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E U R O P E



Portugal's Recheio Cash & Carry, S.A.
p. 20





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A voyage of discovery

– By Andrew Williams

The voyages of the 15th and 16th Centuries are perhaps the most famous period in Portugal's long history of overseas exploration, when sailors such as Vasco da Gama were at the vanguard of a new Age of Discovery. Fast-forward to today, and Da Gama's pioneering spirit is certainly alive and well in this southwest corner of Europe.

This issue's cover story puts the spotlight on market-leading cash and carry retailer Recheio, which is aiming for all its stores to use 100% natural refrigerants by 2030. After visiting Recheio's first CO₂ transcritical store – in Da Gama's birthplace of Sines – we spoke to Angela Soares at headquarters in Lisbon to hear more about the firm's sustainability journey ([p. 20](#)).

With CO₂ transcritical refrigeration technology already well established in European supermarkets, it is now making inroads into convenience stores too. With its new factory in the northwest Polish city of Szczecin, Advansor looks well placed to capitalise on a growing market ([p. 28](#)).

In Belgian capital Brussels, heat reclaimed from a CO₂ transcritical refrigeration system is used to warm a greenhouse on the roof of a Delhaize supermarket. Food grown on this rooftop Urban Farm is sold in the store below ([p. 16](#)).

Further afield, METRO China – part of German giant METRO AG – has installed the Chinese retail sector's first CO₂ transcritical system, in a METRO wholesale store in Beijing ([p. 34](#)).

Natural refrigerants are penetrating the North American residential market as apartment buildings in Seattle

install CO₂ heat pump water heaters ([p. 48](#)). At this year's AHR Expo, European companies were on hand to bring their natural refrigerant innovations to the US market ([p. 56](#)). And in Ohio, a low-charge ammonia packaged chiller is providing air conditioning at a Campbell Soup plant ([p. 42](#)).

The United Nations Development Programme (UNDP) is supporting the technology changes that will deliver the HFC phasedown targets enshrined in the Kigali Amendment to the Montreal Protocol. We visit the UNDP regional office in Istanbul for an exclusive interview ([p. 62](#)).

Award-winning professor, researcher and entrepreneur Pega Hrnjak is a familiar face to anyone who follows natural refrigerants. In our interview, he sheds light on his quest to optimise the use of natural refrigerants in myriad HVAC&R applications ([p. 68](#)).

While refrigeration continues to make big strides towards natural refrigerants, air conditioning still lags behind in many European countries. In the year of Mostra Convegno Expocomfort in Milan and ATMOSphere Europe in Riva del Garda, this issue's Technology Focus looks at what European companies are doing to close this gap ([p. 72](#)).

Features on an ice hotel in northern Sweden ([p. 40](#)), Australian independent retailer Drakes Supermarkets ([p. 32](#)) and an EU policy update ([p. 60](#)) are among some of the other stories waiting for you in this edition.

Here at *Accelerate Europe*, we see 2018 as an opportunity for new adventures too. We are delighted to present our new-look magazine – I hope you enjoy reading it!



ABOVE
Accelerate Europe at
Recheio Cash & Carry,
Sines, Portugal



Andrew Williams
Editor

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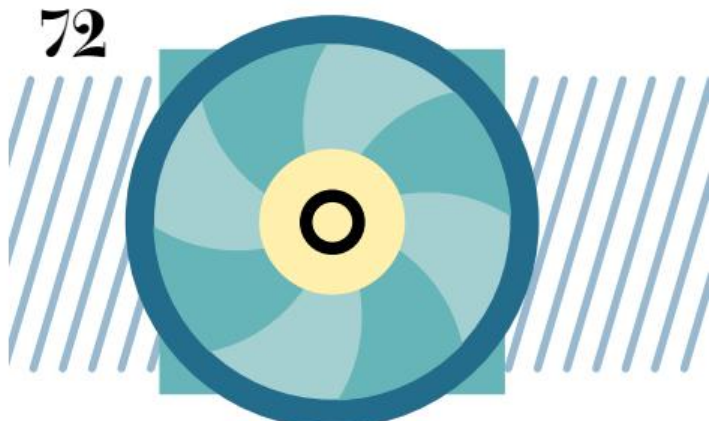
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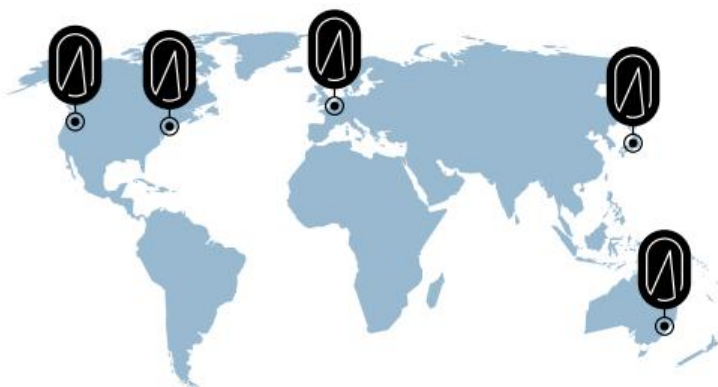
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FOCUS:
UK market trends
PUBLICATION DATE:
May

// ISSUE #12 *Autumn 2018*

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TBC
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December

// ISSUE #14 *Spring 2019*

FOCUS:
TBC
PUBLICATION DATE:
March



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MAR—APR

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MAY—JUN

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EUROPE IN BRIEF

British Paralympic team skates on ammonia-chilled ice

Although the 2018 Winter Paralympics in PyeongChang, South Korea (8-18 March 2018) are being played on HFC-based ice rinks, Great Britain's (Team GB) wheelchair curling team, as well as its Olympic curling team, have been practising on an ammonia ice rink.

The UK's National Curling Academy (NCA) in Stirling, Scotland has been open since summer 2017.

To cool the NCA's ice rink, Star Refrigeration installed an air-cooled Azanechiller 2.0 package that uses natural refrigerant ammonia indirectly with a refrigerant charge of just 0.18kg/kW. ■ CM

Viessmann heat pump wins German climate award

The 'ESyCool green', an energy system for cooling applications from German company Viessmann, has won an Innovation Prize for Climate and Environment (*Innovationspreis für Klima und Umwelt* or IKU) in the category 'process innovations for climate protection'.

The IKU award is presented every two years by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and the Federal Association of German Industry.

The ESyCool green's refrigeration/heating system comprises brine water heat pumps operating with natural refrigerant R290 (propane) in small, hermetically sealed refrigeration circuits. ■ CM

New Carrefour Express opens in Romania

A new Carrefour convenience store in Judetul Ilfov, near Romanian capital Bucharest, is using propane (R290) in tandem with a glycol loop.

Lithuanian firm FREOR provided the store with refrigerated vertical cabinets and cooling for the cold rooms. All the store's refrigerated display cases use R290 as the refrigerant.

Marco & Alex (FREOR's official partner in Romania) installed FREOR's 'Hydroloop' glycol system – a refrigeration system with which excess heat is removed via a glycol line. It connects the refrigerated and frozen food cabinets to the cold rooms using the circuit of pumped glycol. ■ AW

French government facilitates higher charge limit

The increased limit is enshrined in a new fire safety guide governing the use of flammable refrigerants in shops and shopping centres.

The 'Practical guide for fire safety in retail stores and shopping centres' accompanies the implementation of updated regulations and states that the maximum permitted propane (R290) charge per circuit is 1.5 kg in circuits located on the ground floor of the retail facility and 1 kg in circuits located in underground areas accessible to the public (in line with updated European standard EN 378-1). ■ AW

CO₂ at centre of Atlético Madrid's new stadium

The Spanish football giant's new Wanda Metropolitano stadium, which opened its doors in September 2017, is equipped with a CO₂ transcritical system with parallel compressors and multi-ejectors.

The system provides cooling for a large kitchen serving different restaurants and VIP lounges.

The installation features cold rooms at 0°C (fresh food) and -20°C (frozen food), blast freezers at -30°C, and kitchen rooms at +10°C. The CO₂ system also uses heat recovery to make hot water and heat the football pitch. ■ PA

Supermarkets 'could save millions' with hydrocarbons over CO₂

A study conducted by Emerson in conjunction with HVAC&R research institute ILK Dresden asserts that propane-based (R290) integral (or self-contained) display cases are more efficient than remote CO₂ transcritical rack systems.

The study focused on a typical European discounter's store with 10 display cases and a vending area of approximately 1,000 m². It found that retailers could achieve savings on maintenance, energy consumption and refurbishment of €50,000 per store over a 10-year period.

Extrapolated, it means an operator with 10,000 stores could achieve savings of more than €500 million over ten years. ■ CM

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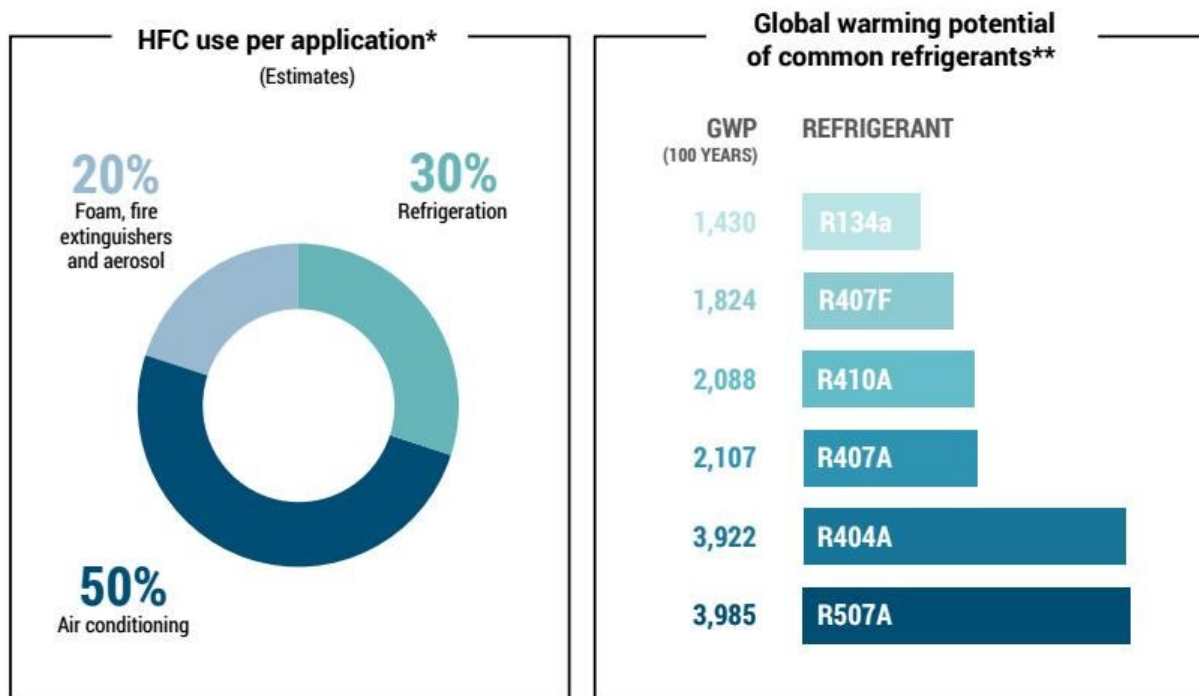
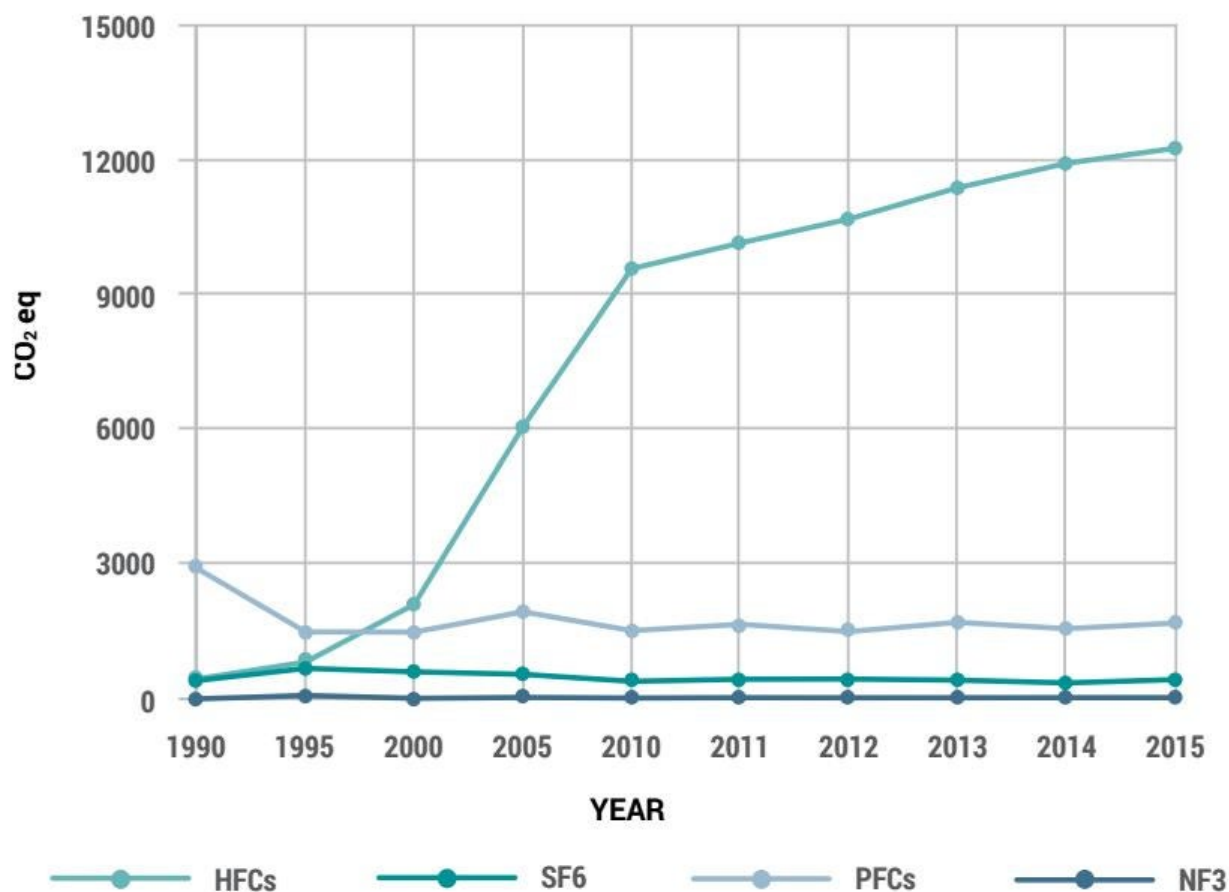
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Italy's f-gas landscape

Growth of f-gases in Italy in CO₂ equivalent (CO₂ eq)*



* Source: Italian Greenhouse Gas Inventory 1990-2015: National Inventory Report 2017 by the Italian Institute for Environmental Protection and Research (ISPRA) / ** Source: F-gas Regulation: Shaking up the HVAC&R Industry (shecco)

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The 2018 Winter Olympics:

A missed opportunity for natural refrigerants

Jörgen Rogstam, managing director at ice arena specialists EKA (Energi & Kylanalys), reacts to the news that the ice rinks at the PyeongChang 2018 Olympic and Paralympic Winter Games are using HFCs.

Most of the ice rinks at the PyeongChang 2018 Olympic and Paralympic Winter Games are temporary designs and constructions.

To some extent the refrigeration and ice rink equipment is leased and may be used for other purposes after the Games. In this case rather simple solutions have been chosen, which unfortunately are not the most environmentally friendly.

The Olympic arenas in South Korea are of an indirect type on the cold side, which implies that they use a secondary refrigerant – probably glycol, implying either ethylene or propylene glycol. Neither of these have particularly good properties. Therefore they have not been used much in permanent installations in northern Europe.

The Olympic ice rink facilities have been built over the last couple of years and the refrigeration units use HFC blend R404A as the primary refrigerant. Two different types of glycol are used in ice rinks: ethylene and propylene. Both have rather poor properties in an ice rink context.

The disadvantage with glycol in general is a rather high pumping power, which drives the energy usage of the facility. This can mean that a facility owner may pay electricity costs two times for an increase in pumping power – firstly as input power to the pump, and secondly to cool the increased amount of heat generated by the pump by the secondary refrigerant. It is not uncommon that the secondary refrigerant pump power share of a total refrigeration system energy cost is around 10-15% for the facility owner.

There are few other applications than ice rinks where the conditions could be better for natural refrigerants. In Europe and specifically Sweden,

most ice rinks have historically been built with ammonia and only a few with HFCs. Since ammonia has been a well-established refrigerant for many years, it should also have been a feasible solution in South Korea. Small-charge ammonia systems have also proven to be both energy-efficient and safe solutions.

Today we see rapid growth for CO₂ in the ice rink segment and we estimate that there are now close to 100 ice rink systems using this natural refrigerant in the world, some dating back to 1999. About 60 of these are of the second-generation type using CO₂ as the primary refrigerant. Most of them have been built since 2010. The numbers are growing rapidly. Approximately 20 of these CO₂ transcritical systems are in Europe and about 40 are located in North America.

Out of the Swedish ice rink crop, about 12% still use HFCs and the rest use ammonia (84%) or CO₂ (4%). As an estimation, eight out of 10 new projects nowadays choose to go CO₂ and very rarely HFCs. In Sweden alone, there are 15 CO₂ ice rink systems in operation this season and another 10 will likely be installed by next season. This illustrates the rapid growth rate in the use of CO₂ systems.

Recent studies of different arenas using CO₂ as the refrigerant have shown that larger arenas may save 80-90% of the total heat demand by using recovered heat from the CO₂ system. Smaller arenas can often be completely self-sufficient by using a well-designed heat recovery system.

Propylene glycol is the least environmentally harmful of the two glycols that are used and is therefore often used in temporary installations, which may make sense since there is a larger risk of leakage.

In permanent installations the most commonly used fluid today in Sweden is ammonium hydroxide (ammonia dissolved in water), also referred to as 'aqua ammonia'. It is used in about 30 Swedish ice rinks today, for both new constructions and retrofits. This is an environmentally friendly and very energy-efficient fluid, which offers

low corrosivity and very low pumping power. Compared with ethylene glycol it will use only 45% of the pump power and with propylene glycol as a reference the corresponding figure is as low as 19%! In modern installations using ammonium hydroxide as a secondary refrigerant, the pump power share is often less than 5% of the refrigeration system's total power cost.

Today we see growing interest in using CO₂ as a refrigerant in winter sports applications in Europe, America and also China. The primary reason is often simply that CO₂ is not an HFC and currently there are no viable alternatives to HFCs out there.

Low-charge ammonia is a very good alternative but sometimes national safety regulations can make it difficult to use. Secondly, the use of CO₂ offers the added bonus of being able to recover huge amounts of heat, which can make winter sports facilities nearly self-sufficient with heat. It also allows recovered heat to be used for functions where it has previously not been used, such as dehumidifier reactivation.



Jörgen Rogstam

EKA Managing Director Jörgen Rogstam has designed many of the CO₂ ice rinks that are now operating in Sweden. He has also presented research papers on CO₂ ice rinks at key refrigeration events, including the Gustav Lorentzen conference on natural refrigerants.

CO₂ AT HEART OF DELHAIZE'S NEW URBAN FARM

Heat reclaimed from a transcritical CO₂ refrigeration system is used to warm a greenhouse on the roof of a Delhaize supermarket in Brussels. *Accelerate Europe* reports from Ixelles, a suburb of the Belgian capital.

– By Andrew Williams

PICTURE

Rooftop greenhouse,
Delhaize's Boondael store

Photography by
Anna Salhofer.



1 / The greenhouse sits alongside solar panels on the supermarket roof.

2 / David Schalenbourg, Delhaize Belgium.

3 / Produce grown in the rooftop greenhouse is sold in the store below.

In a European first, heat reclaimed from the transcritical CO₂ refrigeration system at the heart of a Delhaize Belgium supermarket in Brussels is being used to warm the greenhouse of the retailer's new rooftop Urban Farm.

"This is the first greenhouse in Europe on top of a supermarket," David Schalenbourg, director of department – building projects, format & maintenance at Delhaize Belgium (part of the Ahold Delhaize Group), told *Accelerate Europe*. "It's a new concept."

Up on the roof, seasonal produce grown in the open air and in the greenhouse – such as strawberries, tomatoes and aubergines – is sold in the Delhaize Boondael store underneath. The supermarket was remodelled in 2016 and the rooftop farm opened on 18 October 2017.

The idea of the Urban Farm is to shorten the food chain, improve sustainability and make use of rooftop space that traditional supermarkets generally fail to exploit. "Growing produce on the roof and selling it only in the supermarket downstairs eliminates emissions related to transporting food to market," Schalenbourg argues.

The Ahold Delhaize group encompasses 21 local brands across some 6,500 stores around the world. By 2050, the group is aiming to reduce its greenhouse gas emissions by 40-70% compared to 2010 levels. 13% of the group's sites already have natural refrigerant-based installations.

Delhaize is proud of the Urban Farm's location at the heart of the Ixelles community. Local schoolchildren can learn about the food chain – from planting and harvesting through to the shop floor – in classrooms on site. "We want people to be part of this story," Schalenbourg says.

RECLAIMING HEAT FROM CO₂ RACK

At the concept's heart is a state-of-the-art new CO₂ transcritical rack provided by Danish manufacturer Advansor. "We always reclaim heat from our CO₂ installations, to heat our stores and produce hot water," says Schalenbourg.

At the Boondael store, the engineers went one step further. Excess heat from the refrigeration system is used to heat the greenhouse too.

The Urban Farm project thus tackles two sources of Delhaize's CO₂ emissions. "One is food waste and the food





Heat reclaimed from the rack warms the greenhouse on the roof.

chain, and the other is refrigeration – the type of refrigerant. This project addresses both of them,” Schalenbourg says.

“It’s a holistic approach – there is this interaction between both ideas,” he explains.

Schalenbourg is confident that the Urban Farm will help to raise the profile of natural refrigerants like CO₂. “There is a certain complexity in explaining to non-professionals what it’s all about. This kind of project makes it possible to tell a compelling story,” he enthuses.

“Our sustainability team was looking for a suitable spot to put a farm on a rooftop. It was a synergy between two ideas – an efficient store with a CO₂ installation from which we had excess energy, and an Urban Farm project with a greenhouse that needed to be heated.”

What challenges did the Delhaize team face in Ixelles? “We added another floor on top of the building. Structurally it was quite a challenge. We had to ensure that the existing structure was sufficient to support the solar panels, greenhouse and layers of soil that we put on top of the building,” Schalenbourg says.

REPLICATING THE PROJECT

Does Delhaize plan to build Urban Farms elsewhere? “Other cities are eager to welcome the Urban Farm concept,” reveals Schalenbourg.

He believes Urban Farms make most sense in high-density city environments. “We’re looking for the right buildings in the right urban context,” he explains.

The Boondael project was a remodelling of an existing store in a densely populated area of Brussels, overlooked by residential buildings. “We’re exploiting space which

would normally be neglected or used only for technical installations,” says Schalenbourg.

“Urban Farms bring the greatest added value to city centres, which is why we’re looking at other Belgian cities,” he says.

“We need to check feasibility at the structural level (from building to building) and at the urban level (in terms of permits and local acceptance),” he explains.

FUTURE PLANS

What’s next for Delhaize and the group at large? “What we’re doing now is trying to put transcritical CO₂ technology in our smaller stores, because it saves space. Certainly for smaller banners in city centres, space is quite expensive,” Schalenbourg says.

At first, Delhaize Belgium focused on larger supermarkets over convenience stores, partly because its smaller stores were operated by franchises. But the retailer is currently expanding its network more quickly than it can find new franchise holders.

The change of strategy is opening the door to natural refrigerants in convenience stores too. “We’re taking more of them on to our side – then my team goes in,” Schalenbourg says.

The efforts of David and his colleagues are dramatically reducing the average global warming potential of Delhaize Belgium’s store portfolio. “More than half of Delhaize Belgium-operated stores are already on CO₂,” he says.

Schalenbourg cites energy efficiency and immunity from any future synthetic refrigerant phasedown regulation among the most compelling reasons to opt for CO₂ systems.

“We’re passing the message on to our affiliated partners – CO₂ is the way to go.” ■ AW

A CO₂ ADVENTURE

An *Accelerate Europe* voyage of discovery reveals how Portuguese cash and carry retailer Recheio is setting sail for a 100% natural refrigerant future.

— By Andrew Williams

Gaze out over the Atlantic from the seafront in the Portuguese port city of Sines, and the sense of adventure in the air is unmistakable. For this is the birthplace of ground-breaking explorer Vasco da Gama, whose discovery of the sea route from Europe to India in the 15th Century paved the way for a new age of global exploration.

Fast forward to 2018, and Da Gama's pioneering spirit is alive and well on this brisk February afternoon on the Alentejo coast. For *Accelerate Europe* is in Sines to see how a cutting-edge CO₂ transcritical refrigeration system from Danish manufacturer Advansor is helping to keep market-leading cash and carry retailer Recheio on an environmentally sustainable course.

Recheio Cash & Carry, S.A. is the biggest cash-and-carry chain operating in Portugal, with 40 stores currently in its portfolio.

"We want to be HFC-free – meaning 100% natural refrigerants – by 2030," says Angela Soares, the firm's chief operations officer (COO).

"Our main milestone was in 2016, when we opened our first CO₂ transcritical store, in Sines," Soares says.

Founded in Figueira da Foz in Portugal in 1972, today Recheio is owned by Jerónimo Martins, a Portuguese retail giant that also operates the Pingo Doce supermarket chain.

Soares has been with the Jerónimo Martins group for 22 years. After 10 years at Recheio, she changed to Pingo Doce for the following decade, the final two years of which she spent in Madeira. She returned to the mainland to take up the role of Recheio COO two years ago.



Recheio Cash & Carry, Sines, Portugal

Portuguese contractor Hiperfrio made the Sines installation in summer 2016. At the system's heart is a CO₂ transcritical rack from Advansor.

"The rack is used for refrigeration, space heating, and space cooling – using water," says Joana Costa, Advansor's regional technical manager for Portugal and Spain. "It also serves the store's heating needs, even in winter."

Recheio outsources its technical department to Gesfuste, an equipment sales and maintenance firm based in Braga which works for other brands in the Jerónimo Martins group too, including Pingo Doce.

Gesfuste's Francisco Meireles picks up the Sines story. "Recheio wanted to move towards natural refrigerants, and then Joana appeared in the process," Meireles says. "I met her at the ATMosphere Europe conference (organised by *Accelerate Europe* publisher shecco) in Barcelona in 2016."

Advansor's long experience with CO₂ transcritical technology helped to convince Meireles of its potential to help Recheio reduce its environmental footprint.

"Advansor is a very good player in this market, with plenty of experience of installing racks," says Meireles.

**"We want
to be
HFC-free
– meaning
100% natural
refrigerants
– by 2030."**

– Angela Soares, Recheio



► Upon returning to Portugal, Meireles and Costa continued their discussion. "We were using a new technology, and Joana was able to clarify things very quickly for us," Meireles says. It was not difficult to convince Recheio to proceed.

Back in Portuguese capital Lisbon, *Accelerate Europe* sits down with Recheio's Soares at the firm's headquarters to find out more about how natural refrigerants are playing a central role in delivering the firm's sustainability targets.

"We're innovating. It's about finding the best technology solutions, both for the environment and for our customers," Soares says. "It's about everything, from lighting to refrigeration racks."

"This philosophy affects every decision we make, from investing in electrical machinery to lithium batteries," Soares explains. "Everything helps, however small."

"Everything we're doing is about moving towards that goal of using 100% natural refrigerants by 2030," she says.

Recheio operates 40 cash and carry stores in Portugal. So what is the strategy for delivering its target of moving to 100% natural refrigerants for all its heating and cooling needs?

"It's a journey. We're not opening many new stores, and obviously we're not refurbishing all 40 of our existing stores at the same time," Soares says.

The opening of the Sines store in 2016 – the first Recheio store to be fitted with a CO₂ transcritical system – therefore represented a crucial marker in this voyage of discovery.

"We're going step-by-step towards our goal," says Soares.

In Sines, Advansor's Costa picks up the thread. "After the ATMOSphere Europe conference in Barcelona in 2016, our main customer in Portugal – Jerónimo Martins – decided on a strategy to implement CO₂," she says.

References from end users from other countries had inspired other parts of the Jerónimo Martins group to try CO₂ transcritical systems in higher ambient temperatures for themselves. At the same time, Meireles was processing the good things he had heard from Costa at ATMOSphere.

ABOVE

Francisco Meireles, Gesfuste (left) & Angela Soares, Recheio Cash & Carry (right)

Photography by Anna Salhofer.



"Here in the south of Europe, some people still doubt the performance of CO₂ in warmer climates," Meireles says. "The information that Joana gave us – based on data from installations in places like South Africa and Seville – is that we wouldn't have any problems."

In Sines, the Advansor rack serves the large, freestanding cabinets and all the wall-mounted ones. It also provides cold water for the air conditioning. 'Free' heat recovered from the rack provides hot water to clean the store (see 'System Specification' box for more information).

"The system is performing perfectly in Portugal's warm summers," says Jaime Cortes of Hiperfrio, one of five different contractors Advansor works with in Portugal. "We haven't had any problems."

With natural refrigerants becoming increasingly mainstream HVAC&R options to help Europe's food retail sector to comply with the HFC phasedown taking place under the European Union's F-Gas Regulation, installers are becoming more comfortable with the technology and suppliers are more supportive.

Having entered into force on 1 January 2015, the new EU F-Gas Regulation aims to reduce the bloc's HFC use by 79% by 2030 (compared to average levels

About Jerónimo Martins

Jerónimo Martins – formally known as Jerónimo Martins SGPS, S.A. (JM) – is headquartered in Lisbon. Founded in 1792, today the group employs over 100,000 people across a retail portfolio that includes health and beauty stores, pharmacies and coffee shops as well as supermarkets, cash and carries, and convenience stores.

Jerónimo Martins operates over 3,600 stores in Portugal, Poland and Colombia. In addition to Recheio, its food retail divisions include Pingo Doce (Portugal), Biedronka (Poland) and Ara (Colombia).

in the period 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 GWP's above 150 in new centralised and plug-in commercial refrigeration equipment will come into effect.

"At the beginning, people were looking at CO₂ transcritical in the manner that kids look at a new toy – they're curious about it, but don't always want to play with it straight away," says Advansor's Costa.

"Nowadays, the market is more mature. They're coming back to us, to find out more and to ask for quotes. This is a good sign!" she enthuses.

"We already have tried-and-tested solutions that are ready to use."

A chemical engineer by education, Costa spent the early part of her career doing building energy assessments in Portugal, including for supermarkets. Next, she moved to the United Kingdom, where she entered the HVAC&R sector. It was during her three and a half years in the UK that she worked with CO₂ transcritical refrigeration systems for the first time.

Two years ago, she moved back to Portugal to join Advansor. "Things started really slowly in Portugal, but

after two years, we now have 30 CO₂ transcritical installations here compared to 11 in Spain," Costa says.

"The growth in Portugal has been fast, and I must admit, a little unexpected," she says.

Within the Jerónimo Martins group, Advansor's natural-refrigerant supermarket installations are at capacities of up to 125 kW on the medium-temperature side and up to 30 kW on the low-temperature side. "We also do hypermarkets, warehouses and logistics departments," Costa says.

She confesses that the beginning was tough. "When I joined Advansor in 2016, at the beginning it was terrible – nobody wanted to talk to us!"

"Maybe people were waiting for the decision by the European Commission to confirm the deadlines for f-gas restrictions in commercial refrigeration," Costa says. "Or maybe the chemical lobby had got to them!"

Hiperfrio's Cortes is also optimistic that the market will continue to grow. "Demand for CO₂ transcritical systems here in Portugal is increasing a lot," he says.

"All our clients are asking us for this solution," Cortes says. "Once one client goes CO₂, another one follows."

How does Cortes see the Portuguese market for natural refrigerant-based HVAC&R solutions developing in future? "The demand is coming from the customers themselves," he says. "The market is moving to CO₂ transcritical."



"The system is performing perfectly in Portugal's warm summers."

– Jaime Cortes, Hiperfrio

ABOVE RIGHT
Jaime Cortes inspects the Advansor CO₂ transcritical rack. Recheio Cash & Carry, Sines

RIGHT
Joana Costa, Advansor



SYSTEM SPECIFICATION

Recheio Cash & Carry, Sines

Rack manufacturer: Advansor

Key figures:

- ▶ MT capacity: 241 kW at -8°C
- ▶ LT capacity: 17 kW at -27°C
- ▶ Gas cooler capacity: 2 x 335 kW
- ▶ Design temperature: +29°C

MT compressors

- ▶ 1 x MT compressor, model: Bock HGX 34/290T S – Inverter: 30-70 Hz
- ▶ 1 x MT compressor, model: Bock HGX 34/290T S
- ▶ 1 x MT compressor, model: Bock HGX 46/354T S

Parallel compressors

- ▶ 1 x Parallel compressor, model: Bock HGX 34/230T S – Inverter: 30-70 Hz
- ▶ 2 x Parallel compressor, model: Bock HGX 34/230T S

LT compressors

- ▶ 1 x LT compressor, model: Bock HGX12e/20-4 S – Inverter: 30-70 Hz
- ▶ 1 x LT compressor, model: Bock HGX12e/30-4 S
- ▶ 1 x LT compressor, model: Bock HGX12e/40-4 S

Gas coolers

- ▶ 2 x Luvata KCE 86B (4+2) SP15 130

Heat recovery/Space heating

- ▶ 1 x heat exchanger, model: Alfa Laval AXP52
- ▶ Capacity: 225 kW

Climate

- ▶ 1 x heat exchanger, model: Alfa Laval CBXP112
- ▶ Capacity: 241 kW

Installer:

- ▶ Hiperfrio – Refrigeração Industrial e Comercial, Lda.

Advansor has long been convinced that CO₂ can compete with HFCs and newly developed synthetic alternatives known as HFOs, both in terms of efficiency and lifecycle costs.

"The rising price of HFCs is a good incentive to opt for CO₂," says Costa.

Contractor Hiperfrio is similarly convinced that CO₂ can hold its own in Portugal. "We always try to sell CO₂. It's still a new solution here, and we like it," says Cortes.

Although initial investment costs may still be higher for state-of-the-art CO₂ transcritical systems compared to their HFC-based counterparts, Cortes is confident that this is changing as HFC quotas and phasedown schedules begin to bite under the terms of the EU F-Gas Regulation.

"In the future, the price gap will close completely," predicts Cortes. "Every week, HFC prices are getting higher."

Asked to assess the level of awareness of looming f-gas phasedown deadlines under the EU F-Gas Regulation, Cortes says: "From zero to ten, among supermarkets, it's nine! They are very much aware."

Ripe for growth

To build on Advansor's success in Portugal, Costa is confident in the potential of CO₂ to make greater inroads into the Spanish market too. "If it works in Portugal, it works in Spain!"

Why does she think the Spanish market is proving a tougher nut to crack?

"The Spanish tend to rely on their own manufacturing. Portugal is a smaller country, without many home-grown manufacturers," she argues. "Perhaps that's why the Portuguese seem to be more open to working with manufacturers and technologies from elsewhere."

Another possible reason is the perception that CO₂ transcritical systems cost too much money. "Yes, the necessary add-ons are expensive, but not all that much," she says.

"As CO₂ transcritical systems become more standard, I'd say the cost will decrease," Costa argues. She highlights greater efficiencies over equivalent HFC-based systems as another source of cost savings.



1 & 2 / In the Sines store, the Advansor CO₂ transcritical rack serves large freestanding and wall-mounted cabinets and a cold storage space.





"The rising price of HFCs is a good incentive to opt for CO₂"

— Joana Costa, Advansor

3 / Recheio Cash & Carry, S.A. is headquartered in Lisbon.

NatRefs 'part of the business'

Back in Lisbon, how optimistic is Soares that Recheio will meet its target of becoming HFC-free by 2030? "The natural refrigerants target is part of the business," she explains. "We need to make money to achieve this goal."

Next on the agenda is the imminent commissioning of Recheio's first CO₂ transcritical system to be fitted with an ejector. The store is located in suburban Lisbon in the parish of Corroios, south of the city centre on the opposite bank of the Targus River.

Soares readily admits that Recheio is by nature cautious about communicating its sustainability activities. Yet she is proud of the results achieved in Sines.

As for Angela herself, what does she like most about her current role? "The fact that no two days are the same."

From a sustainability perspective, does she practice at home what she preaches at work? "Yes!" she grins.

"Many of my co-workers are enthusiastic about environmentally friendly solutions too," Soares says. "Our people become more environmentally conscious with every passing day, which is very satisfying for us."

As a market leader in Portugal, Recheio is conscious of its position of responsibility in Portuguese society. "Our actions are important for our business and the values we aspire to," Soares says.

By committing to becoming HFC-free by adopting 100% natural refrigerants, Recheio is certainly playing its part. ■ AW



Destination Poland: Advansor's CO₂ journey

CO₂ transcritical refrigeration technology is already well established in European supermarkets. Now it is making inroads into convenience stores too. *Accelerate Europe* reports from Advansor's new factory in Szczecin.

– By Andrew Williams & Álvaro de Oña

Advansor – a market-leading manufacturer of high-quality CO₂ refrigeration systems – is a major supplier of transcritical CO₂ racks for supermarkets.

The company's optimism in the growth potential of CO₂ led it to build a state-of-the-art 3,000m² production facility in northwest Polish city of Szczecin, close to the Baltic sea and the German border.

Smaller store formats, too, are a promising growth area for the Danish company. With this in mind, it launched a new product for convenience stores – the compSUPER XXS mini-booster – at the EuroShop tradeshow in Düsseldorf in March 2017.

Seeking to capitalise on the European trend towards smaller food retail stores, the new compSUPER XXS transcritical CO₂ unit has a cooling capacity of 30 kW at -10°C and a freezing capacity of 4-5 kW at -30°C.

Since the product launch at EuroShop, Advansor has built 400 of these so-called 'mini-boosters' for Biedronka, a Polish convenience store chain that is part of the Jerónimo Martins group. "From April 2017 to December, we produced 140," says Advansor's Szymon Prybyl.

Prybyl manages the Szczecin plant, which opened in 2017. "50% of the mini-booster orders were produced from the factory in Poland."

ABOVE LEFT
CO₂ training at
Advansor's new factory.

RIGHT
Advansor's new factory.

Biedronka leads from the front

Biedronka is Poland's largest discount supermarket chain, boasting 2,823 stores in its portfolio (2017 figures). The owner of Biedronka is Portuguese retail group Jerónimo Martins, which is also the parent company of Recheio Cash & Carry, S. A. ([see cover story on page 20](#)).

Biedronka's name translates as ladybird, hence its cartoon ladybird logo. One of the most popular supermarket chains in Poland, it primarily sells local (Polish) products, many of which are manufactured under the company's own label. It also sells some Portuguese-made products.

Johan Sommer Jermiin, Advansor's director of operations in Szczecin, is pleased with the progress made at the new plant so far.

"Production for Biedronka has been running really smoothly," Jermiin says.

The factory hopes to soon be producing 20 mini-boosters per week.

Indeed, the Danish manufacturer has the capacity to ramp up production significantly. "Everybody we talked to with experience of starting their own production in Poland told us: 'think big, go big with your production, otherwise in two years' time, you'll run out of space,'" says Jermiin.

"In two years' time, this facility will be really, really busy!"



Such stellar success does not come without growing pains. "It's about starting the business in a controlled way. That's important, because Advansor is not a huge organisation," Jermiin explains.

"When you experience growth of almost 40% in 2017, you don't really have the manpower to set aside and concentrate on the new factory."

The Szczecin plant currently employs 12 people. Advansor is aiming to employ 35 there by the end of the year. "We want to slowly ramp it up to a bigger capacity," Jermiin explains.

New recruits receive training in Advansor's home country of Denmark. "The idea is to employ a maximum of 50 people in Szczecin," Jermiin says.

BELOW

The factory produces up to 1,200 small racks per year.

Polish market ripe for growth

Morten Sminge, from the product support, internal sales & projects department at Advansor, picks up the thread. "The factory's capacity should be around 1,200 small racks per year," Sminge says.

Plant manager Prybyl stresses the importance of providing local support. "In securing the order from Biedronka, maybe it helped that we're local, or were about to become local," he says.

Advansor is optimistic that its relationship with Biedronka represents the start of something special. "Internally, the Polish market is a very good market for future growth. It's a big market," Prybyl says.

"It also has quick access to Germany and the south. And in the event of an emergency, we can still get support from Denmark as it is within six hours' drive."

In a recently refurbished Biedronka convenience store, located at *ulica Struga 18* on the edge of Szczecin, Robert Petryk, Advansor's regional sales manager for Central Europe, shows *Accelerate Europe* how a 30 kW mini-booster is providing the medium-temperature cooling.

"I helped commission the first few Biedronka stores, but now local installers are skilled enough to take the lead," Petryk says.

"Initially we trained them in Denmark, but then we built the training centre in Poland. We've trained over 200 installers in this country."

In 2017 alone, Biedronka fitted CO₂ systems in 300 stores. Advansor delivered 200 of them. "Biedronka's target is 300 stores per year," Petryk says. "In 2018 they expect to achieve it again."

"That works out at roughly one store per work day!" he says.

Advansor's new factory in Poland is clearly a successful step in increasing capacity to meet growing European demand for CO₂ transcritical racks for supermarkets. ■ AW & AdO





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AUSTRALIA'S CO₂ PIONEER

Leading independent retailer Drakes Supermarkets is more committed than ever to its CO₂ transcritical future. *Accelerate Australia & NZ reports.*

– By Devin Yoshimoto & Caroline Rham

Drakes Supermarkets' history with CO₂ dates back to 2007, when the retailer became the very first to install a transcritical CO₂ system in a southern-hemisphere supermarket.

In 2018, Drakes – which boasts some 60 stores in the states of South Australia (SA) and Queensland (QLD) – is once again investing in CO₂ transcritical systems.

The company, founded by Roger Drake in 1974, began as a single three-lane supermarket on Henley Beach Road in Torrensville, South Australia. Today, Drakes Supermarkets is the largest independent grocery retailer in Australia, with an annual turnover of over \$1 billion.

Drakes is opening three new CO₂ transcritical-based supermarkets. It expects CO₂ transcritical to save upwards of 20-25% on running costs compared to stores fitted with traditional HFC-based systems.

The stores, located at Goodwood Road, Wayville (SA), Stebonheath Road, Penfield (SA) and Ardrossen Road, Caboolture (QLD), were due to open by the end of February 2018.

Accelerate Australia & NZ travelled to the head office of Drakes Supermarkets in Torrensville to meet Bob Soang, the firm's general manager.

AHEAD OF THE CURVE

Since 2007, Drakes has installed subcritical CO₂ cascade systems at 14 store locations. "When we first started with CO₂ [in 2007] and it was transcritical, it was a problem," admits Soang, who boasts 38 years of experience at Drakes.

"But from that day onwards, we've had no problems with the technology. The [subcritical] CO₂ systems have worked brilliantly."

Not only were the subcritical CO₂ systems running reliably, but they were also delivering 10-15% savings on running costs compared to Drakes' standard HFC-based systems.

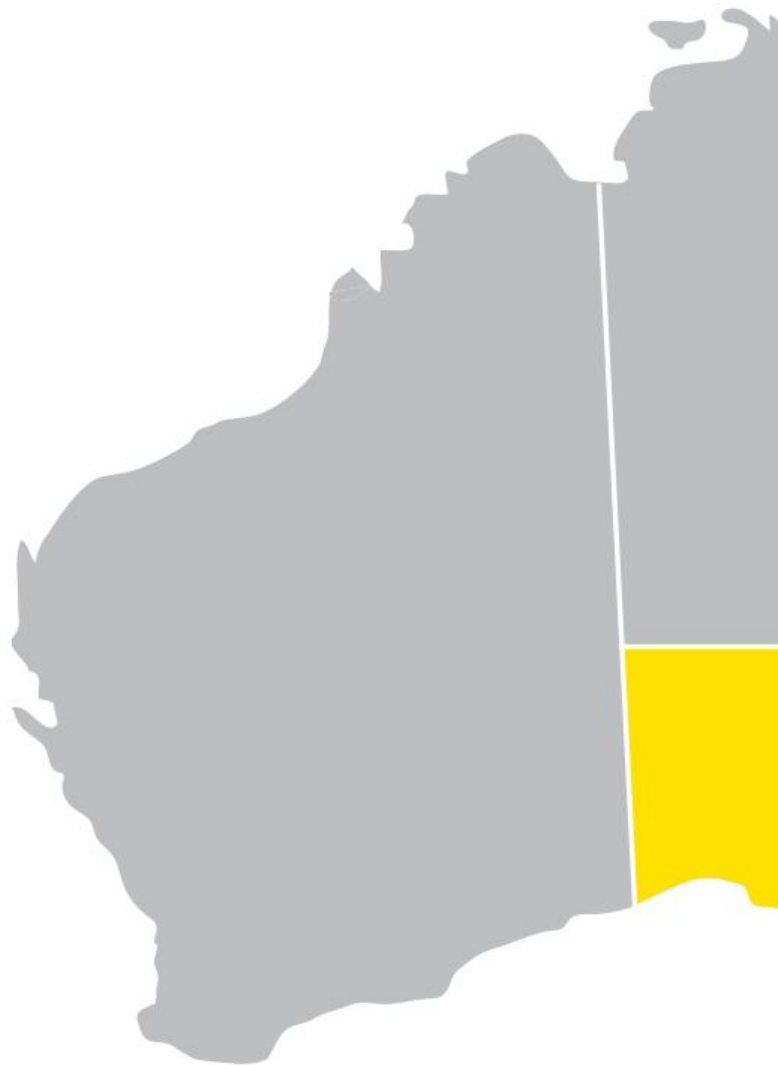
In the intervening years, Soang has been closely watching the level of transcritical CO₂ technology improve rapidly year on year.

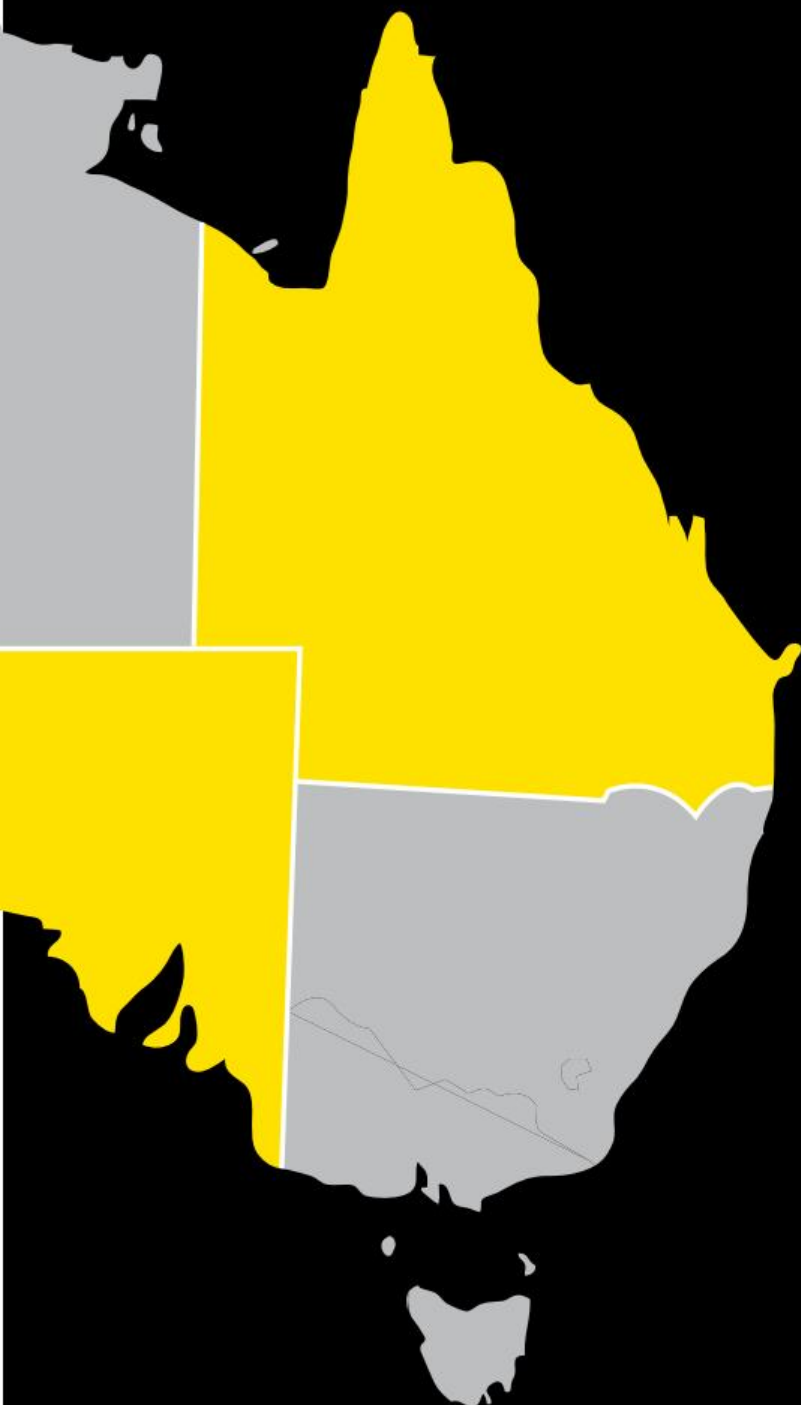
The improvements in technology and design, combined with the promise of even further energy savings, have driven Drakes to take a second look at transcritical CO₂.

"Now, I've got to say, transcritical has raised its head again and there is a lot more modern technology that's now making us reconsider our position on transcritical CO₂."

Indeed, with the scheduled opening of the three new transcritical CO₂-based stores, Drakes has already begun to act. Soang is expecting a further 10% energy savings.

"Now I know that the transcritical systems will be even more efficient than the current cascade





systems that we've been using," he says. "They are still CO₂ but just more efficient CO₂, because the technology is more efficient."

THE TIME IS NOW

As Drakes moves forward with its plans for transcritical CO₂ in 2018, Soang hopes that the experience will serve as an example for other independent retailers in Australia.

"It's an opportunity to be a), investing money in refurbishments and b), to be doing them properly, because you benefit down the track," says Soang.

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

This philosophy is in line with Drakes' overall culture, set by its founder, Roger Drake. "We are long-term players in the industry so in every decision we make, we never consider the choice of 'Let's buy it cheap and let's do a cheap and nasty job'. We've never believed that works," says Soang.

"Roger has always been a guy that appreciated the value of technology and that we have to keep up with it."

Though Drakes considers itself to be a small player compared to the larger food retail chains in Australia, the investments made by the company in the past calendar year have been some of the most significant spends in its recent history.

"Last year, I think we spent \$27 million (€17 million) in refurbishments and fit-outs of stores," says Soang.

"Historically, we just know that it is worth the extra money to buy the right cases, to buy the right technology, and to run those cases and install them efficiently."

THE FUTURE IS NATURAL

In terms of refrigeration technology, where does Soang see Australia's commercial retail industry heading in the next couple of years? "I have no doubt that the direction that we're in is the direction that we're going to continue to go," he says.

Soang believes the future is transcritical because of the energy savings he has seen with these systems compared to cascades.

"Transcritical is going to be the new future because, yes, it is slightly more expensive," says Soang. "But the savings on running costs and operating efficiencies are such that that's where the future is going to take us over the next few years."

He expects the move to natural refrigerants to take place not just in commercial retail operations, but in industrial-sized systems too.

"We run a couple of fresh food warehouses – one in South Australia and one in Queensland, and when you look at warehousing, you start talking about ammonia."

Soang admits that his knowledge of ammonia-based refrigeration systems remains limited. But the efficiency benefit of these systems is piquing his interest.

"I wonder: if [ammonia] is that efficient, then perhaps that might be the future – the next step," says Soang.

Drakes' natural refrigerants journey has now reached a turning point, where previous risks and experience gained are beginning to pay off. ■ DY & CR

BLUE-SKY THINKING

Chinese retail's first transcritical CO₂ system

1 /

The installation of China's first transcritical CO₂ system in the retail sector, in a METRO wholesale store in Beijing, is just the first step in a journey that will see the German multinational fit transcritical systems in all its new Chinese stores by 2025.

– By Devin Yoshimoto, Jan Dusek & Yingwei Tao

It was a beautiful day in Beijing.

One week before the grand opening of METRO China's new Beijing Lishuiqiao wholesale store in January, *Accelerate China* could not help but notice the clear blue skies and fresh, crisp air.

Despite Beijing's international reputation as a city with high levels of pollution, the situation is now changing. The Chinese government is continuing its aggressive push to curb pollution and put the country on a more environmentally sustainable footing.

Industry leadership is crucially important in this regard. By installing the Chinese retail sector's first transcritical CO₂ refrigeration system, METRO China hopes to demonstrate the potential of natural refrigerant-based HVAC&R systems to benefit both businesses and the environment.

Inside the store, there was a palpable energy as employees rushed to finish last-minute preparations – stocking shelves, threading electrical wiring, and wiping down the glass doors of brand new refrigerated cabinets.

Accelerate China toured the store with key members of the METRO China team – led by Head of Facility Management Alan Lin – alongside the main installation contractor, Shanghai Fute Refrigeration & Electrical Engineering Co., Ltd. (Fute), to learn more.

1 / Alan Lin,
Head of Facility
Management,
METRO China

2 / The produce
cabinets are
cooled by the CO₂
transcritical racks.

Photography by
Yingwei Tao.



2 /

A MAJOR MILESTONE

METRO China's parent company, Germany-based METRO AG, is a world-leading international wholesale and food retail company that has built a global reputation as a committed player in environmental protection efforts.

The company's F-Gas Exit Program is widely seen as one of the most forward-thinking initiatives to phase out the use of HFCs in the world today.

In place since 2013, the F-Gas Exit 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.

At the inaugural ATMOSphere Asia conference, organised by *Accelerate* publisher shecco and held in September 2017 in Bangkok, Thailand, Olaf Schulze – METRO AG's director of energy management – updated attendees on the programme's progress.

"As of mid-2017, we have replaced f gas-based systems with natural refrigerant-based systems in more than 120 of our existing stores," said Schulze.

"Additionally, every year, we are installing around 30 subcritical or transcritical CO₂ systems in new stores worldwide. In China, to date, we have installed 28 subcritical CO₂ systems."

At ATMOSphere Asia, Schulze also took the opportunity to make a major announcement. "In the next few months, in the northern part of China, we will be installing the country's very first transcritical CO₂ system to be used in the retail sector," said Schulze.

Fast-forward to today, and for the METRO China team, this first installation of a transcritical CO₂ system represents a key milestone as they continue with their f-gas phasedown.

Thus far, the company has been installing subcritical CO₂ systems instead of f gas-based systems. It is now beginning to transition towards using transcritical CO₂ technology as well.



1 /

2020: 'THE END OF R22'

"2020 will be the end of R22 for us," says Lin, METRO China's head of facility management, who oversees the installations.

Lin explains that R22 installations are already banned in new stores and that they will be completely replaced by CO₂-based systems in 2020. "We have just finalised the designs for our cascade systems, at the end of last year," he says.

"So this year we are continuing to go step by step towards preparing for our 2020 target with our first transcritical CO₂ system," says Lin.

"It is planned that starting in 2025, all our new stores in China will be equipped with transcritical CO₂."

PREPARING FOR TRANSCRITICAL

Preparations for METRO China's first transcritical CO₂ system began around two years ago, when the team started an intensive internal research and discussion process.

METRO China worked closely with colleagues at METRO headquarters in Düsseldorf, Germany to discuss and address the most important issues: the first of which was China's high ambient temperatures.

"In China, most urban areas have different temperature ranges," says Lin. "Yet during summer, 80% of the cities will reach over 35°C."

To find out whether transcritical CO₂ technology would be viable in China's climate, Lin and his team flew to Europe last year to inspect at first hand the latest transcritical CO₂ systems already in operation.

"We learned some real cases, like in Spain, where temperatures in some cities reach over 40°C," says Lin.

"When we saw that the transcritical CO₂ systems were functioning there, we thought to ourselves, 'OK, we can go this way', and got the confidence to move forward."

While in Europe, Lin and his team also took the time to visit other areas and learn about the technology's latest advancements by speaking to the facility managers directly.

"We saw the actual cases and had discussions with the maintenance contractors to ask specific questions like, 'when exactly do they conduct maintenance?' or 'what are the biggest differences between transcritical CO₂ systems and other systems?'" Lin says.

Gaining an initial understanding of the technology and witnessing the systems at first hand was very important during the initial planning phase, he explains.

"It was a good thing for us to first take these past two years, with the support of our colleagues at our headquarters in Germany, to develop this understanding."

1 / Shanghai Fute Refrigeration & Electrical Engineering Co. Ltd. team.

2 / The system itself consists of two separate transcritical booster racks, provided by Italy-based CO₂ system manufacturer SCM Frigo.

A second issue the team faced was the lack of local maintenance service providers in China.

"This was the biggest challenge," admits Lin.

"For system components like the compressors and condensers, it would be OK to have them imported. But we thought the cabinets were the most important things."

Lin highlighted the example of something going wrong with the refrigerated cabinets on the sales floor.

"If something were to break in the sales area, you can't imagine what kind of things would happen. Then if we needed to change some specific part, we'd have to send an order to Europe and wait two months – no chance," Lin says.

Only once the METRO China team had found the cabinets, the component suppliers, and the maintenance staff to service them within the local Chinese market did they decide to move forward.

CHINESE RETAIL'S FIRST TRANSCRITICAL CO₂ SYSTEM

For this pilot transcritical CO₂ project in Beijing Lishuiqiao, METRO China decided to use the simplest version of the technology currently available on the market: a transcritical CO₂ booster system.

"For the first store, we are taking the safe way. Our goal is to first gain a better understanding of how the transcritical system works for ourselves," says Lin.

"We'd like to find out how suitable it is to China's environment and how it can be improved."

The system itself consists of two separate transcritical booster racks, provided by Italy-based CO₂ system manufacturer SCM Frigo.

With a total cooling capacity of 334 kW, the centralised system serves the cooling requirements of the entire store, including its fresh sales areas, freezer room, cold room, and prep room.

The installation contractor selected for the project was Shanghai Fute Refrigeration & Electrical Engineering Co., Ltd. (Fute), a locally based company with several years of experience working with CO₂ systems in the Chinese market.

Commissioning was completed in December 2017, and the store celebrated its grand opening on 17 January 2018.

Key to the success of the first six months of operation, Lin explains, is training the in-store technicians and store-operation team.

In collaboration with their suppliers and contractors, METRO China will be conducting training on a constant basis for the first two years.

"Together with SCM Frigo and Fute, we created a training programme for our store, which will consist of two parts," says Lin.

"The first is a deep introduction to the system, for our staff, covering the basic processes needed for daily maintenance and checking," he explains.

"Second will be an ongoing training programme that will be held consistently for the next two years to help control the system, and train not only our store technicians, but technicians from other stores as well."

For this, Lin explains that installation contractor Fute is scheduled to remain permanently in-house.

"Training for this system cannot be a one-off. They need to understand the transcritical system, and how it is different from normal cooling systems. We need to prepare our people," Lin says.

SET STANDARDS, REDUCE COSTS

As training gets underway, Lin and the METRO China team are now looking forward to tackling the challenges that remain.

Asked to outline the biggest challenge right now, Lin replies that initial investment costs remain a barrier. However, Lin does see them falling in the near future as more suppliers enter the market.

"Right now, initial costs [for transcritical CO₂ systems] are very high compared to cascade systems," says Lin.

"So, our ambition is that we do the first one, let others see the potential, and that will encourage more newcomers to enter the Chinese market."

Lin is optimistic. He has seen the number of companies supplying subcritical CO₂ technology increase in recent years.





Island freezer showcases

"We would like to have a list of about five suppliers for transcritical CO₂ in China, so that they can really help us roll these systems out and at the same time drive down initial investment costs," he says.

"When these systems are available at a reasonable price level, it will encourage the wider industry to use this technology."

Asked how quickly he expects this to happen, Lin replies: "In the next one to two years, we hope to see all of the key suppliers appear in the China market."

In addition to reducing initial costs, the wide availability of industry standards is key to triggering more local investment and interest in new technology.

To foster this, METRO China is taking a very proactive stance, beginning to benchmark data from its stores.

"Right now, we are focused on gaining a more thorough understanding of the technology and gathering data, such as energy usage, temperature changes, and refrigeration usage, for business analysis," says Lin.

With this data, METRO China hopes to lay the foundations for new industry standards. METRO China believes that the time is ripe to work with the government and key industry associations on this task.

SPREADING THE WINGS OF NATURAL REFRIGERANTS

As for METRO China itself, more CO₂ systems are coming.

Though exact details are not yet available, the wheels are now in motion for the next few installations of transcritical CO₂ systems.

"Over the next couple of years, we are planning for several more installations of transcritical CO₂ systems at both new and existing stores," says Lin's colleague Olaf Schulze, from METRO AG headquarters in Düsseldorf.

METRO China's plans to achieve its sustainability goals are not limited to the refrigeration systems, of course, but encompass the entire energy profile of each store.

"2020 will be the end of R22 for us."

— Alan Lin, METRO China

"In terms of our overall energy strategy, refrigeration of course plays an important part," says Lin.

"But we also plan to have more 'green stores' in China. These green stores will need only 50% of the usual energy demand and 40% the usual carbon emissions," he adds.

The METRO 'green stores' – three of them are operating in Putuo, Jinan and Dongguan – are implementing a subcritical cooling system, closed cooling furniture, full LED (inclusive daylight usage), and smart air conditioning.

"All this reduces the electricity demand by 50%. Heat recovery will 'produce' the necessary heat, and the rooftop, top parking canopy and south façade photovoltaics produce electricity," Lin says. "This is combined with an indoor energy management system, rainwater usage system, waste management system, and for our customers, AC & DC electric vehicle chargers."

Though this is only the Chinese retail sector's first CO₂ transcritical installation, its potential to shift the future direction of one of the world's most dynamic and influential markets is not lost on the METRO China team.

"You know, we have to travel a lot. I'd like to see blue skies and enjoy fresh air wherever I go," Lin reflects.

"Perhaps we have only done a very small thing. But we want this small thing to have a butterfly effect."

"Certainly, I believe, this can be very powerful." ■ DY, JD & YT

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SLEEPING ON CO₂-COOLED ICE



Two CO₂ transcritical racks are cooling the IceHotel in northern Sweden.

– By Charlotte McLaughlin

ICEHOTEL 28, 2017-2018
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Sweden, long famed for dark nights and the Northern Lights, has been home to a year-round IceHotel since December 2016.

In summer the hotel, located in Jukkasjärvi, employs solar energy to benefit from the 100 days of constant daylight experienced every year in northern Sweden. It is located some 200 km north of the Arctic Circle where the sun never sets in summer.

The CO₂ transcritical system keeps the ice in the hotel frozen during the summer months. In winter, the cold ambient temperature does the job itself.

Yngve Bergqvist, the hotel's founder and creator, says: "According to our calculations, IceHotel will reduce its total energy requirements. This is because our solar cells take advantage of the nearly continuous daylight during the summer months."

"Consequently, we'll be able to produce roughly 75 kilowatts from April to September, which gives us an energy surplus that we can use to run our existing buildings, like our restaurants, offices and warm rooms."

The refrigeration units, provided by Denmark-based system manufacturer Advansor, maintain the temperature inside the hotel at -5°C during the summer months.

Feedback received so far has been positive, according to Advansor, which stated in a press release that the "cold rooms are available all year and the racks run smoothly, making the project a huge success".

The racks are connected to a brine system that cools the cold room. A mixture of snow and water is sprayed inside the hotel to create a snow-cave effect.

The installation has an overall cooling capacity of 70 kW, with possible heat recovery of 50 kW.

The project was completed with the help of Swedish installer TEO-Kyl Hässleholm using two Advansor water-cooled compSUPER XS 2x0 VP racks with heat recovery.

The heat recovery system provides the hotel showers with 2,000 litres of hot water, which is also used in 10 suites fitted with jacuzzis. ■ CM



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AMMONIA FOR AIR CONDITIONING

A low-charge ammonia packaged chiller is providing air conditioning at a Campbell Soup plant in the US state of Ohio, opening the door for ammonia chillers to take the place of air-conditioning units using HFCs and R22 in industrial and commercial spaces.

– By Michael Garry & Andrew Williams



In Napoleon, Ohio, in the northwest corner of the state, a giant Campbell's tomato soup can stands next to a Campbell Soup Company soup production plant. Passing drivers on state Route 110 just south of the Maumee River sometimes pull over to take a look or snap a photo.

But the can is not just there as a roadside attraction – it contains up to 200,000 gallons (757,000 litres) of water for the facility's sprinkler system, according to Ohio Magazine.

What is less obvious about this location – but much more consequential – is another, much smaller metal container located next to the soup production building. The container holds an air-cooled, low-charge ammonia chiller that generates cold glycol used by an air handler in the building to generate air conditioning – one of the first such chillers used for this application in North America.

The chiller/air handler delivers comfort cooling to a labelling and packaging section of the building where the distinctive red-and-white labels are applied to soup cans – and where a cool environment is needed to ensure proper adherence of the labels to cans. (The area did not have air conditioning previously.)

This year-old, packaged low-charge chiller, produced by Missoula, Montana-based Azane (a division of the UK's Star Refrigeration Group), is part of a new breed of low-charge ammonia packaged chillers also made by OEMs Mayekawa and Evapco. The chillers represent a new direction for the natural refrigerants industry in North America.

They offer a portable, efficient and future-proof air conditioning alternative to industrial plants and potentially other large commercial and residential units currently using HFC or R22 chillers. Virgin R22 will no longer be available in North America in 2020, while HFCs are targeted for a global phasedown under the Kigali Amendment to the Montreal Protocol.



1 /

Ammonia's zero-GWP and ozone-depletion potential protects it from a phasedown, and in small charges ammonia falls below the 10,000-lb. (4,536-kg) threshold for strict federal safety regulations.

FAR FROM THE MACHINE ROOM

One advantage of a low-charge ammonia chiller is that it offers industrial plants that deliver cooling from a remote machine (engine) room a lower-cost option for areas that would otherwise require extensive piping from the machine room. That was the case at the 60-year-old Napoleon soup plant.

"The Azane unit lent itself well because it's a good distance from the engine room," says Bing Cheng, Campbell's manager of utilities engineering, based at the company's Camden, New Jersey headquarters. "We just put down a foundation pad outside, put the unit on top and hooked it up."

Using a flooded plate heat exchanger, 450 lbs. (204 kg) of ammonia in the chiller cools a glycol solution to 44°F (6.7°C), and the glycol is piped to an air handler in the building, where the air is cooled to about 65°F (18.3°C). The chilled air is blown through ductwork to a section of the labelling area. The chiller is designed to supply glycol to two other air handlers for the same area that have not yet been installed. The total load requirement is 300 TR (1,055 kW), at 1.5 lbs (0.7 kg) of ammonia/TR.

Cheng praises the portability of the chiller. "If your cooling needs change or you need refrigeration elsewhere at the plant or at another facility, you can move it to another location." For more than two decades, Campbell Soup has been one of the industry leaders in shifting from large ammonia or R22 systems to low-charge systems. But rather than packaged systems, Campbell has opted to install self-designed low-charge ammonia skids in a centralised engine room, typically using ammonia as the primary refrigerant and glycol or chilled water as a secondary refrigerant piped to the cooling or freezing areas.

For example, since 2011, Campbell has converted four Pepperidge Farm bakeries from R22 to low-charge ammonia, with another facility in Denver, Pennsylvania, scheduled for conversion. At a bakery in Richmond, Utah, which was converted in 2013, the machine room houses low-charge ammonia/glycol skids dedicated to HVAC. At a bakery in Lakeland, Florida, converted in 2016, water is used instead of glycol with the low-charge unit because of the warmer ambient temperatures.

A number of Campbell's thermal facilities have small charge (less than 10 TR; 35 kW) HVAC units using HFCs, which Cheng plans to replace over time with a natural refrigerant option (low-charge ammonia and/or CO₂ systems). The Napoleon plant, for example, has two HFC "spot coolers" in production areas and others serving office space, says Allen Jackson,



2 /

project foreman for Dunbar Mechanical, Toledo, Ohio, the plant's HVAC&R contractor.

"Down the road as HFC units break down, we typically design enough capacity in our low-charge ammonia [machine room] skids to replace the HFC units with air handling units that could use glycol or chilled water," says Cheng.

However, in the event an air-conditioning load is far from the machine room (as in Napoleon) or the machine room lacks sufficient capacity, Campbell would consider installing more low-charge packaged units as a complementary solution, says Cheng. In fact, at its thermal plant in Paris, Texas, "we are looking to supplement the current machine room capacity," he notes. "Instead of expanding the machine room, which would be costly, we're looking at using an Azane unit to provide the new refrigeration load."

Though packaged low-charge ammonia chillers are new to the North American market, Jackson of Dunbar Mechanical is comfortable working with it, given his 30+ years of experience with ammonia systems. "It wasn't completely different," he says, though it was the first air-cooled system he has worked with.

Start-up of the Azane unit, which includes pressure and leak detection tests and on-site charging, may take a couple of weeks. But once it begins operation, the unit, with its

1 / Bing Cheng, utilities engineering manager, Campbell Soup

2 / Campbell Soup cans

industrial-quality design, is low maintenance compared to commercial HFC chillers that use copper pipes and hermetic compressors that are more prone to leaking or failure, Nelson says.

Jackson acknowledges that he originally had "reservations" about the Azane unit because it was air-cooled. But having worked on it for over a year, he pronounced it "a good system" that has been running well, requiring "very little" maintenance, and experiencing no ammonia leaks.

Structural advantages

In assessing the potential for a packaged low-charge ammonia chiller to supply air conditioning on a wide scale, Nelson pointed out several factors weighing in its favour.

Azane chillers, which range in capacity from 40 to 340 TR (141 to 1,196 kW), offer certain structural advantages, such as not requiring a machine room and being built off-site. Because of their proximity to the load, they eliminate the need for long ammonia piping, which, besides being expensive, may cause an efficiency penalty due to a suction line pressure drop and extra heat gain into the system.

The industrial construction of the chiller, incorporating steel piping and steel condenser tubing, allows it to run for 30+ years, says Nelson. By contrast, an HFC chiller may need to be replaced after 10-15 years.

Because they generally use an air-cooled condenser, the units require no chemical water treatment and offer savings on water and sewer bills, he says. The Azane chillers also include automatic oil return, saving the cost of manually draining oil.

Azane has also designed the chillers with four levels of safety to keep the ammonia contained inside the system in the event that the system pressure rises. "The control system will unload compressors, then shut them down," Nelson explains. "If pressures still rise, redundant mechanical switches will kill power to the compressors. If pressures continue to rise in this case, then you likely have some external heat source – a building fire for example – and there is an emergency pressure control system built in that mechanically diverts high pressure gas to the low-pressure side of the system."

If the pressure still rises, ammonia is released through a safety relief valve. That triggers leak detectors and ramps up the condenser fan speed to 100%, sucking fresh air into the chiller and dispersing the ammonia vapour 30-40 feet (9-12m) off the top of the unit "where it should continue to rise and dissipate further into the outside air," Nelson said.



Water tank for sprinkler system (and roadside attraction) at Campbell Soup plant, Napoleon, Ohio.

A machine room is required by code to have at least 30 air changes per hour of ventilation. That is not required of an outside unit, but Azane's chiller nonetheless offers 300 times that much, or 9,000 air changes per hour, notes Nelson. "Even if the fans failed, we would have several times the requirement for natural ventilation where no emergency ventilation is required."

Azane monitors the energy and performance of its chillers remotely. To save energy, air handler can include an economiser that brings in outside air and turns off the chiller when the ambient temperature is low enough.

At the Napoleon site, the chiller is performing "as planned," said Nelson. This means that at full load (with three air handlers), seasonal performance will be close to 0.75 kW/TR, without VFD drives on the compressors. "So, the efficiency we're seeing is really a baseline for our standard offering," he says.

The next version of the chiller (Azane chiller 2.0) is offering seasonal performances well below 0.6 kW/TR, "and we're seeing a huge request for these already," says Nelson. "These are efficiencies the HFC chillers can't get to – even with every bell and whistle."

What's more, "energy is not your only utility bill," says Nelson. "With evaporative and water-cooled systems, you also pay higher water and sewer bills and pay for chemical water treatment."

In terms of capital cost, a low-charge ammonia package will have a lower first cost than a machine-room ammonia system, said Nelson. In comparison to an HFC chiller serving multiple air handlers, a comparable Azane chiller will be more expensive. However, with its efficiency advantage, "we should expect to see a payback over [the cost of] HFC chillers in the five-to-seven-year range, depending on application," he says.

In industrial facilities requiring larger capacities, non-standard operating conditions, or special forms of heat reclaim – not well accommodated by a standard HFC chiller – an ammonia chiller can show cost parity with an HFC option where multiple, non-standard packages are required, Nelson adds.

HFCs are facing an uncertain future as the target of a global phasedown under the Kigali Amendment to the Montreal Protocol. "We use a future-proof refrigerant, so you can use the chiller as long as you maintain it," Nelson says. ■ MG & AW

GREEN PLANT OF THE YEAR

Before Campbell Soup installed a low-charge ammonia packaged chiller to provide air conditioning at its manufacturing plant in Napoleon, Ohio, the facility was named 2014 Green Plant of the Year by Food Processing magazine.

The award was based on energy efficiency, innovative or alternative sources of energy, water use, green building construction, innovative design and economic sustainability.

Among its accomplishments, the plant:

- ▶ Transitioned to natural gas.
- ▶ Was recycling 95% of its materials.
- ▶ Installed a solar field with 24,000 panels, described as the largest in the US supplying solar energy to a single private facility.
- ▶ Deploys a bio-digester that converts fruit-and-vegetable waste into methane to fuel two generators.
- ▶ Pre-treats wastewater and funnels it back to the Maumee River.

Campbell said at the time that the Napoleon facility makes more than two-thirds of its beverage volume and over a third of its soup volume in North America.



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CO₂ ENTERS US RESIDENTIAL MARKET

Natural refrigerants are penetrating the North American domestic market as apartment buildings in Seattle and elsewhere install Sanden's CO₂ heat pump water heater.

— By Michael Garry & Andrew Williams



Charlie Rogers,
City of Seattle's Office of Housing

Photography by
David Ryder.

Over the past decade, as natural refrigerants – CO₂, ammonia and hydrocarbons – have emerged in North America, they have been increasingly used in commercial and industrial applications like supermarket display cases, vending machines and cold storage warehouses.

Yet household appliances – refrigerators, air conditioners and heat pumps – are for the most part still to make the transition to natural refrigerants in North America, despite their progress elsewhere in the world.

But that scenario appears to be changing.

The Association of Home Appliance Manufacturers (AHAM), for example, is expecting a transition in domestic refrigerators and air conditioners to hydrocarbon refrigerants (see *'Are home fridges in US turning toward hydrocarbons?'*, *Accelerate America*, November-December 2017).

Change is coming to the heat pump water heater market too. Sanden, a major Japanese manufacturer, is marketing its CO₂-based SANCO₂ domestic heat pump water heater, which extracts heat from the outside air, in the North American market. The system has been widely adopted in Japan as well as in Europe and Australia.

Introduced in North America in August 2016, the SANCO₂ units have been approved by ETL (Electrical Testing Laboratories). The Environmental Protection Agency (EPA) allows CO₂ to be used in heat pumps designed for heating water (but not space heating).

The original CO₂ heat pump water heater – dubbed the Eco Cute – debuted in Japan around 2001. Today several companies, including Sanden, Mitsubishi, Fujitsu, Panasonic and Daikin, market a similar product in Japan, selling about 500,000 units annually, out of a total of three million domestic water heaters (including 2.3 million gas-driven units), according to John Miles, general manager for Eco Systems, Sanden International (USA), based in Plymouth, Michigan.

In the United States, says Miles, eight million water heaters are sold annually, including 3.9 million electric-resistance and 4.1 million gas units. The market also includes 70,000 to 80,000 heat pump water heaters, mostly using HFC R134a.

In North America, the Sanden CO₂ unit faces some headwinds. The initial cost of the unit is higher than that of electric-resistance, gas and HFC-refrigerant heat pump water heaters. Operating costs for gas water heaters may be tough to compete against because of low gas prices (though not all areas receive gas

distribution). And the water heater market in the US is a traditional one, so it's hard for a new product like Sanden's to penetrate, notes Miles. "The [initial] cost and the uniqueness of the product make it difficult."

But the CO₂ unit is a climate-friendly system, and Sanden is positioning it as a more efficient – and less costly to operate – alternative, particularly in the "green early adopter market," says Miles.

FOCUS ON ENERGY COSTS

Among such early adopters are grant-supported low-income housing developers. The Sanden unit caught the eye of Charlie Rogers, property rehabilitation specialist for the HomeWise Weatherization Program, part of the City of Seattle's Office of Housing.

HomeWise, which receives funding from local, state and federal sources (including the US Department of Energy and the Bonneville Power Administration), focuses on reducing the energy burden and utility costs for low-income households.

Rogers and his team collaborate with the non-profit owners of these housing developments to make upgrades. "We go to sites and conduct energy audits," says Rogers. The audits assess mechanical systems like space heating, lighting and water heating, and recommend energy-efficiency improvements.

Using energy-modelling software, HomeWise calculates grants for low-income housing providers to cover the cost of the enhancements. "Our grants are a function of cost effectiveness and energy savings," says Rogers. "The more energy saved, the larger the grant". He requires a "savings-to-investment ratio" of one or more for any grant to be awarded.

The non-profits regard the HomeWise agreement "as a way to help pay for rehabilitation costs, [maintain] their properties, and reduce the energy burden on their clients," Rogers says.

HomeWise determined that 24 low-rise town homes in six buildings at the Kingway Apartments in Seattle, owned by Bellwether, were a good fit for the Sanden heat pump water heaters, with a savings-to-investment ratio determined to be 1.05.

Each of the homes comprises large households, averaging six people, requiring a lot of hot water. The Sanden system mixes cold water with the hot water to bring the temperature down from one of three settings – 130°F (54.4°C), 150°F (65.5°C) or 170°F (76.7°C) – to "a safe 120°F (48.9°C), which is what the tenant sees," says Rogers.



HomeWise thought Sanden was a good technology in part because of its high heat-recovery rate – much higher than that of a heat pump using R410A, said Rogers. The unit has a first-hour rating of 97.8 and a water-heating rate of 0.31 gallons/min (1.17 litres/min), 50°F in (10°C), 150°F out (65.6°C).

“It refills the tank with hot water very quickly, and I wanted something that without question would provide hot water when the occupants needed it,” Rogers says.

According to Miles, the Sanden unit's first hour rating “is the highest for all heat pump water heaters because of the ability of CO₂ refrigerant to lift the water temperature”.

After learning about the Sanden CO₂ heat pump water heater, Rogers realised that “none of our contractors had installed it”. So he organised a training session and “invited everyone we could”. Miles, who was brought in as the trainer, was able to “get our contractors comfortable and knowledgeable on how to do installations”. He selected Resicon, based in Tacoma, Washington, as the contractor for Kingway.

Craig Christensen, the owner of Resicon, has also put a Sanden unit in his own home. “It is working quite well, even in freezing weather,” he says.

Previously, each of the 24 apartments at Kingway Apartments used a dedicated electric-resistance water heater, which was replaced by a Sanden unit. The Sanden installations began last summer and were completed in December. Fewer Sanden units could have been used, but “there was no easy way to do that because of the way the previous units were metered,” says Rogers.

Bellwether Housing, the owner of Kingway Apartments, “has always looked for opportunities to upgrade our systems to be more energy efficient and better performing,” says Martin Gleaves, senior facilities manager for Bellwether.

Its partnership with HomeWise offered an opportunity to “remove inefficient [water heater] equipment prior to failure and replace it with the best option based on energy usage and maintenance savings”.

OTHER BENEFITS

The Sanden unit's split configuration – the heat pump is located outside and connected to a 43-gallon (163-litre) water tank inside in a small closet underneath a staircase – suits the design of the Kingway town homes.

A traditional HFC-based heat pump water heater positions the compressor on top of the tank inside the building, requiring a certain volume of surrounding air to operate effectively. A small closet would have to be fitted with a duct or passive grill to bring more air in. “It gets complicated,” says Rogers. In addition, the compressor makes noise while the evaporator generates cold air that would need to be ducted to the outside.



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Town homes at Kingway Apartments, Seattle.

▶ The biggest benefit of the Sanden unit is its energy efficiency. Rogers calculated that the 24 heat pump water heaters at the Kingway Apartments would save 81,500 kWh per year compared to the previous electric resistance water heaters. "That equates to about \$300 (€242) per year in avoided electric bill costs for each family," he says.

All the energy-cost saving is accrued by the tenants. "The owner isn't seeing that but is getting lower maintenance costs," Rogers says.

He applied an energy factor (EF) of 2.9 for the Sanden unit, compared to an EF of 1.0 for an electric-resistance unit. "So Sanden should be using about one third as much energy, a huge saving," he notes.

Rogers derived the 2.9 EF from a study done by the Bonneville Power Administration and Washington State University Energy Extension showing that the Sanden heat pump water heater provides an average EF of 2.9 in Seattle's climate. According to the Northwest Energy Efficiency Alliance's qualified product list, Sanden's models range from 2.9 to 3.3, which are comparable to HFC heat pump water heaters.

Sanden rates its heat pump water heater to a maximum of 3.84 EF, compared to 3.0 for an HFC heat pump, 0.95 for an electric-resistance water heater, 0.95 for a tankless gas water heater and 0.67 for a gas storage model. The Sanden unit has a maximum COP of 5.2. "The more hot water used, the more efficient [the Sanden unit] becomes," says Miles.

Rogers notes that with above-average hot-water use, "it's possible that the [HFC] R410A system EF would drop significantly, given that those systems have lower [heat] recovery rates and begin to use electric resistance heat when the compressor can't keep up with demand". By contrast, the Sanden unit "has very high recovery rates and doesn't even have electric-resistant back-up heat, so we can feel more certain about its performance".

Rogers points out other aspects of the Sanden unit that motivated him to install it. For example, all of its heat pump equipment is contained in the outdoor units, reducing the risk of installer error.

In addition, the Sanden unit is factory-built, so "the chances for refrigerant leaks [due to faulty installation] are much lower," he says. Another advantage of the Sanden unit, he said, is the durability of its tank, which is made of glass-lined stainless steel. "There's not as much corrosion so the tanks should last a long time," he says.

One challenge associated with the Sanden system, Rogers acknowledges, is its higher cost. The price of a Sanden unit was about \$3,000; €2,417 (\$5,500; €4,430 with everything included), about twice that of a standard water heater, he says. "But in this application, with very large family sizes, so much hot water use and much greater energy savings, we were able to justify the cost."

NEW PROJECTS

Rogers is working on two new Sanden water heater installations, both at low-rise, low-income Seattle apartment dwellings with large family sizes, similar to Kingway Apartments. One is at Croft Place, a 21-unit, mostly duplex, building, owned by Delridge Neighborhoods Development Association; the other, Cedarvale Village, a 24-unit structure owned by the Seattle Housing Authority (which is separate from the city).

As at Kingway, the Sanden heat pump water heaters will replace electric-resistance water heaters in both communities. Rogers estimates a May 2018 completion date for Croft Place while he is hoping to finish Cedarvale by September 2018. HomeWise grants will pay the full cost of both projects. ■ MG & AW

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Natural refrigerants to shine at Italian shows in 2018

Italy, home to many of Europe's HVAC&R companies, will play host to the latest natural refrigerant technologies at two crucial events this year.

– By Pilar Aleu & Andrew Williams

As countries worldwide begin to phase down HFCs in response to global and local policies such as the Kigali Amendment to the Montreal Protocol and the EU F-Gas Regulation, two major events in Italy will provide a platform to demonstrate that natural refrigerants are market-ready alternatives.

Mostra Convegno Expoconfort (MCE), one of world's biggest comfort technology tradeshows, opens its doors from 13-16 March at Fiera Milano Rho. More than 2,000 exhibitors and 150,000 attendees will gather to display the latest technologies and discuss the integration of heating, cooling, water and energy in the commercial, industrial and residential sectors.

Frascold, CAREL, Rivacold, GEA, Bitzer, Wieland, Conex Bänninger, Panasonic, Modine and Castel are among the companies exhibiting at the 2018 Mostra Convegno.

Rivacold, for example, will present new technologies that harness propane (R290). New for CO₂, the firm

will present its CO₂NNEXT transcritical condensing unit and a centralised booster system with semi-hermetic compressors.

Italian refrigeration institute *Centro Studi Galileo* and the *Associazione Tecnici del Freddo*, meanwhile, will host an event at MCE on Thursday 15 March at 2pm focused on the transition to alternative refrigerants.

Italy will also host this year's ATMosphere Europe conference on natural refrigerants, organised by shecco, publisher of this magazine. End users, policymakers and HVAC&R professionals will descend on Lago di Garda on 19-21 November to discuss the latest technology, market and policy trends.

One special topic on this year's programme is technology for applications in warmer countries, while participants will have the chance to network in a dedicated exhibitor's room at the venue, the *Riva del Garda* conference centre.

Ahead of both events, make sure to read *Accelerate Italy*, a special edition of *Accelerate* magazine focusing on natural refrigerants in the southern European country.

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CROSSING THE ATLANTIC: EUROPEAN INNOVATION AT AHR

At this year's AHR Expo – one of the world's largest HVAC&R trade shows with 72,000 visitors and 2,155 exhibiting companies occupying some 163,000m² of floor space – European companies were on hand to bring their natural refrigerant innovations to the U.S. market.

– By Michael Garry & Charlotte McLaughlin

Many European exhibitors at the AHR Expo – held on 22-24 January at McCormick Place, Chicago, concurrently with ASHRAE's Winter Conference – showed off their natural-refrigerant innovations to a U.S. audience.

Italian manufacturer Dorin, which had already presented its CO₂ transcritical compressors for the industrial market at Chillventa 2016, also brought them to the Chicago-based event. "Especially in the U.S., we got very good feedback about CO₂ entering the ammonia field," Giacomo Pisano, Dorin's sales manager, CO₂ compressors, told *Accelerate Europe*.

"Our feeling is this will be a reliable alternative to ammonia," added Giovanni Dorin, the company's marketing director. "Ammonia has issues with security and safety."

"This [design] is totally unique in the market," he said. The high capacity of the CD500 line of transcritical CO₂ industrial compressors means fewer compressors are needed for an application, reducing costs, added Pisano.

CAREL, another Italian company, introduced its CO₂ technology at the show. Its EmJ modulating ejector line, which it is introducing to the North American market this year, was launched in 2016 in a partnership with Carrier at the ATMOSphere Europe conference hosted by shecco (publisher of *Accelerate Europe*).

The ejector is being piloted in transcritical systems installed in 15 supermarkets in Europe. CAREL will begin selling it in North America and Europe in June.

Italian manufacturer Refrigeri Industriale S.r.l. had to adjust its CO₂ transcritical valves, which can withstand the high pressures of transcritical systems, for the U.S. market.

"This product was developed for the U.S. market to meet the requirements of the UL certification," said Gabriele Bertossi, export area manager for Refrigeri.

Swedish manufacturer Alfa Laval announced at the Expo that it would open a U.S. factory for brazed heat exchangers in Richmond, Virginia.

The facility should start production in the first quarter of 2019. "This is a key step to strengthen Alfa Laval's competitiveness in North America," said Fredrik Ekström, president, business unit, brazed and fusion-bonded heat exchangers.

1 / Jerry Lozano, Güntner, talking to a customer.

2 / Parker's booth

The company currently does not sell many CO₂ heat exchangers in the U.S. market. "Japan and Europe are driving the move to CO₂," said Pierre Hultbäck, Alfa Laval's head of channel sales, brazed & fusion-bonded heat exchangers. On the other hand, "ammonia is very present in industrial systems," he added.

German manufacturer Güntner is finding that adiabatic coolers are proving a big hit with U.S. customers. "One thousand [from all manufacturers] have been sold so far [in the U.S.], of which 250 are probably CO₂," said Jerry Lozano, sales and applications engineer, Güntner.

The OEM, which manufactures adiabatic condensers, estimates that the main source of this growth in CO₂ adiabatic coolers comes from innovative end users like retailer ALDI US (the U.S. arm of German retailer ALDI Süd). Other manufacturers of adiabatic condensers include U.S. companies Baltimore Aircoil and Evapco.

U.S. COMPANIES TAKE ADVANTAGE

In a sign of the growing popularity of natural refrigerant systems in U.S. supermarkets, Micro Thermo Technologies, a maker of control and energy management systems, is increasingly seeing its units used with CO₂ transcritical installations in the U.S., said Charlie Cunliffe, senior technical sales engineer with Micro Thermo, a division of Sporlan (a subsidiary of U.S. component manufacturer Parker Hannifin).

Cunliffe explained that most of the demand comes from the Midwest area, from Milwaukee to Chicago, and on the east coast between Maine and New York. "This is the hot bed," he said. For example, Parker Sporlan is currently operating one of the Micro Thermo systems in a Hannaford supermarket (part of European retail group Ahold Delhaize) with CO₂ transcritical.

The system allows the store to be monitored with an app remotely. Cunliffe demonstrated to *Accelerate Europe* through the app that the Hannaford store was running perfectly and all its components and racks were operational. Cunliffe acknowledged he was sceptical of transcritical at first.

"Now I know the power of CO₂. When you watch the temperature drop [during the hot gas defrost cycle] with CO₂, the temperature drops like a rock," he said. By contrast, HFC systems, he said, have a slow defrost cycle. "This means when you have your Häagen-Dazs ice cream, the ice cream melts a little and forms with ice crystals [but] with CO₂ you get back to the temperature quickly."

Emerson plans to bring its Dixell IProRack controller for CO₂ systems, sold in Europe, to North America, said André Patenaude, director of food retail growth strategy, cold chain, Emerson Commercial and Residential Solutions.

1 /



2 /





1 /



2 /

1 / Huayi's R290 compressors

2 / Kulthorn's R290 condensing unit

▶ "It has built-in, native CO₂ functionality," overseeing suction groups, high-pressure and flash-tank by-pass valves, heat reclaim, condenser VFDs, and parallel compression, he said.

For hydrocarbons, Brazilian multinational Embraco showed off its new multi-voltage propane compressor, the FMFT413U, which accommodates the voltage of any country in the world.

An end user simply attaches a geographically correct power cord, whether for the U.S. (120 V), European countries (230 V), Japan (200 V) or elsewhere. "We came up with one solution: you just change the power cord," said Michel Moreira, commercial refrigeration sales senior manager, North American region, Embraco.

The compressor employs variable-speed technology, helping to improve temperature control and reduce energy consumption by up to 30%, Moreira said.

ASIAN COMPANIES IN THE USA

Asian companies are also seeing opportunities in the U.S. market for natural refrigerants.

Thailand-based compressor manufacturer Kulthorn is seeing growth for light commercial and fractional HP units using hydrocarbons in North America. "There is more and more demand for small and commercial applications," said Dean Rafiee, Kulthorn's director of business development.

In North America, the company is focusing on further optimising its complete range of hydrocarbon compressors.

Meanwhile, Huayi Compressor Barcelona, a Chinese-Spanish manufacturer of hydrocarbon compressors, is also optimistic about the market prospects for hydrocarbons. "We see the U.S. market as promising a lot of opportunities and especially with natural refrigerants," said Pedro Olalla, sales director at Huayi Compressor Barcelona. "Some customers are already going to – and a lot are thinking about – natural refrigerants."

The company is working with OEMs and end users to drive the light-commercial market towards hydrocarbons. "We have a lot of experience with R290," Olalla said. A major driver in the U.S. has been large food and beverage manufacturers that have converted many of their HFC-based fridges to hydrocarbons.

Japan's Mayekawa believes its small packaged ammonia-CO₂ units will take off for use in display cases, walk-in coolers, process cooling, HVAC and data centres.

The product on display at the AHR Expo was an ammonia/CO₂ compact chiller called the Sierra-A. It has a "smaller capacity than the NewTon and is air-cooled," said Tadashi Hamaoka, vice-president, Mayekawa Canada.

As *Accelerate Europe* left the show, it was clear that European, North American and Asian companies are helping drive the market for natural refrigerants in the U.S. ■ MG & CM



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New EU legislation poised to boost NatRef adoption



The new EU F-Gas Regulation is not the only legislative driving force for natural refrigerants in the European Union. Numerous measures to decarbonise the cooling sector are about to be adopted, as part of the proposed 'Clean Energy for All Europeans' policy package.

– By Marie Battesti

Introduced on 30 November 2016 by the European Commission, the 'Clean Energy for All Europeans' package is a set of legislative measures to support the clean energy transition in the European Union.

The HVAC&R sector must therefore prepare for several pieces of legislation that will significantly influence the market and should create opportunities to adopt equipment based on natural refrigerants such as CO₂, ammonia and hydrocarbons.

The Clean Energy package includes updates of the Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED). Among the highlights are requirements for Europe's building stock to be fully decarbonised by 2050 (new Art. 2a EPBD) and a proposed new 30% energy efficiency target for 2030 (EED).

Once adopted, the directives are expected to influence the type and size of cooling equipment being placed on the market. Natural refrigerants are widely accepted as very energy-efficient refrigerants, and therefore stand to benefit from the updated EPBD and EED.

Increased share of renewable energy

In 2014, the European Union agreed on a binding target of providing from renewable sources at least 27% of the energy consumed in the EU by 2030. The proposed Renewable Energy Directive, part of the 'Clean Energy for All Europeans' package, reaffirms this binding target and puts in place a framework and tools to achieve it.

The legislation is expected to create further opportunities for natural refrigerants used in district cooling, as well as expand the market for natural refrigerant-based heat pumps.

More efficient and sustainable products

The Eco-design Directive and the Energy Labelling Directive, together with their accompanying regulations, are also being implemented and will extensively modify the regulatory landscape for HVAC&R products in the European market.

The directives include requirements for energy performance levels. The Eco-design Directive requires appliances to comply with mandatory energy performance requirements.

The appliances concerned include professional refrigeration products (condensing units and process chillers, etc.), commercial refrigeration products, space heating and cooling products, and high-temperature process chillers.

New product groups such as refrigerated containers and Building Automation Control Systems in residential buildings (BACs) are included in the proposed Eco-design update.

Natural refrigerant-based equipment can help manufacturers to reach the targets set by the Eco-design Directive due to its energy efficiency.

In addition the gradual phasedown of HFC refrigerants under the EU F-Gas Regulation, combined with the energy performance requirements under Eco-design, is expected to accelerate investment in refurbishing existing installations. This will create further opportunities for new installations designed for natural refrigerants.

The legislative process for all the above-mentioned measures is still ongoing. Final adoptions are not expected until this summer at the earliest. ■ MB

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UNDP backing green HVAC&R technologies

Having passed the required ratification threshold in November 2017, the Kigali Amendment to the Montreal Protocol will enter into force on 1 January 2019. Implementing agency UNDP is supporting the technology changes that will deliver the Kigali HFC phasedown targets. *Accelerate Europe* reports from Istanbul, where one of UNDP's regional teams working on the Montreal Protocol is located.

– By Eda Isaksson

The entry into force of the Montreal Protocol in 1989 represents one of the most significant steps the world has taken to protect the ozone layer. The Montreal Protocol phases out the production of numerous substances that are responsible for ozone depletion; starting with CFCs and later including HCFCs. 197 parties have ratified the treaty (which includes 196 states and the European Union). In October 2016, the parties adopted the Kigali Amendment to bring HFCs under the scope of the Montreal Protocol too.

HFCs are widely seen as the world's fastest-growing climate pollutant and are used in air conditioners and

refrigerators. Kigali sees developed countries take the lead on phasing down these potent greenhouse gases, starting with a 10% reduction in 2019 and delivering an 85% cut in 2036 (compared to the 2011-2013 baseline).

Developing countries are split into two groups. The first one – which includes China and African and Latin American nations – will freeze consumption of HFCs by 2024, with their first reduction steps starting in 2029. A second group including India, Iran, Iraq, Pakistan and the Gulf countries will meet a later deadline, freezing their use of these gases in 2028 and reducing consumption from 2032.

To help countries phase down HCFCs, UN agencies run projects in developing countries: non-investment projects like those of UN Environment, which supports policy changes, runs technical training sessions and raises awareness, rather than funding technology change in private companies directly. A second category is investment implementing agencies such as UNIDO (United Nations Industrial Development Organization) and UNDP (United Nations Development Programme) which are multilateral agencies working to facilitate technology changes in recipient companies.

"I think there is no multilateral agreement that has gone as far and as intensively and effectively facilitating the phase out and the pickup of alternatives," says UNDP's Etienne Gonin, programme analyst (Europe/CIS, Arab states and Africa), Montreal Protocol and Chemicals Unit. "When you see what has been achieved, it is quite a unique international cooperation. You can always dream of more in a perfect world, but honestly it is a well-functioning system, already offering lots of opportunities," he remarks.

"For the moment, we engage with companies to commit to reducing the use of mostly HCFCs – and tomorrow HFCs," Gonin says. "We provide them with expertise, and funds come either from the Multilateral Fund (MLF) or from the Global Environment Facility (GEF) to change the technology. This is the most direct interaction with the private sector," he notes.

UNDP advocates for energy-efficient solutions that fight global warming. Which is where natural refrigerants come in, although as a UN agency, UNDP must remain technology-neutral. "Everything is an

option for developing countries that is allowed by the Montreal Protocol. Obviously natural refrigerants are part of the solution, but we're not ruling out other acceptable low-GWP alternatives," says Gonin.

Although there are multiple sources of UNDP funding, the MLF and GEF are the key mechanisms. Projects in Article 5 countries (147 countries) are funded by the MLF. The GEF covers non-Article 5 countries without access to the MLF (less than 10 countries, which are considered 'transition countries' in Eastern Europe and Central Asia).

"When companies want to implement technology changes, the way to access these funds available through the UN is through national governments, specifically through National Ozone Units, generally under the Ministry of Environment of the countries," says Selimcan Azizoglu, a project manager at the UNDP who works for GEF-funded regional projects in Europe, Central Asia and Africa related to the HCFC phase-out. He coordinates project implementation at regional level, providing support to developing countries in the areas of policy, technology conversion, capacity building and regional cooperation.

LEFT

Uniting continents:
The Bosphorous
and the UNDP.

RIGHT

Selimcan Azizoglu,
project manager,
UNDP

About the UNDP

The United Nations Development Programme (UNDP) is an agency of the United Nations that aims to facilitate global development. It achieves this by helping countries to develop policies, leadership skills, partnering abilities, institutional capabilities and build resilience in order to sustain development results. UNDP focuses on many important issues to accomplish the Sustainable Development Goals (SDGs) and encourage global development, including energy and environment, and social development.





LEFT

Etienne Gonin, programme analyst, UNDP

RIGHT

General view: energy complex of Santa Bremor, Brest (Belarus).

Photo credit: Pishchik Valery, Santa Bremor LLC

One example of a UNDP project to phase down HFCs under the MLF is in Zimbabwe, where a company called Capri, a manufacturer of refrigerators and chest freezers, is considering converting its domestic refrigerator line from R134a to natural refrigerant R600a (isobutane). This project is in the preparatory phase, with funding from the MLF. Another is for Bangladesh, to convert compressor production lines from R134a to R600a at Walton Hi-Tech Industries. Other examples of UNDP-backed projects include the ammonia air-conditioning chillers in Tashkent's biggest hospital (from R22) and a transcritical CO₂ supermarket in Chile.

"If you're a company in this field, you have opportunities for changing your technologies. However, there are some limitations for supply – particularly in Africa," Gonin remarks. "Even the natural refrigerant supply may be hard to ensure: for example, good quality hydrocarbons are hard to find

in some developing countries," he says. "Making sure that equipment using natural refrigerants is available and supplied can also be a challenge in most developing countries."

UNDP funded a demonstration project in Nigeria on how to produce high-grade hydrocarbon refrigerants. "Now we need to scale it up to actually make hydrocarbons available in the market, particularly in African markets," says Gonin.

As it is still a relatively new technology, it is difficult to find hydrocarbon-based air conditioning units in Africa. "There is a strong demand and interest from African countries for this technology," Gonin says.

"Demand is there, political support is there. It's mostly difficult to make it happen logistically, practically," says Gonin. "It's all about setting up the supply chain to some African countries."

Another important role that UNDP plays in the HVAC&R sector is to reach out to refrigeration associations and hold training, particularly, to achieve technician certification and promote recycling. "We aim to strengthen refrigeration associations through bilateral exchanges but this is not developed enough in some countries," notes Azizoglu.

Training is a major subject for UNDP worldwide. "We use training institutes for all key natural refrigerants.

We had two trainings last year in Germany, with the participation of technicians from Belarus, Tajikistan, Uzbekistan and Ukraine (countries for the project he is managing)," says Azizoglu. "It was good for these countries to see a great example for themselves."

Cost can also be a challenge. "Mass-produced HFC air-conditioning units are cheaper than natural refrigerant solutions. Economic incentives need to be put in place in the form of taxes and incentives for environmentally friendly solutions," says Gonin.

Technical capacity is another issue. "Safety concerns are another barrier," says Gonin. "There is big demand for training and certification programmes, to alleviate the legitimate concerns."

The booklet *'Past Successes and Future Opportunities: Case Studies from the UNDP Portfolio and Innovative Approaches to Cooling without Warming'* outlines the UNDP's work in protecting the ozone layer, advancing sustainable cooling solutions and tackling climate change. ■ EI



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REMOVING BARRIERS TO HYDROCARBONS

In a move that should boost the market penetration of hydrocarbons in Europe's HVAC&R sector, the EU-funded LIFE FRONT project seeks to help create a level-playing field for flammable natural refrigerants within standards.

– By Anti Gkizelis

Current international and European standards set safety requirements on hydrocarbons that do not allow their potential to be fully exploited. Limits on the maximum allowable charges of hydrocarbons anchored in industry standards were not established on the basis of scientific assessment and the assumptions do not reflect the realities in the field.

In a bid to remove these barriers, the EU-funded project '*Flammable Refrigerant Options for Natural Technologies – Improved standards & product design for their safe use (FRONT)*', aims to establish calculation methods for charge limits that reflect these realities and improve system design to address flammability risks. The objective of the project, which runs from mid-2017 to mid-2020, is to encourage and increase wider availability of climate-friendly alternatives to fluorinated gases.

The team behind the project is led by shecco, publisher of this magazine, and includes five other partners – AHT Cooling Systems GmbH, ait-deutschland, NIBE, ECOS and HEAT. To map and analyse existing relevant European and international standards, the project partners conducted a literature review, which will be made available to the public later in the project.

The project consortium is now working on a market study to evaluate the availability of non-fluorinated flammable refrigerant products and the impact of standards on market uptake of these products. The literature review and market study should be published as a public report by the end of August 2018.

COMMON BARRIERS

The review of current standards demonstrates that the primary barriers to flammable refrigerants in safety standards are mainly related to refrigerant charge limits, which limit the ability of systems to provide the desired cooling capacity.

These charge limits take shape as:

- ▶ Charge size limits applied to air conditioners, heat pumps and dehumidifiers when in 'human comfort' conditions
- ▶ Charge restrictions for HVAC&R systems below ground
- ▶ 150g limit for systems installed regardless of room size
- ▶ Charge size limitation for large systems

The project seeks to identify risk mitigation measures to address the identified barriers to wider uptake of flammable refrigerants and increase the permitted refrigerant charge. The review has determined that the following risk mitigation measures are of use:

- ▶ Improved system tightness
- ▶ Systems with integral airflow
- ▶ Charge leak test method
- ▶ Housing design
- ▶ Sources of ignition test method

To reflect the commercial dimension of the standards barriers, an EU-wide survey was launched recently to directly exploit the results of the literature review by investigating the impact of current (restrictive) standards on the European RACHP industry and its customers. The goal of the study is to map available technology and product groups using hydrocarbon refrigerants, their expected future availability, and the impact of standards on such market developments. ■ AG

Industry stakeholders and end users are invited to participate in the survey, the results of which will be a reference for the standard-making processes and wider communication on the topic. Contribute to the survey and help remove the barriers for hydrocarbons: <http://www.surveygizmo.com/s3/4150423/LIFE-FRONT-WP3-2-Survey!>



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Pega's quest

Award-winning professor, researcher and entrepreneur Pega Hrnjak continues to search for ways to optimise the use of natural refrigerants in myriad HVAC&R applications.

– By Michael Garry



Pega Hrnjak

Photography by
Seth Lowe.

When Predrag Hrnjak – known universally as Pega – was a visiting scholar at the Technical University of Denmark in the early 1980s, he took a trip to the Norwegian Institute of Technology in Trondheim, Norway, where he met Gustav Lorentzen.

Lorentzen, already a renowned thermodynamics scientist, would secure his place in history in the late 1980s by rediscovering how CO₂ could be used effectively as a refrigerant in cooling and heating.

"I saw him at his desk meeting with a student," Hrnjak recalled recently in an interview with *Accelerate America* at Creative Thermal Solutions (CTS), his research and consulting business in Urbana, Illinois. "He radiated strength, knowledge and charisma. Later, when I talked to him, he strengthened the initial impression he made. In a relatively short time, he left a deep impression. It was clear why they called him Iron Gustav."

Hrnjak, a charismatic and deeply knowledgeable figure himself, would also go on to leave an indelible mark on the global HVAC&R industry, helping to advance the CO₂ revolution that Lorentzen and his last Ph.D student Jostein Pettersen set in motion, and making significant contributions in many other applications as well.

Born in Belgrade, Yugoslavia (now Serbia), Hrnjak received a doctorate from the University of Belgrade, where he taught for many years. He resettled in the United States in 1993, becoming research professor at the University of Illinois at Urbana-Champaign, as well as co-director and then director of the University's Air Conditioning and Refrigeration Center. He founded CTS in 2003.



Pega Hrnjak with transcritical CO₂ system for high-ambient conditions

In 2011, his accomplishments were recognised at the International Congress of Refrigeration in Prague, Czech Republic, where he fittingly received the prestigious Gustav Lorentzen Prize, one of many awards he has received. "That award reminded me of the man who influenced not only me but the entire world," he said. (Lorentzen passed away in 1995.)

Ammonia is another natural refrigerant for which Hrnjak has made major contributions, particularly in the development of microchannel heat exchangers that dramatically reduce its charge. This charge reduction technology, which he originally designed in the 1990s, has helped bring about the recent growth of low-charge systems and packaged units in industrial refrigeration, including an 'ultra-low-charge' system made by CTS itself.

CTS has grown from a small house and Quonset-style lab to a five-building campus, including 49 temperature- and humidity-controlled environmental test rooms and a 120-seat conference room. It employs 42 full-time employees – more than half with advanced degrees – including engineers, physicists, brazing

experts, metallurgists, machinists, and refrigeration, mechanical and electrical technicians.

Known globally as a hub for HVAC&R research, CTS is a kind of engineering playground, where Hrnjak and his crew can explore the fundamentals of heat transfer in creating their own innovations while at the same time helping clients optimise their HVAC&R systems. From 50% to 60% of its projects involve natural refrigerants.

"Whether natural refrigerants will take all applications in refrigeration, air conditioning and heat pumps – that remains to be seen," said Hrnjak. "But I'm absolutely certain that their growth is getting stronger and their operation is getting dramatically better – efficient and inexpensive. We will see more natural refrigerants in every segment."

CTS's clients span several industries, from automotive and residential to food retailing and industrial refrigeration. CTS has also worked on power generation, military, aircraft and space applications. For the military, it created a refrigerated vest that could keep soldiers from overheating in the desert.

Hrnjak sees CTS as a bridge from the more theoretical work he does at the University of Illinois to real-world projects that can be commercialised. "The objective from the beginning was to make prototypes and new systems, evaluate them, and present these new technologies with results in real conditions," he said.

CTS prides itself on being "unbiased and independent," he said. This, for example, enables CTS to be called upon to help in standards development. After working on several SAE International (Society of Automotive Engineers) standards, CTS is currently working a hot-gas defrost project for AHRI that "will result in a standard that's the same as an ongoing project for ASHRAE," he said.

With its myriad of projects across industries and applications, CTS is able to take advantage of the cross-fertilisation of ideas. "This is our great opportunity," said Hrnjak. "[Other places] stay in their own silo."

As a researcher pushing for the upper limits of HVAC&R systems, Hrnjak takes the long view of technology acceptance. "To be more than a niche application, it can take 20 years," he said. "Look at CO₂. We have been working with CO₂ for more than 20 years; it goes up and down and up and down – it's never completed."

Just as he was inspired by Lorentzen and carried on his mission, Hrnjak has a message for the colleagues and students who will succeed him:

"Try to go beyond the tracks that have been running for many years. Think about inexpensive, good ways to improve efficiency and capacity and reduce cost with creative, innovative approaches. Don't be shy of that."

■ MG



ASSESSING HFOs' ENVIRONMENTAL IMPACT

A report released by the Norwegian Environment Agency in December looked at the impact of these low-GWP refrigerants.

– By Michael Garry

HFOs or hydrofluoroolefins are unsaturated organic compounds composed of hydrogen, fluorine and carbon, which are looked on as low-global-warming-potential alternatives to hydrofluorocarbons (HFCs).

One drawback of HFOs is that they produce an atmospheric by-product called trifluoroacetic acid or TFA.

A report commissioned by the Norwegian Environment Agency, released in December, called the '*Study on environmental and health effects of HFO refrigerants*', noted that currently the consensus among academic experts is that "TFA will have a negligible effect on the environment".

The report, prepared by UK-based consultancy Risk & Policy Analysts Ltd., is based on a review of existing academic and 'grey' literature on the topic, as well as consultation

with stakeholders, including an HFO manufacturer, a reclaimer of HFO refrigerants, academic experts, a non-governmental organisation and a refrigeration industry association.

However, the report pointed out a number of "knowledge gaps" that would need to be filled to support that conclusion, including studies on the cycle of TFA in the atmosphere and hydrosphere, the amount of TFA used globally, and other potential sources of TFA in the environment.

Notably, the report said the risks presented by TFA – a highly durable chemical – increase if emissions of HFOs such as R1234yf increase. "[TFA] is very persistent and concentrations of TFA will only be expected to increase," it said.

As a result, the report suggests taking pre-emptive measures with regard to HFOs. "Phasing out HFOs (and consequently TFA), or emission reduction strategies along with best practice measures that help ensure efficient capturing of HFO/TFA during recycling operations, will help reduce the risk to human and environmental health."

The largest risk to human health, the study added, "is likely to be close to areas of production facilities and urban areas where it is used in devices for personal and domestic use".

The HFO R1234yf has an atmospheric lifetime of about six days, after which it degrades completely into TFA, the report said. In the atmosphere, TFA is partitioned into droplets of clouds, rain and fog, "with

wet precipitation assumed to be the major source of TFA in the biosphere," it said.

TFA is found in a wide range of water bodies, including rivers, streams, lakes and wetlands. Of tested aquatic organisms, only the alga *Raphidocellis subcapitata* "displayed sensitivity to TFA," said the study.

It also enters soils on its way to aquatic environments, the report said. But no studies have been reported on concentrations of TFA in crops for human consumption, both raw and processed foods, it noted.

In a study on toxicity of TFA, the study reported that the ECHA (European Chemicals Agency) critiqued studies on pre-natal development toxicity in a rat or rabbit. "ECHA considers that there is not sufficient weight of evidence from several independent sources of information which would allow to assume/conclude that the substance does not have a particular dangerous property, i.e., reproductive toxicity," the report said.

Responding to the report, Janos Maté of Greenpeace said: "There is no credible reason for governments to accept at face value industry's claims regarding the safety and technological benefits of HFOs."

Greenpeace called on governments to set production quotas on HFOs so that industry is curtailed in its commercial aspirations for these products. ■ MG

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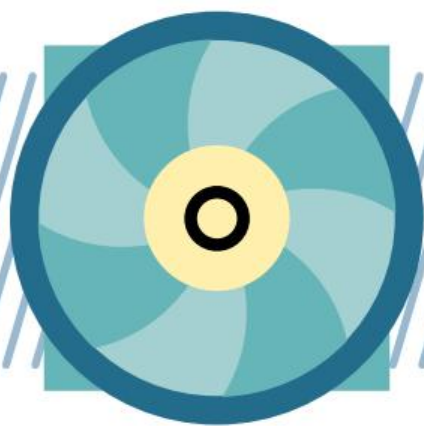


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FROM COOLING YOUR FOOD...

While refrigeration continues to make big strides towards natural refrigerants, air conditioning is still lagging behind. *Accelerate Europe* reports.

– By Charlotte McLaughlin

Around the world, every segment of the HVAC&R market – from commercial and residential to industrial – is taking the natural refrigerant plunge. Yet progress is faster in some sectors – and in some geographies – than in others.

A report produced by the Replenishment Task Force of the Technology and Economic Assessment Panel (TEAP) – an advisory body to the Parties to the Montreal Protocol (the treaty which is phasing out ozone-depleting refrigerants and has been amended to also phase down HFCs) – argues that, “by 2020 around 75% of new refrigerators will likely contain [hydrocarbon, HC] R600a (a small proportion using HC-HFO blends), with the remainder containing HFC-134a or HFO-1234yf”.

The light commercial sector is also increasingly moving towards hydrocarbon refrigerants such as propane (R290), isobutane (R600a) and propylene (R1270). Austrian company AHT Cooling Systems GmbH estimates

that it currently has some 1.5 million plug ‘n’ play hydrocarbon cabinets operating worldwide; it is producing new units at a rate of over 300,000 per year.

The number of CO₂ transcritical supermarkets in the EU, Norway and Switzerland, meanwhile, has tripled in the last three years. It is now estimated to represent 12% of the overall food retail market, according to research conducted by sheccoBase, the market development arm of shecco, publisher of this magazine. Ammonia, meanwhile, has long had a strong foothold in industrial refrigeration.

“Europe has led the way in the adoption of natural refrigerants since the introduction of the new F-Gas Regulation,” Manuela Rallo of Italian HVAC&R equipment manufacturer Tecnofreddo told *Accelerate Europe*. “It is still playing a pivotal role in stimulating innovation and green technology in the HVAC&R sector, to move away from high-GWP HFCs,” says Rallo, sales area manager at the firm, which includes propane chillers in its portfolio.



...TO COOLING YOUR OFFICE

Air conditioning (AC), by sharp contrast, does not boast the same number of natural refrigerant-based systems. Yet with demand for comfort cooling expected to soar – UN Environment estimates that global stock will reach \$1.5 billion by 2030 – electricity consumption and greenhouse gas emissions will increase too unless significant market changes take place to meet climate commitments.

The air-conditioning sector, which is often the largest source of electricity demand in warm climates, is booming thanks to increasing urbanisation, rising incomes and falling air-conditioner prices in many developing economies. This means by 2030 an additional 700 million units will be added to the global air-conditioner stock, according to the Environmental Investigation Agency (EIA), an NGO. It should also be noted that 65% of HFC usage comes from air conditioning (UN Environment).

Global temperature increases, accelerated in part by emissions of greenhouse gases, are expected to increase demand still further. 2017 was the third consecutive year in which average global temperatures were more than 1°C above late 19th Century levels, according to NASA scientists.

Meeting the demand for air conditioning in a sustainable manner is therefore essential. A good way to start is by using propane chillers, which are traditionally used in refrigeration and process cooling, for air conditioning too.

“Propane will be one of the main refrigerants from 5-500 kW, which will be a cheap alternative to CO₂ and ammonia,” Jonas S. Nielsen, from Danish company Bundgaard (which focuses on chillers and heat pumps), told *Accelerate Europe*.

Nielsen argues that propane is a particularly successful refrigerant in water-loop systems in “small convenience stores and supermarkets

where the refrigeration system has to supply the condenser side in the integral cabinets in the shop, the air conditioning in the shops, the cold water for the ventilation system, and at the same time produce hot water for taps or the heating system”.

Equipment for propane chillers is also widely available. “Most of the principal components – including condensers and evaporators; filter driers; sight glasses; check valves; safety valves; shut-off valves; solenoid valves; pressure switches; and thermistors – are no different from those fitted in an HFC or HCFC refrigerant chiller,” notes a 2016 report by the UK-based Chartered Institution of Building Services Engineers (CIBSE). “Expansion valves specifically designed for use with the operating conditions of the propane refrigerant should be fitted to chillers.”

Training & safety: Two sides of the same coin

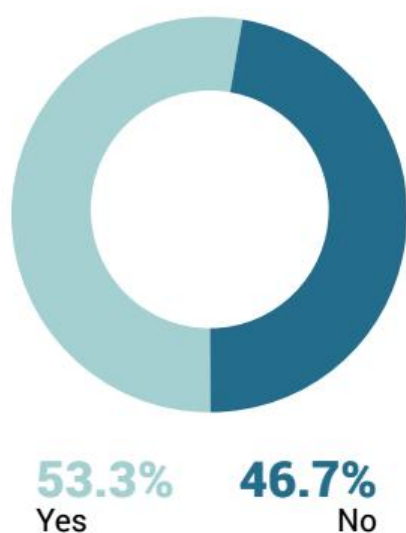
Though similar in design to chemical refrigerant-based systems, propane chillers do require manufacturers to pay extra attention to safety. "Propane's high flammability raises concerns from a safety point of view, both in use and maintenance. It is concerning that there is still a lack of R290 general safety standards and adequate training," argues Tecnofreddo's Rallo.

"More trained and certified technicians will accelerate the safe growth of this technology," Rallo predicts.

Italian chiller manufacturer Euroklimat is working hard to change this. "After the results of [a survey of 30 of our customers], we really believe that bigger efforts in training on hydrocarbon refrigerants are necessary," Giulia Fava, product developer at Euroklimat, told *Accelerate Europe*. The company organises customer training sessions focused on the safety devices it uses in propane chillers.

Is training on hydrocarbon refrigerants available in your country?

(30 respondents)



Euroklimat propane chiller

"Today, there are a lot of companies and training centres in Europe that are specialised in hydrocarbons," says Fava, noting that perception remains a problem.

Beyond Italy's shores, UK-based Cool-Therm is also providing training to improve awareness of the specificities of flammable refrigerants in the context of the HFC phasedown.

"We are working hard with clients and consultants through our 'Continuous Professional Development' programmes to ensure the need to move away from HFC refrigerants is clearly understood," says Emma Pender, marketing consultant at Cool-Therm.

Keeping the hydrocarbon charge as low as possible is as important as training the people working with the technology.

"From Tecnofreddo's point of view, as a manufacturer, the key is to limit the charge of propane. Less charge in the system will involve less security actions to take," Rallo says. "Appropriate components that limit refrigerant charges, control possible leaks and allow the extraction of any flammable substances, as well as electrical safety precautions, are some characteristics that Tecnofreddo has chosen specifically for this technology."



Tecnofreddo propane chiller

Marketing natural refrigerants

Rallo expects the market for propane chillers to grow substantially in the future. At the moment hydrocarbon systems account for just 5% of the Tecnofreddo products already operating worldwide.

The chiller manufacturer has installed its largest R290 air-cooled water chillers in a dairy and meat processing plant with a reversible heat pump.

"R290 chillers supplied for such applications were up to 400 kW, with one or more circuits, heat recovery (partial or total), hydronic modules, and using semi-hermetic compressors and equipped with EC fans, inverter and dedicated PLC," Rallo says.

Euroklimat, which primarily focuses on R290 chillers and heat pumps, is already seeing the market shift as a result of the EU F-Gas Regulation. "When we started, more than 10 years ago, the customers were predominantly based in northern European countries. Today, we have R290 chillers installed in many European countries and customers/consultants in England, Ireland, Norway, Sweden, Denmark, the Netherlands, Belgium, Switzerland, Germany, Austria, Poland, Romania, France and Italy," says Euroklimat's Fava.

She says large commercial refrigeration end users are driving the market.

In early 2018 the Italian company reports growing demand for its propane chillers. "Comparing January 2018 vs. January 2017, we can see a 50% increase in incoming R290 orders," Fava says.

Cool-Therm also expects sales to increase in 2018. "The European market is buoyant at the moment, driven by the need to move away from HFC refrigerants due to the f-gas legislation and the reduced quotas of HFC refrigerants now available," Pender says.

Cool'n Tool, a Polish company founded in 2014, is expecting sales of its modular small propane chillers to increase.

In 2016 7% of Cool'n Tool's product portfolio was for natural refrigerants CO₂ and propane, which Jessica Kuhle, the company's sales manager, predicts will rise to 37% within two years.

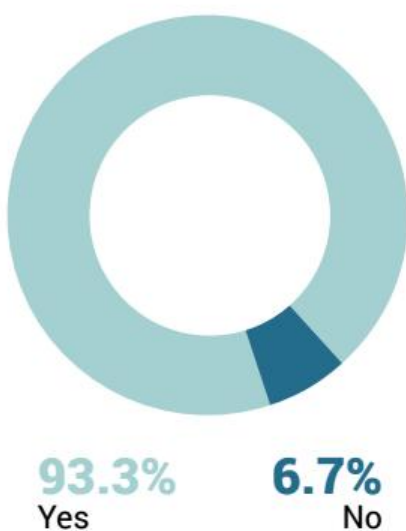
The company has so far installed natural refrigerant technologies in over 400 installations.

Manufacturers argue that the energy efficiency of propane chillers versus their HFC counterparts makes them a good solution.

Customers in warm climates stand to benefit from this technology. Tecnofreddo's Rallo gives a comprehensive account of why this is the case: "R290's behaviour shows a lower increase of energy consumption with increasing ambient temperature. More precisely, it has favourable thermodynamic properties and low energy requirements during compression."

R290 discharge pressures are also 20% lower with propane than with HFCs. "Lower operating discharge pressures reduce the work that the compressor has to do, thus improving the life of the compressor by improving stability of the refrigerant and lubricant," Rallo says.

In your experience, is R290 interesting for comfort applications?



Source: Euroklimat market research.

"The lower density of R290 also reflects the lower requirement of refrigerant mass, which results in better heat transfer coefficients in the evaporator and condenser. All these advantages equate to a big energy saving and efficiency compared to HFCs."

Fava agrees that the "maximum condensing temperature is very high, up to 65°C (Frascold semi-hermetic) / 70°C (Copeland Scroll)" which helps increase the efficiency of these systems.

Tecnofreddo's Rallo says: "Thanks to the peculiar thermodynamic properties, the energy consumption in hydrocarbon systems is between 12 to 15% lower than a similar application with R404A."

Euroklimat has measured the performance of propane compared to different HFCs like R410A, R407C and R134a, finding that the coefficient of performance is comparatively high.

Cool'n Tool agrees: "We estimate an energy consumption saving of round about 30% compared to 'traditional' technology by using propane chillers," says Kuhle.

The Polish company believes the secret to high efficiency comes down to an innovative heat exchanger that increases overheating and undercooling and provides a stable evaporating process.

The company's end users agree. "The energy consumption was reduced. Thanks to that, the number of defrosts could be changed from seven to four per 24 hours after the installation, an energy saving calculated to about 25%. I have also noticed a remarkable difference of the shelf life of the vegetables stored in the walk-in fridge," says Magnus Engeborn of the Radisson SAS Royal Viking Hotel, in Stockholm.

Magnus Pojen of McDonald's, which installed a Cool'n Tool unit in its Orebro restaurant, reports "savings in energy consumption between 25-40%".

Moving the air-conditioning market

The efficiency of propane could help make it a viable alternative to HFC-based chillers used in AC applications.

Cool Therm supplies some R290-based, air-cooled water chillers (mainly for comfort cooling applications in large commercial buildings) but has only supplied a limited number so far.

Tecnofreddo, meanwhile, hopes to enjoy similar success in the AC market to that which it is reporting for process cooling.

"Propane systems can be used in building air-conditioning systems, although their application in such sectors is a more recent practice. Although Tecnofreddo has provided propane chillers mostly for process cooling, the company believes that as long as charge limits and safety standards [are] regulated [well], there will be increasing demands for this type of technology in the building industry, since R290 presents a very good environmentally friendly alternative," says Rallo.

Euroklimat sees larger buildings as a promising future growth area for propane chillers. "We have different experiences of R290 chillers for air conditioning, especially for large buildings and high cooling demands," Euroklimat's Fava explains.

"We think that this is perfect business in which we need to invest, as we got the following information from a survey to our customers: 93% of them (from a sample of 30) believe that comfort applications are interesting for R290," she says.

Propane chillers, then, look set to move beyond refrigeration into air conditioning. Stay tuned for more on this story! ■ CM

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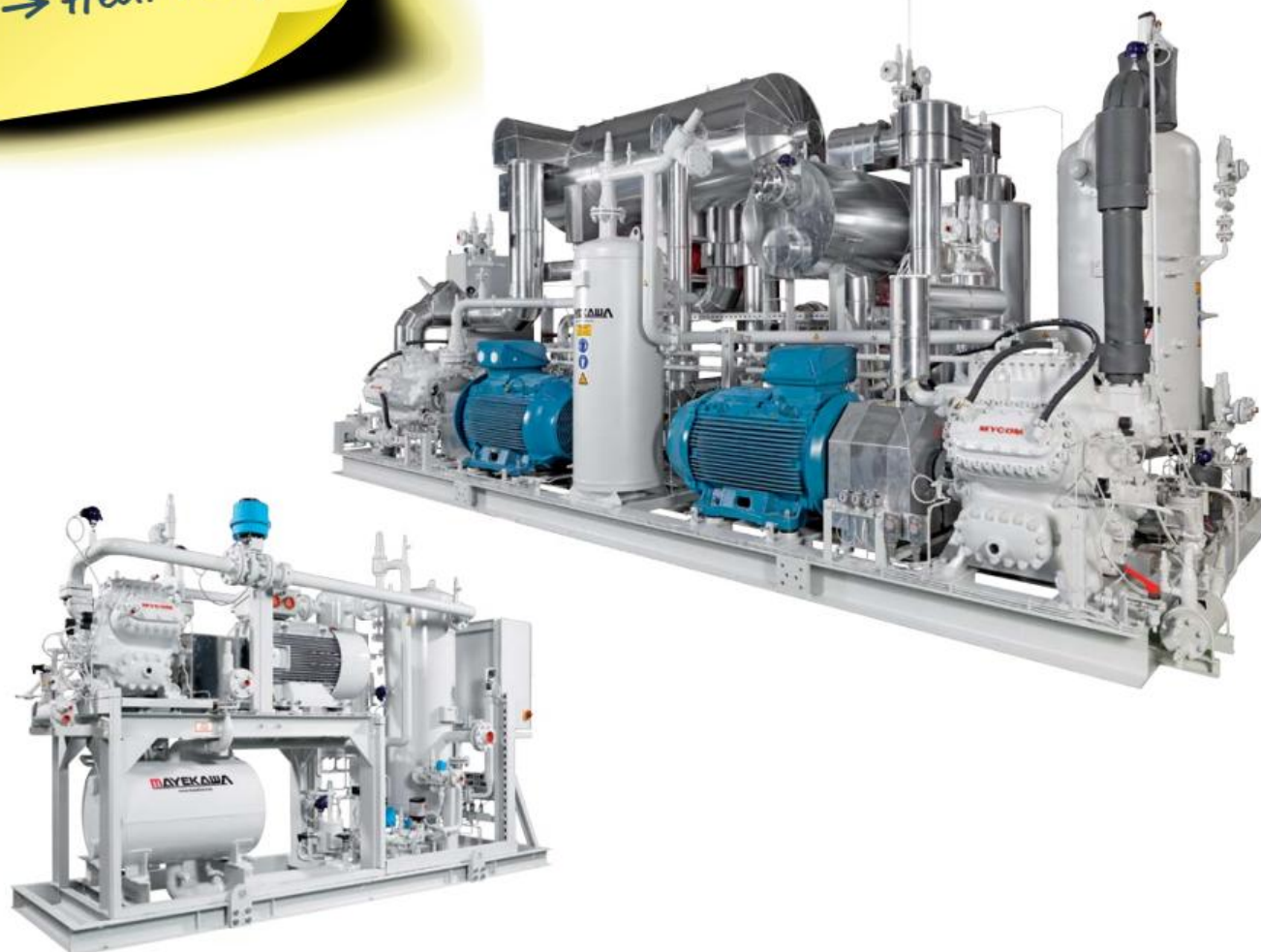
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