

SPRING 2019

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EUROPE

Joachim
Lemberg & team,
F. Hoffmann-
La Roche Ltd.

p. 22

An Icelandic
district-heating
saga

p. 18

How to build
an efficient
cold store

p. 72

Roche's
climate
remedy

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Leadership is about having the courage to do what's right. It's about seizing opportunities that others don't see. And it's about anticipating change to stay ahead of the game.

The most successful business leaders know this. With its global reach, the Roche Group understands the responsibility it shares to help put the world on a more sustainable environmental path. Hence the multinational biotechnology company's decision to phase out halogenated refrigerants. In Basel, Switzerland, I visited the Roche team to hear why natural alternatives are the best medicine for achieving this goal (p. 22).

Another highlight of this issue is a very special Icelandic district-heating saga. Turn to [page 18](#) to land in Vestmannaeyar, which will use an ammonia heat pump to help reduce energy costs.

Last year, Lidl France opened its first supermarket to use propane for 100% of its cooling needs. Since then and from now on, each of the retailer's new stores uses this natural refrigerant (p. 34). Aarstiderne, a Danish organic food delivery company, also chose to replace HFCs with a natural alternative (p. 32).

Ajinomoto is aiming to phase out HCFC and HFC use from its entire business by 2030 (p. 44). The frozen food manufacturer attended our ATMOsphere Japan conference in February, where natural refrigerant movers and shakers were recognised with *Accelerate Japan* awards (p. 52).

In the United States, the NHL and Chemours are promoting HFO blends R449A and R513A as 'green' refrigerants, but many rink operators may prefer ammonia and/or CO₂ (p. 38). Products that boost natural-refrigerant efficiency were on show at the AHR Expo in Atlanta (p. 48).

Early in 2019, industry experts interviewed for this issue are confident that the market for natural refrigerant-based HVAC&R solutions in Europe remains strong and steady (p. 60).

Lyon-based Carly understands the benefits of investing early in disruptive technologies. The French firm is confident that its commitment to natural refrigerants will keep it on an upward growth trajectory (p. 56).

Policy continues to help pave the way for a smoother transition away from halogenated refrigerants in Europe. France's 2019 Finance Bill, officially adopted last December, confirmed the entry into force of a tax on HFCs as of 2021 (p. 66).

Germany has chosen a different path, by extending its natural refrigerant subsidy programme until the end of 2021 (p. 65). The UK government, meanwhile, has provided guidance on administering the EU F-Gas Regulation in the event of a no-deal EU exit (p. 64).

Reducing electrical energy consumption in cold stores is a complex matter, but will become necessary to achieve EU energy efficiency goals. This issue's Technology Focus looks at what can be done to reduce the energy consumption of cold stores (p. 72).

The development of low-charge ammonia, meanwhile, is heading in two directions – packaged units and central systems. Experts from North America and Australia consider their respective merits (p. 68).

With so many exciting developments, the future is bright for supporters of natural refrigerants. Enjoy the issue!



ABOVE
Roche headquarters,
Basel



Andrew Williams
Editor

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About Accelerate Europe

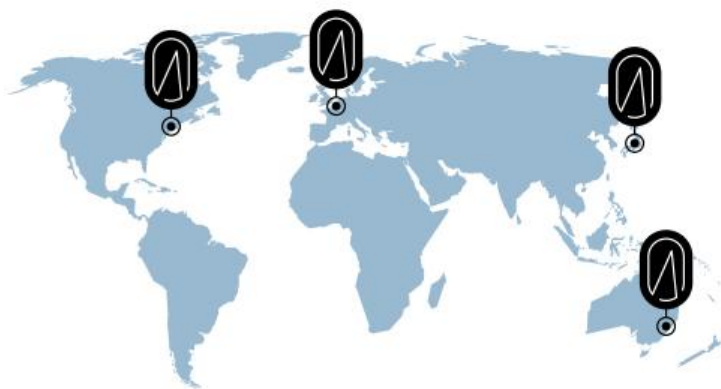
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MAR-

5-7.03

Futurebuild 2019
London, UK

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11-15.03

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Germany

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<https://ish.messefrankfurt.com/frankfurt/en.html>



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12-14.03

CFIA
Rennes, France

CFIA (*Carrefour des Fournisseurs de l'Industrie Agroalimentaire*) is a reference exhibition for the food-processing sector in Europe.



<https://cfiaexpo.com/en/exhibition>



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18-24.03

MCE IN THE CITY
Milan, Italy

MCE returns to Milan during Sustainable Energy Week organised by Milan Municipality.



www.mcexpocomfort.it/en/Events--Conferences/MCE-in-the-City



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2-4.04

Vending Paris
Paris, France

Vending Paris is a leading international exhibition for the automatic distribution sector.



<https://www.vendingparis.com/en-gb/the-show.html>



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MAY

11-13.04

Ammonia and CO₂ Refrigeration Technologies Ohrid, North Macedonia

The 8th International Conference on Ammonia and CO₂ Refrigeration Technologies.



https://www.mf.edu.mk/web_ohrid2019/ohrid-2019.html

6-8.05

Euroheat & Power Congress Nantes, France

The Euroheat & Power Congress focuses on topics related to district energy.



<https://www.ehpcongress.org>



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13-17.05

EU Green Week 2019 Brussels, Belgium

EU Green Week 2019 puts the spotlight on implementing EU environmental law.



https://ec.europa.eu/info/events/eu-green-week-2019_en



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15-16.05

Heat Pump Forum 2019 Brussels, Belgium

The Heat Pump Forum 2019 puts heat pump technology at the centre of the debate on the energy transition.



<http://www.hp-forum.eu>



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7-9.05

Seafood Expo Global Brussels, Belgium

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EUROPE IN BRIEF

New Serbian CO₂ transcritical booster system

Soko Inžinjeri, a Serbian producer and installer of RAC equipment, exhibited its first CO₂ transcritical booster system at a HVAC&R show in Belgrade, Serbia in December 2018.

The booster system is a custom unit, which the Serbian company will bring out in six cooling capacities, according to Jelena Jergović, marketing manager at Soko Inžinjeri.

The transcritical booster system will be sold commercially once final testing is finished. "We had to design and plan carefully every detail for the product's development. For the Serbian market, CO₂ cooling is still not as common as in some foreign markets," said Jergović. ■ **MGM**

Electrolux offers R290 in foodservice equipment

Electrolux, one of the world's biggest home appliance manufacturers, has been using propane (R290) in its 'ecostore' cabinets for catering and foodservice since January.

"The introduction [of] R290 [...] is the latest step on our sustainability journey," said Steve Bowler, design and product manager at Electrolux Professional UK. "Not only will it help extend the operational life of the application-critical components within the unit, ensuring the unit's performance will remain at the high level we expect, but R290's enhanced environmental credentials will ensure our impact on the planet is kept to an absolute minimum." ■ **CM**

Denmark ends district heating heat pump grants

The Danish Energy Agency, having awarded 33 heat pump projects a total of DKK 51.3 (€6.87) million from 2017 to 2018, is now ending its grants for district heating heat pumps.

"This was the last round of applications to the subsidy for large heat pumps for district heating," said Michele Rosa, an advisor in the supply centre at the Energy Agency.

According to the Danish Technology Institute (DTI), Denmark boasts 41 large natural refrigerant-based heat pumps with capacities ranging from 0.2 to 10 MW. ■ **CM**

Tumble dryer harnesses R290 heat pump

The Siemens IQ700 tumble dryer, with a European Union Energy Label rating of A++, uses an R290 (propane) heat pump, according to Siemens.

Using a heat pump system allows the tumble dryer to achieve considerably shorter drying times than before, according to the German white goods manufacturer.

It also uses a self-cleaning system, which makes the condenser obsolete and keeps energy consumption constantly low, Siemens says.

It also can be connected to an app, allowing customers to access and control the dryer remotely. The tumble dryer is on sale throughout Europe. ■ **CM**

SCM Frigo CO₂ condensing unit wins 'Refrigeration Product of the Year'

The CUBO₂ Smart CO₂ condensing unit by Italian system manufacturer SCM Frigo (a parent company of Beijer Ref) won 'Refrigeration Product of the Year' at the UK's National ACR & Heat Pump Awards 2019 in January.

The event, organised by UK HVAC&R magazine ACR Journal, was held on 24 January at the Midland Hotel in Manchester, UK.

"I think this is very important for the SCM FRIGO team who worked hard to make the CUBO₂ Smart a successful product," commented Nicola Pignatelli, SCM Frigo's managing director, on winning the award. ■ **CM**

'Europe's first' professional school for HVAC&R technicians opens in Italy

A professional school for HVAC&R technicians opened in Magenta, a suburb of Milan, Italy, in February. The school is the fruit of a partnership between Italian heating and cooling trade associations *Assocold*, *Assofrigoristi* and *ASLAM*, a professional institute.

The school, which according to Italian OEM Epta is the first of its kind in Europe, will offer training sessions on a continuous basis to teenagers and adults.

Students will learn how to work with CO₂ and propane-based systems. The facility also boasts a reproduction of an entire CO₂ transcritical supermarket. ■ **DB**

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EUROPE IN BRIEF

Refrigera 2019: CO₂ CDUs on rise in Italy

On 20-22 February 2019, the first edition of the Refrigera tradeshow was held in Piacenza, Italy. Refrigera is Italy's first tradeshow dedicated to the Italian HVAC&R market, and will be held every two years.

CO₂ condensing unit (CDU) manufacturers Panasonic and SCM Frigo reported growing demand in Italy's convenience store market. "Now we have 20 [CO₂ CDUs] in Italy," said Giorgio La Motta, national key account manager at Panasonic.

Nicola Pignatelli, managing director of SCM Frigo (part of the Beijer Ref Group), expressed enthusiasm. "It's happening; there's a good trend," Pignatelli said. "We're doing a lot of training [at the Beijer Ref CO₂ Academy in Italy]." ■ CM

R290 split AC training comes to Germany

The *Bundesfachschule Kälte-Klima-Technik* (BFS), a German technical school based near Leipzig, will soon offer training on propane-based (R290) split air-conditioning (AC) systems.

BFS Principal Dr. Ralf Catanescu is happy that, "students can practice with new products to study similarities and differences to conventional technologies in order to prepare them for upcoming new technology solutions in the market," according to the Green Cooling Initiative (implemented by German aid agency GIZ Proklima).

"Given its compliance with the appropriate safety standards, the installation of such a unit follows the same steps as for any other conventional split AC unit," said Christopher Bösel, a lecturer at BFS. ■ CM

Low-charge NH₃ chillers deliver energy savings at Snozone

After installing two Star Refrigeration low-charge ammonia Azanechiller 2.0 units in 2017, Snozone Milton Keynes – an indoor skiing and snowboarding venue that ranks among the UK's top indoor leisure attractions – is celebrating multiple savings on electricity and CO₂ emissions.

In only four months, Snozone saved 56% on electricity bills and reduced CO₂e emissions thanks to the efficiency of the Azanechiller 2.0.

The two ammonia-based units, which replaced the original HFC chillers, provide a cooling capacity of 360 kW and use Vahterus plate and shell heat exchangers to minimise the ammonia charge to only 85 kg per chiller. ■ AR

Huurre to retrofit Finnish ice rink with CO₂

In 2019, Huurre (a supplier of CO₂ refrigeration systems and automation solutions) will retrofit the *Euromaster Areena* in Ylöjärvi, southern Finland, with a digital CO₂ energy system.

The Euromaster ice arena, which is currently using climate-damaging f-gases, will replace them with CO₂ (a refrigerant with a GWP of 1), according to Finnish system provider Huurre.

This is the first digital CO₂ energy system to be used in Finland. It employs Huurre's ECO ICE DX equipment and software, using CO₂ as the refrigerant, which is "digitally steered, [and uses] groundbreaking direct expansion technology [guaranteeing] that it is uniquely energy-efficient," said Huurre. ■ CM

ALDI Nord employs CO₂ integrated HVAC tech in new Spain store

In November 2018, German retailer ALDI Nord opened a new supermarket in Estepona (near Malaga, Spain) using a CO₂ transcritical system that integrates HVAC and refrigeration technology, reports Spanish HVAC&R news website *interempresas.net*.

ALDI Nord's choice of system for the new Spanish store matches the firm's wider strategy of adopting a mixture of natural refrigerant-based technologies that also service its HVAC needs.

The Estepona store employs CO₂ transcritical refrigeration technology using parallel compression, provided by Spanish company Tewis Smart and installed by local firm Friex. ■ CM

New CO₂ plant for UK food-processing company

Greencold has installed a new CO₂-based cooling plant at a food-processing firm in the United Kingdom. The plant, which has a cooling capacity of 180 kW, comprises six identical cooling chambers for low-temperature blast chilling of meat down to -20°C.

For the end user, the choice of CO₂ was motivated by price and the desire for future-proof technology, according to Greencold.

The customer initially considered an ammonia-based pumped recirculation system. But this was subsequently ruled out due to price, space, delivery time and site-specific safety considerations. ■ RM

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Can we achieve the high efficiency required in the future?



Alexander Cohr Pachai,
Technology and product
manager (CO₂ systems),
Johnson Controls Denmark

Alex has extensive experience of implementing natural refrigerant-based HVAC&R projects around the world, also using ammonia, hydrocarbons and water.

There is currently much focus on increasing the efficiency of refrigeration systems. Numerous studies have been made over the years, and many showed that refrigeration system performance was not always optimal. In most cases, it was found that the system efficiency could be improved by better controls settings, cleaning of heat transfer surfaces, removing air and dirt from the system, and so on.

Without wishing to point fingers, very often this lack of efficiency points in the following different directions. The customer or the end user of the system is not aware of the problem, or they are not able to solve it on their own. In other cases, the level of technical expertise on site is not adequate, and due to a lack of training, the technician does not know the consequences of changing set points or skipping proper servicing of the system.

The solution to this is right in front of us. We need better education and training of staff to help them to understand the processes and the requirements needed to keep the system running at optimal efficiency. In principle, you may say that even the best system will fail without proper service and maintenance.

For many years, the standard EN 13313 has been the standard reference within the EU when discussing the skills of competent persons. This standard has

now become an ISO standard (ISO/DIS 22712), which means that it is relevant in most parts of the world where ISO 5149 is being used. The standard describes the minimum required skills of persons performing tasks ranging from design to decommissioning of a plant, including service and maintenance. This means that it is important for everyone who works with a system surrounding a refrigerant to be able to provide proof of being competent for the specific task he/she is performing.

When discussing the future requirements for higher efficiency, it is a little difficult to be conclusive, because this is a moving target. What we do know is that the impact of human activities must be reduced in general. This includes more cycle economy-oriented strategies, less air pollution, less harmful waste in nature, protection of fresh potable water and groundwater, clean oceans free of plastic, and so on.

Furthermore, we are running out of important resources such as copper, which is one of the main parts of efficient electrical motors. The human race has caused the extinction or near-extinction of many species of mammals, fish, insects, and so on, and if pollution continues, energy efficiency will be the least of our problems. The survival of humanity is at stake. How much do we really care?



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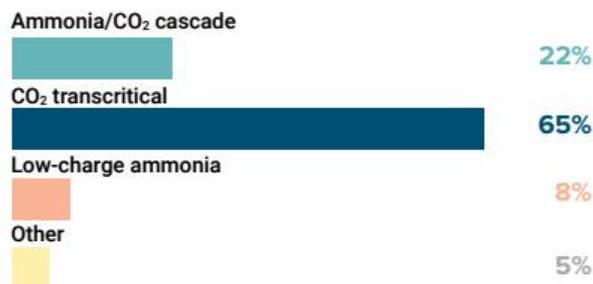


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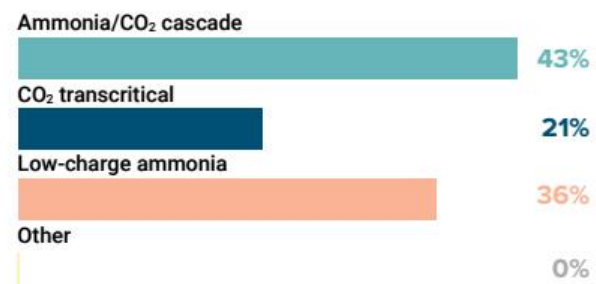


Which natural refrigerant-based technology holds the biggest potential for industrial refrigeration in your region over the next five years?

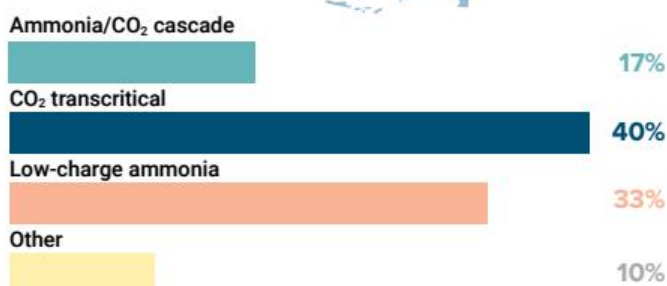
EUROPE



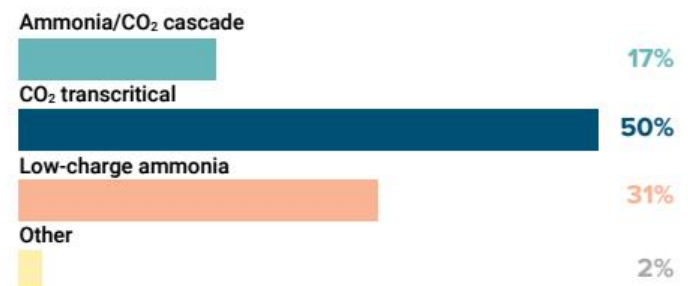
NORTH AMERICA



ASIA



AUSTRALIA



Participants in 2018 ATMOSphere events, a series of natural refrigerant conferences organised by shecco, publisher of this magazine, were surveyed on what natural refrigerant-based technology holds the greatest potential for the industrial refrigeration sector. Their feedback was collated through sli.do polling at ATMOSphere America (28 answers), ATMOSphere Asia (30 answers), ATMOSphere Australia (48 answers) and ATMOSphere Europe (96 answers), held in various locations throughout 2018.



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FROM LAVA TO AMMONIA: AN ICELANDIC DISTRICT- HEATING SAGA

Vestmannaeyjar's district heating system has been running on lava and electric boilers. It will now use a 10 MW ammonia heat pump system.

— By Charlotte McLaughlin

Iceland's Vestmannaeyjar once had "one of the weirdest district heating systems ever designed" — it ran on lava from a volcano, Ragnar Ásmundsson from Varmalausnir — Heat RD tells *Accelerate Europe*.

The story begins in 1973, when the Eldfell volcano erupted on Heimaey ('Home Island'), the largest of the Vestmannaeyjar ('Westmen Islands' in English), an archipelago, municipality and group of 15 islands in southern Iceland. The lava came in handy.

"They had lava flowing through half of the town. So obviously they left. Then they came back and thought to use the heat from the lava for the district heating system," explains Ragnar, who was in charge of installing a new ammonia heat pump that services over 4,200 inhabitants in the municipality.

After the eruption, residents were able to exploit the lava for 10 years, says Ívar Atlason, regional manager of district heating company HS Veitur's Vestmannaeyjar operations. The young Ívar fled Heimaey for the mainland back in the 1970s.

"By 1988 the heat from the lava was gone," Ívar says. "We've been using the electric boiler to heat up water [for residents' homes ever since]. Now [we'll use a] heat pump to heat the water."

Guzzling electricity

Unlike lava, which provided more or less free energy for 10 years, electric boilers are costly — especially for district heating. "We were using an electric boiler to produce vapour and a heat exchanger to heat up the circulation water, [but] the electricity price [keeps] going up," Ívar observes. "It always goes up. Electricity prices are not going down."

Energy costs have steadily increased in Iceland amid demand from heavy industries such as aluminum smelting and production of ferrosilicon, which consume nearly 80% of all the electricity generated in the country, according to *Orkustofnun*, the National Energy Authority of Iceland.

"It's been evolving in that direction. The district heating companies always have more of a struggle to get the same low prices they used to have," says Varmalausnir — Heat RD's Ragnar, whose company provides different heating solutions across the land of ice and fire.

"Heat costs just a quarter of the price of electricity. You're downgrading the value of electricity if you turn it directly into heat," Ragnar argues.

In most of Iceland, district heating companies — most of which are owned by local government — are able to exploit natural geothermal energy just under the surface.

"They tried to look for geothermal [in Vestmannaeyjar] and there are many wells there. In my former job I participated in a project there some years ago," Ragnar says. "But we couldn't find a good source. The island is more or less porous. You have seawater running through it, so it cools down any geothermal system that could possibly survive there."



Heimaey, Vestmannaeyjar, Iceland

Photography: Ívar Atlason, HS Veitur

HS Veitur (owned by various local municipalities in southwest Iceland) produces heat for Heimaey residents, via electricity delivered by undersea cables. 1 kW of electricity generates 1 kW of heat.

The new ammonia heat pump, the first of its kind for district heating in Iceland and the second that Ragnar's company has installed, will produce 3 kW of heat for every 1 kW of electricity when it is completed.

"Where did we get the 2 kW from? It comes from the sea. We don't have to pay for heat from the sea. So that was the reason we started building the heat station – we won't spend as much money on electricity," HS Veitur's Ívar told *Accelerate Europe*.

Gulf Stream warms Vestmannaeyjar residents

In winter, the waters around Vestmannaeyjar reach lows of around 6°C. In summer, the water temperature gets up to 12°C. "We are basically monitoring the temperature to see what it actually is [...]. We are in the best location for this kind of application in Iceland – thanks to the Gulf Stream, the seawater current goes directly through the island or passes by," Ragnar says.

The 10 MW ammonia heat pump system uses four screw compressor heat pumps (each 2.5 MW) from Danish

“They had lava flowing through half of the town. So obviously they left. Then they came back and thought to use the heat from the lava for the district heating system.”

– Ragnar Ásmundsson,
Varmalausnir – Heat RD



1 /

company Sabroe (part of Johnson Controls), an evaporator from Alfa Laval that has titanium plates to prevent problems with saltwater on the receiver, and a cluster of heat exchangers (including the de-superheater, the condenser and the sub-cooler) from Finnish firm Vahterus.

"[The district-heating water] enters the condenser at roughly 35°C and then achieves up to 77°C on the condensing side. That's what's delivered to the customers in the town. Most of them are connected with water pipelines and they receive water in a closed system," Ragnar says.

The heat pumps have a coefficient of performance (COP) of roughly three, which both Ragnar and Ívar are confident will make them the perfect solution for local residents, who mainly work in the islands' fishing and tourism sectors.

"We were talking about 8-10 years [for return on investment], but if the electricity price is higher than we expect, then the payback will be 6-7 years. It all depends on the price of the electricity," Ívar explains.

Residents are looking forward to enjoying lower heat prices over the heat pumps' 40 or so years of operation, upon the project's completion in spring 2019. "The community is very positive about it, because we think in the near future, we can lower the price of the heat," Ívar says. "Everyone on the island is happy with this project." ■ CM



2 /

1 / The new ammonia heat pump facility on Heimaey.

2 / Inside the facility.

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THE NATURAL REFRIGERANT TREATMENT

The Roche Group is committed to phasing out halogenated refrigerants. *Accelerate Europe* visits the multinational biotechnology company at its headquarters in Switzerland to hear why natural alternatives are the best medicine for achieving this.

— By Andrew Williams

In the city of Basel, Switzerland, international cooperation is a way of life. Bordering France and Germany on its outermost edges, it is little wonder that the city is an outward-looking place. This easy confidence makes Basel the natural home of multinational biotechnology company F. Hoffmann-La Roche Ltd. (more commonly referred to as Roche), whose high-rise headquarters looks out on all three countries.

The Roche Group, founded in 1896, is split into two different divisions – pharmaceuticals and diagnostics. Focusing on oncology, immunology, ophthalmology, infectious diseases and neuroscience, Roche ranks among the world's leading developers of targeted treatments combined with corresponding diagnostics. It is also a leading provider of clinically differentiated medicines.

Roche Pharmaceuticals is the world's largest biotechnology company and the world's leading provider of cancer treatments.



Roche by numbers (2018)

- ▶ 30 medicines developed by Roche are included in the World Health Organization Model Lists of Essential Medicines.
- ▶ In 2018, 127 million people were treated with Roche medicines. 20 billion tests were conducted with Roche diagnostics.
- ▶ Group sales of CHF 56,846 million. R&D core investment: CHF 11,047 million. Average spend per day on R&D: CHF 30 million (2018 figures).
- ▶ In 2018, the Roche Group employed 94,442 people worldwide.

Sustainability at Roche

- ▶ Since 2010, Roche has reduced scope 1 and scope 2 greenhouse gas emissions by -52% per employee, reducing energy consumption by -34% per employee in the same period.
- ▶ Absolute scope 1 and scope 2 greenhouse gas emissions cut by 2.1% in 2018.
- ▶ In 2018, Roche's total energy consumption decreased by 1.3% while sales grew 7%.
- ▶ 15.1% increase in sustainable energy use in 2018, bringing the total share of sustainable energy to 21% of consumption.
- ▶ In 2018, chemical waste (incinerated and landfilled) decreased by approx. 85% over 2017.
- ▶ Since 2010, a total of 1,546 energy-efficiency projects have been completed (2018 figures), resulting in an avoidance of approximately 208,267 tonnes of CO₂ emissions. This has led to an estimated cost saving of approximately CHF 47.1 million.

1/ F. Hoffmann-La Roche headquarters in Basel, Switzerland.

With its global reach, Roche understands the responsibility it shares to help put the world on a more sustainable environmental path. "Eliminating halogenated substances in all areas is a big step to achieving our goals here," Dr. Joachim Lemberg, Roche's head of safety, security, health and environment (SHE) data analysis and reporting, told *Accelerate Europe* at the company's Basel headquarters.

The Roche Group's commitment to phasing out halogenated refrigerants is governed by the K6 Directive, one of 24 mandatory corporate directives that every part of the Group must follow. Lemberg is part of the team responsible for implementing K6.

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

The company applies the policy of adopting natural refrigerants where reasonably possible to all the above applications.

The K6 Directive guides Roche in discontinuing its use of substances that have a negative impact on the environment caused by ozone depletion, global warming or persistence in the atmosphere with potential long-term negative effects.

"We have a clear target of phasing out these substances 100%," says Thomas Wolf, Roche's chief environmental sustainability officer. "We want to eliminate them completely."

Wolf held Lemberg's current position until 2012 and was a key figure in getting Roche's halogenated refrigerant phase-out programme off the ground.

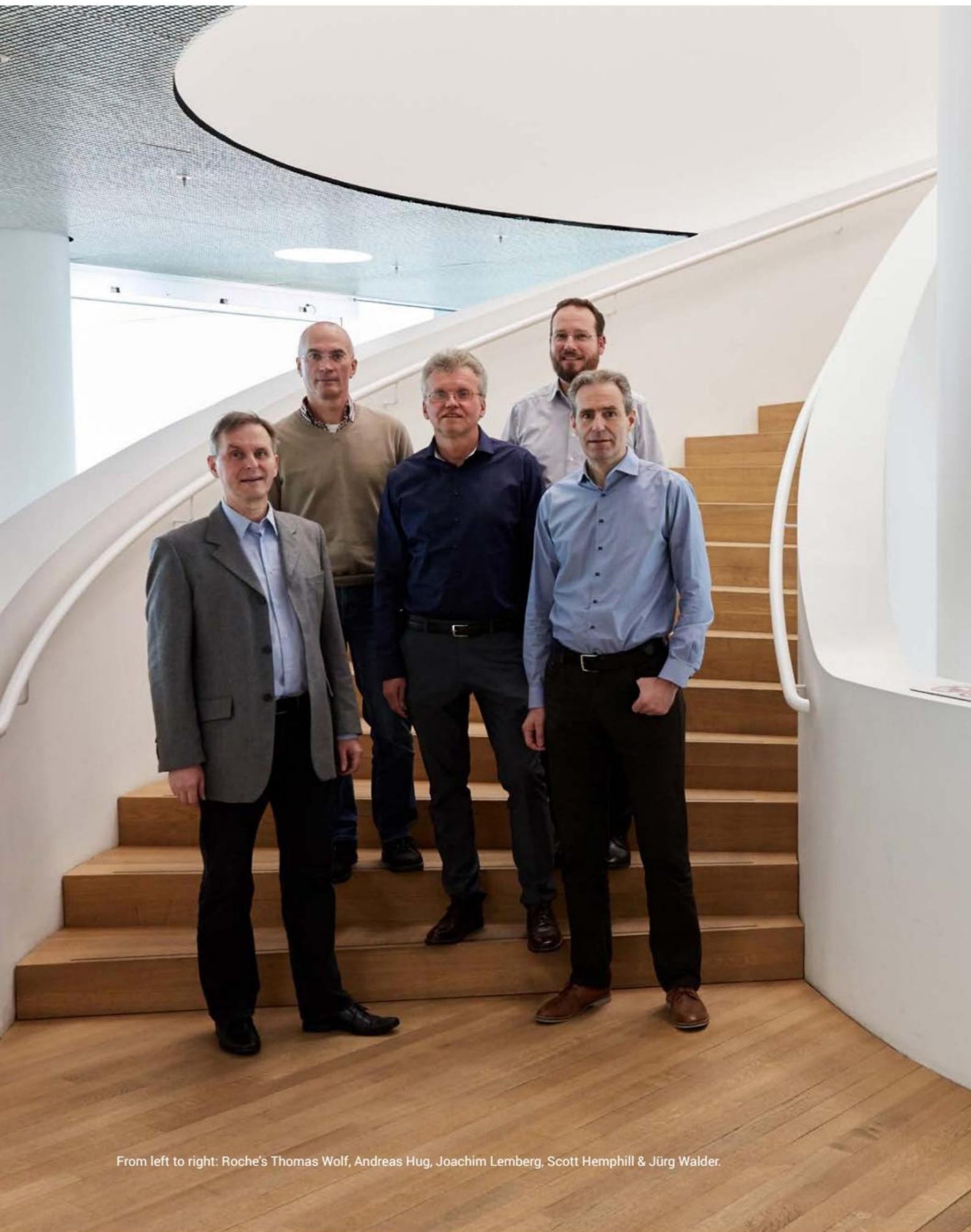
"Other companies harbour similar aspirations to ours, but I can't think of another firm that's as progressive in pursuing these goals as us," Wolf says.

The journey began in the early nineties, when Roche decided to put in place a strategy for dealing with ozone-depleting substances (ODSs). One trigger was the entry into force on 1 January 1989 of the Montreal Protocol on reducing their production and consumption. Later on, the Kigali Amendment to the Montreal Protocol – which was signed on 15 October 2016 and entered into force on 1 January this year – retrospectively confirmed the wisdom of Roche's early move to include HFCs in the global phasedown picture.

"We wanted to stay ahead of any potential new legislation in countries around the world," says Lemberg.

The first edition of the K6 Directive was published on 22 September 1994. "This is when we formally adopted the ambition to phase out ozone-depleting substances," Lemberg says.

Roche's primary target was to eliminate ozone-depleting substances – CFCs, HCFCs and HBFCs (hydrobromofluorocarbons) – by 31 December 2015, which it nearly



From left to right: Roche's Thomas Wolf, Andreas Hug, Joachim Lemberg, Scott Hemphill & Jürg Walder.

achieved. Only small residual amounts were left over, which were then eliminated in 2016.

Starting from 95 metric tonnes, that left 9.5 metric tonnes of fluorinated gases (f-gases) – namely HFCs and PFCs (perfluorinated compounds) – in the Roche Group's inventory. By 2018, there were just 7.5 tonnes of f-gases left. The ultimate goal is to eliminate them all.

While Roche sought to replace ODSs with alternative solutions like natural refrigerants from day one of the K6 programme, in certain cases it installed HVAC&R equipment using HFCs and PFCs as an interim step for business continuity reasons. "But it didn't take long for scientists to discover that fluorinated gases contribute to global warming," Lemberg recalls.

Next, Roche set its sights on completely eliminating its inventory of halogenated refrigerants as well. On 20 December 2002, it formally extended the scope of K6 to target a 100% phase-out of both substance classes – ODSs, and HFCs and PFCs.

When did natural refrigerants come into the picture? Wolf picks up the story. "We began to adopt natural refrigerant systems at the very beginning of the K6 process," he says. "Now we're much stricter about this, after we tightened our approach in the early 2000s."

Scientific uncertainty surrounding the environmental impact of halogenated refrigerants was a key factor influencing Roche's decision to replace them with natural refrigerants instead.

"We decided to eliminate halogenated refrigerants not just because they damage the ozone layer and contribute to global warming, but also because their ultimate impact on the climate and environment is not yet fully understood," says Jürg Walder, global lead – sustainability in the global technical operations department of Roche's pharmaceutical division.

"As a large company, Roche wants to demonstrate that it's an opinion leader on this," Walder says. "We want to go further than what's required by legislation."

Less than 1% of the Roche Group's greenhouse gas emissions come from halogenated refrigerants in refrigeration and cooling plants. Instead, the majority are attributed to the use of energy and for the most part comprise CO₂, according to the company's latest Sustainability Report.

NEW BUSINESS MODELS

Roche strives to apply the precautionary principle in evaluating different technology options. Its HVAC&R portfolio is no different in this regard.

Some halogenated refrigerants end up as trifluoroacetic acid (TFA), which ends up on land or in the oceans. "The anthropogenic increase in TFA that is attributable to HFCs, and its ultimate impact on the environment, is not yet entirely understood," Lemberg says.

As HFCs are phased down, some users of HVAC&R technologies are turning to hydrofluoroolefins (HFOs) – the new generation of synthetic refrigerants – as replacements. But HFOs are an issue of concern for some environmental agencies.

In 2017, a report on HFOs by the Norwegian Environment Agency recommended that a number of "knowledge gaps" needed to be addressed before the ultimate effect of the chemical decomposition in the atmosphere of R1234yf into TFA could be determined. It recommended pre-emptively phasing out the refrigerant. Similarly in 2018, Germany's *Umweltbundesamt* (Federal Environment Agency) warned that TFAs could contaminate the water supply and cannot be removed after contamination has taken place.

Did Roche consider going down the HFO route? Lemberg could not make his opposition any clearer. "No way! We ban them. This is part of our precautionary principle. It's Annex 5 of the K6 Directive," he says.

Walder is keen to offer his own thoughts. "The chemical companies have had some 30 years to develop a new business model," he says. "But every new generation of refrigerants they have come up with has harmed the environment."

He calls on synthetic refrigerant makers to develop new business models based on natural refrigerants instead. "They could involve technology vendors in this, because in most cases, the end user does not buy refrigerants," he suggests.

Pharmaceutical companies need specialist laboratory and production equipment. This can pose a challenge for the halogenated refrigerant phase-out in a technology segment with few alternative options available.



From left to right: Roche's Clemens Keiser, Joachim Lemberg, Thomas Wolf, Andreas Hug & Jürg Walder.

Basel in the spotlight: Installation 1

- ▶ CO₂ transcritical double-stage system.
- ▶ Serves two cold rooms used for storing pharmaceuticals.
- ▶ Cold room -25°C (25 kW). Most of the products are stored at -20°C.
- ▶ 2 x 71 kW with four compressors
- ▶ 12.5 kW engine (compressor)
- ▶ 110 kg CO₂ per chiller
- ▶ Primarily runs in subcritical mode, harnessing groundwater to improve efficiency.
- ▶ Rack manufacturer: Goetz



Installation 1: CO₂ transcritical double-stage system.

"Take centrifuges and climate chambers, for example – the market does not offer us the alternatives that we need," says Scott Hemphill, global environmental sustainability expert in Roche's diagnostics division.

In this sense, Roche is an incubator for new technologies. "In a big multinational company like this, you have the opportunity to make a real difference," Walder says. "This incubation role that we play wouldn't be possible in a smaller company."

He cites pharmaceutical laboratory equipment as an example. "The thermostats we use were only available for HFCs. We spoke to our vendors, and they were willing to invest in new technical development of natural refrigerant-based alternatives," he says. One such vendor, Huber, mentions this on its website.

Wolf, meanwhile, urges potential new suppliers to capitalise on this market for new technologies. "When companies as big as Roche ask for something, they see that there is a clear incentive for them to develop it," he says.

"By designing something completely new, they're giving themselves a cutting edge that distinguishes them from the competition," Wolf adds. He cites the development of a chiller based on the Stirling thermodynamic cycle by a US-based company as an example. "Genentech ensured that company got the funding it needed to develop it in the numbers required," he says.

**“ELIMINATING
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A BIG STEP TO
ACHIEVING OUR
SUSTAINABILITY
GOALS.”**

– Joachim Lemberg, Roche

Phasing out halogenated refrigerants entirely poses a number of challenges. In some applications, natural refrigerant-based alternatives are not yet readily available at the scale required by Roche. In others, it is more cost-effective to wait until equipment reaches the end of its useful life.

The third edition of the K6 Directive, adopted on 21 April 2011, took account of this by setting a 90% phase-out as an interim target with fixed timelines. And the current fourth edition, adopted on 1 December 2013, extended the scope of the directive to include leased assets – whereupon a new challenge arose.

“We don’t own the buildings, but we want to be K6-compliant,” Lemberg says. “We have to convince the landlords who own the buildings, who it can be difficult to influence.”

Walder cites the Group’s operations in the United States as an example here. It has terminated the lease contracts on some premises in San Francisco because they still use HCFCs.

As Roche moves towards a 100% phase-out of halogenated refrigerants, soon the group will put in place new targets for the period 2020-2025 – perhaps a reduction by a further 20-25%, Lemberg says. “This will be harder to achieve, because the low-hanging fruits have already gone.”

Most of the HCFCs and HFCs in the Roche Group’s inventory are contained in large chillers used in major manufacturing facilities. In some cases, the existing technology is yet to depreciate. “We have to look at the best cost-benefit ratio, which means running them until the end of their lifetimes,” Walder says.

He stresses the importance of considering the net benefit for the climate when replacing existing equipment with newer technology. “You basically have an eleven-year period from 2011 to 2022, where we have to reduce 90% of 82.2 tonnes,” he explains.

The 82.2 tonnes refers to the total amount of halogenated refrigerants left in the new Roche Group’s inventory following the acquisition of two wholly owned subsidiaries in the United States – biotech firm Genentech and diagnostics company Ventana Medical Systems. Both are covered by the halogenated refrigerant phase-out, albeit with different timelines.

Chugai Pharmaceutical Co., Ltd., part of the Roche Group, is not included in the scope of the K6 Directive.

Roche sought to eliminate ODSs from both US entities by 2018, by which time it managed to reduce the inventory to 2.3 tonnes remaining. By 2022, it wants to reduce non-ozone depleting substances too, to 8.3 tonnes. It has already achieved a reduction from 82.2 tonnes in 2011 to 47.3 tonnes in 2018.

The Roche Group’s halogenated refrigerant phase-out strategy applies to all new acquisitions. Hemphill picks up the thread.

“According to the K6 Directive, all ozone-depleting substances must be removed within five years of making an acquisition and all HFCs and PFCs must be removed within 10 years,” says Hemphill. Roche Diagnostics has acquired 11 companies since 2011. All must therefore fulfil the directive’s requirements.

Roche incorporates product stewardship into product design. “We produce our products in an as environmentally friendly and efficient manner as possible,” Walder says. “Often the natural refrigerant-based system is simply more efficient than the HFC one.”

Indeed, as natural refrigerants acquire a greater market share, competition between different options is increasing in certain applications. “We use CO₂ for cold chambers, ammonia for big chillers, and hydrocarbons for applications both large and small – particularly for air conditioning in office buildings,” says Walder.

In April 2018, Roche Diagnostics opened its first manufacturing facility in Asia. All the HVAC&R on site – in Suzhou, China – uses natural refrigerants.

“**AS A LARGE COMPANY, ROCHE WANTS TO DEMONSTRATE THAT IT’S AN OPINION LEADER ON THIS.**”

– Jürg Walder, Roche



Roche's Clemens Keiser (left) and Andreas Hug (right)
at an ammonia installation in Basel (see overleaf).



Basel in the spotlight: Installation 2

- ▶ 11 MW ammonia system
- ▶ 2 x 5.5 MW chillers – York (JCI)
- ▶ 1,000 kg ammonia per chiller
- ▶ 1.3 MW engine (compressor)
- ▶ System provides chilled water at +6°C for process cooling, air conditioning and dehumidification as part of the site's district cold supply system (pharmaceutical and biotechnology production facilities are the main consumer).
- ▶ Compressors: York Sabroe
- ▶ Heat exchanger: Alfa Laval
- ▶ System housed in self-contained room. Scrubbers ensure that ammonia emissions to the atmosphere are almost zero.
- ▶ Operates 24/7 in summer; according to demand in winter.
- ▶ No remote monitoring required.
- ▶ Installed in 2007.

Pictured: Installation 2

Roche conducts regular environmental audits on all its sites around the world to ensure compliance with K6 and other directives. Should the audit team uncover deficiencies, headquarters will intervene to address them. Procurement managers and engineers are made aware of the HVAC&R strategy and all new equipment purchases are assessed for K6 compliance.

The K6 Directive also stipulates how Roche Group entities must dispose of equipment, a process that Hemphill and the rest of the team keep a close eye on.

"All our f-gases must be disposed of by waste vendors that Roche has approved," says Hemphill. "We take responsibility for that and document compliance with the K6 Directive in our processes."

At Roche, just like in any large company, implementing major change is a complex matter. The challenges range from the financial and organisational to the technical and personal. "We would not be able to achieve our goals without strong governance and commitment," Lemberg says.

The team is proud of the transformative role that Roche plays in implementing a halogenated refrigerant phase-out programme on such a large scale.

"We're achieving something that's making a huge contribution to what the company wants to achieve," says Lemberg. "We can see the outcome, and it's rewarding."

■ AW

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DROPPING OFF CO₂-COOLED FOOD

A Danish organic food delivery company decided to replace its HFC-based refrigeration systems with CO₂ in 2018.

— By Charlotte McLaughlin

Like many organic food delivery companies in Europe, Denmark's Aarstiderne works in a very straightforward way – simply packing the growing season's best organic food into a box, adding easy-to-make tasty recipes, and delivering it all straight to your door on a subscription basis.

For the last 20 years, the firm has stored food for door-to-door delivery in facilities cooled by HFCs, which is not in keeping with its environmental principles.

"Our success criteria were to get a future-proof system that we could expand while also getting rid of some of our old, standalone HFC systems," said Thomas Slott, COO/CFO, Aarstiderne, "so that we could reduce our energy consumption and reduce our carbon footprint".

"We wanted a solution that produces fewer emissions and protects the environment – and that aligns perfectly with our philosophy. Of course, our investments need to reflect that. That's why the CO₂ system entered the picture," Slott says.

The organic food seller asked JF Køleteknik A/S, a Danish installer of HVAC&R systems, to develop a CO₂ cooling solution to help reduce its greenhouse gas emissions. It was installed and commissioned in early 2018.

"With the cooling capacity we've installed so far, we have removed 40 kilos of HFCs with an average GWP of 3,500," says Morten Hansen, owner of JF Køleteknik A/S. "Those 40 kilos multiplied by 3,500 are the potential CO₂ emissions that we've removed."

"By comparison, we now have 200 kilos of CO₂, which has a GWP of 1. Also, the CO₂ that we're using is actually purified waste gas from gas burners, boilers, and so on, so we're using gas that would have ended up in the atmosphere anyway!" Hansen says.

Aarstiderne's Slott adds: "I'm looking forward to doing the carbon accounts for 2018."

The CO₂ system, with components from Danish multinational Danfoss, cools the 40,000 such crates of food

that are delivered each week from Aarstiderne's facilities at its Barritskov manor near Barrit, located in central Denmark.

The CO₂ system's cooling capacity is 147 kW, which can be scaled up to 175 kW if Aarstiderne expands in future. "We definitely wanted a scalable solution," Slott says.

The AK-PC 782A controller, which was developed by Danfoss specifically for controlling compressors and condensers in transcritical CO₂ systems, is at the heart of the system. It allows both the installer and end user to check the progress of the cooling system online.

"The possibilities for documentation and technical support that I have with Danfoss make the difference to me," says Hansen from JF Køleteknik A/S. "I find Danfoss to be very responsive when we make constructive suggestions. I haven't seen that with other vendors that we've used."

The CO₂ system cools the stores and production rooms for packing the organic food boxes.

"It's been a great process," Hansen says. "The most important thing is that we've created something where we can safely say that we're doing something right for the environment, while also creating a sound business case for the people using the system."

Slott agrees. "To me, the environmental and financial considerations go hand in hand," he says. "And it has worked perfectly. It's a real win-win situation!" ■ CM



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Lidl France banking on propane

In August 2018, Lidl France opened its first supermarket to use propane, a hydrocarbon, for 100% of its cooling needs. Since then and from now on, all the retailer's new stores use this natural refrigerant.

— By Andrew Williams

Operating some 1,500 stores throughout France, Lidl France is acutely aware of the responsibility it shares to help put the world on a more environmentally sustainable footing. Active for almost 25 years, the retailer employs some 35,000 people nationwide.

HVAC&R represents a significant proportion of any food retailer's carbon footprint. In 2010, Europe's commercial refrigeration sector represented 40% of refrigerant greenhouse gas consumption, 85% of which was attributed to large refrigeration systems in supermarkets (which primarily used R404A), [according to a 2012 study](#) conducted for EPEE by UK-based environmental consultants SKM Enviro.

"This implies that supermarkets are the largest consumers of HFCs in Europe, with a share of about one third," the SKM Enviro study says.

According to a [2016 report](#) produced by Swedish research institute KTH for the EU-funded SuperSmart project, 18-30% of annual equivalent carbon emissions in European supermarkets are attributed to their choice of refrigerants (data: Carr-Shand et al., 2009).

Against this background, Lidl France decided to act. In August 2018, for example, Lidl Valenton in the Paris region (Créteil) became the first Lidl France store to use propane for 100% of its cooling needs. "Since then and from now on, our strategy is for all new stores to be 100% propane-based," Nabil Rehab, project manager – refrigeration systems, Lidl France, told *Accelerate Europe*.

By the end of the fiscal year 2018 (which ended in February 2019), Lidl France had converted the cooling furniture to propane in 40 stores.

"This fiscal year, we'll convert an additional 10% of our stores, pursue a programme of 'store transfer', and open new stores using propane," Yassine Rami, head of department (purchasing and store investments) at Lidl France, told *Accelerate Europe*.

"In total, we'll have 250 propane stores by the end of this fiscal year," Rami explains.

The retailer intends to change the cooling furniture in around 100 stores per year. "In a few stores we'll do retrofits, because they're using R404A," Rehab explains.

Lidl France is part of Lidl Stiftung & Co. KG, founded in 1930 by Joseph Schwarz and headquartered in Neckarsulm, Germany.

The parent company operates over 10,000 stores across 28 European countries and the United States. Its chairman and CEO is Dieter Schwarz, who also holds the same positions in hypermarket chain Kaufland.

1 / Lidl France is targeting 250 propane stores by the end of this fiscal year.

2 / Propane cases in Lidl Valenton, the first Lidl France store to be 100% propane-based.

Lidl first used propane in 2016, when it tested a propane system in a supermarket in Munich, Germany. Having initially also considered CO₂, another natural refrigerant, propane ultimately won the day.

What motivated Lidl France to follow suit and adopt propane too? Propane doesn't just reduce Lidl France's greenhouse gas emissions – it also delivers energy savings, Rehab says.

Moreover, installing plug-in and remote semi plug-in cabinets avoids the need for a centralised refrigeration plant. "Propane in itself is a very efficient refrigerant. What we're doing is decentralising production," Rehab explains.

A future-proof choice

The retailer is also acting out of concern for the climate. "The impact of HFCs on the environment today is significant. They make a major contribution to the greenhouse effect, and that's why climate science requires them to be phased down," Rami says.

"We want to stay one step ahead of that curve, while at the same time reducing our impact on the environment," he says.

Lidl France estimates that the cost of HFCs has increased four times over in recent years. "Part of the reason for this is that it's brutally overtaxed," says Rehab. "By choosing propane, we're anticipating such issues and staying one step ahead of such problems."



By 2022, Lidl France expects around 50% of its 1,500-strong store portfolio to be equipped with propane-based cooling equipment. "The move to propane was not primarily driven by economic considerations. It was environmental," Rehab says.

Lidl France's propane journey began within the company itself. "What Lidl France has done is rare – it organises regular meetings between the *frigoristes* (refrigeration technicians), the technology providers, and Lidl France itself," says Sylvain Gillaux, managing director (France) at Hauser, an Austrian OEM and cooling furniture maker that provides Lidl France with cabinets.

"Lidl France plays a kind of 'gentleman organiser' role to ensure that everyone is aligned, and to make their vision concrete," Gillaux says.

“Our strategy is for all new stores to be 100% propane-based.”

– Nabil Rehab, Lidl France

Making the business case

Lidl France's commitment to natural refrigerants extends to cold storage, where it uses either CO₂ or ammonia in all new warehouses. "The objective is to no longer use HFCs – they're polluting, there's going to be less and less of them (meaning that availability is an issue), and they're really expensive," Rami says.

The positive environmental impact of choosing natural refrigerants is clear. But some HVAC&R practitioners believe more could be done to demonstrate their economic advantages to customers.

"The choice that Lidl has made for natural refrigerants – not just in refrigerated cabinets but also for frozen goods, for cold stores, and so on – is ideological," says Gillaux.

"Lidl has decided that it must use natural refrigerants, for environmental reasons," he says.

“The objective is to no longer use HFCs – they're polluting, there's going to be less and less of them, and they're really expensive.”

– Yassine Rami, Lidl France

Gillaux thinks the onus is on manufacturers to communicate the business case for natural refrigerants more clearly. "Most retailers would expect to make huge energy savings, if they were to take the risk of changing to a new technology," he says.

Gillaux stresses the importance of training France's *frigoristes* to use natural refrigerant-based technologies. "This doesn't just take place in training institutes. Manufacturers such as us hold training sessions on new technologies," he says.

Regulation and safety concerns can represent obstacles to wider uptake of hydrocarbons, which are flammable substances.

International standard IEC 60335-2-89 currently limits the use of flammable refrigerants in hermetically sealed commercial refrigeration equipment with an incorporated or remote refrigerant unit or compressor to 150g.

To comply with the regulations, Lidl France uses three circuits per store. "Using three separate circuits of 150g gives us the capacity we need," says Lidl France's Rehab.

The 150g limit prevents refrigeration equipment manufacturers and users from fully exploiting the safe and efficient application of hydrocarbon refrigerants in the commercial refrigeration sector. The new limit on the table is 500g (see '[The home straight](#)', *Accelerate Europe*, winter 2018).

"Clearly, the furniture would be cheaper if the rules were adapted to allow up to 500g in a single circuit," Rehab says.

To strengthen the business case for natural refrigerants, he stresses the importance of looking at energy savings in a holistic manner.

600 of Lidl France's supermarkets already have cooling cabinets with doors, for example. "We hope to put doors on all our cabinets by 2022," Rehab says.

He argues that the environmental benefits of using propane, wedded to the efficiency benefits of other measures such as cabinet doors, air curtains and heat reclaim, is a powerful combination. "It's about improving the whole cold chain," he explains. ■ AW

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Ice rinks: Which refrigerant is best?

The National Hockey League and Chemours are promoting HFO blends R449A and R513A as 'green' refrigerants, but many rink operators may prefer ammonia and/or CO₂. *Accelerate America* reports.

— By Michael Garry

Ice hockey was first played on frozen ponds, which are freezing later and melting earlier as a result of climate change.

Acknowledging the sport's fundamental link to the environment and its preservation, the National Hockey League (NHL) – the 101-year-old organization now consisting of 31 professional ice hockey teams across Canada and the United States – launched the [NHL Green](#) initiative in 2010.

"Most of our players learned to skate on outdoor rinks," said NHL Commissioner Gary Bettman, in announcing the program. "For that magnificent tradition to continue through future generations, we need winter weather – and as a league we are uniquely positioned to promote that message."

For help in 'greening' league games and operations, the NHL consulted with the National Resources Defense Council (NRDC). Each NHL team appointed one or more sustainability representatives to liaise with the league.

In March 2018, the NHL released its second sustainability report, which reported that the majority of NHL arenas still use R22 or HFCs as refrigerants, with about 20% using ammonia.

R22's days are numbered as production and imports of the gas in North America are slated to end in January 2020. In May, the NHL promoted what could be a replacement refrigerant for R22, announcing a multi-year partnership with the U.S.-based Chemours Company to provide Opteon XP40 (R449A) and Opteon XP10 (R513A) to rinks across North America. (The announcement did not disclose any financial terms.)

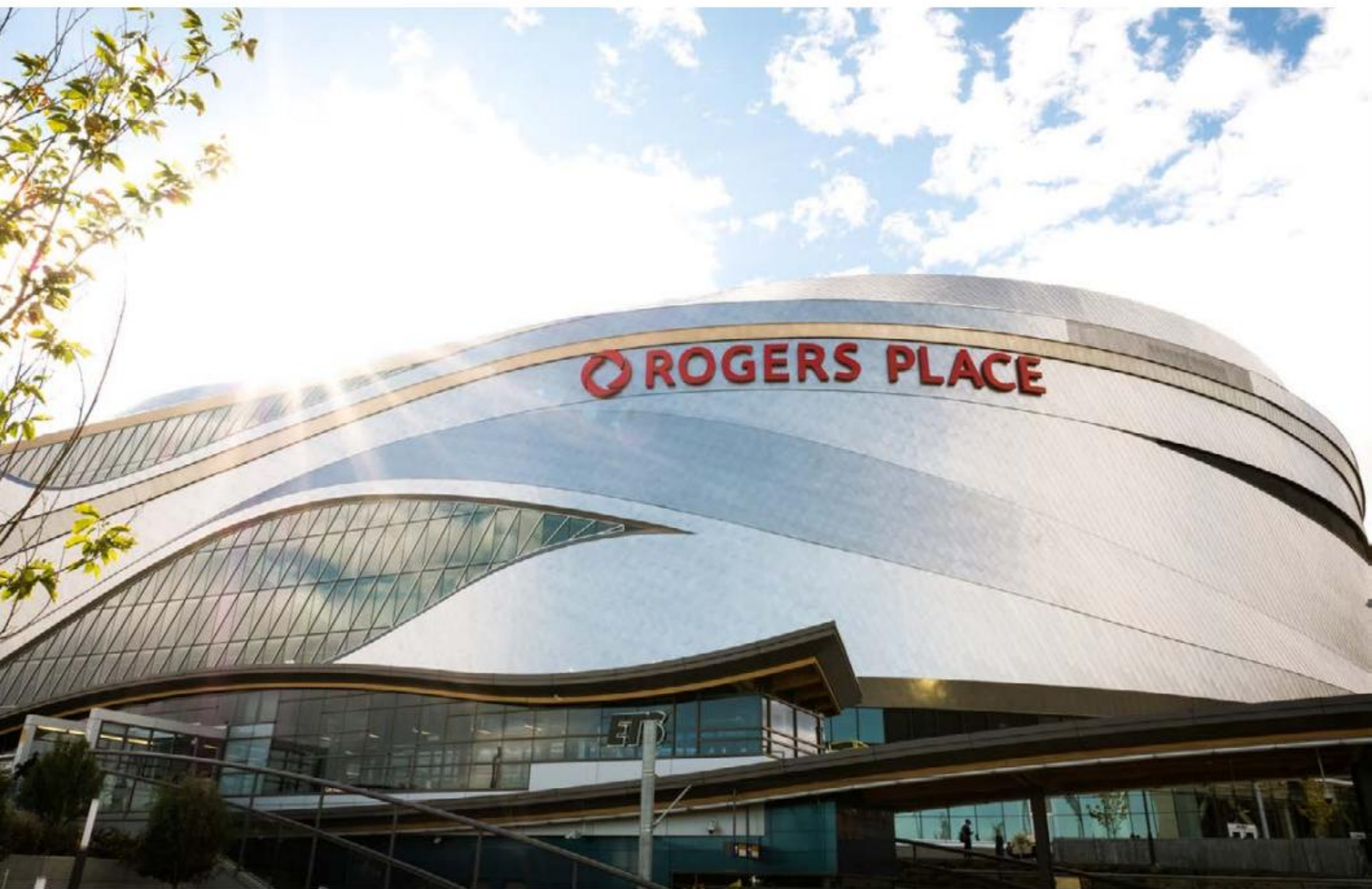
The NHL and Chemours view this partnership as continuing the league's environmental stewardship, saying in the announcement that it "supports the NHL Greener Rinks Initiative".

But are R449A and R513A the most environmentally sustainable refrigerants to use in ice rink systems, particularly in new facilities?

A number of industry stakeholders point to natural refrigerants ammonia and CO₂ as more sustainable and future-proof for ice rinks than the Opteon refrigerants being promoted by the NHL.

"It would be a shame if the NHL bypasses any opportunities to adopt truly low-GWP alternatives such as CO₂ and ammonia," said Christina Starr, climate policy analyst for the Washington, D.C.-based Environmental Investigation Agency (EIA). "Particularly for new rinks and systems,





Rogers Place, home to the NHL's Edmonton Oilers.

these alternatives are available, proven, and offer opportunities for energy improvements over HFCs as well as direct climate benefits."

Operationally, natural refrigerants have performed well in studies of ice rink systems (see the complete story in [Accelerate America, Nov.-Dec. 2018](#) for more). A 2013 study by the Canadian government's CanmetENERGY research group found that CO₂ systems had the best COP (coefficient of performance) for refrigeration and heating (3.9), followed by NH₃ (3.0) and HFCs (2.6); and the lowest annual energy consumption (111,748 TR / 393 MW per hour), followed by ammonia (149,281 TR / 525 MW) and HFCs (173,735 TR / 611 MW).

The global warming potential (GWP) of R449A is considerably high, at 1,282. R513A's GWP (573) is about half that of R449A, but it is still considerably higher than the GWPs of ammonia (zero) and CO₂ (one), making it vulnerable to phase-outs

in U.S. states like California that are looking at capping GWP in non-residential refrigeration systems at 150.

Do NHL teams want these blends?

The NHL declined to be interviewed for this article, deferring questions to Chemours, a chemical producer formed in 2015 as a spinoff of DuPont.

Allison Skidd, Chemours' North America marketing manager (fluorochemicals), described the NHL-Chemours partnership as providing "options for community rinks across North America that are faced with the need to address environmental regulations as well as economic sustainability concerns".

As to which refrigerant or system the 31 NHL teams will ultimately employ, "each team or arena owner will be the final decision-maker after considering the many factors for their situation," said

Skidd. No NHL arena is known to have used Opteon refrigerants to date.

Meanwhile, NHL players have given an endorsement to ammonia. In November 2018 the Edmonton Sun reported that Rogers Place, home to the NHL's Edmonton Oilers, ranked second in ice rink quality in a poll of NHL players, coming in only behind the Montreal Canadiens. Both teams use ammonia-based ice rink systems.

Many ice rink operators are using ammonia as a primary refrigerant coupled with brine or glycol as a secondary refrigerant. Ice rink arenas in North America and Europe are increasingly using CO₂, both in direct and indirect (secondary) systems.

Asked to compare Opteon refrigerants with ammonia and CO₂, Skidd said, "as A1 ASHRAE safety class refrigerants, Opteon XP10 and XP40 offer improved safety – with respect to toxicity and flammability – versus R717 [ammonia].

They also operate at lower pressures than R744 [CO₂], which favorably impacts chiller efficiency, system reliability, and operating cost”.

Sabres and Oilers tout ammonia

Ammonia continues to be a refrigerant employed by NHL teams, including recent installations by the Detroit Red Wings, Buffalo Sabres, Edmonton Oilers, and the Las Vegas Golden Knights. (The Los Angeles Kings recently installed a CO₂ ice rink system.)

The NHL has also employed an ammonia/glycol system to support its annual outdoor games played on temporary rinks in baseball and football stadiums across North America.

Last year, the NHL’s Buffalo Sabres replaced its 21-year-old R22 system with an ammonia-based system, which uses less electricity, said Ian Ott, senior manager of media relations for the team.

“It’s been performing very well,” he added. “Our ice quality is excellent. We haven’t had much in the way of maintenance costs.”

The Edmonton Oilers’ Rogers Place opened two years ago with an ammonia/glycol system supporting two rinks with 400 TR (1,406.74 kW) of capacity.

NHL stars such as Sidney Crosby of the Pittsburgh Penguins and the Oilers’ Connor McDavid have endorsed the ice. The Oilers previously played at the Northlands Coliseum, where they used an ammonia/brine system.

“I’m a fan of ammonia refrigeration,” said Jason Rimmer, director of engineering and ice operation at Rogers Place. “Even for the simple fact that if there’s a leak, you know it. Freon is colorless and odorless, so if your detector is not working properly, you won’t notice a leak.”

Rimmer also prefers ammonia to Freon from an efficiency point of view. His energy costs are also reduced by virtue of the NH₃ system’s heat recovery, which serves an indoor garage at Rogers Place and its hot water supply. “It’s capable of generating 6.25 million BTUs per hour (1,831.69 kW),” he said.

It would be a shame if the NHL bypasses any opportunities to adopt truly low-GWP alternatives such as CO₂ and ammonia.

– Christina Starr, Environmental Investigation Agency

The Rogers Place low-charge system uses only 550 lbs (226.7 kg) of ammonia. "I feel comfortable using it, as there are many safeties in play," Rimmer said. "Additionally, we ensure all of our department is trained in different situations by both classroom training as well as performing drills."

First NH₃/CO₂ system in North America

Ammonia in combination with CO₂ has proved to be an effective refrigerant solution for ice rinks.

Three years ago, Art Sutherland, president and CEO of Accent Refrigeration Systems, Victoria, British Columbia, Canada, designed North America's first ammonia/CO₂ system for the Wells Fargo Sports Complex practice ice rink at the University of Alaska's arena in Anchorage, replacing a leaky direct system with 6,000 lbs (2721.6 kg) of R22. A separate machine house was built for the NH₃/CO₂ system.

"It's a great system," said Glenn Thomas, refrigeration technician for the University of Alaska. "It will last a long time and produce much better ice."

Ammonia/CO₂ is a more expensive option than other systems but offers the best total cost of ownership, said Sutherland. "It's a fairly long payback – over 10 years – but [the energy

efficiency] gives you a payback over the lifetime of the system," he said. Thomas noted that maintenance cost savings alone were considerable.

Sutherland believes an ammonia/CO₂ system is more efficient than a CO₂ system, though CO₂ produces high-grade heat for reclaim while NH₃/CO₂ generates low-grade heat.

But Benoit Rodier, director of business development at CIMCO – a Canadian industrial refrigeration firm and a leading supplier of ice rink equipment to the NHL – contends in Canada's cooler northern climate, transcritical CO₂ would be "a little more efficient than ammonia/CO₂," as well as less expensive. But for larger capacity rinks, NH₃/CO₂ would be needed, he added.

CO₂ refrigeration is a relative newcomer to the ice rink market, with the first installation in 2010 at an arena in Saint Gédéon, Canada. But it is gaining traction as a green alternative in the U.S. and especially in Canada, where there are more than 40 CO₂ ice rink systems, according to Marc-André Lesmerises, president and founder of Carnot Refrigeration, based in Trois-Rivières, Quebec, Canada.

Lesmerises said Quebec has the most installations. Though "there is a lot of interest coast to coast," CIMCO's Rodier argued.

Jörgen Rogstam, managing director of EKA (*Energi & Kylanalys*), a Swedish firm focused on ice rink efficiency, describes CO₂ ice rink development in Northern Europe, especially in Sweden and Norway, as "fantastic," adding that "the cost is lower than ammonia". In February, he estimated that there were 20 CO₂ systems in Europe. European CO₂ ice rink suppliers include Green & Cool, Advansor and SCM Frigo.

Carnot Refrigeration supplies CO₂ systems to ice rink arenas in the United States. Lesmerises believes CO₂ transcritical systems, direct or using a secondary brine/glycol, save more energy in ice rinks than any other system, including those using ammonia.

That's for two reasons, said Lesmerises: CO₂ generates the most heat reclaim; in addition, it is thermodynamically the most efficient system, especially for the many ice rinks that operate for nine months – not during the hot summer months when CO₂ may operate less efficiently. Combining heat recovery and system efficiency makes CO₂ "a no brainer," he said.

Ammonia and its natural refrigerant cousin CO₂, then, appear well positioned to become the de-facto future-proof alternatives for ice rinks.

■ MG

ICE RINK REFRIGERATION SYSTEM COMPARISON



COP for Refrigeration and Heating*

CO₂: 3.9
NH₃: 3.0
HFCs: 2.6



Annual Energy Consumption*

CO₂: 393 MWh
NH₃: 525 MWh
HFCs: 611 MWh



Global Warming Potential

CO₂: 1
NH₃: 0
R449A: 1,282
R513A: 573

*CanmetENERGY 2013 study on ice rink systems for Canadian government

sheccoBase





The Ajinomoto Frozen Foods management team in front of Mayekawa's NH₃/CO₂ refrigeration systems at a factory in Gunma, Japan.

Ajinomoto Frozen Foods to eliminate HCFCs by 2020, HFCs by 2030

Ajinomoto Frozen Foods, a major Japan-based food manufacturer, has been installing natural refrigerant-based HVAC&R systems for nearly a decade. Aiming to completely phase out HCFC and HFC use from its entire business by 2030, the company is proud to help lead Japanese industry towards a more sustainable future. *Accelerate Japan* reports.

— By Devin Yoshimoto, Rena Okabe & Tomoro Sato

Japan's ratification of the Kigali Amendment to the Protocol in December 2018 gave users of HVAC&R equipment there a clear policy signal to phase down the use of f-gases in their businesses – including HFCs.

Japanese food manufacturer Ajinomoto Frozen Foods Co., Ltd. has already made significant progress in this regard. It has been retrofitting its facilities with natural refrigerant systems for close to a decade now.

Headquartered in Tokyo, Ajinomoto Frozen Foods is a division of Japanese multinational Ajinomoto Co., Inc. – a food and amino science corporation best known for creating the original monosodium glutamate (MSG) product branded 'AJI-NO-MOTO'.

The company provides its products globally through the Ajinomoto Group, which makes, sells and conducts R&D into frozen food items in Japan as well as in Europe, Asia and North America.

In 2006, the company pledged to completely eliminate its use of R22 in freezer systems in its domestic food processing factories, replacing systems using this HCFC with natural refrigerant-based systems by 2020.

The move was motivated by increasingly strict regulations on the use of Freon that had been put in place in Japan since 2001, as well as the advent of global regulations such as the Montreal Protocol and its subsequent Kigali Amendment.

As of February 2019, the company had converted a total of 24 freezer units to natural refrigerant systems, with six left to be converted by 2020.

The company is striving to eliminate the use of HCFCs by 2020 and HFCs by 2030 from all of its domestic frozen and cold storage warehouses.

During a recent tour of one of the company's frozen food processing facilities, Ajinomoto Frozen Foods' Executive Officer Tomomitsu Yamasaki spoke to *Accelerate Japan* about the role that natural refrigerants play in the firm's sustainability initiatives.

At its food processing facility in Gunma, the company uses NH₃/CO₂ secondary brine refrigeration systems, provided by Japan-based OEM Mayekawa,



Tomomitsu Yamasaki, executive officer, Ajinomoto Frozen Foods Co., Inc.

in the product freezing process for several food items it sells, including the Japanese dumplings commonly referred to as 'gyoza'.

Asked about the company's motivation to transition to natural refrigerants, Yamasaki explains that, "by introducing natural refrigerant-based equipment, we have achieved a certain amount of energy efficiency".

"However, we won't stop taking action until we have completely eliminated our use of Freon," he adds.

Government policy has a role to play here. "The production and consumption of HCFCs in Japan will officially be prohibited in 2020," Yamasaki says.

"I feel that the general attitude within the industry is that 'it will be fine even if we do not switch to natural refrigerant equipment just yet'," he says.

"However, if there is a refrigerant leak, our plant would stop operating and we would cease to function as a frozen food company. So, in order to avoid such risks and to sustain ourselves as a company, we are aiming to completely eliminate our use of Freon."

Several of Ajinomoto Frozen Foods' natural refrigerant system installations were supported with subsidies provided by the Japanese Ministry of Environment.

These subsidies are awarded specifically to natural refrigerant system installations in the food retail, food manufacturing and cold storage industries.

The budget for the 2018 financial year (FY2018) was ¥6.4 billion (€47 million). In December, the Japanese Ministry of Environment confirmed that a budget of ¥7.4 billion (€58 million) had been set for financial year 2019.

These subsidies, Yamasaki explains, are especially important for end users in the food manufacturing and cold storage industries, which often see initial costs as the biggest barrier to natural refrigerant adoption.

"In our industry, the profit margins are never high and it is the same even for major companies," says Yamasaki.

"Product prices are low and there are operational costs," he continues. "When adopting natural refrigerant equipment, the initial costs are currently 20-30% higher than existing



1 /



2 /

1 / Ajinomoto Frozen Foods food production line spiral freezing system.

2 / Japanese 'gyoza' dumplings frozen in a spiral freezer powered by natural refrigerants NH₃ and CO₂.

Freon-based systems. For the frozen food industry, which has many small and medium-sized enterprises, not much progress can be made due to these financial concerns."

Yamasaki, however, remains committed to the company's Freon elimination goal.

"It is our single mission to work on the complete elimination of our use of Freon. Although for the past 2-3 years we've not been able to replace as much as we expected, we're determined to continue. We've made progress with establishing our replacement process and we plan on proceeding with replacing the rest of the equipment at our remaining facilities as planned," he says.

In addition to food processing freezers, Ajinomoto Frozen Foods also operates its own frozen and cold storage warehouses, which it has included in its Freon phase-out plan.

The company aims to replace a total of 75 refrigeration systems at all its cold storage warehouses, instead adopting natural refrigerants or refrigerants with a GWP value of less than 150 by 2030.

To date, it has already installed and begun testing transcritical CO₂ systems from Japanese manufacturers Nihon Netsugen Systems (NNS) and Mitsubishi Heavy Industries Thermal Systems Co. Ltd. (MHI) at two of its cold storage facilities in Japan.

Overseas, the company operates cold storage and food processing facilities in Thailand, China and Poland. The company aims to eliminate the use of HCFCs by 2020 and HFCs by 2030 at these facilities as well.

Ajinomoto Frozen Foods, Yamasaki explains, is also keen to spread the word about the benefits of natural refrigerants to the wider world.

"I hope to communicate beyond the industry's borders about our company's future environmental sustainability efforts," says Yamasaki.

"Both our environment and way of life are continuing to be threatened by global warming, as evidenced by the recent increase in natural disasters and various environmental problems," he says.

"While manufacturers are continuing to pursue technological development, we also need end user companies to fulfil their responsibilities to shift towards using renewable energy and natural refrigerants as effective measures to prevent global warming," he argues.

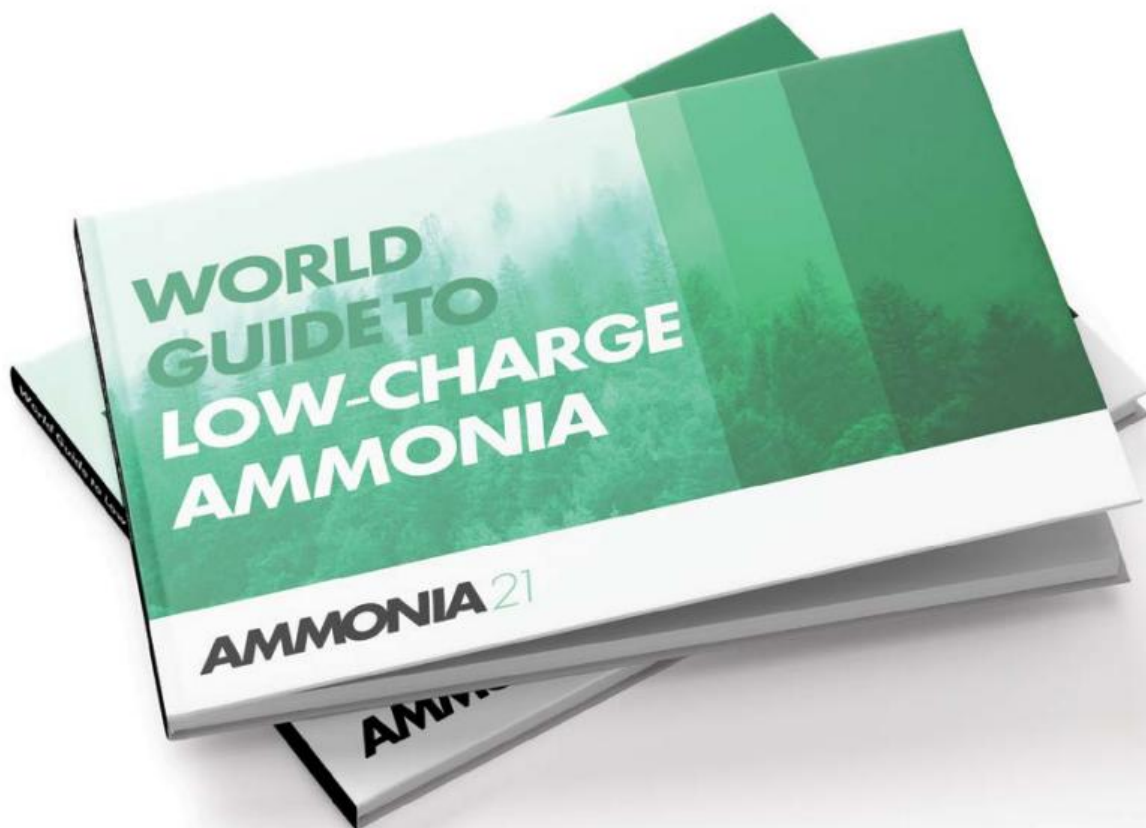
The Ajinomoto Group is committed to making improvements in response to the global environmental problems facing the world. "We intend to lead this industry in this respect," Yamasaki declares.

■ DY, RO & TS

A21

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EFFICIENCY DRIVES NATREF BUSINESS CASE

CAREL, Embraco and BAC were among the companies showcasing products that boost natural refrigerant efficiency at the AHR Expo in Atlanta, Georgia. *Accelerate America* reports.

— By Michael Garry

In January, the AHR Expo continued to prove it is one of the largest exhibitions of HVAC&R equipment in the world in its latest iteration at the Georgia World Congress Center in Atlanta (14-16 January), held concurrently with ASHRAE's Winter Conference.

With a decided focus on HVAC among the 1,824 exhibitors, the expo did not have a substantial number of natural refrigerant products on display for the 45,078 attendees. Yet many component makers supporting CO₂ and hydrocarbon applications were on hand.

'FULL COMMERCIALISATION': CAREL BEVERAGE COOLER SYSTEM

Italian multinational CAREL plans to start North American marketing of its Heez propane (R290) beverage cooler technology, which the company says can reduce the energy consumption of a cooler by 52% below the U.S. Department of Energy's 2017 standard.

The Heez system, which includes a controller, controller display, electronic expansion valve (EEV) and a BLDC inverter single-rotary compressor, was displayed in a 0.4 m³ vertical closed cooler at the AHR Expo.

CAREL makes the system's components, except for the compressor, which is designed by CAREL and manufactured by QING AN. The Heez system also incorporates two variable-speed DC fans.

With the Heez system, "every device in the refrigeration cycle is modulated," said Brandon Marshall, application manager (refrigeration) for CAREL's U.S. division, located in Manheim, Pennsylvania. "The compressor slows down as the temperature is reached, the valve maintains the evaporator's efficiency with low superheat, and the fans modulate."

For the AHR Expo cooler, at an internal temperature of 3.3°C/-18.9°C, the Heez system enables the unit to consume 1.08 kWh/day, which is 52% less than the U.S. Department of Energy (DOE) standard and 39% less than the 2017 ENERGY STAR standard. The system also cuts temperature pull-down time in half, Marshall added.

CAREL showed a medium-temperature version of the system at AHR Expo; another medium-temperature and two low-temperature models are expected.

Heez was launched in North America a year ago and "is reaching full commercialisation in 2019," Marshall said. It will serve beverage coolers, as well as under-counter and upright refrigerators and freezers.

Customers for the system include beverage brands and OEMs of self-contained retail and foodservice refrigeration equipment. Heez-based equipment has been installed in Europe and South America, he noted.

The Heez system also features NFC and Bluetooth connectivity, enabling technicians and end users to monitor and manage performance via a new mobile app called Applica. "You can turn lights on and off, activate energy-saver mode, slow down the compressor, increase the set point, monitor alarms and load parameter lists," said Marshall.

"There is also an area on the app for contractors that simplifies commissioning and servicing of the equipment," he added.

CAREL has also developed a cloud service called Armilla that tracks all of its cooler equipment and offers data on a software-as-a-service basis.

Marshall acknowledged that the Heez system is "a little more expensive" than comparable systems but "most bottle coolers do not incorporate DC [inverter] technology, electronic expansion valves and variable-speed fans". He also pointed out the considerable energy savings enabled by the technology.

VARIABLE-SPEED COMPRESSORS 'TAKING OFF'

Brazilian compressor manufacturer Embraco sees highly efficient variable-speed compressors for propane (R290) "taking off" in North America since "we started promoting it" a year ago, said John Prall, application engineer for Embraco.



ABOVE & BELOW: AHR EXPO 2019 took place at the Georgia World Congress Center on 14-16 January.
Photography: AHR Expo



SHECCO CEO: STAKEHOLDERS CAN PUSH FOR INCENTIVES IN CALIFORNIA

As the California legislature considers how much funding to provide for natural equipment subsidies under the California Cooling Act, industry stakeholders can push for those subsidies until the summer of 2019, said shecco CEO Marc Chasserot at the AHR Expo. shecco is the publisher of this magazine.

"This will be an opportunity to get some incentives for natural refrigerant-based equipment in supermarkets and industrial applications," said Chasserot during a presentation called 'Global Market and Policy Trends for CO₂ and Ammonia in Refrigeration'.

(Stakeholders interested in communicating with relevant parties in the California government with regard to the incentives should email klara.skacanova@shecco.com.)

Other highlights of Chasserot's presentation included:

- ▶ There are now more than 615 transcritical CO₂ systems installed in stores in North America, including more than 370 in the U.S. and more than 245 in Canada.
- ▶ Europe remains the leader in transcritical CO₂ with more than 16,000 installations, which accounts for about 14% of all stores.
- ▶ Transcritical CO₂ systems are being installed in some challenging high-ambient environments, such as Jordan, India and Mexico.
- ▶ More than 6,000 stores are using CO₂ condensing units or mini-boosters globally.
- ▶ More than 420 low-charge ammonia systems are used in North America, including more than 200 in Canada and more than 220 in the United States.

He shared his views on the R290 market at the AHR Expo, where Embraco introduced an R290 variable-speed compressor (model FMFT415U) at the show that has a 20% higher capacity than previous models.

"Variable speed is the way to achieve energy targets in a cost-effective way, particularly for freezers," Prall said.

Marek Zgliczynski, director of research and development for Embraco, pointed out that by saving compressor energy, variable-speed units generate less waste heat in air-cooled commercial systems, reducing the burden on a store's air-conditioning system.

The cost of a variable-speed compressor may be higher than a conventional compressor, "but people don't understand that the return is quick – a few months for a freezer," Zgliczynski noted.

Prall explained that the cost of a variable-speed compressor might range from zero to 50% higher than a conventional unit. But its energy efficiency reduces the cost of other components in a self-contained case, rendering the overall cost of an optimised case the same as a standard HFC case that is not optimised.

BAC'S LARGER ADIABATIC CONDENSERS

Baltimore Aircoil Company (BAC) recently released larger versions of its Trillium adiabatic condenser, which can be used to support installations of transcritical CO₂ systems at larger supermarkets and industrial plants.

The larger models can handle capacities of "over 4,000 MBTUs," said Philip Hollander, BAC's business manager for North American Refrigeration, at the AHR Expo. One of the adiabatic condensers is being used in a very large industrial plant in the United States.

While smaller retail outlets like those operated by ALDI US have used the Trillium units for CO₂ transcritical systems, "we are seeing CO₂ systems applied at larger supermarkets as well as industrial sites," said Hollander.

Adiabatic condensers enable transcritical CO₂ systems to operate in the more efficient subcritical mode in warm weather.

BAC works with customers to show that the Trillium condenser can save energy and thus generate a payback for the investment in the system, Hollander said. The payback, he added, is at most three years, and often "dramatically less," depending on the climate, electric rates and other factors.

The company expects to see more growth in the transcritical CO₂ market in the United States this year as food retailers loosen their purse strings for capital investment after a period of retrenchment over the past few years, he said. ■ MG



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Case Studies

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Commercial End User Panel

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Technomercials

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Industrial End User Best Practice*

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Farewell Drinks Reception

*Private Meeting

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Movers and shakers recognised with *Accelerate Japan* awards

Across the HVAC&R spectrum, Japanese companies are setting an example for other parts of the world by committing to natural refrigerants. Food retailer Lawson and other key players were recognised for their efforts with inaugural *Accelerate Japan* awards at ATMOsphere Japan 2019.

— By Devin Yoshimoto & Andrew Williams

With Japan having ratified the Kigali Amendment to the Montreal Protocol and the government having confirmed €58 million in subsidies for natural refrigerant systems for financial year (FY) 2019 – alongside new and stricter HFC recovery regulations – the stage was set to hear from leading adopters of natural refrigerant technology at this year's ATMOsphere Japan conference, held on 12 February 2019 in Tokyo.

"We're taking a long-term perspective by proactively introducing natural refrigerants," Shinichiro Uto – who heads the store development division at Lawson, a leading Japanese retailer – told the event.

Lawson is aiming to install CO₂ transcritical systems in over 4,000 of its convenience stores by the end of February 2020. By the end of December, it had already installed CO₂ transcritical systems in 3,272 stores across Japan's 47 prefectures.

"As the CO₂ refrigeration market expands, we're endeavouring to advance the HVAC&R industry as a whole by field-testing products from a number of manufacturers," Uto said.

"We're seeking to move towards a multi-supplier system by FY 2020, to establish a stable supply, improve cost-competitiveness, and hedge risks," he added.

Kenji Funamori, a manager in Metro Cash & Carry Japan's asset management department, outlined the company's plans to introduce hydrocarbon technology into stores due to its favourable energy efficiency benefits.

Funamori also pointed to the need for more natural refrigerant solutions for existing store installations. "My message to technology manufacturers is: please try to help us find a solution for our existing stores," he said.

Ajinomoto Frozen Foods, Kokubu Group, Daisen Nyugyo Agricultural Cooperative Association and the Japan Association of Refrigerated Warehouses represented Japan's industrial refrigeration sector at the event.

Ajinomoto Frozen Foods is committed to phasing out HCFCs by 2020 and HFCs by 2030 ([see story on page 44](#)). Other end users in the cold storage industry, such as Kokubu Group, are on a similar path.

"Electricity consumption per square metre of refrigerated warehouse space is reduced by about 30% when using natural refrigerants versus using Freon," Kokubu Group's presentation stated.



FIRST-EVER ACCELERATE JAPAN AWARDS

The conference included the first edition of the *Accelerate Japan* awards, which recognise thought leaders in commercial and industrial refrigeration that are doing the most with natural refrigerant solutions in Japan.

Accelerate magazines and ATMOSPHERE conferences are both produced by shecco, a global market accelerator for natural refrigerant systems.

The Best-in-Sector Light Commercial award went to Coca Cola. In Japan, Coca Cola has been leading the adoption of natural refrigerants in beverage equipment such as bottle coolers and vending equipment. The company aims to be 100% HFC-free in all vending equipment in Japan by 2020.

LEFT

Shinichiro Uto, head of Lawson's store development division.

BELOW

From left to right: Stan Mah, Coca-Cola, Shinichiro Uto, Lawson, Tomomitsu Yamasaki, Ajinomoto Frozen Foods, and Syoji Miyajima, Mayekawa.



The Best-in-Sector Food Retail award went to Lawson. As one of the country's leading convenience store operators, Lawson has been driving natural refrigerant adoption in Japan since 2010.

Lawson is leading cost-reduction efforts by working with several technology suppliers to test and trial several types of natural refrigerant solution.

The Best-in-Sector Industrial award went to Ajinomoto Frozen Foods.

Ajinomoto Frozen Foods is a division of the Japanese multinational Ajinomoto Co., Inc. – a food and amino science corporation best known for creating the original monosodium glutamate (MSG) product branded 'AJI-NO-MOTO'.

The company has worked to eliminate Freon (a Chemours-branded CFC class) use in all of its domestic food processing factory freezer systems since 2006. The company wants to phase out HFC use in all of its domestic and overseas facilities by 2030.

The winner of this year's Innovation of the Year award is Mayekawa for the NewTon NH₃/CO₂ system.

"We were so surprised and honoured to receive this award. Thank you so much," said Mayekawa's Syoji Miyajima upon receiving the award.

"The point is how can we stop global warming. That is our mission, we believe. The refrigerant issue is of course important, but more than that, it has to be used to reduce energy consumption, so we would like to continue our effort towards that," Miyajima said.

The public chose the Innovation of the Year in an open vote. ■ DY & AW

ABOVE RIGHT

Kenji Funamori,
Metro Cash & Carry Japan.

BELOW RIGHT

Akio Motohashi,
Kokubu Group.





World Guide to CO₂ transcritical refrigeration

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Innovation made in France

Carly, a French refrigeration component maker, is confident that its commitment to natural refrigerants will help keep it on an upward trajectory. *Accelerate Europe* reports from the family-owned firm's factory and headquarters near Lyon, France.

— By Andrew Williams

Founded in 1923, Carly has been in the refrigeration business for over 70 years. It launched a line of standard components dedicated to natural refrigerant CO₂ in 2014 – starting with filter driers for pressures of 60, 90 and 140 bar.

“We made this strategic decision because Carly is fully customer-oriented,” Cyrille Berthet, the company’s president and CEO, told *Accelerate Europe* at Carly’s factory and headquarters in Lissieu, near Lyon, France.

“We make more than 50% of our turnover with OEMs and, historically, we have strong technical partnerships with rack manufacturers for supermarket applications,” Berthet says.

“After developing various prototypes requested by many of our historical customers for transcritical systems, we decided to design and manufacture standard lines of components for transcritical CO₂,” he explains.

Berthet is excited about what the future may hold, and relishes the “technical challenges” facing OEMs, distributors, contractors and component manufacturers in rolling out natural refrigerant-based technologies on a wider scale.

Components initially designed for the 46-bar pressures of subcritical CO₂ systems are not suitable for the higher 140-bar pressures of CO₂ transcritical systems.

“The functions of the products are the same: for example, filtering and drying the refrigerant or oil separation, but the working conditions are extremely different and demand a completely new design of component,” Berthet says.

These challenges represent a business opportunity. “Carly is the perfect size to play in this market segment,” Berthet argues. “Components that in the past may have been considered as basic commodities are now more valuable and more technical, because of the new working conditions.”

Carly is ready for this transformation. The firm built upon its reputation as a leading manufacturer of oil separators for traditional refrigerants, for instance, by developing a model for CO₂ transcritical systems.

“Oil separation in transcritical systems is very different,” Berthet says. “That’s why Carly worked to develop a completely new oil separator for more than two years, eventually launching the TURBOIL-R P14 INTEGRITY.”

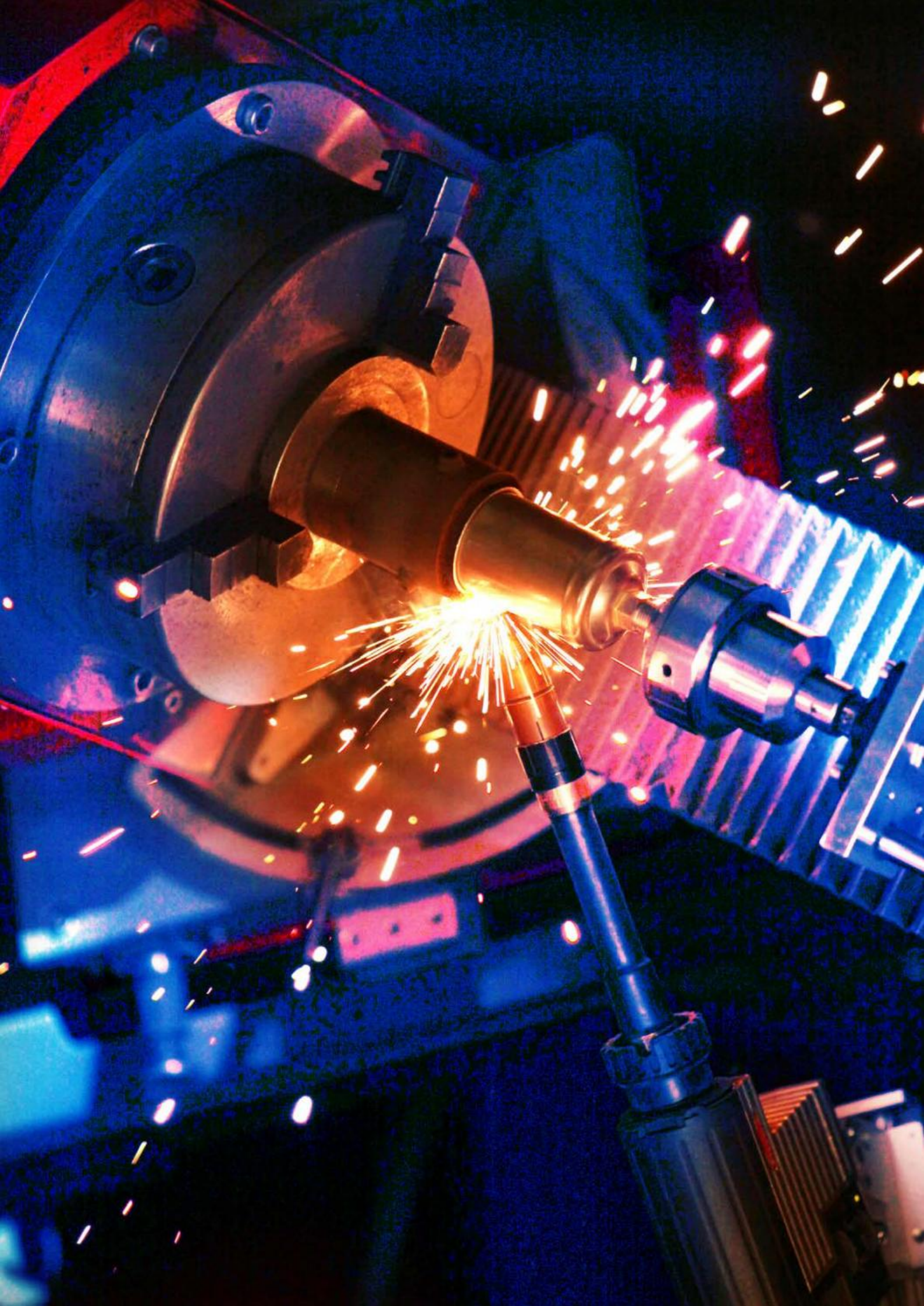
“We see an exponential increase in the share of natural refrigerant system components in our global activity,” Berthet says.

“

With CO₂, companies are able to do something that makes sense from an environmental and economic point of view – there is a positive dynamic.”

”

– Cyrille Berthet, Carly



CARLY'S CO₂ PORTFOLIO

Carly's CO₂ product portfolio developed in three distinct stages.

Step 1: Filters

Carly entered the refrigeration business over 70 years ago with sealed-type filter driers. When the firm decided to enter the market for CO₂ transcritical systems, its expertise in this area made filter driers the obvious place to start. The firm offers:

- ▶ Sealed-type filter driers, 60 and 140 bar
- ▶ Replaceable core-type filter driers, 60 and 140 bar
- ▶ Sealed-type filters, 60 bar
- ▶ Sealed-type oil filters, 60 and 140 bar.

Step 2: Various components

- ▶ Check valves 90 bar
- ▶ Discharge mufflers 60 and 140 bar

Step 3: Oil separators

- ▶ Oil separator 140 bar

LEFT

Carly's factory is in Lissieu, near Lyon, France.

Berthet broadly characterises natural refrigerant trends in the refrigeration market as the following – hydrocarbons for smaller capacities, and CO₂ for medium- to high capacities. "In some applications, there is a small overlap," he says.

Most of Carly's clients are OEMs. The firm's biggest customers are manufacturers of refrigeration racks for supermarkets, but Berthet sees increased interest in CO₂ components from companies working in other applications too.

To Berthet, the adoption of natural refrigerants like CO₂ simply makes sense. "With CO₂, companies are able to do something that makes sense from an environmental and economic point of view – there is a positive dynamic," he says.

After attending business school, Berthet worked for two years in Denmark for Rhône-Poulenc, a chemical company. He joined his father at Carly 29 years ago. "I've stayed in this nice French company all my life ever since!" he smiles.

WHAT IS HE MOST PROUD OF IN HIS CAREER AS CEO OF CARLY?

"My team, and more personally, my loyalty to the values I want to live by as a person," says Berthet, without hesitation.

In 1981, Carly's turnover was the equivalent of €200,000, and the firm employed seven people. "Today, we're at around €9m, with 70 people. That's a nice success story," Berthet says.

Carly's company logo is a smiling snowman – a fact which isn't lost on Berthet, who himself strives to go to work each morning with a smile on his face.

"Every day, I'm proud of the 70 or so people in our team, and of our results. We export 60% of our Made-in-France components – even to China!" he beams.

"You can find the Carly snowman in helicopters, on the TGV, in boats...we've developed components in carbon steel, stainless steel, aluminium..." he says.

As Carly has grown, Berthet is proud that the company has retained its family values. "We've kept the human dimension in every decision we've made for Carly," he says. "That's very important. There is meaning in everything we do."

What advice would Berthet give new engineers starting a career in the HVAC&R sector? "Develop your knowledge of CO₂, ammonia and hydrocarbons. This is a must," he says.

"When first used over 100 years ago, natural refrigerants gave satisfaction for their technical, economic and environmental attributes. Today, they're back on the market – for the same reasons," he concludes. ■ AW

Looking ahead: Industry expectations in 2019

Europe-based makers and suppliers of HVAC&R components and systems for natural refrigerants have expressed confidence that CO₂, hydrocarbons and ammonia will reach new heights in 2019, particularly in commercial and industrial refrigeration and particularly in Europe.

"We expect a 50% increase in [our installations of] CO₂ plants, and threefold or more increase for plug-in propane cabinets," argues Enrico Zambotto, refrigeration director at Arneg, an Italy-headquartered retail solutions provider. He puts this down to the EU F-Gas Regulation, "and its [effect on] increasing [HFC] prices". "Personally I think people are also increasing their sensitivity to the environment."

Italian companies make up a large share of HVAC&R manufacturers (see *'From Italy to the world', Accelerate Italy*, February 2018). Arneg is not the only Italian firm to be optimistic that the natural refrigerant market will grow.

Italian multinational CAREL has already seen strong growth in its CO₂ portfolio. In 2018, the number of its energy-efficient CO₂-based refrigeration projects with DC inverter technology tripled, the company [said in December](#).

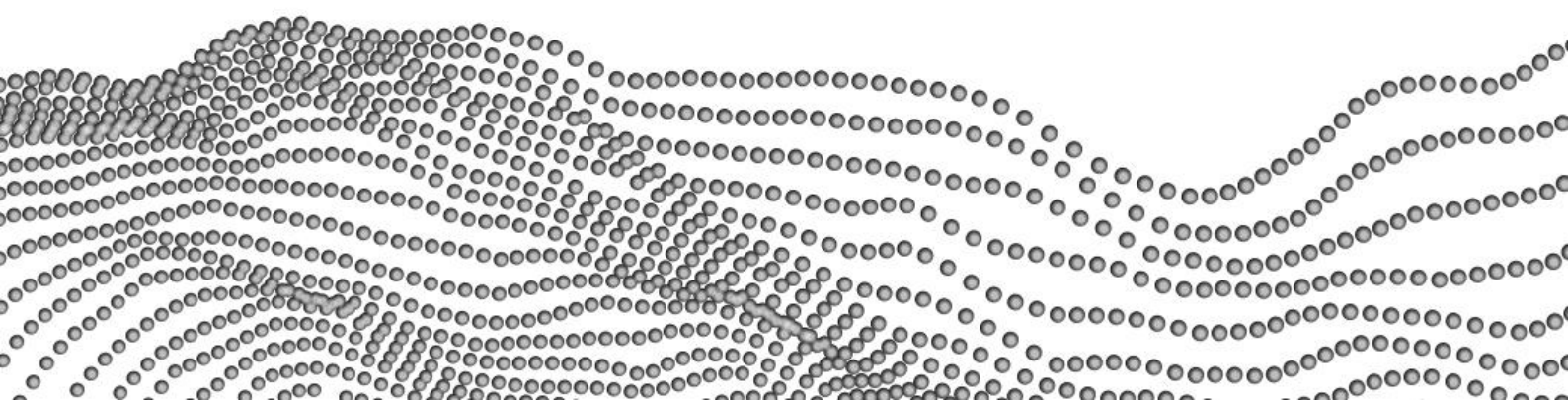
Early in 2019, the market for natural refrigerant-based HVAC&R solutions in Europe looks strong and steady. *Accelerate Europe* asks industry experts in key southern European markets – Spain, Italy and France – what technology, market and policy trends they foresee this year.

— By Marie Battesti, Dario Belluomini & Pilar Aleu

Frascold, an Italian compressor manufacturer, expects increased customer confidence in natural refrigerants to help achieve greater sales. "We work every day to provide increasingly innovative solutions. For 2019 we expect to consolidate our CO₂ technologies," says Elisa Argenta, the firm's marketing manager.

Luca Rossi from Swiss system provider Biaggini installed a new CO₂ transcritical system in a Migros supermarket in Riazano, in the Italian-speaking part of Switzerland, in February 2019. Rossi argues that CO₂ is now the benchmark technology for commercial refrigeration throughout the Alps.

Manuela Rallo, sales area manager at Tecnofreddo, an Italian system manufacturer, predicts that new markets will soon open up for ammonia. "Although



ammonia's growth has been almost flat in recent years, our expectations are that ammonia chillers will [...] remain dominant in the European market," she says.

Rallo is particularly upbeat about Tecnofreddo's ammonia units finding their position in medium to large-scale air conditioning.

STRONG GROWTH FOR CO₂ IN SPAIN

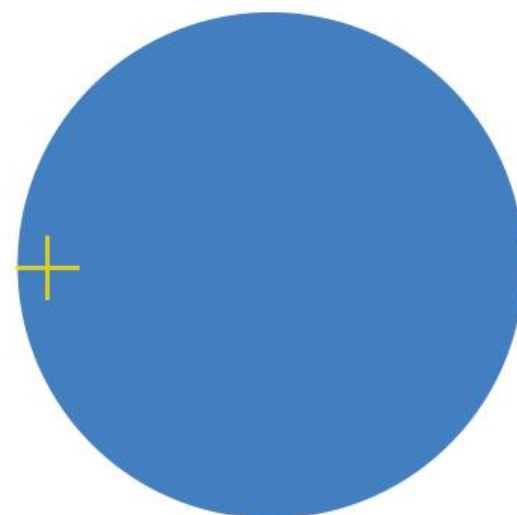
EXKAL, a manufacturer of refrigeration equipment, expects to see "two-digit market growth in commercial refrigeration" for CO₂ in Spain.

Italian multinational system manufacturer Epta is tapping into the growth potential of this technology in Spain, particularly thanks to its Full Transcritical Efficiency (FTE) technology solution for improving performance in warm ambient temperature climates.

"Our intention during 2019 is to continue promoting the Full Transcritical Efficiency technology that, due to its simplicity and efficiency, allows the use of CO₂ in hot climates such as those in Spain," said Diego Ortega, a trade marketing manager at Epta Iberia.

"We're introducing FTE technology in Spain: important supermarket chains have installed FTE in cities such as Alicante and Lloret de Mar. SPAR in La Palma will be next," Ortega says.

Hydrocarbons are also expected to continue their steady growth in the Spanish commercial refrigeration and HVAC sector. "Today one of the candidates with the most potential is propane (R290) for cooling systems as well as for heat pumps or water chillers," says Stephane Marchetti, director (Spain and Portugal) at Emerson, a US multinational.



THE INTERNET OF THINGS

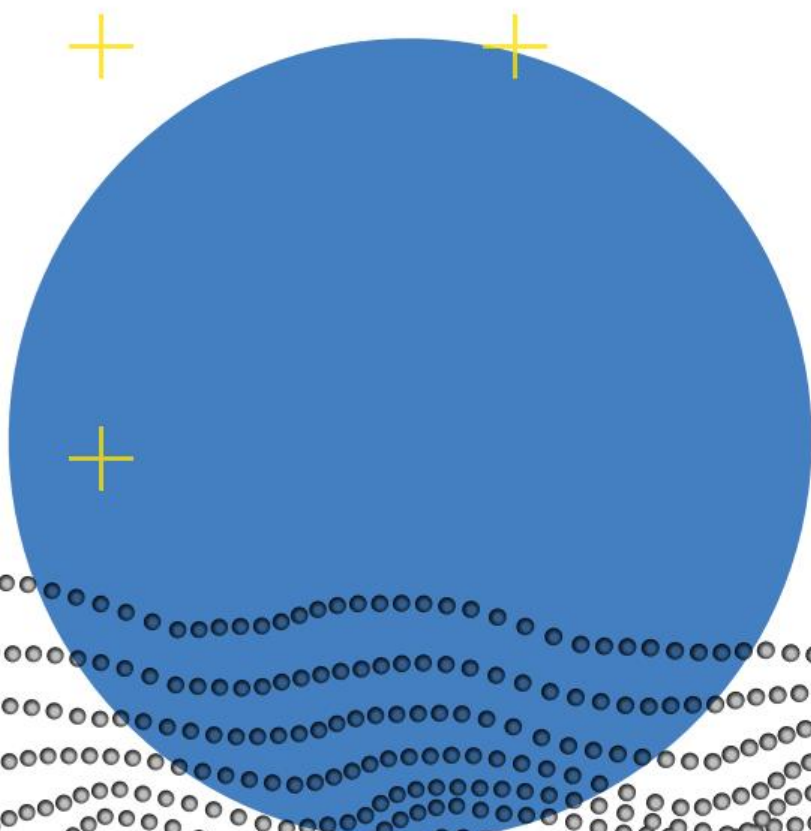
In France, refrigeration experts see growing demand for HFC-free solutions in small stores in urban areas as a key driver for natural refrigerants – alongside artificial intelligence.

Céline Perez, co-director of CTA Holding, which manufactures hydrocarbon-based chillers, told *Accelerate Europe* that CTA is banking on connectivity: "Smart applications and artificial intelligence are the future of the industry. They help end users track their electricity consumption and manage after-sales maintenance, among other things."

Benjamin Tissot, who when interviewed for this publication was sales engineer at SANDEN INTERNATIONAL EUROPE Ltd., sees great potential for installing CO₂-based equipment in small stores: "CO₂ condensing units in small shops are now a big trend," he says.

"Mentalities are changing in France. Natural refrigerants are becoming a mature technology. People now come to tradeshow to ask practical questions, rather than just curiosity about the feasibility of the technology," Tissot observes.

Pierre Boyer, general manager at Profroid, foresees increased interest in integrated HVAC&R systems: "CO₂ offers the possibility of very efficient heat recovery in commercial refrigeration systems."



With a tax on HFCs set to enter into force in France in 2021, Boyer is upbeat about the market potential for natural refrigerant-based technologies. "The latest regulatory measures adopted in France send a strong signal to all manufacturers of commercial refrigeration equipment to provide responsible refrigerant options and to ensure, in the long term, the use of natural refrigerants," he says.

HIGHER HYDROCARBON CHARGE LIMIT

Professionals working in the commercial refrigeration sector expressed confidence to *Accelerate Europe* that a proposed increase of the charge limit for A3 (flammable) refrigerants under the auspices of the International Electrotechnical Commission (IEC) would go ahead when the final vote takes place later this year.

The charge-limit increase from 150g to 500g will apply to hydrocarbons including propane and isobutane in commercial refrigeration equipment under the IEC global standard 60335-2-89. The higher charge would likely widen the use of hydrocarbons as natural refrigerants worldwide.

"For sure [the vote] will have an impact," Claudia Reggiani, marketing manager at Huayi Compressor Barcelona, S.L., told *Accelerate Europe*. "Today there are still some applications that cannot be covered with 150g and this is a limitation on expanding the use of hydrocarbons (HCs). With the new charge limit, this limitation will disappear and will help to faster expand the use of HCs in the light commercial market."

Diego Malimpensa, business unit manager, retail solutions at CAREL, agrees that the charge limit increase will boost the potential for hydrocarbon-based technology. "CAREL, with its water-loop and plug-in solutions, is already able to support systems with a propane charge exceeding 150g, with both single- and multi-circuit options," Malimpensa says.

It remains to be seen whether the charge limit increase will encourage HVAC&R firms to invest a greater proportion of their R&D budgets in hydrocarbon technologies.

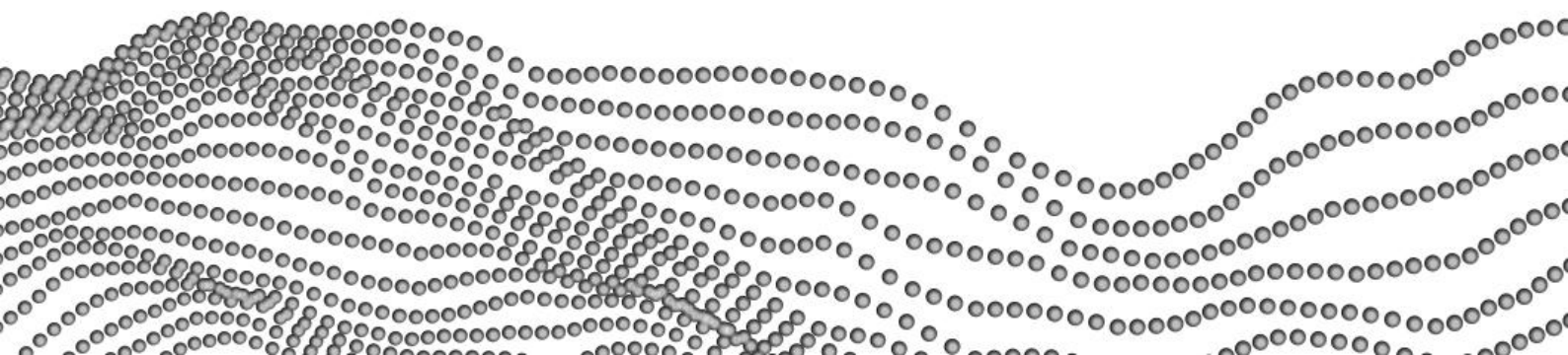
"Smart applications and artificial intelligence are the future of the industry."

— Céline Perez, CTA Holding

With more hydrocarbon-based systems likely to be adopted, it is essential to ensure that there are enough technicians trained to install and maintain them. Since 1975, Italian training institute *Centro Studi Galileo*, based in Casale Monferrato – between Turin and Milan – has trained over 60,000 refrigeration technicians on refrigeration, air-conditioning and heating technologies. "For 2019 the calendar is once again full of events of great importance," says Silvia Romanò, the institute's head of international affairs.

"In addition to the courses that take place every month in 15 locations throughout Italy, we will also have some specific courses tailored for the needs of companies (about ten a month) and abroad for the United Nations, on various continents," Romanò explains.

As the first quarter of 2019 draws to a close, natural refrigerants appear to be on a positive growth path in Europe. ■ MB, DB & PA



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2019
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BREXIT CLOCK TICKS DOWN ON EU F-GAS

The UK government has provided guidance on its plan to administer the new EU F-Gas Regulation in the event of a no-deal exit from the European Union.

— By Charlotte McLaughlin

On

13 September 2018, the UK government confirmed that in the event of a 'no deal' exit from the European Union (EU), it would continue to implement the EU's F-Gas Regulation – phasing down HFCs

by 79% by 2030 (compared to 2009-12 levels) and adopting the bloc's quota method and schedule – but administer it independently through the UK's Environment Agency (EA).

The UK needs to agree a deal with the European Union (EU) by 29 March 2019 if it wants to prevent a 'no deal' Brexit, which would mean no formal agreement on what to do about the EU F-Gas Regulation. At the time of going to press, no Brexit deal had been reached.

"Businesses that produce, import or export HFCs or ODSs [ozone depleting substances], or products and equipment pre-charged with HFCs or ODSs would need to apply for [a] UK quota to place them on the UK market," the UK government announced in September.

"The current EU-wide HFC quota which companies receive would be split into two parts: one quota for placing on the UK market, issued by the UK government, and another for placing on the EU market, issued by the European Commission," the government added.

The EA would administer HFCs placed on the UK market by establishing a new UK-based IT system that doesn't change current requirements facing businesses (which would remain the same as under the EU F-Gas Regulation).

POTENTIAL COST INCREASES FOR UK COMPANIES

Companies might need to pay fees regarding the new IT system, as hinted at in a guidance document issued by the Environment Agency on 11 February 2019. "The Environment Agency [...] will consult before deciding whether to charge. The consultation will include the level of any charges and the activities to which they would apply."

So what should companies do now? "Before 30 March 2019 you should continue to use your EU quota to place HFCs on the UK market," the new EA guidance says. "After 30 March 2019 you'll need a UK HFC quota [in the event of a 'no-deal' exit] if your business places on the UK market HFCs equivalent to 100 tonnes or more of carbon dioxide per year. This total includes any imports to the UK from the EU."

UK-registered companies listed as using f-gases on the EU F-Gas Regulation portal should have received an email from the EA asking them to register for the new system. Companies that are yet to receive this email should contact f-gassupport@environment-agency.gov.uk.

Companies that were not in the EU F-Gas quota system in 2015, 2016 or 2017 but would like to import f-gas equipment or make bulk imports of f-gases into the UK should register with the EA by Friday 12 April 2019 ([here](#)).

"You'll need to apply for UK new entrant quota even if you had a new entrant quota for 2018 from the European Commission. You can use your EU new entrant quota to place HFCs on the UK market only until 29 March 2019," the EA warns.

For placing HFCs on the EU market, the European Commission will still allocate a quota to UK companies under the EU F-Gas Regulation's quota system. ■ CM

Subsidy boost for NatRefs in Germany



Germany has extended its natural refrigerant subsidy programme until the end of 2021.

— By Charlotte McLaughlin

The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has extended subsidies for refrigeration and air-conditioning equipment based on non-halogenated refrigerants (commonly known as natural refrigerants) until 31 December 2021.

The announcement, made at the turn of the year, extends the previous subsidy scheme. That scheme sought to reduce the energy consumption of refrigeration and air-conditioning systems alongside subsidising natural refrigerant-based systems, and ran from 1 January 2017 until 1 January 2019.

As with the previous iteration, the new programme is open to companies, not-for-profit organisations, local authorities, special purpose associations, and schools, hospitals and church organisations (regardless of the intention to make a profit).

The scheme particularly focuses on increasing the uptake of natural refrigerant-based systems in stationary refrigeration applications (renovated and new builds) and air conditioners in vehicles, such as in buses and trains.

The scheme specifically cites the following stationary refrigeration and air-conditioning (RAC) systems:

- ▶ Liquid chillers with A3 refrigerants like propane (R290), propene (R1270) and isobutane (R600a);
- ▶ Liquid chillers with ammonia (R717) or a mixture of ammonia and dimethyl ether (R723);
- ▶ Other chillers such as adiabatic evaporative cooling systems, deep-freeze stages with CO₂ (R744) in combination with liquid chillers and in booster supermarket/commercial refrigeration

plants with R744; along with turbo-compressors with R718 (water as a refrigerant) in adsorption and adsorption plants and vacuum ice machines (using turbo compressors).

- ▶ Components and systems such as air coolers, adiabatic re-coolers (hybrid coolers), re-coolers for liquid-cooled systems, independent heat pumps with non-halogenated refrigerants for waste heat utilisation in refrigeration systems, refrigerated cabinets for supermarket refrigeration systems, cooling oil circuits and systems for free cooling operations.
- ▶ Hot and cold energy storage using refrigeration technology.
- ▶ RAC systems using non-halogenated refrigerants in CHP (combined heat and power) generation.

The subsidies can also be used to retrofit trains with natural refrigerant-based air-conditioning systems, as well as electric buses.

Much like the 2017-2019 scheme, the funding an end user receives depends on the type of installation and the cooling capacity, as well as on other requirements. The German Federal Office of Economics and Export Control (BAFA), which is implementing the project, provides more information on calculating the funding on its website [here](#) (in German).

Each end user is entitled to receive a maximum of 150,000 euros per installation.

Interested parties can [apply for funding](#) on the BAFA website by submitting the right documents. For a guide on what and how to submit (in German), please visit the [BAFA website](#) and the [National Climate Initiative](#) website. ■ CM

HFC tax adopted in France

France's 2019 Finance Bill, officially adopted on 30 December 2018, confirmed the entry into force of a tax on hydrofluorocarbons (HFCs) as of 2021.

– By Marie Battesti

France will begin to tax HFCs as of 2021 after the tax was officially adopted in the country's 2019 Finance Bill on 30 December 2018 – minus a cancellation clause that it had previously contained. The proposed text had included a provision stating that the tax would only be introduced should industry fail to accelerate its HFC phasedown of its own accord.

The new French scheme will also support the adoption of HFC alternatives from 1 January 2019 until 31 December 2022.

To help companies to transition to HFC-free alternative technologies, an income tax discount is applicable until 31 December 2022 for companies subject to French tax.

Companies can deduct from their taxable profit an amount equal to 40% of the original value of all HFC-free refrigeration and air conditioning equipment – including that based on natural refrigerants.

The tax discount of 40% for HFC alternatives is applicable to new refrigeration and air-conditioning installations for the next four years.

The tax rate increases over time, and is set at 15 euros per ton of CO₂ equivalent (€/tCO₂e) in 2021, €18/tCO₂e in 2022, €22/tCO₂e in 2023, €26/tCO₂e in 2024, and €30/tCO₂e as of 2025.

The tax applies to the entity that makes the first delivery of HFCs in France (producers and importers).

A SERIES OF SETBACKS

The final decision marks the latest twist in a series of developments regarding the proposed tax.

In July 2017, former Environment Minister Nicolas Hulot announced that a tax on HFCs would be included in the 2019 Finance Bill as part of a national carbon-pricing scheme. The measure is part of the government's Climate Plan.

Industry expressed strong opposition to the proposed tax, whose chances of entering into force were further weakened by Minister Nicolas Hulot's resignation in September 2018. Hulot admitted that his resignation was partly due to frustration at not being able to achieve his objectives because of pushback from private interests such as industry.

An amendment to the 2019 Finance Bill (introducing the HFC tax) was finally presented on 3 October 2018, but the French Parliament's finance committee rejected the text later that month.

The tax reappeared on 9 November 2018 in another amendment introduced by MP Joël Giraud, who is the general rapporteur of the parliament's finance committee. MP Giraud coordinates with various parliamentary committees to adopt budget bills. He is from French President Emmanuel Macron's political party *La République En Marche* (LREM).

Riots in France against environmental taxes slated for the 2019 fiscal year led the government to scrap a proposed fuel tax rise and to consider removing carbon tax increases from the 2019 budget. As the HFC tax is part of the carbon tax scheme, its future was uncertain until the final vote.

At the time of going to press, protests – and even riots – against France's environmentally motivated fiscal measures were ongoing. Yet as the subsidy scheme has already started to support the transition towards HFC-free HVAC&R equipment, the tax should be protected from any potential fiscal policy adjustments. ■ MB



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Scantec's central low-charge NH_3 (300 kg) plant room, in Brisbane.

LOW-CHARGE AMMONIA: PACKAGED OR CENTRAL?

The development of low-charge ammonia is heading in two directions – packaged units and central systems; experts from North America and Australia discuss the differences.

— By Michael Garry & Devin Yoshimoto

The benefits of lowering the ammonia charge in industrial refrigeration are clear: improved safety, less stringent government regulations, improved efficiency and faster installation.

However, the road to these benefits has split into two directions: a packaged system, often installed on a rooftop over the refrigerated rooms, sometimes with multiple packages at one site; or a central system with a machine room, similar to traditional setups but altered to enable significant charge reduction. Each has been installed at cold storage and food processing plants.

At ATMosphere America 2018, held in Long Beach, California last June, industry stakeholders had an opportunity to hear about each system type, installed at facilities in Canada. (ATMosphere America is organised by shecco, publisher of *Accelerate* magazines.)

Equipment manufacturer Evapco is one of the pioneers in North America of packaged low-charge ammonia systems. Evapco installed four of the company's LCR-P Evapcold packaged units at a high-rise cold-storage freezer (-10°F; -23°C) warehouse in Alberta, Canada.

The system provides 266 TR (935 kW) of capacity. High-rise cold-storage facilities are becoming more popular in North America due to their high storage capacities and use of automated storage and retrieval systems (ASRS), said Kurt Liebendorfer, vice-president, Evapco, at ATMosphere America.

"These are the latest technologies coming into the warehouse industry to eliminate the largest cost component, which is labour," says Liebendorfer. "These warehouses are essentially 100% automated for material handling."

The Alberta facility is 110 ft. (33.5 m) tall and has three air-cooled low-charge ammonia packaged systems installed on the roof, with one additional unit installed above the warehouse's dock/staging area (35°F; 1.7°C).

The system's low charge of ammonia was one of its key selling points, said Liebendorfer. Each of the three units uses 490 lbs of ammonia, for a total of 1,470 lbs. "If this were to have been stick-built, it would have easily been 10,000 pounds, so there is a great reduction in charge for no sacrifice in performance."

Liebendorfer described the penthouse design as a "perfect application for this type of building" because it takes advantage of "eliminating field piping to the top of the roof that would come from a central plant".

This scenario offers energy benefits, he said. "By eliminating those long hundreds of feet of pipe runs, you're eliminating the associated pressure drops and temperature losses. [That] really does improve your system efficiencies."

The rooftop packaged units enable additional energy efficiency through better management of "suction levels". In a traditional central



ammonia plant, with "house" suction temperature levels, "whatever your room temperatures are, they have to regulate down to that nearest suction level," which causes energy losses, Liebendorfer explained.

"With these packaged units, you have a suction level for every room per unit, minimising your temperature approaches and raising your suction as high as possible, which optimises your performance," he said.

PermaCold Engineering, which served as the main design and installation contractor for this project, used SolidWorks Fluid Flow Analysis Software to avoid short circuiting the air flow and determine optimum air distribution. "The target is to keep up air velocity and cover the freezer," said Jeff Buxton, mechanical engineer for PermaCold.

Buxton also presented a projected annual system operating cost comparison between the Evapcold system and a central system with evaporative cooling; this looked at power for compressors, receivers and condensers, as well as water treatment (none for the air-cooled Evapcold units).

"There's some room for debate, but overall I calculated about 14% savings against a well-built, stick-built ammonia refrigeration system" – \$161,888 (€142,821) vs. \$183,412 (€161,810), he said.

Annual energy savings alone for the Evapcold system was close to 100,000 kWh/yr. The installed system cost of the units was not provided.

Liebendorfer acknowledged that the heavy weight of the systems on the roof was a concern, but added that this was balanced by the strength of the high-rise facility's supporting structure. "These Evapcold units [are] pretty big, weighing around 48,000 lbs (21,772 kg)," he said.

"The ability to support that on a traditional building certainly has to be addressed, but with these high-rise buildings, the rack structure is so robust, it was told to me that our units equate to about 17 pallet positions. [That's] not much given the quantity of pallet positions already in there."

In 2017, Frick Industrial Refrigeration, a division of Johnson Controls, unveiled a novel low-charge centralised system (LCCS) that limits the liquid ammonia to rooftop condensers – "remote distributed condensers" (RDCs) – located close to the cooling loads; they feed a small amount of liquid to a vessel that supplies multiple evaporators in or near the storage space.

The system employs an engine room containing only compressors and a control panel. The RDCs could be adiabatic, plate-and-frame, dry or evaporative. Sensors monitor the RDCs to make sure a sufficient quantity of ammonia is fed to the evaporators. In this scenario, ammonia vapour, not liquid, is distributed throughout the plant.

The ammonia charge in the system ranges from 1.5-3 lbs/TR (0.7-1.37 kg); industrial systems commonly have charge ratios of 20-23 lbs/TR (9-10.4 kg).

The RDCs are what distinguish the Frick system, said Darryl Stauffer, product manager for Frick, at the ATMOsphere America conference. "In a traditional system, you have liquid vessels throughout," he said. "We've introduced what we call the RDC where you only have vapour being distributed through the plant – not liquid – so that the condensing [fluid] is now [only] being distributed to the point of use."

Stefan Jensen, managing director of Australian firm Scantec Refrigeration Technologies (Scantec), expects low-charge ammonia systems to continue to change the game in the global cold storage and logistics industries through superior design and efficiency.

Jensen is excited about their energy potential. "We may be getting close to being awarded a central, low-charge NH₃ refrigeration plant for a high-rise cold store in Asia," he says.

"The existing central liquid overfeed plant with screw compressors in two-stage configuration has an energy consumption of 59 kWh/m³ per year to service 37,000 m³ of refrigerated volume," Jensen says.

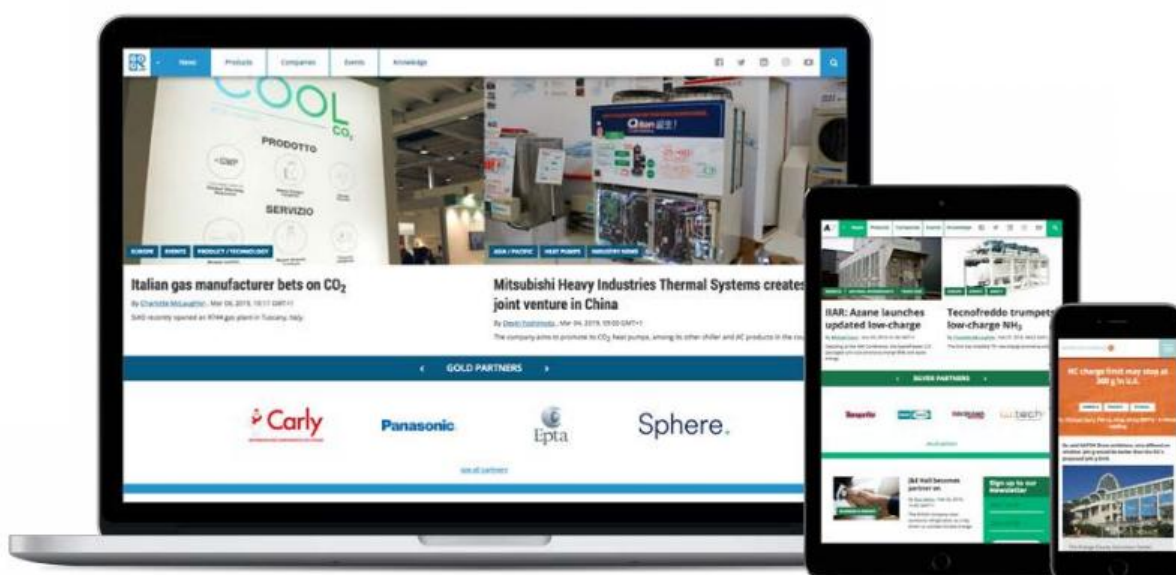
"The predicted energy consumption of the new low-charge NH₃ system servicing the additional 110,000 m³ is 11 kWh/m³ per year," he adds. "This has the capacity to be a game-changer."

Jensen predicts that a huge ammonia retrofit market is emerging globally. "Millions of existing ammonia plants are currently likely to be a long way away from the best energy performance they could deliver if modified appropriately," he says.

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How to build an efficient cold store

Reducing electrical energy consumption in cold stores is a complex matter but will become necessary to achieve EU energy efficiency goals.

— By Charlotte McLaughlin

The European Union's '*Clean Energy for All Europeans*' strategy – a legislative framework agreed in 2018 – put in place strong targets to mitigate the effects of climate change.

The new climate plan includes a binding target of improving energy efficiency in the EU by 32.5% by 2030, which contains an upward revision clause in 2023. "This deal is a major push for Europe's energy independence," EU Climate Action and Energy Commissioner Miguel Arias Cañete said when the political agreement was struck in June 2018.

"Much of what we spend on imported fossil fuels will now be invested at home in more efficient buildings, industries and transport. The new target of 32.5% will boost our industrial competitiveness, create jobs, reduce energy bills, help tackle energy poverty and improve air quality," Cañete said.

Member states have until 19 December 2019 to transpose the energy efficiency target into national legislation. Reducing energy consumption in buildings and industry will play a key role in meeting the target.

"Cooling and air conditioning systems account for around 15-20% of world energy consumption," according to data present in an EU project on

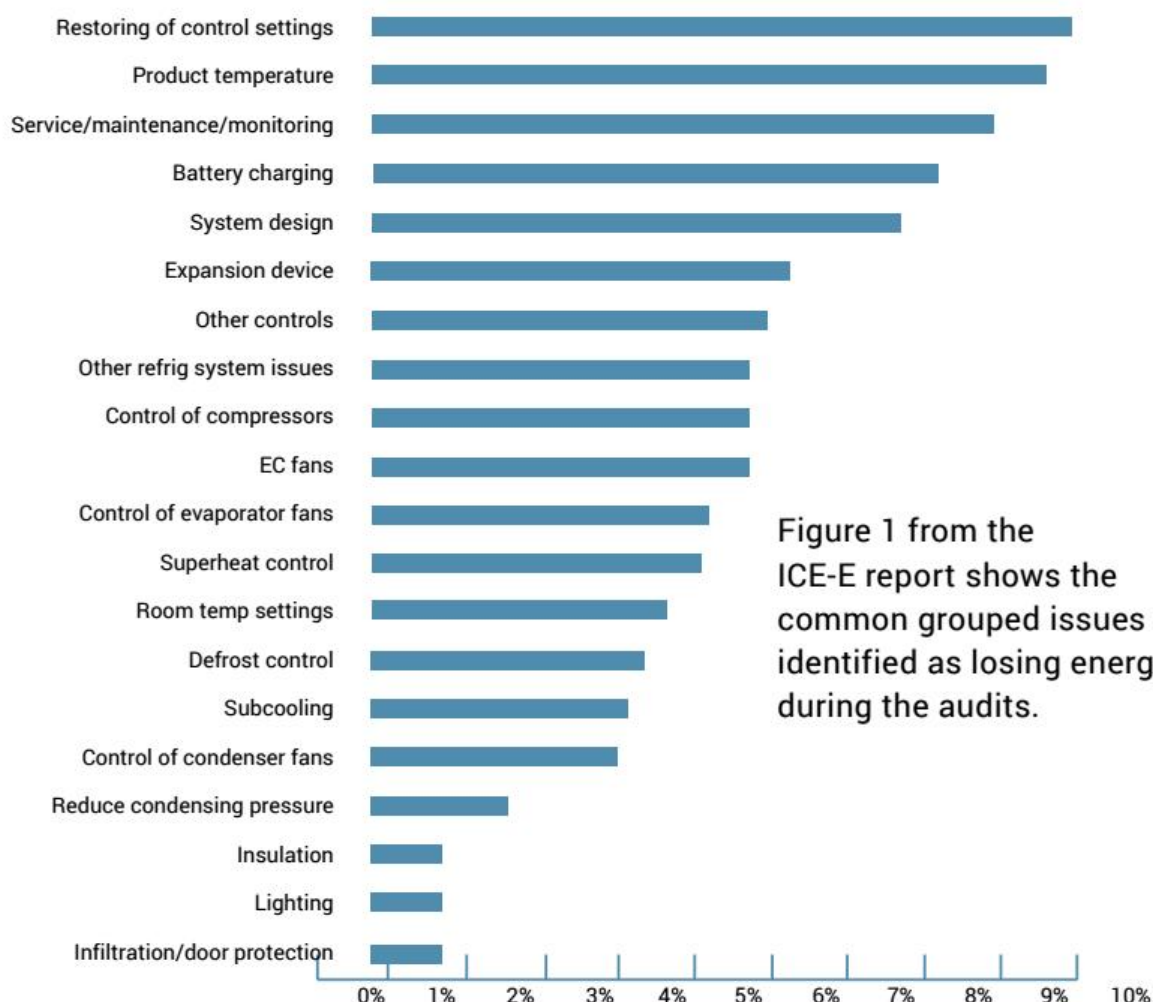


Figure 1 from the ICE-E report shows the common grouped issues identified as losing energy during the audits.

cost-effective strategies to improve energy efficiency in cooling systems in the food and drink sector, called [COOL-SAVE](#).

The project, completed in 2015, reports that, "industrial cooling installations [...] due to their significant energetic impact [need] effective and realistic saving strategies".

Another EU project, completed in 2012, called '[Improving Cold Storage Equipment in Europe \(ICE-E\)](#)', reports that, "within cold storage facilities, 60-70% of the electrical energy used is for refrigeration". Reducing demand for cooling could go a long way to meeting the energy efficiency targets.

The cold chain is believed to be responsible for approximately 2.5% of global greenhouse gas (GHG) emissions through direct and indirect (energy consumption) effects, maintains the ICE-E project, which was funded by two now defunct parts of the European Commission: Intelligent Energy – Europe (IEE) and the Executive Agency for Competitiveness and Innovation.

How easy is it to address efficiency?

In considering how to reduce energy consumption in cold stores, it is worth looking at how energy is measured. Unfortunately there has been very little research into this area, according to Claudio Zilio, an HVAC&R researcher at the University of Padova in Italy, who also took part in the ICE-E project.

"There is a limited amount of research available about cold stores' energy consumption," Zilio explains. "Based on the previous figures and considering that as a rough estimate, the total cold store volume installed in the world is about 300 million m³, the reader may speculate about the yearly worldwide energy consumption for cold store operation."

Dr. Andy Pearson, group managing director of Star Refrigeration, offers his perspective. "Calculating efficiency should always be done as a measurement of kWh/m³/year [known as SEC or Specific Energy Consumption] in order to account for the effect of seasonality and the

economies of scale in larger facilities," Pearson told *Accelerate Europe*. "The end user should also have a means of correlating his cold store performance with the level of business activity – either production output or cold store throughput."

The average estimated SEC is between 30 and 50 kWh/m³/year, according to a 2002 study carried out by the France-based International Institute of Refrigeration (IIR), but the ICE-E project concluded that this isn't often the case for the majority of cold stores.

"Previous surveys carried out on a small number of cold stores have shown that energy consumption can dramatically exceed [the IIR] figure, often by at least double," the ICE-E project found. "These surveys also demonstrated that energy savings of 30-40% were achievable by optimising usage of the stores, repairing current equipment and by retrofitting of energy-efficient equipment."

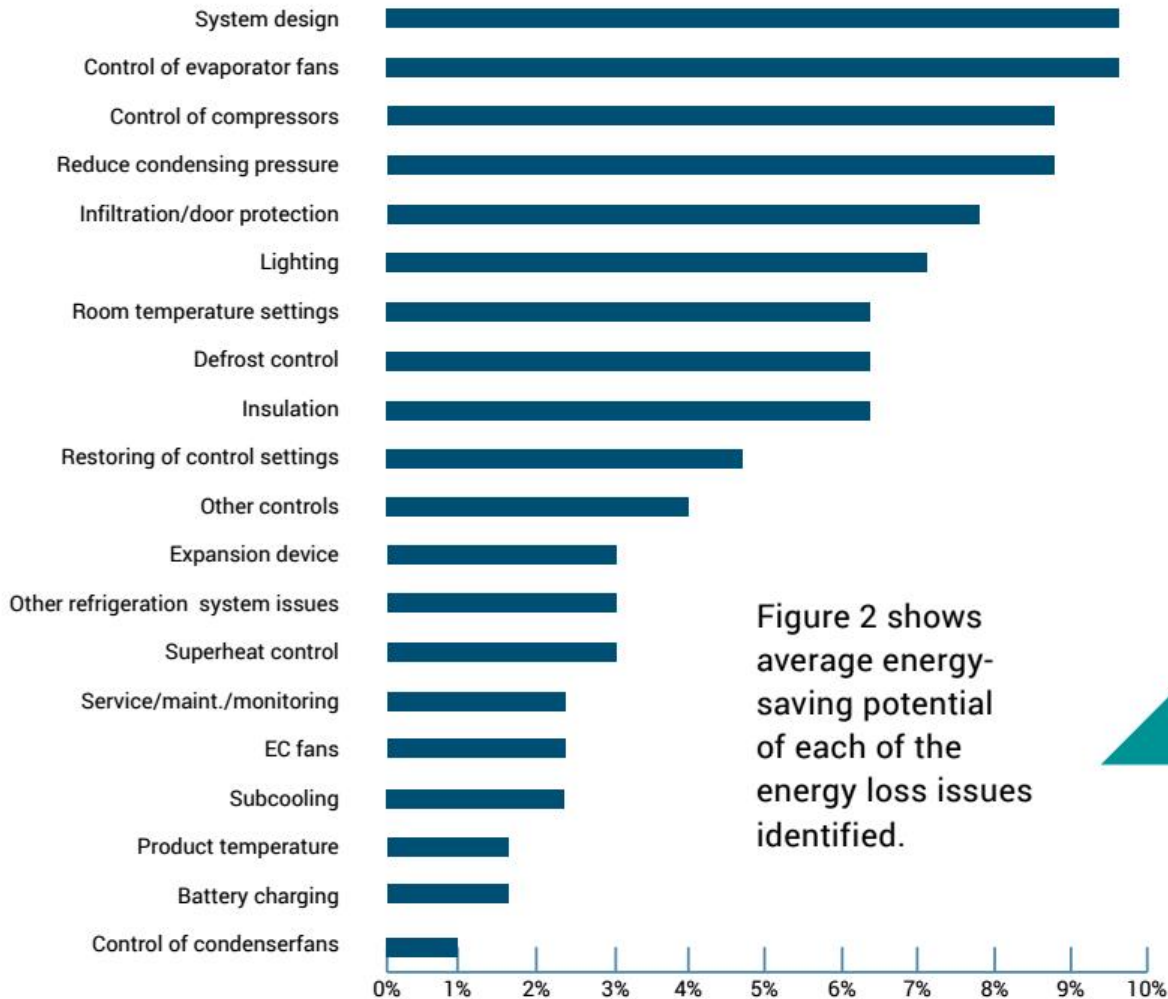


Figure 2 shows average energy-saving potential of each of the energy loss issues identified.

SEC measurements can also be plagued by variables that are not shown in the data, explains Simon Andrew, director of Greencold, a UK-based contractor specialising in CO₂ refrigeration.

"If the product entering the store is not at the pre-agreed temperature of acceptance, then the plant would work harder and for longer to remove the excess heat from the product in order to obtain the required set point for the room storage temperature," Andrew says. He explains that this is often due to the need for cold stores to cool down products quickly.

"We would not tend to use a calculation of kW x m³ to compare systems, as we believe there are just too many variables that can influence the results," says Greencold's Andrew.

"Practically the first big question our clients ask us is, 'how much will the plant cost?'," Andrew says. "Often the cheapest plant will be the most expensive to run, so it is our task to

encourage them to make wiser choices on the energy-efficiency front."

How to reduce a cold store's energy consumption

Regardless of such calculation issues, SEC remains an important way to benchmark a cold store's performance. "All cold stores are different, so the key to improvement is to enable operators to compare against benchmarks," says Star's Pearson.

He adds: "The end user should also have a means of correlating his cold store performance with the level of business activity – either production output or cold store throughput. A good surrogate measure for this is the number of door openings in the cold store."

He explains that this, "assumes that every time a door opens, a fork truck goes through – so it relates the level of activity to door use".

While measuring 360 cold stores throughout Europe, the ICE-E project found, "that 47% of chilled stores, 35% of frozen stores and 50% of mixed stores had an SEC of less than 50 kWh/m³/year [the average predicted]. This demonstrates that there is considerable potential to reduce energy consumption in cold stores".

The ICE-E project partners subsequently carried out energy audits on 28 cold stores across the EU (nine in the UK, nine in Italy, five in Denmark, four in Bulgaria, and one in Belgium).

The audits were carried out by estimating heat load (including electrical load), investigating the electrical consumption, analysing the refrigeration system, and identifying and quantifying potential savings.

The researchers initially expected to discover high energy consumption to be caused by similar issues from cold store to cold store; instead they found that all 28 had very different issues.

"Apart from maintenance-type issues, which are all quite different but that you could at least class under maintenance, we didn't find anything much that was common. All the stores had different issues," Professor Judith Evans, a researcher on air conditioning and refrigeration at London South Bank University and who was part of the ICE-E project, told *Accelerate Europe*.

"In total 130 options were identified, which could be grouped in 20 different issue-groups," the ICE-E report says. "No one issue dominated in terms of the energy that could be saved." (See the figures on these pages. Source: ICE-E report).

To solve these issues it is generally necessary to turn to a refrigeration engineer, but Evans also noted nearly "40% had issues that could be solved relatively simply by someone that is not highly technical" – for example, by checking the cold storage facility for issues with a check board.

The refrigerant question

This benchmarking, conducted under the original ICE-E project, could also be a clear way to reveal how different natural refrigerant systems perform.

At ATMosphere Europe 2018, held by *Accelerate Europe* publisher shecco in Italy last November, Enrico Zambotto, refrigeration director at Arneg, presented data that did just that.

He compared an ammonia/CO₂ system in an 18,400 m² cold store in Tarquinia, Italy, to an updated worldwide benchmark study (which took some of the original ICE-E research) conducted by J. Evans *et al.* in 2015 on 'Specific consumption index per unit of volume' in 439 cold stores.

Compared to this baseline, the Tarquinia system's energy consumption was "62% below the world average, 58% below the European average, and 46% below the Italian average, thanks to energy efficiency solutions adopted," he said.

Not even benchmarking is always accurate, warns Evans of London South Bank University. "All you can do is try, by having a large enough data set. Even if you're worse than that average, it doesn't necessarily mean you're bad [in terms of energy use]. It means there might be a good reason for it," she says. "It might mean there's something you can do about it."

The best way of finding out is by cold stores doing regular audits on energy and by measuring changes in a system. "When you make a change, people should see a big drop with actual vs. predicted energy. So you know you can see quite clearly if you've made a significant change," she says.

Star's Pearson maintains that ammonia is a better performer than HFCs. "You can generalise about these systems – for example, a direct ammonia system will usually be more efficient than a direct R404A system or a glycol system, but the variables in operation store-to-store will be greater than the differences caused by refrigerant, so it's wrong to say ammonia is always the most efficient."

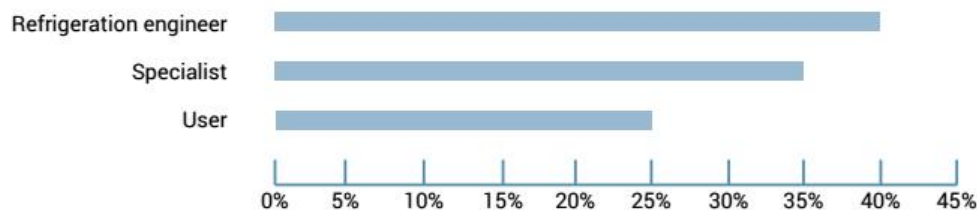
The ICE-E project did create models to help installers to design systems, but "often upfront cost is really important to people [as] they don't always invest in the most energy-efficient technologies," says London South Bank's Evans.

Cost is a big factor in why "big cold stores built by refrigeration contractors usually [opt for] ammonia," Evans argues. "Then you have the smaller cold stores that aren't bespoke in any way and are more flatpack-type stores. You buy them and you put an extra panel in the wall to make it bigger. They're very traditional and created for a [flat] price," she explains.

Maintaining efficiency

Greencold's Andrew does try to get the cost factor across to end users. "Yes, we would look at several types of system and compare the purchase price against 'on paper' lifetime operational energy consumption cost based on the same running hours, along with anticipated annual service costs of the plant, and

Figure 3 demonstrates level of expertise required to solve energy-related issues identified in the audits.



present our findings to the client. [The end user] can make an informed decision based on initial capital cost vs. running costs for the plant's full lifecycle."

Sometimes, the efficiency of a cold store declines over time. "Over the years people [change] things [and make] a very inefficient [cold store] without realising [it] over time," Evans says. She recommends continually monitoring performance.

In reassessing system performance, some changes are simply too expensive or too difficult for cold storage operators to make.

One cold store had lots of lighting, Evans says, so moving to LEDs would be more efficient. However, it was very difficult to get on the roof and "they used the store all the time," Evans says, so change would have cost too much.

Another non-technical barrier is lack of information. "We found out relatively quickly that people either didn't have that information or the person, often the energy manager, looks at how efficient the cold store is and very often doesn't have the refrigeration information – because the refrigeration manager or engineer has got that. So you end up with this sort of block, as no single person has all the information," Evans says.

This lack of information explains why Evans could not take into consideration the refrigerant in these cold stores, as energy managers and cold store operators simply lacked this data.

Zilio from the University of Padova points out that the ICE-E report found, "that a significant percentage of the 'small' stores in Europe still operate with R22". Zilio said: "I can't find a reliable and consistent number of published case studies to address the crucial choice for cold store operators and owners: to replace R22 with a transition mixture or to install a new plant. In both cases, which is the best refrigerant to adopt?"

"It is time to broaden the competencies and studies that have so far been developed for air-conditioning and supermarket refrigeration applications to display new efficiency enhancement opportunities and to increase the sustainability of the 'old' and still reliable technology adopted in refrigerated warehouses," Zilio argues.

Star's Pearson suggests it is ultimately down to end users themselves to monitor the performance of their cold storage facilities. "A few of our customers look at their refrigeration system energy consumption and benchmark it, but they are very unusual," he says.

Pearson also stresses the importance not just of measuring the information, but also acting upon it, if cold store performance is to be improved. "Otherwise, on that basis it is impossible to tell whether the refrigeration plant is good, bad or indifferent," he concludes. ■ CM



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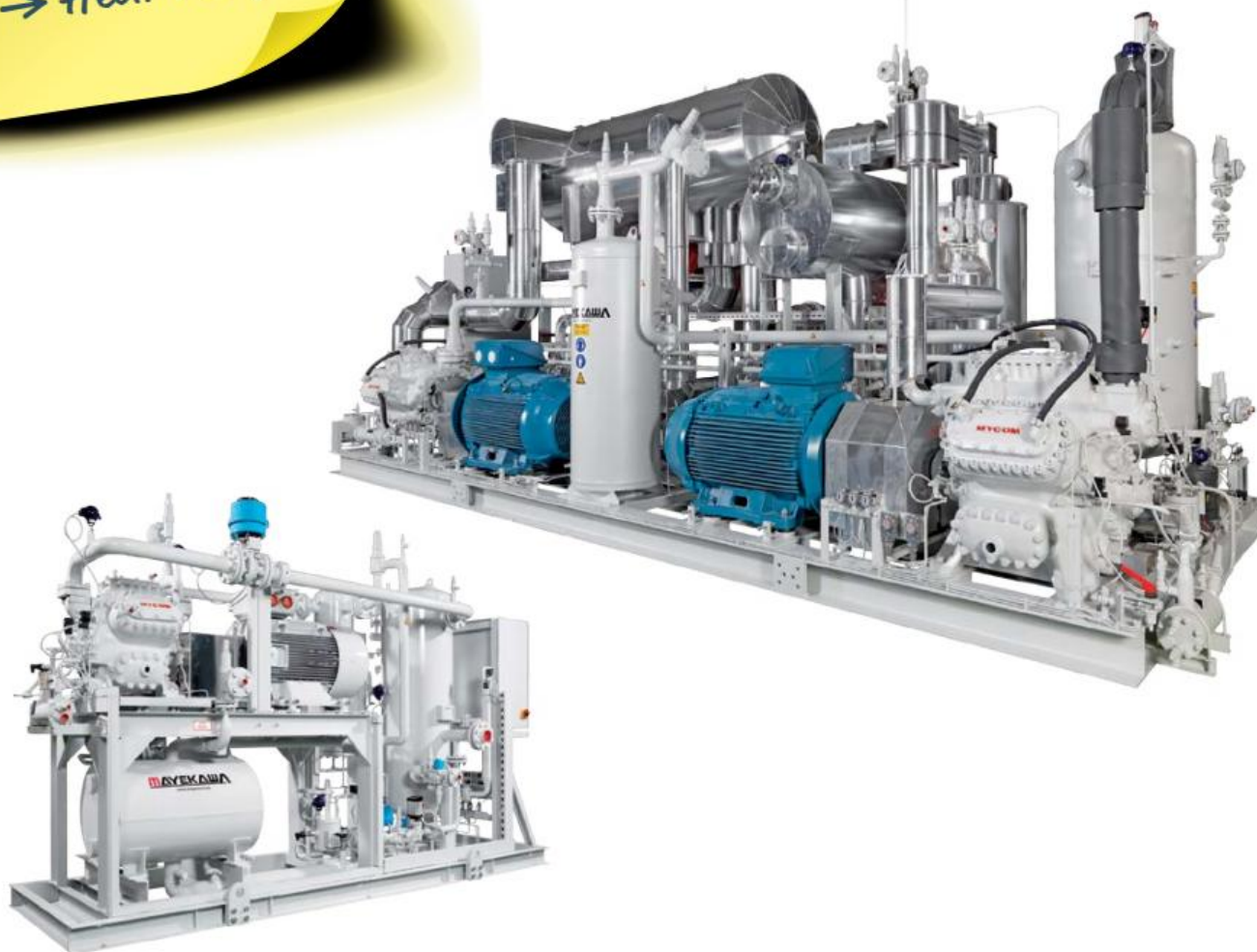
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