kyushu island, which is the southernmost of Japan's main islands. The region experiences some of Japan's hottest and most humid climates with temperatures sometimes reaching 35°C (95°F) during the summer months.

But energy performance and reliability of transcritical CO₂ systems in hot climates have been less and less of a concern with end users around the world as CO₂ technology like ejectors, parallel compressors and adiabatic condensers has rapidly advanced in recent years.

Energy performance data at the Yoshio Ice facility has helped bolster this confidence – a point made at the ATMOsphere Japan 2019 conference held in Tokyo in February.

The three CO₂ Booster Super Green systems installed at the Fukuoka cold storage facility were provided by Tokyo-based manufacturer Nihon Netsugen Systems (NNS), which unveiled the system last year at the FOOMA Japan exhibition. The systems use a water-spraying system with the gas cooler to maintain efficiency in high ambient temperatures.

During the ATMOsphere Japan 2019 conference, Nihon Netsugen Systems' president, Katsuhiko Harada, presented energy performance metrics for the facility from April through December 2018. The power consumption for the period was 27 kWh/m³ – less than what was predicted (around 35 kWh/m³), and far less than Japan's industry annual average of around 61 kWh/m³.

Choosing CO₂ for safety

Touring the facility in June of 2018, *Accelerate Japan* (a Japanese-language sister publication to *Accelerate Magazine*) learned more about how the project originated.

The three CO₂ transcritical systems service one 4,700-m³ frozen storage room (at -25°C/-13°F), as well as a 3,700-m³ cold room (at 5°C/41°F) and a 4,700-m³ loading area (at 5°C).

Shigekatsu Koganemaru, Yoshio Ice's president, first heard about NNS's CO₂ transcritical system at a general meeting of the Japan Association of Refrigerated Warehouses (JARW) in 2016.

“Subsidies that bear the burden of half of the installation costs are very much appreciated.”

– Shigekatsu Koganemaru, Yoshio Ice

"After speaking with NNS and learning about the system's technical specifications in detail, I determined that the system had reached a sufficiently usable level," said Koganemaru. "We then decided to install it at our new warehouse which was being planned at the time."

Koganemaru, who also spoke at the ATMOsphere Japan 2018 event, explained that as a board member of JARW and vice-chairman of the association's Environment and Safety Committee, he understands the important role to be played by natural refrigerants in this sector, both now and in the future.

According to 2016 JARW data, 14% of Japan's cold storage facilities use NH₃/CO₂ cascade systems and 11.3% employ NH₃ systems, while 68% still utilize R22. But Koganemaru preferred to use a CO₂ transcritical system over an NH₃/CO₂ cascade or traditional NH₃ system out of concern for his employees' safety.

Koganemaru, who has previously worked in factories where ammonia was considered dangerous to handle, acknowledged that safety standards used to be more ambiguous than they are now. He said it was once normal to be exposed to intense odors when liquid ammonia leaked from valves, sometimes leading to burns or other minor injuries.

Helped by subsidies

The installation of the CO₂ transcritical systems at Yoshio Ice were supported by subsidies provided by the Japanese government in fiscal year 2017 (which ends March 31, 2018).

The majority of the refrigerated warehouse industry consists of small companies that benefit from subsidies, said Koganemaru. "For these companies, the replacement of factory equipment and machinery is a very big investment. That is why subsidies that bear the burden of half of the installation costs are very much appreciated."

These subsidies are expected to continue into this year with the Japanese Ministry of the Environment already having confirmed that it has set the budget for fiscal year 2019 at ¥7.4 billion (\$65 million). ■ DY & RO & TS & AT



Manabu Onishi, Panasonic Appliances Company, speaking at ATMOsphere Japan 2019

PANASONIC TARGETS INDUSTRIAL SECTOR WITH TRANSCRITICAL CO₂

The Japanese CO₂ leader is testing an 80-HP rack, moving beyond its stronghold in food retail

— By Devin Yoshimoto

“We want to make a CO₂ family,” said Shigeru Dohno, Panasonic’s then-managing director of the company’s food retail equipment business division, during the ATMOsphere Japan 2018 conference.

Dohno’s statement reflected the company’s intentions to grow its CO₂ product portfolio to include larger capacities for the industrial refrigeration market.

“At the moment, our natural refrigerant products are supplied to supermarkets and convenience stores,” he noted. “We want to expand our portfolio to include large-scale systems for logistics companies and warehouse companies.”

Panasonic is already a world leader in CO₂ installations, with 10,260 condensing units deployed at 3,700 stores in Japan as of December 2018.

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In April 2019 the company followed through on its expansion plans by debuting an 80-HP transcritical CO₂ rack at the China Refrigeration 2019 trade show in Shanghai.

The system is manufactured in Dalian, China, but will be used in the Japanese market, explained Manabu Onishi, general manager, cold chain business division, Panasonic Appliances Company. Field tests will begin in Japan this year.

Onishi said that Panasonic identified a need for CO₂ systems in the Japanese industrial refrigeration market. "In Japan's cold-storage sector, there are still many R22 refrigeration systems," he said. "Due to global regulations, these systems must be replaced with systems that use new alternative refrigerants."

For the industrial sector, Panasonic decided that rack-type systems would be easier to use than outdoor condensing units. "So for these customers, we thought to first offer an 80-HP low temperature-only system," Onishi added.

In China, the system is manufactured by Panasonic Appliances Refrigeration System (Dalian) Co., Ltd. (PAPRSDL), with compressors supplied by Bitzer and controls supplied by Eliwell (part of the Schneider Electric Group).

PAPRSDL is a joint venture between Japan's Panasonic Corporation and China's Bingshan Group.

80-HP TRANSCRITICAL CO₂ RACK SPECIFICATIONS:

Evaporating temperature range:
-45°C to -20°C (-49°F to -4°F)

Ambient temperature range:
-15°C to 43°C (5°F to 109°F)

Compressor quantity (MT/LT): 4 (2/2)

Cooling capacity (at an evap. temp. of -32°C/-26°F): 63 kW (17.9 TR)

Cooling capacity (at an evap. temp. of -40°C/-40°F): 43.2 kW (12.3 TR)



Panasonic's 80 HP transcritical CO₂ rack on display at China Refrigeration 2019

MOVES IN KOREA AND CHINA

While Panasonic begins testing its CO₂ rack in Japan, several other announcements made in recent months show that it could also be preparing for more CO₂ adoption in China and Korea.

For example, on April 1, the company announced that Tetsuro Homma, its senior managing executive officer, would become the CEO of the company's newly established China and Northeast Asia business division. Homma previously served as president of Panasonic Appliances Company, where he oversaw much of the uptake of Panasonic's CO₂ condensing units in Japan over the past decade.

"The last three or four years for us have been an experimental stage to prove that CO₂ should be a mainstream, next-generation refrigerant technology," Homma said. "And now we have confidence that CO₂ has the potential to be the most popular technology in

this industry. So, we'll start to market not only in Japan and other Asian countries, but also Europe and the United States."

In addition, the company will be installing some of its first CO₂ outdoor condensing units in Korea. Hytron Airtech, Panasonic's Korea-based distribution partner, said at the HARFKO 2019 exhibition, held in Korea in March, that it is scheduled to install CO₂ condensing units at a cold storage facility in Korea's agricultural sector this year.

"I've been interested in CO₂ since last year," said Kwang Sun Cho, president of Hytron Airtech "R22 is old and not eco-friendly. I think CO₂ has more of a future."

With CO₂ adoption continuing to be seen not only in Japan but also in China and Korea, the company's strategy for growing its "CO₂ family" throughout Asia appears to be progressing. ■ DY



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Greening China's High-Speed Railway with CO₂

The country's high-speed rail network, the largest in the world, is set to implement a CO₂-based air-conditioning system

— By Devin Yoshimoto and Angie Tao

With China already established as a global leader in high-speed railway transport, the country is now turning its attention towards making its railways more eco-friendly.

China-based engineering firm CRRC Dalian Locomotive Research Institute (CRRC Dalian Institute) is playing a key role in this effort, having recently developed one of the world's first CO₂ (R744)-based air-conditioning systems for railway transport. The system will be used by CRRC Changchun Railway Vehicles Co.

The following is an interview with Bai Gang, technology research director for CRRC Dalian Institute.

//Accelerate Magazine: How did the CO₂ air-conditioning project come about?

Bai Gang: At present, most of the air-conditioning refrigerants for rail vehicles (in China and outside of China) have a high global warming potential (GWP) value. To address this problem, we began our research of the corresponding global policy regulations (such as the Kigali Amendment to the Montreal Protocol, European F-Gas regulations, etc.) and also analyzed the refrigerant replacement process in academia and industry.

Through our research, we found that CO₂ is the world's first choice for the next generation of natural refrigerant-based green air-conditioning technology. It has an ozone depletion potential (ODP) value of zero, a global warming potential (GWP) value of one, is nonflammable, non-explosive, easy to obtain and

cheap. R744 is safe, reliable and has good thermodynamic characteristics.

In the field of railway transportation, R744 refrigerant can be used as a new alternative refrigerant. The development of R744-based air-conditioning systems in the field of railway transportation is still new, so there are good market opportunities.

The project itself started in January 2016.

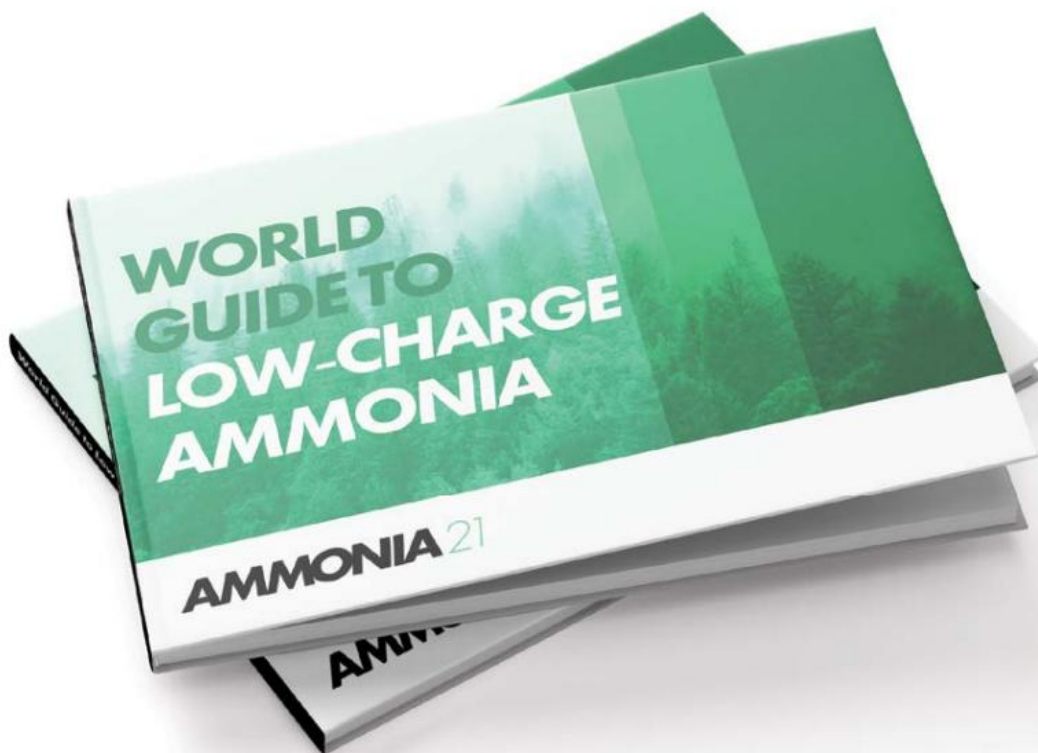
//Accelerate Magazine: What was the goal of the project?

Bai Gang: The project was aimed at designing an R744-based air-conditioning system for the fastest class (G-series) of railway transport vehicles in China. The railway transport vehicle air-conditioning system had to have a compact structure to fit in tight spaces. The system also had high reliability requirements, which brought us great system design challenges.



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Bai Gang, CRRC Dalian Institute

“In the field of railway transportation, R744 refrigerant can be used as a new alternative refrigerant.”

— CRRC Dalian Institute

//Accelerate Magazine: Can you provide some basic technical details of the system?

Bai Gang: The system has a 45 kW [12.8TR] cooling capacity and an energy efficiency ratio of 2.3. This is also the world's first high-speed electrical multiple unit (EMU) CO₂ air-conditioning system, which reaches a world-class level.

At the same time, the design of the heat exchanger in the system is also very different from traditional refrigerant-based systems. Finally, we installed safety valves to protect the safety of personnel under extreme conditions.

//Accelerate Magazine: When did CRRC Changchun Railway Vehicles Co., Ltd. agree to use the system?

Bai Gang: They agreed to use the system in December 2016.

//Accelerate Magazine: What was the main driver of interest in the system?

Bai Gang: In our communication with CRRC Changchun Railway Vehicles Co. — the largest manufacturer of high-speed EMUs [electric multiple units] in China — we found that they have a forward-looking vision.

They fully recognized the technologically advanced nature of our products, so they became really important people in our project. The success of the project is thanks to them and their great effort.

At the same time, the project is in line with the Chinese government's desire to push for more green technology development. The characteristics of this new environmentally friendly refrigerant has aroused their interest. Our project can completely meet the world's most demanding environmental requirements.

//Accelerate Magazine: What is the status of the project now?

Bai Gang: At present, the project has completed product assembly and ground-test verification and is ready for loading.

//Accelerate Magazine: What are your goals now?

Bai Gang: We are working on a CO₂ solution for vehicles [in Europe], including Germany and Portugal. We also want to provide more efficient and environmentally friendly air-conditioning systems for more customers. ■ DY & AT

ANOTHER PLAYER

In addition to CRRC Dalian Institute's research and development efforts, China-based Guangzhou Dinghan Railway Transportation Equipment Co. (Guangzhou Dinghan) has introduced a CO₂ air-conditioning system for high-speed rail.

In December 2018, senior executives from Guangzhou Dinghan and its subsidiaries, along with several industry experts, attended an event introducing the CO₂ AC system at the company's factory in Guangzhou.

The company's chief engineers presented technical details on the CO₂ air-conditioning system as well as its potential in the market and competitive advantages.

"The volumetric flow rate of the CO₂ refrigerant is small," the company stated on its website. In addition, "the performance of CO₂ refrigerant in low-temperature environments is excellent."

Guangzhou Dinghan worked closely with Shanghai Jiaotong University to develop the system. Professor Chen Jiangping from the university, together with his team, attended the Guangzhou Dinghan event and gave a presentation on the "Research Progress of CO₂ Vehicle Air Conditioning Systems."

Speaking at the recent ATMOSphere China 2019 conference, held in April in Beijing, Chen provided more details about the system. The cooling capacity, he said, is about 44 kW (12.5 TR) at 35°C/29°C (95°F/84°F) with a coefficient of performance (COP) of about 2.4.

Professor Chen said that the system will be installed on a train for testing sometime this year, with further investigation into heat pump and ejector-cycle systems also being conducted.



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A RETURN TO AMMONIA IN CHINA

The country is revising safety standards, focusing on training and considering new technology to overcome concerns stemming from major accidents

— By Devin Yoshimoto

It is safe to say that safety is the number one issue that comes up in regard to the future use of ammonia in industrial refrigeration in China.

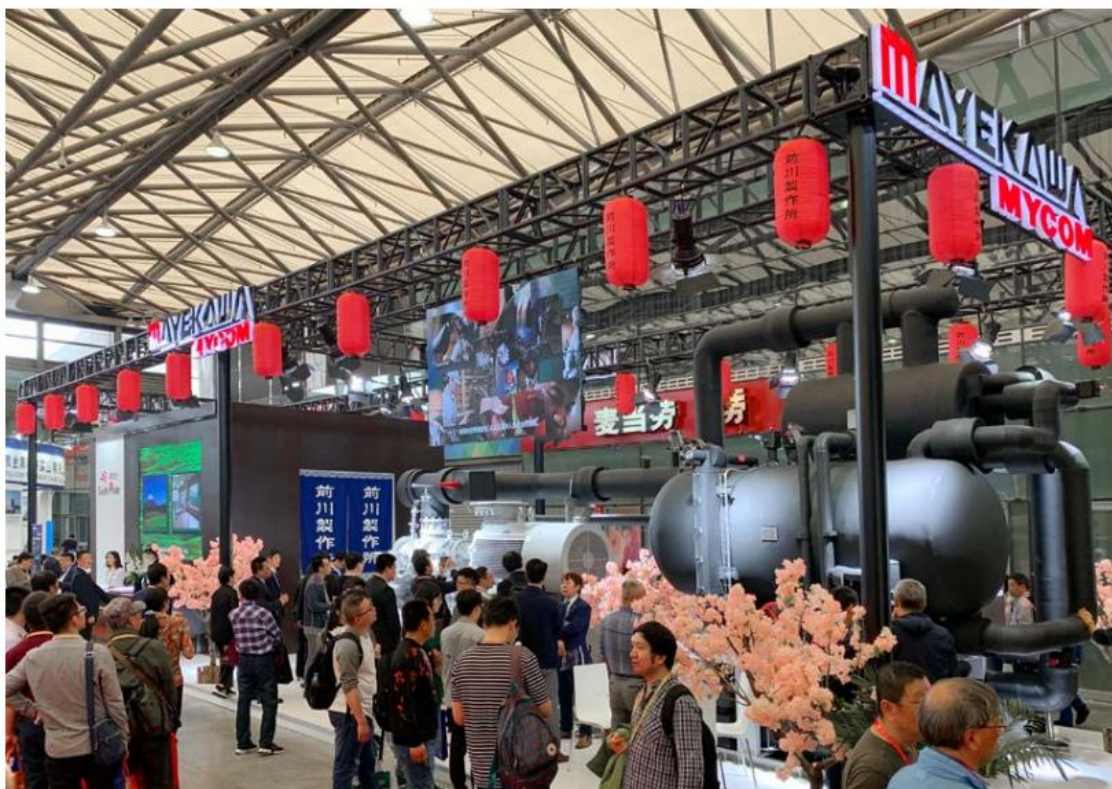
But it's an issue that the country, under increasing pressure to phase out synthetic refrigerants, needs to address.

The situation is not being helped by local governments, which have unilaterally blacklisted ammonia following major accidents involving the gas in recent years.

This, however, has only increased the determination of those who intend to lead China back towards a path where ammonia is used safely in industrial refrigeration.

This determination was articulated at the ATMOSphere China 2019 conference, held in Shanghai in April. (The conference was organized by shecco, publisher of *Accelerate Magazine*.)

Leading associations and technology suppliers discussed updating and revising ammonia standards along with adopting cutting-edge low-charge ammonia and CO₂ technologies.



Mayekawa South Polar NH₃/CO₂ system on display at China Refrigeration 2019

UPDATING SAFETY STANDARDS

During the ATMOsphere China's "Safe Use of NH₃ in China's Cold Chain" session, Jin Ma, from the Chinese Association of Refrigeration (CAR), acknowledged two "huge accidents" in 2013 involving ammonia-based refrigeration systems in China.

Ma serves as deputy director of the Cold Storage and Cold Processing Committee at CAR, the leading industrial refrigeration association in the country, which is responsible for the creation of safety standards and design codes.

The accidents, he said, were not related to the system itself. "Rather, the main problem [lay] in compliance to safety and design standards by employees."

In any event, Ma said, the result was "a huge blow to the ammonia refrigeration industry in the country."

In response, stakeholders at the conference agreed that an increased focus on safety standards and practices combined with more training of technicians, would be key to the return of ammonia use in the country.

Yifan Yang, deputy secretary general for CAR, noted that a number of the group's industry safety standards and design codes have been or are being updated.

For example, professional standard AQ 7015-2018, which has been in force since December 2018, includes several safety standards and specifications for ammonia refrigeration technology. Nine-year-old Chinese National Standard GB 50072-2010, described as a "code for the design of cold storage facilities," has recently been under revision.

Revisions include having more content on CO₂ refrigeration systems and greater safety requirements for ammonia refrigeration systems.

According to CAR, GB 50072-2010 is now in the final approval process, which is expected to be completed this year.

Finally, CAR has published a new group standard titled "Safety assessment methods for ammonia refrigerating systems" (CAR2018-01), which will go into effect in June 2019.

THE NEXT GENERATION

With China's leading industry association preparing and revising safety standards, it is clear that the Chinese market is now ready to adopt the next generation of ammonia and CO₂-based solutions for the industrial refrigeration market.

Several of the world's leading suppliers of cutting-edge industrial refrigeration technology were present at the ATMOsphere China 2019 conference.

They described the solutions they are currently offering to the market as well as activities supporting education and training in the industry.

Japanese technology supplier Mayekawa announced the development of a new NH₃/CO₂ refrigeration system dubbed "South Polar," which is designed for quick-freezing applications in China's industrial food processing sector.

Mayekawa, which is the manufacturer of the NewTon NH₃/CO₂ cascade packaged refrigeration system, worked with a local Chinese manufacturer, Square Technology Group, to develop the new system. The system debuted at the China Refrigeration 2019 exhibition, also held in Shanghai in April.

In addition, refrigeration and chiller OEM Johnson Controls discussed its "ammonia safety roadshow," which it conducted last year.

"We made six different stops in China where we promoted ammonia safety and how it can be continued to be used in a sustainable and energy efficient way," said Cicci Xi, Johnson Controls' Asia director of product technology for Global Industrial Refrigeration.

Danfoss also recently held several events where it tried to convince stakeholders of the benefits of using ammonia rather than R22. And Hansen Technologies Corp. is also supporting ammonia use in China.

"From our standpoint, ammonia has a lot of potential in China," said Marvin Moreno, international sales director for U.S.-based Hansen Technologies Corp. "The foundation for that potential really has to be safety, awareness and education."

"From our standpoint, ammonia has a lot of potential in China."

— Marvin Moreno,
Hansen Technologies Corp

U.N. TECHNOLOGY TRANSFER

While overseas suppliers are helping bring know-how and technology to China, the United Nations Development Programme (UNDP) has been focused on supporting technology transfer and capability at the local level.

UNDP does this mainly by funding the local development of new technology and converting domestic production and manufacturing lines.

Yun Hong, representing China's UNDP office, informed ATMOsphere China participants that, as of March 2019, they have converted a total of 33 production lines, with 20 of them now using natural refrigerants.

In addition, Hong said that Chinese manufacturer Moon-Tech, with the UNDP, recently developed its new "GEPT-R290/CO₂" system aimed at "chemical process cooling" applications where traditional water chilling units are used. R290 is the primary refrigerant and CO₂ is the secondary refrigerant. The system was exhibited at the China Refrigeration 2019 exhibition.

Though China has seen a big shift towards synthetic refrigerant use in industrial refrigeration in recent years, it seems this change is only temporary, with a return to ammonia on the horizon.

■ DY

ROYAL DUTY FREE IS FIRST IN THE PHILIPPINES WITH ALL-R290 STORE

Growing interest in propane water-loop systems is driven by 25%-30% energy savings

— By Devin Yoshimoto

In August, Royal Duty Free — a Philippines-based chain of duty-free supermarkets — will retrofit one of its stores to use only R290 plug-in units combined with a water-loop system, according to a local refrigeration contractor, Cold Front Technologies Asia, Inc.

The store is located in Subic Bay — a special economic zone a few hours' drive northwest of the Philippines' capital city of Manila.

It will be "the first store in the country to use 100% R290-based refrigeration," according to Emilio Gonzalez La'O, Cold Front's president.

Royal Duty Free requested zero store downtime during installation — "which will be a challenge," said Gonzalez La'O — but is possible due to the ability of R290 water-loop systems to be installed quickly compared to centralized remote refrigeration systems.

Cold Front has experience installing water-loop systems in the country, having installed the first one (not for all cases) in the Philippines at a Citimart supermarket located in the province of Batangas in November 2016.

"[Many stores] want something different, but are not interested in remote systems due to the difficulties with maintenance and other issues."

— Emilio Gonzalez La'O, Cold Front Technologies Asia

"Part of why we are seeing a lot more interest, and why we are pushing for R290 and water-loop systems together, is the feedback we are receiving on energy savings," said Jennifer V. Gonzalez La'O, Cold Front's vice president of finance & administration. "The testimony, at least from engineering and based on our own numbers, is that the combination of the water loop with R290 was resulting in anywhere from 25%-30% energy savings."

Another reason for interest in R290 water-loop systems, noted Emilio Gonzalez La'O, is that many stores using traditional plug-in units that emit a lot of heat inside the store "want something different, but are not interested in remote systems due to the difficulties with maintenance and other issues that they see with these systems."

TARGETING ASIA

Meanwhile, Freor, a major Lithuanian provider of R290 water-loop systems, has been promoting the technology in the Asian market.

Freor recently exhibited its R290 water-loop system for the first time in Japan, where it generated significant buzz at the Supermarket Tradeshow 2019 exhibition, held at in Tokyo in February.

Cold Front, an exclusive distributor of Freor's products in the Philippines, has since installed Freor's water-loop systems at three Rustan's supermarkets in Manila.

CONSIDERABLE ENERGY SAVINGS

One of the factors driving interest in R290 systems for new and remodeled stores over the past few years is the very high cost of electricity in the Philippines coupled with the energy-saving capability of R290.

The company, which supplies supermarket chains throughout Western Europe and the Nordic regions, has seen strong sales growth for its R290 systems and believes there is big potential for them to thrive in the Japanese market.

"Freor's sales of propane-based equipment almost doubled in 2018 compared to 2016," said Jūratė Mizarė, Freor's marketing manager, during the exhibition.

Although CO₂ is the dominant green commercial refrigeration technology in Japan, Freor is aiming to introduce hydrocarbon water-loop systems as an important alternative green technology, especially for smaller format stores, Mizarė said,

"We believe propane-based water-loop technology is the best commercial refrigeration choice for convenience stores, discounters and smaller supermarkets," said Mizarė.

At the Supermarket Tradeshow, Freor jointly exhibited with Japanese OEM Nihon Netsugen Systems (NNS) in introducing this technology to Japan.

The reaction from Japanese customers at the show was positive, said NNS CEO Katsuhiko Harada.

"At first, people say that the design is so different and they don't understand the difference in function," said Harada. "But once we explain the functionality for the water-loop system or the built-in R290 compressor showcases, people are really surprised and think that it is a kind of revolutionary application."

Though Harada sees that customers in Japan are still a bit skeptical, he believes that, through more education and awareness building, adoption of the technology can slowly begin as soon as this year.

"This year we want to establish one to three stores in Japan with this R290 and water-loop system," said Harada. ■ DY

"Part of why we are seeing a lot more interest, and why we are pushing for R290 and water-loop systems together, is the feedback we are receiving on energy savings."

— Jennifer V. Gonzalez La'O, Cold Front Technologies Asia



Phononic Aims to Disrupt Cooling World with Solid-State System

Its compressor-free thermoelectric cooler, which employs CO₂ and water, is being used by a range of end users, including Unilever, Pepsi Bottling and ThermoFisher Scientific

— By Devin Yoshimoto and Michael Garry



Phononic ice cream freezer at checkout.
(Photo courtesy of Phononic)

“As Phononic enters its next stage of growth, it is focused on shifting from a creator to an enabler.”

— Nicole Scott, Phononic

During a televised interview on CNBC's "Power Lunch" show on May 15 (<https://cnb.cx/2EeKFGG>) Tony Atti, CEO and co-founder of Durham, N.C., Phononic, discussed how the company's solid-state thermoelectric cooling technology can be used on a drone that is transporting a small payload like a human organ for an emergency transplant. The PrecisionHawk drone sat on a table nearby.

"The weak link in cold-chain logistics is how to deliver any perishable good at the appropriate temperature," he said. "With PrecisionHawk, we have been able to showcase a compact solution that runs off battery power with the drone itself for cold-chain transport."

Drone transportation is one of several potential applications that the Phononic system can serve, in addition to current applications ranging from food retail to healthcare to optoelectronics.

As it enters a variety of sectors and partners with companies like Unilever, Pepsi Bottling Ventures and ThermoFisher Scientific, the decade-old company has been growing and gaining greater recognition for its compressor-free alternative to vapor-compression cooling systems. Phononic has 140 employees and has raised nearly \$160 million in investment at a valuation of \$284 million, said CNBC.

In May, Phononic was selected 17th on CNBC's "Disruptor 50" list of cutting edge start-ups, marking the third time the company has been named to the

list. Additionally, in 2017 the company received the Emerging Technology Award from the U.S. Environmental Protection Agency's ENERGY STAR program for its Evolve 5.5 ft3 Protect Plus undercounter refrigerator. That year the unit became the first solid-state refrigerator to earn ENERGY STAR certification in the refrigeration and frozen category.

Phononic currently has refrigerators commercially available up to 5.5 ft3, but the technology can scale to the 10-20+ ft3 range.

"Phononic's solid-state cooling and heating technology is disrupting all industries where compressors currently play and those where they can't, and we're empowering innovators globally to rethink solutions to the world's toughest thermal challenges," said Atti in a statement.

For food stores, Phononic has partnered with Unilever to provide countertop ice cream freezers for placement at the checkout. Pepsi Bottling Ventures has installed Phononic refrigerators at the end of aisles near registers in some North Carolina supermarkets and convenience stores, said CNBC.

Phononic has also partnered with Singapore-based Temasek Foundation Ecosperity to test its technology in air conditioning.

Other new partners include PNC Arena, a professional sports facility in Raleigh, N.C., and Bryte Labs, which is using the Phononic system to create cooling and heating zones in its BRYTE Bed.

To attract more partners, Phononic has created a "Design with Phononic" platform that welcomes collaboration with "engineers, industrial designers and manufacturers across the globe," said Nicole Scott, director, product management, Design with Phononic.

"As Phononic enters its next stage of growth, it is focused on shifting from a creator to an enabler," she said. "With this, Phononic has the potential to impact industries like HVAC, cold chain, wearables, furniture and bedding, smart homes and more."

Phononic's equipment is "price competitive in the market across both the life sciences and healthcare and food and beverage segments," added Scott.

How it works

Phononic's solid-state cooling and heating system is based on a small thermoelectric chip that Scott said enables "quiet operation, compact size, temperature uniformity and long-lasting reliability."

According to Scott, thermoelectric chips are traditionally made of two copper-lined ceramic pads, connected by "legs" made of two different types of semiconductor materials. "As electricity flows through the semiconductor legs, the dissimilar materials create a temperature difference, making one side of the device hot and one side cold," she explained. Phononic has expanded on this effect by solving "the complex thermal, mechanical and electrical problems typically associated with thermoelectric systems."

Phononic has packaged this thermoelectric cooler (TEC) into what it calls a "Thermal Engine" – in effect, a solid-state heat pump, or what Scott called a "heat-accept-and-reject system."

To generate its ultimate cooling effect, the Phononic system also incorporates two-phase natural refrigerants – low-pressure CO₂ gas and water – "which are constantly and automatically flowing to keep temperature uniform in the refrigerated compartment," said Scott. "CO₂ is used on the accept, cold side, of the TEC, while H₂O is used on the reject, hot side of the TEC," where heat is released into the ambient air.

On CNBC, Atti explained that the system is moving heat from one side to the other. "The magnitude of the temperature gradient, coupled with the amount of heat it pumps per unit area, drives a cooling effect into the surface of the chamber that you want to make cold." Moreover, he said, heat is driven around the entire surface area of a unit's shell rather than focused at one point, allowing Unilever's ice cream freezer to be located at the checkout counter.

A Phononic YouTube video (<https://bit.ly/2MkecFt>) further explains that the CO₂ absorbs and transfers heat "away from the chamber and toward a solid-state heat pump where it dissipates into the ambient environment."

The Phononic unit, the video adds, comes equipped with "a dual redundant refrigeration system that, when coupled with early warning indicators, allows ample time to respond to potential issues before [they become] critical."

The thermal engine is able to pump "tens, hundreds, even thousands of watts," said Scott. And because the Phononic system does not use a compressor, it can provide "up to 40% more storage capacity compared to systems that use a compressor" and utilize "up to 40% less energy compared to traditional compressor models," she said. ■ DY & MG

LINEAGE LOGISTICS TO DEPLOY ON-DEMAND SUBCOOLER AT AMMONIA PLANT

Rebound's IcePoint system provides bursts of cooling that boost throughput and save energy in blast freezing

— By Devin Yoshimoto & Michael Garry

Lineage Logistics, a major U.S. cold-storage operator, will deploy Rebound Technologies' IcePoint subcooling system to accelerate freezing times and save energy for an ammonia blast-freezing system, based on a successful pilot at a Lineage facility in Oxnard, Calif.

The deployment take place this fall at a Lineage warehouse in Unadilla, Ga., said Kevin Davis, CEO and co-founder of Rebound Technologies. The Unadilla site will use a full-size two-skid IcePoint system with a two-stage economized large-charge ammonia system.

According to Davis, IcePoint reduces the energy consumption of a single-stage economized ammonia system by 35%. It also offers peak-energy mitigation.

But 80% of the economic value of the system for end users — initially as a retrofit in large liquid-overfeed ammonia systems used by cold-storage and food processing facilities — is from the acceleration of the freezing cycle, he said.

The key advantage of IcePoint is in its ability to provide precise on-demand, dynamic bursts of cooling capacity.

At the Oxnard facility, which installed a single-skid IcePoint system in February 2018 with a single-stage economized large-charge ammonia system, the blast freezing of 1.7 million lbs of strawberries was accelerated by 2.3%, delivering 40,000 additional lbs of frozen strawberries over 5,000 hours. This increased revenue by providing more frozen strawberries in the same amount of time.

The largest burst of cooling provided by IcePoint in Oxnard was for 10.5 TR (37.5 kW), using a tank temperature of -22°F (-30°C), with a COP of 3.3, reported Davis. The system can deliver capacity boosts of up to 140 TR, he added.

Rebound's full-size commercial unit, operating for 5,000 hours during peak strawberry season at Oxnard, would help the facility freeze up to 11 million pounds of additional strawberries," said Davis.

HOW IT WORKS

IcePoint's subcooling is needed when a refrigeration system's suction temperatures are rising and the system "doesn't have enough capacity to keep those temperatures down," Davis explained. "That's when IcePoint can provide these strategic bursts of cooling to bring those temperatures and pressures back down to their set points."

Instead of vapor compression, IcePoint uses a "freeze point suppression cycle" to generate cooling. Initially water is frozen at the most economical time of the day and stored in a tank. Next a non-chloride salt, or freeze suppressant, is injected into the bottom of the tank, mixing with the ice and lowering its temperature to about -25°F (-32°C)

The low-temperature slurry can then be used at the appropriate time to subcool the liquid ammonia.

In generating ice, the IcePoint system employs a condensing unit that currently runs on an HFC refrigerant. However, Davis emphasized that the condensing unit is refrigerant agnostic. "If ammonia or CO₂ gets to the right economic price point, we're in, 100%," he said. "We'd prefer to be in."

Meanwhile, David is focusing on validating the technology in ammonia systems. "Once we validate that, the sky's the limit." ■ DY & MG

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A Conversation with Professor Pega

Refrigeration legend Pega Hrnjak of the University of Illinois at Urbana-Champaign talks about the state of the natural refrigerants industry and some of his latest projects

— By Michael Garry

One of the foremost refrigeration researcher professors in the world has been gracing the halls of the University of Illinois at Urbana-Champaign since 1993.

That's Predrag (Pega) Hrnjak, a native of Belgrade, Yugoslavia (now Serbia), who is also director of the university's Air Conditioning and Refrigeration Center. And on top of that, he runs his own research and consulting business, Creative Thermal Solutions (CTS), which he founded in 2003.

At CTS and the university, Hrnjak has been engaged in seminal research on a wide range of natural refrigerant projects, from low-charge ammonia to ejectors for transcritical CO₂ to some of the early CO₂ mobile air conditioning systems.

Accelerate Magazine was lucky enough to find time in Pega's busy schedule to query him about his recent work and the state of natural refrigerants.

// Accelerate Magazine: As you look at the North American and global marketplaces, how would you size up the status and potential of natural refrigerant solutions for HVAC&R?

Pega Hrnjak: I would say that the status and potential of natural refrigerant solutions for HVAC&R are stronger than ever. Generally, the F-Gas Regulation in Europe is well established, the effect of legislation in California is more prominent while changes in China are more than obvious.

Probably the greatest impact at the moment comes from the IEC's increase of allowed charge for hydrocarbon systems to 500 g. (See page 24.) I believe that change will affect primarily small self-contained products for commercial refrigeration (bottle coolers and various display cases) and distributed secondary loop systems. The next in the line for hydrocarbons will be small unitary air-conditioning systems.

CO₂ heat pump systems are considered strongly for automotive reversible systems (thermal management), primarily for electric cars. We are witnessing very important inroads of new CO₂ air-conditioning systems for trains and similar autonomous vehicles like buses. CO₂ supermarket refrigeration – and to some degree industrial as well – are getting even stronger.

Ammonia is just as resilient thanks to the industry-inspired and promoted reduction in charge, especially unitary systems with charges around 50 – 100 kg (110-220 lbs).

// Accelerate Magazine: What is your most interesting current research project involving natural refrigerants?

Pega Hrnjak: At CTS we are very intensely working on various projects in almost all of the areas described above.

// Accelerate Magazine: Can you update us on the status of the low-charge ammonia tests you started last year?

Pega Hrnjak: CTS has perfected new facilities for the evaluation of ammonia low-charge unitary systems in terms of air and refrigerant mass-flow rates, capacity, and efficiency (COP). That's thanks to essential support from Southern California Edison (Senior Engineer Paul Delaney, in particular), and strengthened recently by Lineage Logistics' involvement.

These measurements are difficult primarily because of the sizes, capacities and complexities. But CTS provides much more than just a rating. Once a unit is put into the evaluation program, it is much easier as well as essential to explore ways to improve performance, and we do that on almost a regular basis and with great success. The program is completed for several units, and several more are in line.

// Accelerate Magazine: Are you still pursuing commercial opportunities for the super-low-charge air-cooled ammonia chiller?

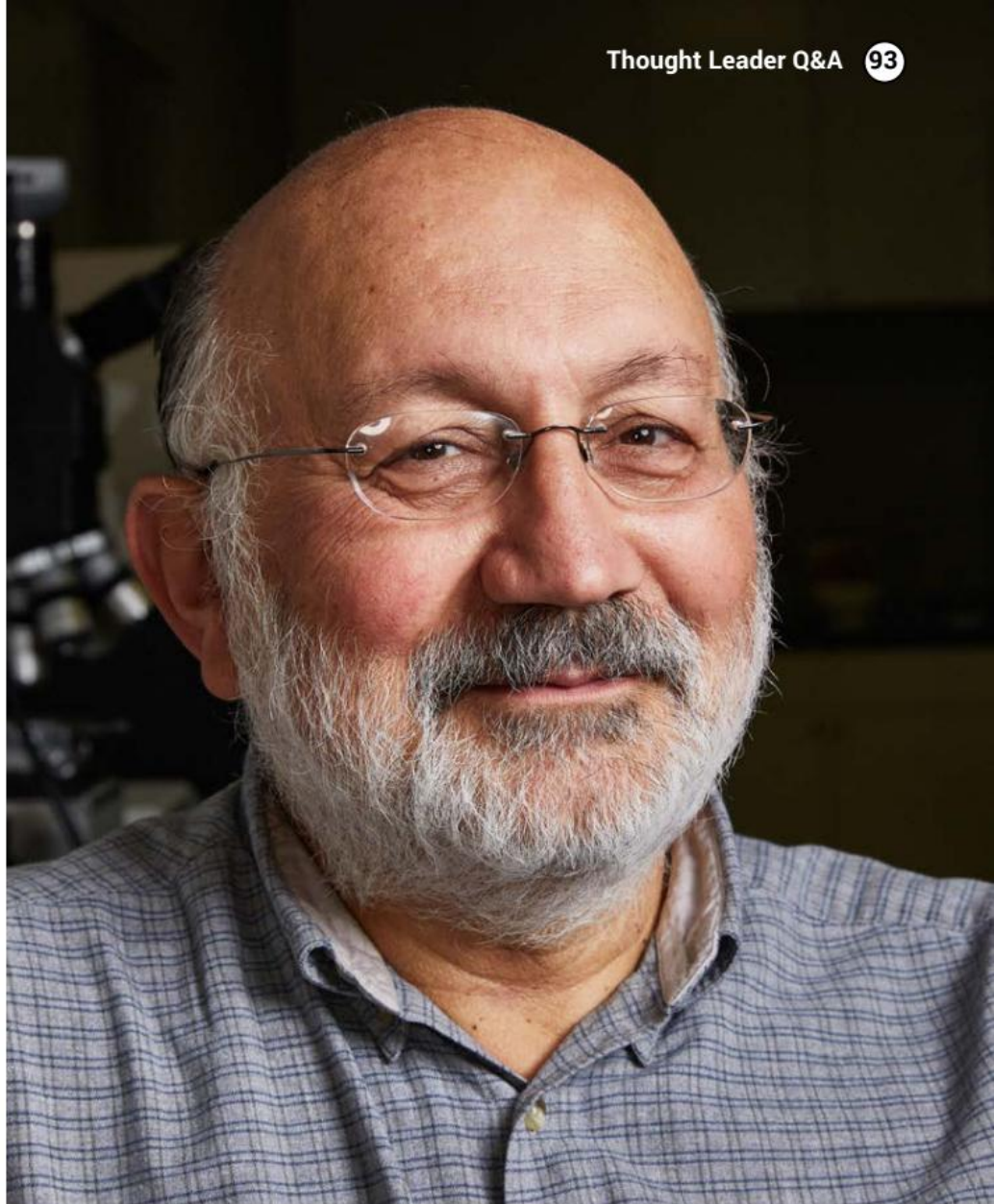
Pega Hrnjak: Yes. That is one of my dreams; it's the same as low- and ultra-low charge systems used to be 20 years ago. Today everyone realizes the value of charge reduction in ammonia

systems and I am sure we will see the same development in super-low-charge air-cooled ammonia chillers. Our system is very efficient, ultra-low charge (1 pound per 10 TR) and with very-low-cost components. We are still looking for an appropriate partner for realization, but we are continuing to develop this system on our own.

// Accelerate Magazine: We have an article about Chinese Railway companies planning to use a CO₂-based AC system, including CRRC Changchun Railway Vehicles Co./CRRC Dalian Institute, and Guangzhou Dinghan Railway Transportation Equipment Co. (See page 80.) Can you explain your contribution to that?

Pega Hrnjak: Yes, CTS was engaged with both but at different levels. We have done a complete project for CRRC Dalian Institute, with CRRC Changchun Railway Vehicles Co. as a customer.

CTS started from a baseline R407C system, measured its performance, redesigned the components and the system for CO₂, built or ordered all components, and built the fully functional prototype that fitted into a 10% smaller frame. The measured efficiency was significantly above the COP of the baseline at the same capacity and identical conditions. We are helping the technology transfer to the customer who delivered the units to CRRC Changchun Railway Vehicles Co.



Pega Hrnjak

We have been invited by Guangzhou Dinghan Railway Transportation Equipment Co., but had to decline because of our contractual obligations at that time. CTS continues to cooperate with CRRC on further developments.

// Accelerate Magazine: What is the status of CO₂ heat pump development for electric vehicles?

Pega Hrnjak: The push from automotive companies is very strong but their reversible systems for electric vehicles are much more complex than for railway systems, for example. That is the reason why we see so many different architectures or approaches for thermal management

in new cars, whether for CO₂ or synthetic refrigerants. I would characterize the status as under strong development in the final phases, and really attractive solutions will be presented soon.

// Accelerate Magazine: Do you see CO₂ condensing units for small retail stores coming to the North America market in the wake of the Epta-Kysor Warren merger?

Pega Hrnjak: It is difficult to predict exactly what, or even more importantly when, that merger will really bring in CO₂ condensing units for small retail stores. I believe it will, but to be honest I anticipated the same after the Panasonic and Hussmann merger but it is going slower than I expected. ■ MG



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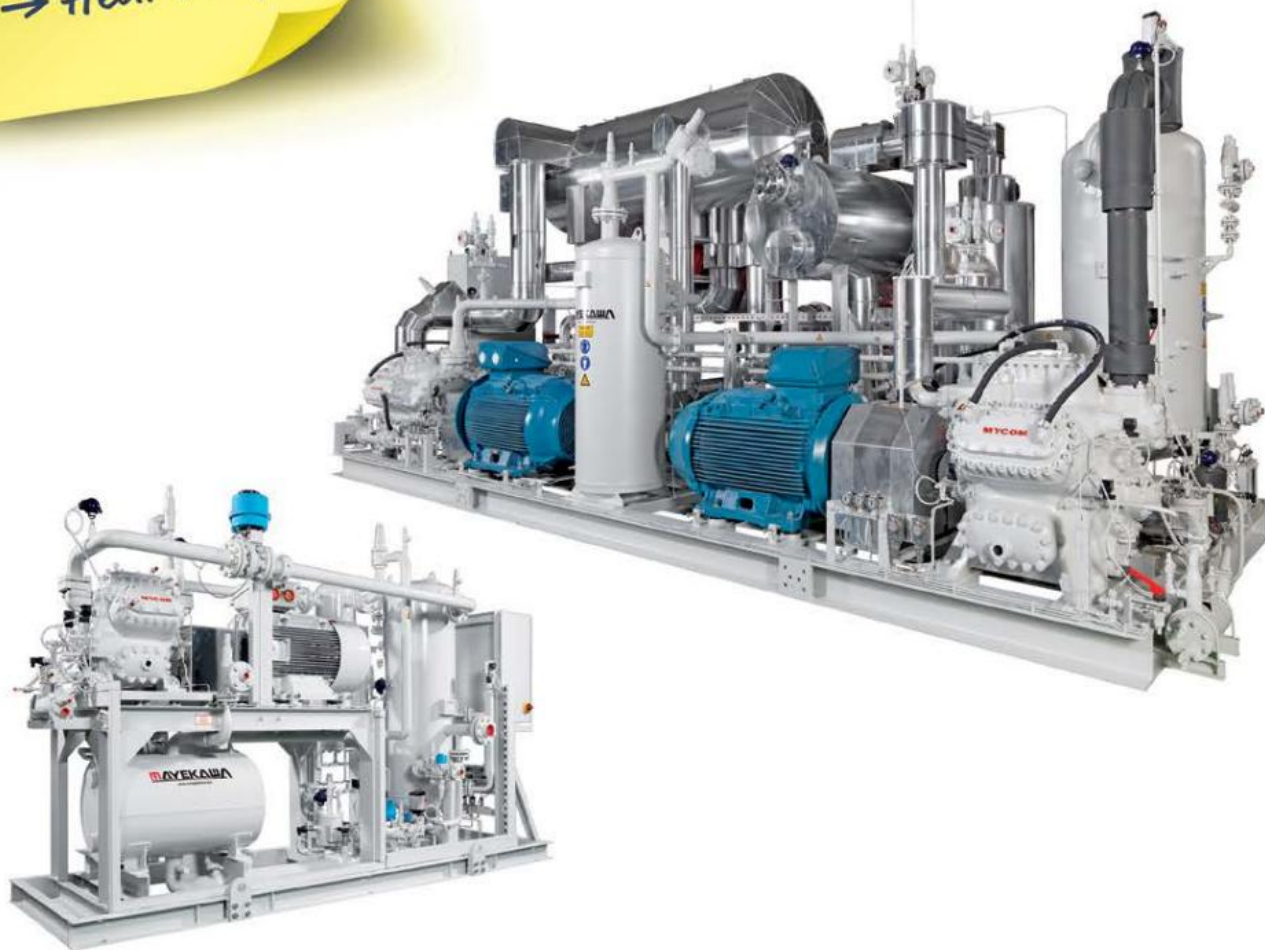
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