

ACCELERATE

ADVANCING HVAC&R NATURALLY

EUROPE



Migros
Supermarkets

p. 22

IN
MIGROS'S
DNA

NATURAL
REFRIGERANTS



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Refrigeration Consulting & Engineering

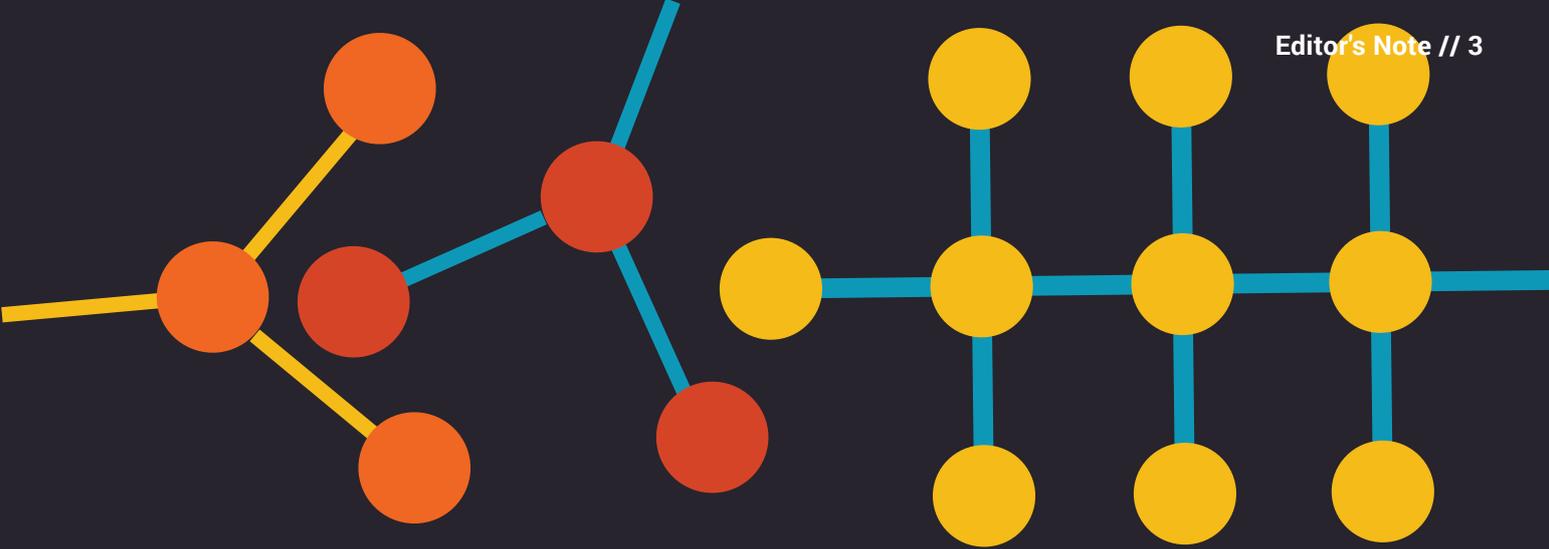
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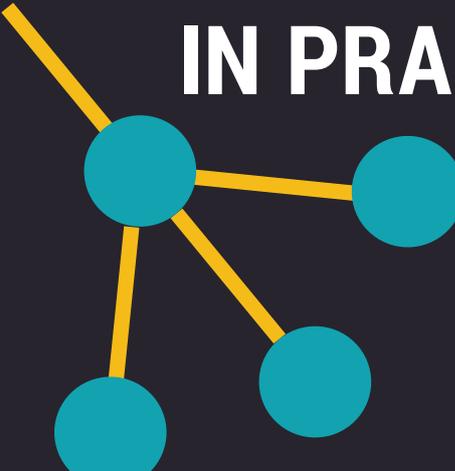
ADVANCED NATURAL REFRIGERANT TECHNOLOGY RESULTS IN:

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

30 years
FRIGO-CONSULTING



IN PRAISE OF INNOVATION



All over the world, in every industry sector, new technologies are revolutionising our lives.

The HVAC&R industry is no different in this respect. Progressive end users are turning to progressive manufacturers to help them adopt sustainable heating and cooling systems that can help to preserve our environment for future generations to enjoy.

Migros is one of these innovators. After building Europe's first ammonia-based supermarket in 1994, since 2010 the Swiss retailer has been installing CO₂ transcritical systems as standard in all its stores. Today it is testing propane-based water-loop systems as an alternative in smaller shops (p. 22).

German food wholesale specialist METRO AG, meanwhile, is also continuing to show leadership on natural refrigerants. This summer, it opened its first CO₂ transcritical stores in Russia, and its first in Bulgaria (p. 30).

Heat pumps are another important technology segment in which natural refrigerants are progressing.

In the Swedish city of Malmö, E.ON is harnessing waste heat from sewage treatment and waste incineration plants for district heating – thanks to ammonia heat pumps (p. 18).

The Gustav Lorentzen conference in Valencia in June showcased cutting-edge research into natural refrigerants conducted by leading experts from around the world. Some of the papers presented will no doubt contribute to bringing innovative new technologies to market (p. 38).

At Venditalia, meanwhile, competition between natural refrigerants hydrocarbons and CO₂ was picking up in the vending sector (p. 50).

Politicians can help boost uptake of natural refrigerants by pursuing policies that support the HFC phasedown, while training initiatives can help familiarise HVAC&R stakeholders with their use. We report from our ATMOSphere France conference in Paris (p. 44).

The Kigali Amendment to the Montreal Protocol, implementation of which was discussed this summer in Vienna (p. 62), an increase in hydrocarbon charge limits (p. 64), and soaring HFC prices in Europe under the F-Gas Regulation (p. 66) serve as further examples of how policy can support uptake of natural refrigerants.

Further afield, participants in ATMOSphere America 2018 were keen to debate how the rise of online shopping would change the market for natural refrigerants in the commercial refrigeration sector in the United States (p. 54).

South Africa has a unique opportunity to leapfrog straight from HCFCs to natural refrigerants. Another of our ATMOSphere conferences, in Johannesburg, helped end users to showcase how they are doing just that – with the help of HVAC&R firms at home and in Europe (p. 58).

Southeast Asian firms are also turning to natural refrigerants to help them to reduce their environmental footprint. If companies such as CP Foods and MClean represent the future direction of this region's huge market, then natural refrigerants have a bright future there (p. 34).

A fascinating exposé on the development of CO₂-based mobile air conditioning technology (p. 72) and a 30th anniversary interview with Frigo-Consulting (p. 68) bring this issue to a close.

Happy reading!



Andrew Williams
Editor

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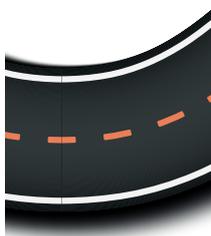


38 NatRef innovators take to Gustav Lorentzen stage

Industry experts explain effectiveness of CO₂, ammonia and hydrocarbons at event named for CO₂ pioneer.

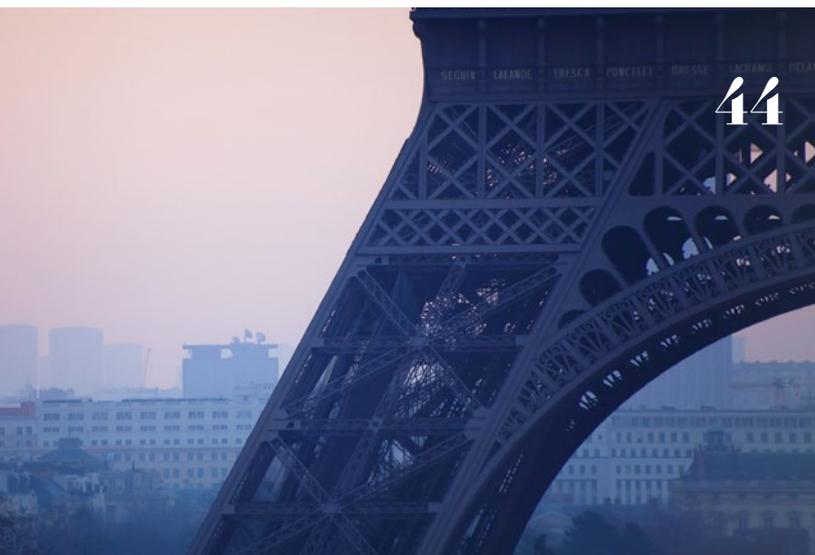
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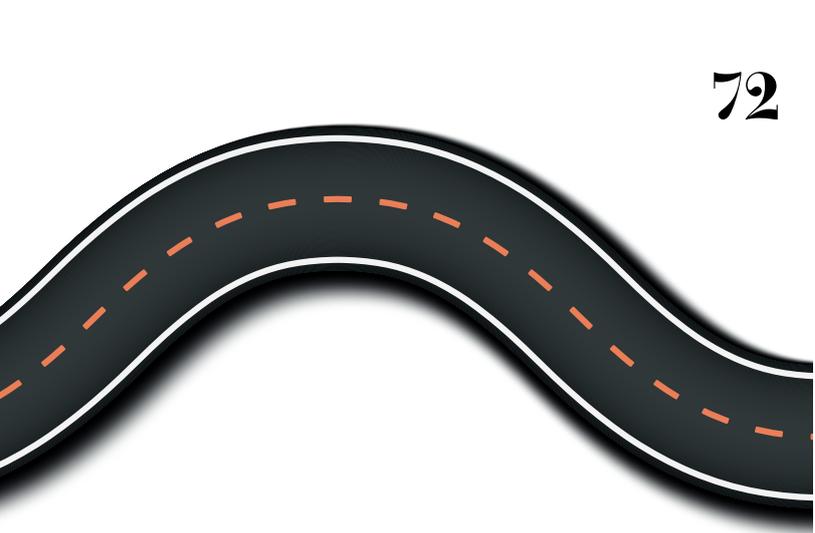




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ACCELERATE

ADVANCING HVAC&R NATURALLY EUROPE

About Accelerate Europe

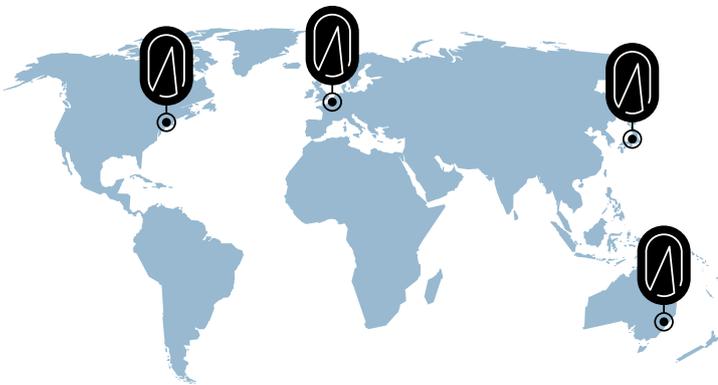
Brought to you by shecco, the worldwide experts in natural refrigerant news, *Accelerate Europe* is the first quarterly news magazine written for and about the most progressive business leaders working with natural refrigerant solutions in all HVAC&R sectors.

The *Accelerate* family of magazines includes editions in Europe, America, Japan, China, Asia, and Australia & New Zealand.

Printed copies are available to pick up at leading HVAC&R tradeshow and are posted to key end users and industry professionals.

www.accelerateEU.com

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



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Editorial Calendar

// ISSUE #13 *Winter 2018*

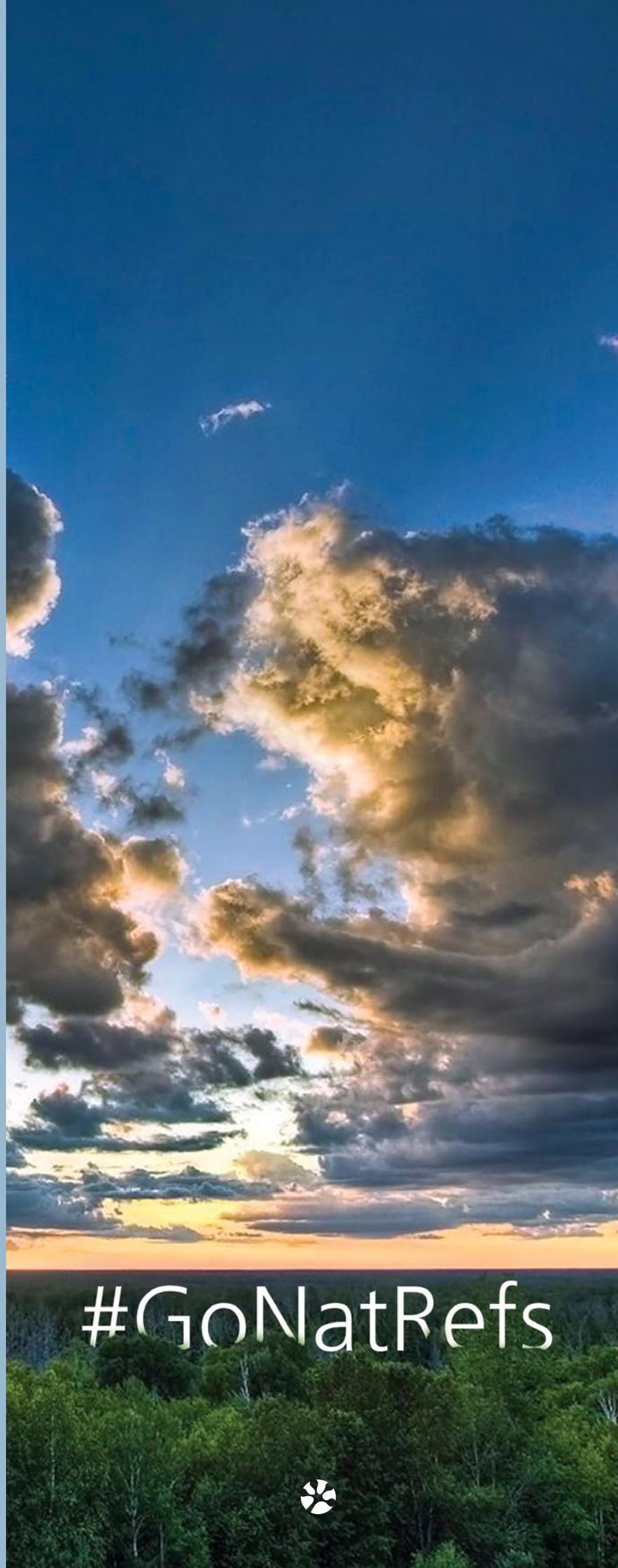
FOCUS:
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PUBLICATION DATE:
December

// ISSUE #14 *Spring 2019*

FOCUS:
TBC
PUBLICATION DATE:
March

// ISSUE #15 *Summer 2019*

FOCUS:
TBC
PUBLICATION DATE:
June



#GoNatRefs



SEP — OCT

19-20.09

**TECNOFRÍO'18
Madrid, Spain**

TECNOFRÍO'18 will analyse the current state of Spain's HVAC&R sector, including air conditioning and industrial processes.



www.congresotecnofrio.es/index.php

20-27.09

**IAA Commercial Vehicles 2018
Hannover, Germany**

IAA Commercial Vehicles 2018 is a unique platform for professional exchange between attendees from all over the world.



<https://www.iaa.de/en/>

25.09

**#Build2050
Brussels, Belgium**

Conference organised by trade association EHI on future policies to decarbonise buildings by 2050.



www.ehi.eu/build2050

25-28.09

**Eurovent Summit
Sevilla, Spain**

The indoor climate, process cooling, and food cold chain industry from Europe, the Middle East, and Northern Africa will be at the EUROVENT Summit.



<https://eurovent-summit.eu/en/>



3.10

**IOR seminar on CO₂
Aberdeen, UK**

The IOR's Scottish branch is organising two evening seminars looking at the resurgence of CO₂ as a refrigerant.



<https://ior.org.uk/scottish-branch-northern-evening-seminar>

3.10

**European Week of Regions
and Cities
Brussels, Belgium**

An annual four-day event during which cities and regions showcase their capacity to create growth and jobs.



https://europa.eu/regions-and-cities/programme/sessions/106_en



OCT — DEC

16-18.10

Chillventa 2018 Nuremberg, Germany

Learn about the latest natural refrigerant technology trends at one of the world's leading HVAC&R shows.



<https://www.chillventa.de/en>

6.11

ProKlima Baden, Switzerland

Every year, industry group ProKlima hosts its 'Day of Building Technologies', which attracts manufacturers, planners and consultants from all over Switzerland.



<http://www.proklima.ch/CFDOCS/cms/admin/download.cfm?FileID=1091&GroupID=265>

19-21.11

ATMO Europe Riva del Garda, Italy

The 9th Annual ATMOSphere Europe conference will be held on Italy's Lake Garda. Industry leaders will share their natural refrigerant expertise with a diverse audience.



<http://www.atmo.org/events.details.php?eventid=67>

28-29.11

Sifa 2018 Lyon, France

Sifa is France's leading event dedicated to all HVAC&R players: manufacturers, installers, end users and OEMs.



<http://www.expo-sifa.com/en/>



5.-7.12

Serbian HVAC&R Society: International Congress & Exhibition Belgrade, Serbia

The event will present new HVAC&R products used in buildings and to supply energy to buildings.



<http://kqh-kongres.rs/index.php/en/>



EUROPE IN BRIEF

Spain approves €1.5m subsidy

The Spanish government has approved a new subsidy to help support the transition to sustainable refrigeration systems.

In late August, Spain's Council of Ministers, at the behest of the Ministry for the Ecological Transition, approved a Royal Decree establishing a €1.5m subsidy for installing refrigeration systems with zero or low-GWP refrigerants. The funding is part of the 'PIMA Frio' plan.

The subsidy aims to promote the use of efficient and sustainable HVAC&R systems in the commercial sector in the context of future restrictions on f-gases under the EU F-Gas Regulation.

"With this new subsidy we would like to provide additional support to facilitate the transition to sustainable refrigeration systems," said Guillermo Martínez from the Spanish Ministry of Environment. ■ PA

LU-VE to strengthen presence in China

Continuing its Asian expansion, Italy-based heat exchanger manufacturer LU-VE will move its Chinese production to a new, bigger plant.

LU-VE's current Chinese factory, located in Changshu (Jiangsu Province), is 7,000 m². It will open a new 19,000 m² plant in Tianmen (Hubei Province) in 2019.

The LU-VE Tianmen plant will be almost totally devoted to assembly and production. A further expansion of another 10,000 m² is expected for 2021.

The move to Hubei Province will allow LU-VE to be closer to its Chinese clients, and to benefit from fiscal advantages (e.g. ultra-low rents for five years) granted by the Chinese authorities in the framework of the 'Belt & Road Initiative', which aims to attract foreign investment to China's western and central regions. ■ DB

Mahou San Miguel invests €3.3m in propane chiller

Spanish brewer Mahou San Miguel has invested €3.3m in developing a propane-based (R290) chiller for the hospitality sector.

Mahou San Miguel estimates that the new 'Ecocooler' chiller, provided by Spanish commercial refrigeration firm effcold, will reduce energy costs by 12-15% compared to HFC-based equipment.

"Our investment in this initiative is part of our constant commitment to providing value solutions to the hospitality industry through innovation and, of course, with the sustainable development of our business and that of our customers, taking care of our environment," said Segura Peio Arbeloa, general director of Mahou San Miguel's Spanish unit.

By harnessing propane, the ozone-depleting potential (ODP) of the chiller is zero while its global warming potential (GWP) is just three.

The cooler was designed with the limited space of bars and hotels in mind. It is available in three sizes – all of which are smaller than chillers currently produced by the company, according to FoodBev Media, a food and drink news website.

Mahou San Miguel has pledged to invest a further €30m in rolling out the chillers over the next three years as part of its 'We Are 2020' sustainability programme. ■ AW

Fraunhofer develops propane heat pump

The Fraunhofer Institute for Solar Energy Systems (Fraunhofer ISE) has developed a heat pump based on propane that harnesses the natural refrigerant in a heat cycle.

Propane has an ozone-depleting potential of zero and a global warming potential of three. Yet its high flammability poses challenges when used in a heat cycle.

The Fraunhofer research team employed highly compact, brazed, finned heat exchangers – which function well with small volumes of liquid – to transfer the thermal energy from one flowing substance to the other.

"The liquid should completely vaporise or re-condense over the running length. To guarantee they operate efficiently, the vapour-liquid ratio must be identical in all the channels. Generally, that's not easy to achieve, and it becomes especially tricky if you're also trying to limit the volume of refrigerant," said Dr. Lena Schnabel, head of department (heating and cooling technologies) at Fraunhofer ISE.

To solve the problem, the research team developed a distributor with a continuously branching structure like the branches and twigs of a tree. ■ AW

SUSTAINABLE CO₂

REFRIGERATION SYSTEMS

With every breath, the average person exhales between 3 and 4 % CO₂. Our breath probably contains more CO₂ because **we live and breathe for the application of CO₂** in the world's best, sustainable CO₂ refrigeration systems.

CO₂ is often associated with global warming. **However, we don't lose our cool.** Literally. Because CO₂ is one of the most climate-friendly refrigerants; it is non-toxic, and it does not affect the ozone layer. It will help put a chill on global warming. That among other things why we are **cool with CO₂**

We hope to meet you at Chillventa! 16.-18.10.2018
Please visit us in hall 9, stand 9-529

ADVANSOR
a **DOVER** company

EUROPE IN BRIEF

EU industry group flags illegal refrigerant trade

The European Association of Refrigeration, Air-Conditioning and Heat Pump Contractors (AREA) has warned of illegal imports and black market trade in refrigerants in some EU member states.

"In some countries there are still significant quantities of R22 circulating in the black market and old systems that are topped up using these illegal quantities," said AREA in an August submission to a European Commission consultation on the review of the EU's Ozone-Depleting Substances (ODS) Regulation.

"Such systems are the most likely to produce leakages but it is cheaper to re-charge than to repair the leak. Without worldwide bans on production of R22 and other ODP gases, the market will continue to use them illegally," AREA said in its submission. ■ AW

Beijer Ref expands European AC distribution network

Swedish multinational Beijer Ref has acquired Lumelco S.A., which sells air-conditioning products in Spain and Portugal.

Lumelco employs 65 people and its 2017 sales amounted to €38.5m. Operations will continue as normal under the Lumelco brand.

Lumelco has been a distributor for Mitsubishi Heavy Industries for over 35 years.

In May, Beijer Ref announced the acquisition of Lyon-based air conditioner distributor GH2C.

GH2C distributes Daikin and Toshiba products in France. GH2C delivers air conditioners within the professional and residential segments. ■ AG

Reftronix, Invertek Drives announce partnership

UK-based company Invertek Drives Ltd. and Danish CO₂ refrigerant control specialist Reftronix will launch a new CO₂ condensing unit controller (CDU) and variable frequency drives (VFD) for OEMs at Chillventa, the international HVAC&R exhibition, in Nuremberg, Germany, in October 2018.

The goal of their technical partnership is to provide an energy-efficient, natural refrigerant-based solution to comply with the requirements that the EU's F-Gas Regulation and Eco-Design Directive impose on the HVAC&R industry.

The companies predict energy efficiency gains of at least 25% with the controller and VFD compared to a traditional 'on and off' control. ■ RM

HFC phasedown to mitigate 'Hothouse Earth' risk

Even if humankind succeeds in reducing greenhouse gas emissions to the extent enshrined in the Paris Agreement, irreversible changes taking place on Earth will disrupt these efforts and trigger unsustainable levels of drought, according to a study published on 6 August. But the HFC phasedown can help mitigate the risk, the researchers find.

Average temperatures on Earth could stabilise at 4°C or 5°C above those of the pre-industrial era, warns the study, published in the journal *Proceedings of the National Academy of Sciences* (PNAS).

It mentions HFC management as one of the solutions to help mitigate the effects of such a scenario. ■ MB

IIAR to develop safety standards for HC systems

The International Institute of Ammonia Refrigeration (IIAR) will collaborate with ASHRAE to write a safety standard for hydrocarbon systems used in commercial and industrial applications.

ASHRAE already has a design standard for hydrocarbons, so IIAR will work with ASHRAE's Standard 15 committee "to determine current gaps in their design standard," said the IIAR's Dave Rule.

The IIAR's standards committee will address the design gaps and submit new text to the Standard 15 committee for adoption in the ASHRAE standard, added Rule.

The IIAR committee will develop a separate standard for hydrocarbons to address "installation, maintenance and other safety issues, since [Standard] 15 does not cover these specific areas". ■ MG

Nestlé to open new NH₃-cooled UK warehouse in 2020

Swiss multinational Nestlé has joined forces with transport and logistics company XPO Logistics to open a new ammonia-cooled UK distribution centre at the East Midlands Gateway Logistics Park in Leicestershire.

The food and beverage giant will move into the new 638,000 sq. ft. (59,272 m²) facility in 2020.

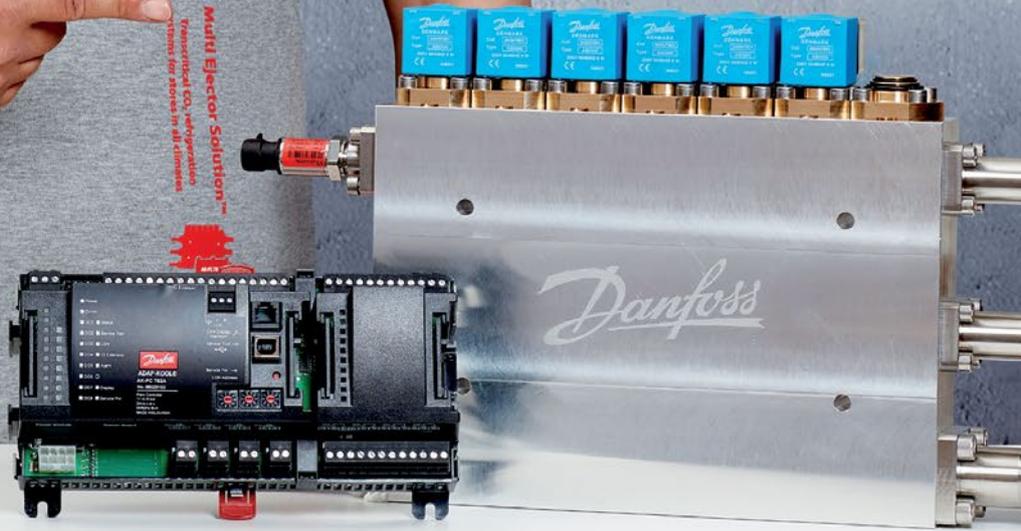
Nestlé is already using natural refrigerants for over 90% of its industrial refrigeration needs worldwide.

LED lighting, air source heat pumps and rainwater harvesting technology will be among the other environmentally friendly technologies on the East Midlands site. ■ AW

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ENGINEERING
TOMORROW



NO MORE FEAR OF FIRES

Paraphrasing the lyrics of Gary Brooker's great song 'No more fear of flying' provides food for thought. For many decades, we were accustomed to 'safe' refrigerants: not flammable, and non-toxic (although we often forget the serious risk of asphyxiation). Fast-forwarding to today, almost all low-GWP refrigerant alternatives are flammable, inducing fear. But fear is a bad counsellor.

When will we hear the final word? Or should that be: will there ever be a final word? Relying on compliance, and taking as final the words of recognised safety standards, would be the easiest way. Yet would that really be the final word? Technology progresses. Every risk is manageable – even from nuclear power plants. So why not also from several kilograms of hydrocarbon refrigerant?

Safety standards must continuously evolve, to remain up-to-date. A chain of committees and working groups must continuously work, as the decades pass, to develop and revise these standards, in the frameworks of ISO, CEN, IEC, CENELEC and various national bodies. Significant progress is being made to increase the rigid 150g flammable refrigerant limit to higher values, under certain conditions. But it may still take time for a revised standard to be approved and published. Recently a new working group – Working Group 12 in the framework of CEN/TC-182 – began to assess existing European safety standards in order to identify and remove barriers for the application of flammable refrigerants, in particular hydrocarbons. But

the variety of equipment details, application conditions and innovative safety improvements is so huge that standards alone may never provide the final word...

Will it all one day become a joke? This subject is too serious for jokes. And yet, to return to the history books – in the late 1980s, I was working on domestic fridges with hydrocarbon refrigerants, but all home fridge manufacturers unanimously disqualified any option of applying hydrocarbons in such appliances, for safety reasons.

However, thanks to the fantastic work by Greenpeace with their GreenFreeze concept, successfully launched in Germany, we have today many billions of domestic fridges all over the world, running with isobutane refrigerant. And based on strong statistical evidence, their safety records are fully acceptable, so the original disqualification by all manufacturers can indeed be considered a joke...

And what about the liars? Safety and risk are ideal subjects for liars. Certain statements may not be true, but they are extremely difficult to oppose on the basis of true facts. Driven by commercial interests, truth may become fluid, and the HFC/HFO market is a global multibillion-euro business, where liars feel comfortable.

On the contrary, hydrocarbons are too cheap. You can't make big profits from hydrocarbon refrigerants – so this is not an attractive environment for liars. My hope, therefore, is that potential liars will take their responsibility to society and the environment seriously.



René van Gerwen
Founder & Managing Director
Entropycs

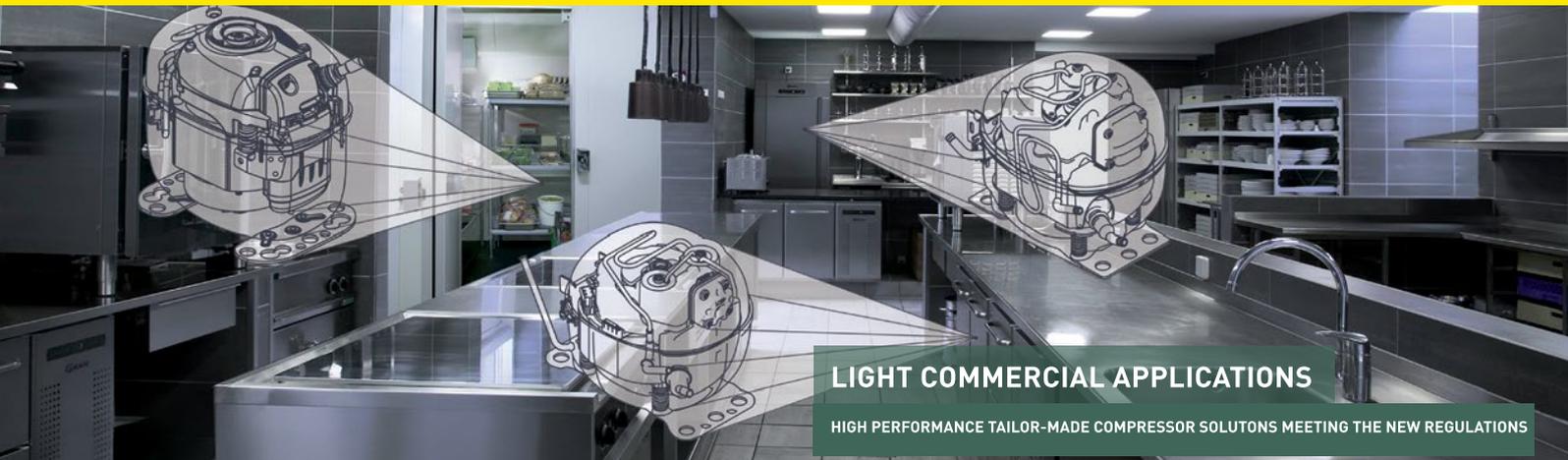
Van Gerwen, a well-known HVAC&R expert with over 30 years of experience in sustainable refrigeration and heat pump technologies, founded engineering and consultancy firm Entropycs in 2016. He has taken major positions in professional organisations such as IIR, IAR and CEN.

“ Don't compromise on safety, but put safety in the right perspective. ”

It's time to leave our song, now, and come back down to Earth. Don't compromise on safety, but put safety in the right perspective. Compliance with recognised safety standards is practical for standard equipment in standard applications, but ultimately manufacturers have their own responsibility to put safe products on the market. So the basis should be a thorough risk assessment, where innovative risk-reducing measures can be applied in order to reach acceptable risk levels.

This is what is gradually happening in all parts of the world – for example, Swiss retailer Migros's use of reduced and confined charges of hydrocarbon refrigerant by applying water loops, as an alternative to CO₂ transcritical – further broadening the market for hydrocarbons.

HIGHLY EFFICIENT HYDROCARBON OPERATED COMPRESSOR TECHNOLOGY



LIGHT COMMERCIAL APPLICATIONS

HIGH PERFORMANCE TAILOR-MADE COMPRESSOR SOLUTIONS MEETING THE NEW REGULATIONS



HOUSEHOLD APPLICATIONS

DELIVERING EVERYDAY COMFORT WITH INTELLIGENT HOUSEHOLD COMPRESSOR SOLUTIONS



DC-POWERED APPLICATIONS

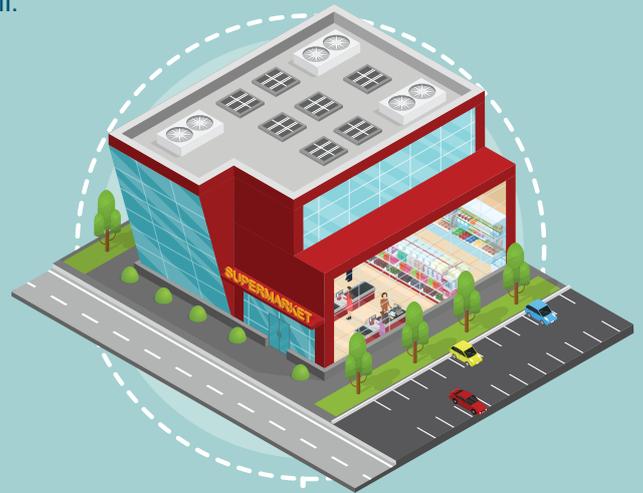
COMPACT DIRECT CURRENT COMPRESSORS FOR MULTIPLE VOLTAGES AT EXTREME CONDITIONS

How to build an eco-friendly supermarket

Tips and tricks from SuperSmart, an EU-funded project promoting uptake of efficient HVAC&R systems in European food retail.

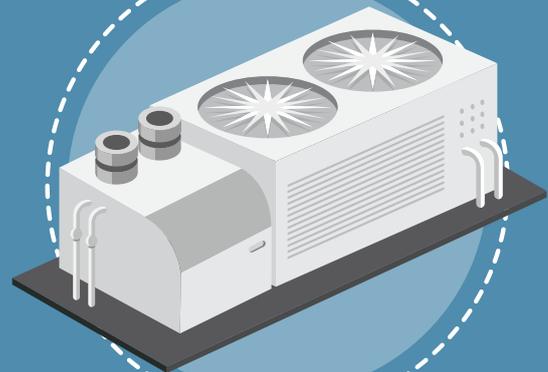
BUILDING DESIGN

- Properly insulate walls, floors and roof.
- Minimise sunshine onto refrigerated products coming through windows and doors to reduce cooling load.
- Install energy-efficient LED lighting and maximise natural light. 20% of supermarket energy demand comes from lighting.
- Introduce to the store layout different climatic zones for different types of product. Hot food should not be kept alongside refrigerated goods, for example.
- Take advantage of roof space to install solar panels or other renewable energy technologies.



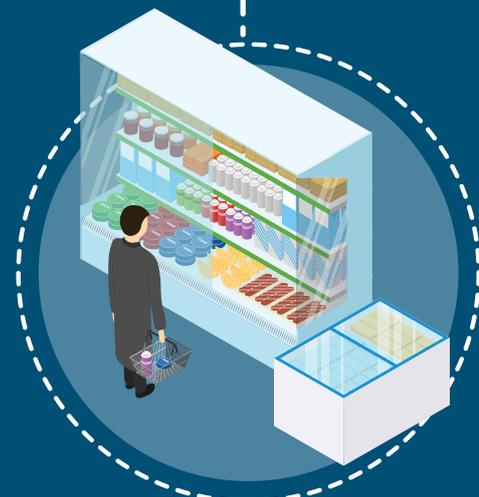
REFRIGERATION AND HVAC

- Refrigeration system – energy-efficient, natural refrigerant-based equipment exists for chillers, booster systems, condensing units, self-contained water-loop systems and packaged units.
- Improve energy efficiency of CO₂ refrigeration systems with parallel compression, ejectors and adiabatic cooling. Similarly, optimise hydrocarbon-based systems through variable speed compressors or by adding a water loop.
- Integrate heat recovery from the refrigeration system for hot water and for heating/air conditioning.
- Thermal energy storage.
- Controls and monitoring.



CABINET DESIGN IMPROVEMENTS

- Reduce energy consumption of fans by 70% with high efficiency fans.
- Place evaporator fan outside cabinet.
- Anti-condensate heaters on display door.
- Insulate with low-GWP foams like cyclopentane.
- Reduce light energy demand by 60-70% with LED lighting.
- Night covers offer energy savings of 25-40%.
- Covering cabinets with glass doors or lids can significantly reduce the cooling load.
- Load units correctly – don't overstuff cabinets.



New range of Booster *for Convenience stores.*



Sweden gets the ammonia treatment

Using the heat from Malmö's sewage treatment and waste incineration plants, four ammonia heat pumps deliver heating to approximately 100,000 homes in the Swedish city.

— By Charlotte McLaughlin

Providing more climate-friendly space heating and cooling can help European countries to reach their climate targets under initiatives such as the Paris Agreement. Currently, heating and cooling buildings and industry accounts for half of the European Union's energy consumption, according to the European Commission (2016 figures). In EU countries, heating and hot water alone account for by far the biggest share of final energy use, with 79% taken up by residential areas.

Germany-headquartered E.ON — one of the world's largest investor-owned electric utility service providers — is looking at ways to reduce greenhouse gas emissions from the electricity and heating it supplies to European and global households and businesses.

Malmö's western harbour area.



A graphic representation of the GEA ammonia heat pump model installed in Malmö.

Credit: GEA



“We will reduce our absolute carbon footprint by 30% [by] 2030 compared with 2016,” says E.ON in its 2017 Sustainability Report.

With this in mind, the utility, “will reduce the CO₂ intensity of our customers – i.e. the CO₂ intensity of our power sales – by 50% until 2030 compared with 2016”.

“One example is Sweden, where renewables already account for more than 50% of energy consumption,” the report says. “In line with this, our local [Swedish] unit has developed ambitious climate protection targets. Under the banner of ‘Clean 2025’, it intends to [provide to its customers] 100% recycled or renewable energy by 2025 and has developed appropriate measures to achieve this goal”.

In Sweden the company owns extensive electricity, district heating and gas networks. District heating networks centralise heating for entire residential and commercial areas, increasing the efficiency of heating compared to individual systems and thus saving costs. Mats Egard, E.ON Sweden’s heating segment project manager, is confident the company will deliver on this goal. “We are going to supply district heating energy that is either recycled or renewable by year 2025,” he explains.

“In 2014-2015, we made an internal investigation of different solutions for the district heating of the future,” Egard says. The company chose heat pumps as one option, along with biomass and other renewable technologies, to mitigate greenhouse gas emissions from heating.

Installing the heat pump

E.ON first decided to use heat pumps for district heating in southern Sweden, where the company decided to install four GEA ammonia heat pumps each with a heating capacity of 10 MW (in total 40 MW), next to a sewage treatment plant and waste incinerator in the harbour area of the city of Malmö. “We started in 2015 and then we got our investment decision in May 2016. We signed the contract in July with *Francks Kylindustri* [a Swedish contractor specialised in cooling and heating with ammonia],” says E.ON Sweden’s Egard.

The heat pumps take advantage of the waste heat from the sewage and waste plants, in the harbour area, to provide heating to approximately 100,000 homes in greater Malmö. Installing the four GEA heat pumps took approximately 14-15 months. Groundwork began in August-September 2016, “and we commissioned the last heat pump at the end of December 2017,” says E.ON’s Egard.

E.ON decided to use the sewage water to provide base heat for the heat pump due to the higher temperature emitted by the sewage plant (14°C) – making the water warmer than the sea near Malmö. “In January and February, sometimes the seawater even goes below zero, and then it’s impossible to get any heat out of it. That’s when the heat is at its most valuable – when it’s colder outside,” Egard says. “Basically the sea outside Malmö is too shallow. If you have deeper seas, you always have 4°C at the bottom of the sea, but you don’t have that here.”

RIGHT

GEA's ammonia heat pump system installed in Malmö.
Credit: GEA



Kenneth Hoffmann is GEA's product manager for heat pumps. He was also involved in the Malmö project, and is keen to chime in. "They have [seawater heat pumps] a lot in Norway with the deep fjords, but then you can get down to the bottom of the sea, which is perhaps 20-30 metres deep – you have a constant temperature down there of 8°C," he says.

The four heat pumps withdraw 30 MW of heat from the sewage water. "On average the wastewater is chilled from 14°C to 8°C," writes Hoffmann in an Institute of Refrigeration (IOR) paper on 'Large scale heat pumps for high efficiency district heating projects'. "The energy harvested is upgraded to useful heat for the district heating network through the heat pumps," he adds.

The heat pump has been integrated with the district heating network to work in conjunction with the nearby waste incinerator plant. "The water from the city returns to the waste incinerator plant at around 50°C, where in the flue gas economiser it is heated to around 55°C before going into the heat pump to 66°C," Hoffmann explains in the paper.

"The water then returns to the waste incinerator plant where it is [...] heated to the requested temperature by the heating network, which can vary depending on the heating demand from 70°C to 90°C. The heat pump is designed for delivering heat up to 80°C, but will rarely deliver temperatures above 71°C," the paper says.

Ammonia: A long-term puzzle

This is not the first time heat pumps have been used in Sweden. "A lot of big heat pump plants were built in the 1980s, when electricity was cheap," notes E.ON's Egard. "So some of them are bigger than ours, but none of them use ammonia."

The four heat pumps work in parallel to deliver the promised temperatures. Each has a coefficient of performance (COP) above 3.50, "so for each 1 kWh of electricity used by the heat pump, 3.5 kWh of heat is produced for the city," says GEA's Hoffmann.

E.ON decided to opt for ammonia rather than chemical-based refrigerants due to the EU F-Gas Regulation, which aims to phase down HFCs by 79% by 2030, and the company's understanding of its environmentally conscious customers.

"It would have been cheaper to install [an] R134a [heat pump], I think by 30%, but we didn't believe in that refrigerant for the future, because we are going to become 100% [renewable]," says E.ON's Egard.

"We're going to supply district heating energy that is either recycled

or renewable by 2025, and if we are then planning to use a heat pump with R134a, we fear that in future our customers might consider this refrigerant not to be totally green, since it has a global warming factor that is high [R134a's GWP = 1,430]," he explains. "So that's one reason we didn't want to choose that refrigerant," he adds.

The EU's F-Gas Regulation is widely expected to increase the price of HFCs substantially, as GEA's Hoffmann notes in the IOR paper. "Whereas older systems were running off f-gas refrigerants, the F-Gas Regulation has made these systems with large refrigerant charges unsustainable," he writes.

He does not see HFOs – the new generation of synthetic refrigerants – as sustainable alternatives either, pointing out that in future they might be phased down like HFCs. Moreover, the cost of these refrigerants is substantially higher than natural alternatives.

E.ON's Egard, meanwhile, told *Accelerate Europe* that the company is not currently working on more heat pump projects. But he did not rule out similar such projects in future. ■ CM

emj

Electronic Modulating Ejector

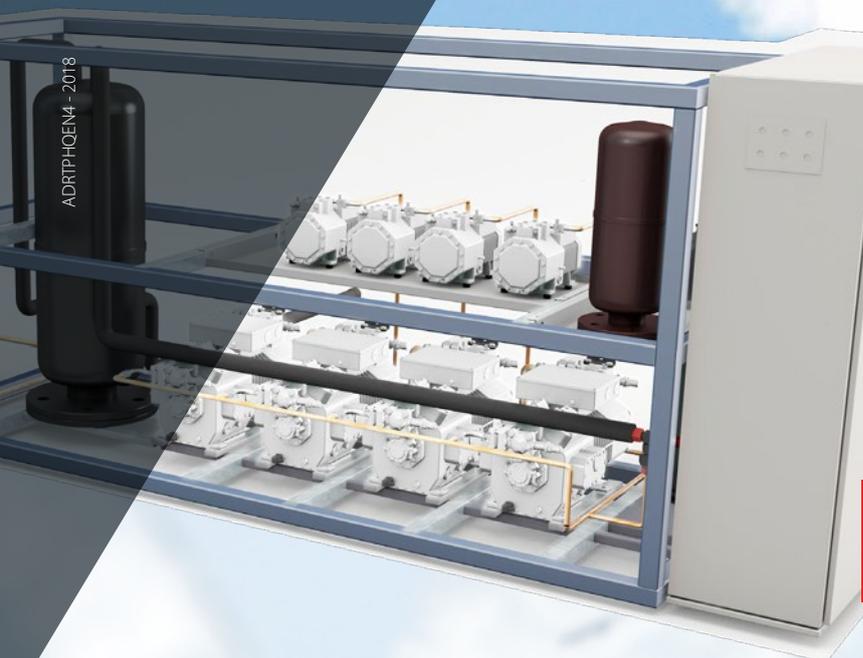
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IN MIGROS'S DNA

Natural refrigerants have been at the heart of Swiss retailer Migros's sustainability strategy ever since it built Europe's first ammonia-based supermarket in 1994. Since 2010, Migros has been installing CO₂ transcritical systems as standard in all its stores. Today it is testing propane-based water-loop systems as an alternative in smaller shops. *Accelerate Europe* reports from Zürich, Switzerland.

— By Andrew Williams

Founded by Gottlieb Duttweiler in 1925, today Migros is Switzerland's largest retail company, its largest supermarket chain and its largest employer. Structured as a cooperative with over two million members across its ten regional divisions, every adult living in Switzerland can become a member, receive one share for free, and vote in the general assembly.

Duttweiler himself once said, "the bigger the company, the more it should concern itself not just with business aspects but also with solving people's problems".

A commitment to sustainability has been part of Migros's DNA since the very beginning. Today, the 'Generation M' programme governs the company's sustainability objectives across five areas – consumption, environment, employees, society and health.

Migros's official target is to reduce greenhouse gas emissions by 20% by 2020 compared to 2010 levels, which it achieved by the end of 2017. The firm is aiming to reduce electricity consumption by 10% (also vs. 2010 levels) by 2020. It had delivered -7.5% by the end of last year. New sustainability targets for 2030 are in the making.

As Switzerland's biggest retailer, Migros is aware of the responsibility it shares to help put the country on an environmentally friendly footing. "It's Migros's understanding that sustainability means reducing emissions if you can," Urs Berger, who heads the Energy and Building Technology department at Migros Engineering Solutions (MES), told *Accelerate Europe* at Migros's headquarters in Zürich, Switzerland.

"We want to be recognised as a driving force for the adoption of natural refrigerants," Berger says.

THE JOURNEY BEGINS

An engineer by training, Berger's HVAC&R career began as an apprentice refrigeration installer. His first job was at Sulzer, a Swiss industrial engineering and manufacturing firm, where he worked on industrial refrigeration installations.

"With knowledge of the damage that refrigerants can cause, I then went to Migros and started their natural refrigerant strategy," he says.

That journey began in the early 1990s, when Berger – who joined the firm in 1989 – identified natural refrigerants as market-ready alternatives to HFCs.

In 1994, Migros installed Europe's first ammonia system for a supermarket. "We recognised in the early 1990s that we were being introduced to new synthetic refrigerants, which have their disadvantages," says Berger.

"Introducing new synthetic refrigerants can seem like a solution, but over the years it becomes part of the problem. I've seen many refrigerants come and go," he says.

"So in the early 1990s, we decided to go directly to natural refrigerants. In the beginning it was with ammonia and a secondary cooling solution," he explains.

In 2002, Migros opened its first supermarket to use CO₂, in a low-temperature subcritical system. It installed its first CO₂ transcritical system in 2005.

"As the availability of CO₂ components improved, first for low-pressure subcritical and then for high-pressure transcritical, over the years we moved to those solutions," Berger explains.

For supermarket refrigeration, all Migros's new and retrofitted installations use CO₂ transcritical systems as standard (since 2010). By 2015, the company was harnessing new innovations such as ejectors to boost efficiency.

Of the 700 supermarkets in Migros's portfolio, 411 are equipped with transcritical CO₂ systems (2017 data).

GOODBYE HFCS, HELLO CO₂!

The decision to phase down HFCs was taken before the entry into force of Switzerland's ChemRRV legislation – which regulates their use nationwide – and before the adoption of the Kigali Amendment to the Montreal Protocol, which governs the phasedown globally. What, then, were the main drivers?

"The main driver is that we want to get rid of HFCs," Berger says.

In retail – including the supermarkets and logistics centres of all ten Migros cooperatives – 34% of direct greenhouse gas emissions in 2016 were from refrigerant leakages.

"So by moving to CO₂ refrigeration, once we've changed our entire fleet, we'll have taken all those emissions out of the picture," Berger says.

Proud of its position among the first movers in phasing down HFCs, Migros sees the current regulatory picture as

MIGROS AT A GLANCE

Founded in

1925

Biggest retail company in



Cooperative society



2m+
MEMBERS



0.5%
REVENUE

for social & cultural projects

400 rail wagons transport daily



1.4m
TONNES' FREIGHT

M-Industry



32
MIGROS'S OWN
COMPANIES



20,000+
OWN PRODUCTS



Urs Berger, photographed by Roland Steiner.

“ We want to be recognised as a driving force for the adoption of natural refrigerants. ”

– Urs Berger, Migros Engineering Solutions (above)

proof that the decision to adopt natural refrigerants was the right one.

“Legislation gives us certainty of investment,” Berger says. “Without that reliable basis for decision-making, it would be harder to decide.”

Supermarket refrigeration is not the only part of Migros’s food retail business to use natural refrigerants. “Our biggest installations in distribution centres use ammonia, and our smaller ones use CO₂,” Berger says.

WATER-LOOP TECHNOLOGY FOR NICHE MARKETS

Proud of its long history at the forefront of innovation, Migros is keen to trial new technologies as it searches for the most effective means of meeting its sustainability targets. This is what drove some Migros cooperatives to begin installing water-loop HVAC&R systems in small supermarkets.

Water-loop systems represent an alternative method for businesses such as small supermarkets to supply their refrigeration needs in a more decentralised manner.

Migros currently boasts 25 supermarkets fitted with water-loop systems based on natural refrigerant propane (R290).

Rather than cooling all the supermarket’s cabinets and cold rooms from a centralised refrigeration plant, each wall-mounted display case runs off its own propane system. The exhaust heat is carried away by a water loop.

Accelerate Europe met Andreas Moser, who works on energy efficiency and climate protection in Berger’s team, at Migros’s pilot propane water-loop store in the Herdern district of Zürich – where the system was installed in May 2016.

“There are three hydrocarbon circuits within each cabinet. The new edition contains only one circuit per cabinet. The water loop rejects the heat to a nearby logistics centre, where it provides hot water for the central heating system,” Moser said.

For Migros, the business case for choosing a water-loop system is at its most compelling if the store is small enough, if there is limited space on site for a machine room, and if there is demand for hot water elsewhere on the premises.

“Part of the motivation for installing these R290-based water-loop systems is if you



MIGROS HERDERN

- ▶ Migros convenience store in Herdern, Zürich.
- ▶ One of 25 Migros supermarkets fitted with water-loop systems based on propane (R290).

SYSTEM:

- ▶ Migros's pilot propane water-loop store.
- ▶ System installed in May 2016.
- ▶ Each wall-mounted display case runs off its own propane system.
- ▶ Exhaust heat is carried away by a water loop, for use in the central heating system of a nearby logistics centre.
- ▶ 'Jupiter Green' cabinets from Freor LT.
- ▶ Installer: HAVO Group

don't have space on site for a machinery room," says André Duppeler of Cooperative Migros Zürich, who is responsible for the system in the Herdern store.

CO₂ COMES OUT ON TOP

Yet with energy efficiency ranking among the most important decision-making criteria, Migros finds that in central Europe, water-loop systems simply can't compete with CO₂ installations for energy efficiency.

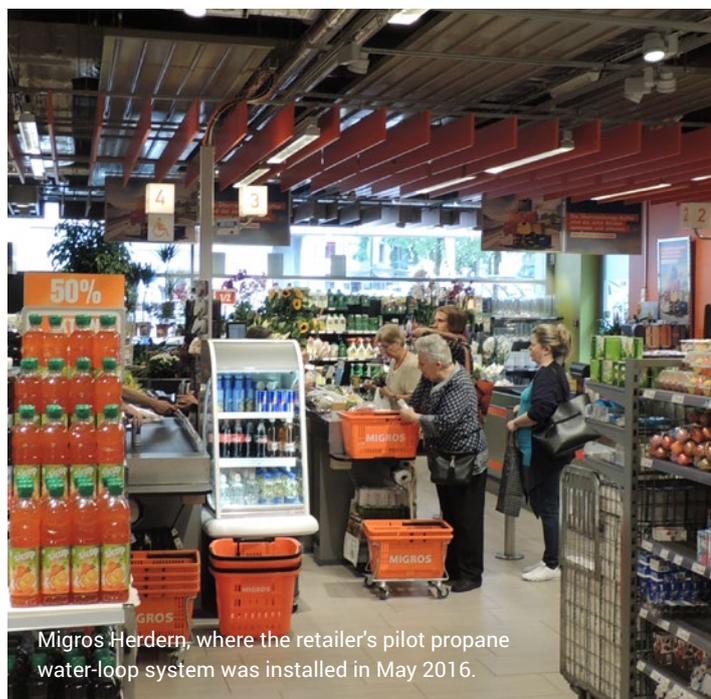
"To be clear, the water loops are only a potential solution for small supermarkets if no CO₂ installation is possible. Energy efficiency is a paramount requirement. Our best CO₂ installations still consume 30% less electricity than our best water-loop system," Moser says.

Migros monitors all its supermarkets. The most efficient receive an internal award. In 2017 the average key performance indicator of its top ten supermarkets was 1,600 kWh/m²*a per metre of cooling cabinet (including heat recuperation), while its best water loop achieved 2,400 kWh/m²*a (without heat recuperation). kWh/m²*a refers to kilowatt hours per metre of cabinet per year, the figure by which Migros measures efficiency.

Asked whether water-loop systems have the potential to become a serious rival to CO₂ transcritical, his colleague Berger replies: "For most supermarket applications, CO₂ will remain the standard. Maybe in the niche market of small convenience stores up to a maximum surface area of around 500 m², and in train stations and petrol stations, there are possibilities."

"Water-loop systems are interesting if you don't have space for machinery to produce the refrigeration centrally," says Berger. "It depends on the location in which you want to install the system."

Lithuanian firm Freor LT provides the 'Jupiter Green' cabinets in Migros's water-loop stores. The system also offers a heat pump box, which is an ideal solution for standalone shops in Switzerland's climate.



Migros Herdern, where the retailer's pilot propane water-loop system was installed in May 2016.



'Jupiter Green' cabinets from Freor LT, Migros Herdern.

MIGROS WALDSTÄTTER, LUZERN

- ▶ Refurbished city centre supermarket.
- ▶ Store reopened on 4 October 2017.

SYSTEM:

- ▶ New CO₂ transcritical rack.
- ▶ Integrated heat pump to warm the store.
- ▶ Serves low and medium-temperature cabinets.
- ▶ Replaced previous HFC-glycol loop system.
- ▶ Performance comparison, per metre of cooling circuit: before = 5,167 kWh/m; after = 1,863 kWh/m.
- ▶ Complemented by propane-based standalone cabinets.

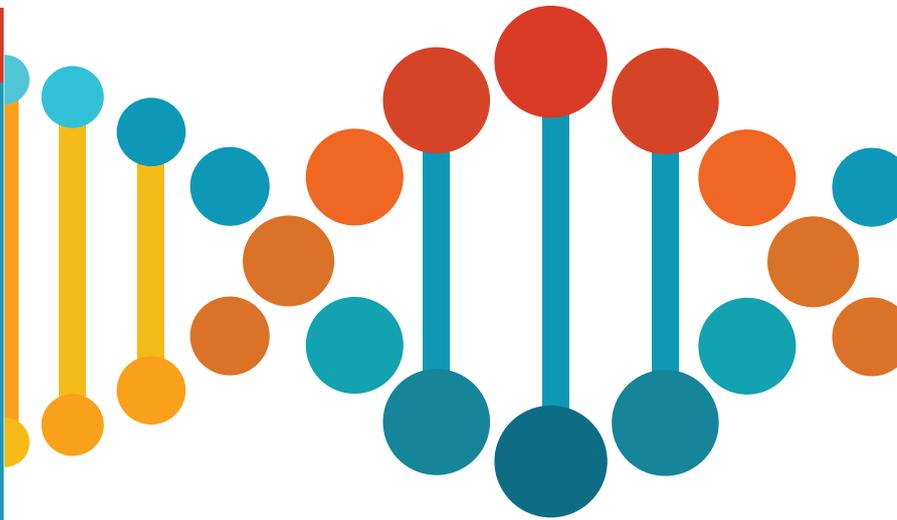


Migros works with the HAVO Group, which supplies Freor products to the Swiss market. In addition to the cabinets, HAVO provides the piping, the controls, and the cooler outside – everything that is required for a complete system. “We seek one installer who is responsible for the lot,” Berger says. “We prefer to have the whole installation in one pair of hands.”

AN ATTRACTIVE CHOICE FOR WARMER CLIMATES

He concedes that in Switzerland’s climate, the efficiency of the R290-based water-loop systems does not compare favourably with CO₂ transcritical solutions.

“If you’re designing CO₂ transcritical systems for the outside ambient temperatures of Switzerland, then you’re designing for up to 34°C,” Berger says. Given that the average annual temperature in Switzerland is 9.5°C, “you’re only operating in that particular scenario for a few hours per year” – meaning that CO₂ transcritical remains the more efficient system by far, he admits.



LEFT

Luzern, home of the Migros Waldstätter supermarket.

The longer a CO₂ system must operate in high ambient temperatures, however, the more attractive a water-loop system becomes as an alternative option. In the warmer climates of southern Europe, Asia or Australia, therefore, the water-loop solution can become more competitive.

Migros will continue to install water-loop systems wherever it isn’t possible to install a CO₂ system, for example due to space considerations.

“A large part of our future expansion will be in small convenience stores, and in railway stations, and such like. We’re looking for good, natural refrigerant-based solutions,” Moser says. “This is one of them.”

Since joining Migros in 2011, Moser has enjoyed the hands-on nature of his work in the MES team. “My driver is my desire to work on sustainability. I love working with people to create solutions for people,” he says.

“Migros is in every area – it’s like a mirror of society. You always have new challenges and you work with great people,” he enthuses.

Migros boasts a number of different natural refrigerant system types across its store portfolio. As these systems become the norm across the different cooperatives in the Migros family, the need to train staff to work on these systems looms large.

“We train our own staff. We run workshops to inform our technical staff about natural refrigerants and how to maintain the systems,” Berger says. “We also subsidised the Swiss Refrigeration Association (SVK) to start a training course on CO₂ technology,” he adds.



Berger (left) and Andreas Moser (right), MES, inspect the Chocolat Frey system. Photographed by Roland Steiner.

CHOCOLAT FREY AG

- ▶ Migros's own brand of chocolate.
- ▶ Annual turnover: CHF 404 million (€357m), of which exports: CHF 138 million (€122m)
- ▶ No. of products: 2,400
- ▶ Sales in tonnes: 43,701
- ▶ Employees: 900
- ▶ Domestic market share: 35.4%
Export market share: 11.4%

SYSTEM:

- ▶ System 1: Three ammonia compressors serve pumped cold-water network (delivering cold water at +6°C/+12°C).
- ▶ Two major ammonia compressors thereof, with frequency converters. One with direct 'free cooling' possibility, without using compressor.
- ▶ System 2: Cold production for re-cooling network (returning hot water at +25°C/+28°C) with two cooling towers.
- ▶ Energy savings: 1,384 MWh_{el} per year, translating into 33% less electricity consumption vs. previous system.
- ▶ Contractor: Wettstein AG.

'VAST MAJORITY' OF STORES TO USE NATREFS BY 2030

With just over half of Migros stores currently using natural refrigerants, what are the challenges in converting the other half? "It's just a matter of time. It's fairly easy. Our supermarkets have a lifetime of 12-18 years, so we follow this refurbishment schedule," Berger says.

"We stopped with new HFC systems in 2010. We're adopting natural refrigerant systems at a rate of 30 to 50 a year. The number is 30-50 new installations, whether in new or refurbished supermarkets," he explains.

"By 2030, the majority of our supermarkets will be CO₂ or other natural refrigerants," he says.

In some stores, the commitment to CO₂ extends to the air conditioning too. Migros owns around half of the buildings that house its supermarkets, which makes it easier to change

air-conditioning systems. A CO₂ transcritical rack or a CO₂ heat pump provides the air conditioning.

Some users of HVAC&R technologies are adopting HFOs, the new generation of synthetic refrigerants, as a means of complying with the HFC phasedown. Did Migros also consider going down that road?

"HFOs emerged over ten years ago and have never gone into mass production. They have their weak points. This is partly why we haven't converted to HFOs," Berger says.

"In a couple of years' time, the discussion will be over – there are very few applications in which HFOs make sense," he argues.

A DRIVING FORCE

What does Berger enjoy most about his job? "Moving forwards in a sustainable direction, and not just being purely investment cost-oriented," he replies.

Asked to name his favourite installation, Berger cites a recent project for a dairy produce factory where he demonstrated the energy-saving potential of natural refrigerants in industrial applications. "There, we saw we had a huge opportunity to reduce energy consumption. We improved efficiency by 30%," he says.

Does Berger try to live in an environmentally friendly manner himself? "Yes. I commute by train. My commuter footprint isn't very big. And since I have a dog, I tend to holiday in Switzerland rather than flying," he says.

Berger is proud of the role that Migros plays in reducing HFC use. "In Switzerland, we represent a significant part of the market. So if we ask for natural refrigerant solutions, we can move the market in this direction," he argues.

With Berger at the helm, no wonder natural refrigerants are in Migros's DNA. ■ AW



MIGROS VERTEILZENTRUM SUHR AG

- ▶ One of the biggest Migros distribution centres in Switzerland.
- ▶ Provides supermarkets and convenience stores with 4,400 different items (except for frozen goods).
- ▶ Opened in 2002; automated order picking began in 2011.
- ▶ Employs over 400 people.
- ▶ Capacity to distribute up to 6,500 pallets (370,00 per units) per day, by rail and by road.

SYSTEM:

- ▶ Original R134a plant built in 2001; subsequently decommissioned.
- ▶ Replaced by ammonia plants.
- ▶ NH₃ plant for brine system begins operating in 2014.
- ▶ Additional NH₃ plant begins operating in May 2018.
- ▶ Cooling loops at -8°C/-2°C, +3°C/+9°C and +12°C/+18°C respectively.
- ▶ Around 60% electric energy savings vs. previous system (latest figures).
- ▶ Contractor: Johnson Controls International.



1 / Inside the ammonia machine room, Migros Verteilzentrum Suhr AG.

2 / The facility provides supermarkets and convenience stores with 4,400 different items. Photographed by Roland Steiner.

2020 TARGETS



-20%
GREENHOUSE
GAS EMISSIONS
(Achieved by the end of 2017)



-10%
ELECTRICITY
CONSUMPTION
(-7.5% achieved by the end of 2017)



870,000+ m²
STORES CONFORM
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ITALIA





1 /

This summer Germany-headquartered food wholesale specialist METRO AG opened its first two CO₂ transcritical stores in Russia, along with its first in Bulgaria.

– By Charlotte McLaughlin

Germany-based METRO AG is a world-leading international food wholesale company that has built a global reputation as a committed player in environmental protection efforts.

By the end of its last fiscal year (1 October 2016-30 September 2017), METRO had reduced its greenhouse gas emissions by 21% compared to 2011.

The company's F-Gas Exit Program is widely seen as one of the most forward-thinking initiatives to phase out the use of HFCs in the world today. For METRO, the three new installations are important steps in the right direction.

In place since 2013, the F-Gas Exit Program aims to phase out f-gases in all METRO stores worldwide by 2030, replacing them with natural refrigerant systems where it is technically and economically feasible to do so.

"METRO operates in 35 countries worldwide. Today in more than 170 of our stores we are using natural refrigerants," Olaf Schulze, METRO AG's director of energy management, investments and technical solutions, told *Accelerate Europe* (July 2018 data).

For METRO, the two stores in Russia – the first of which opened on 26 July in Aparinki, near Moscow, with the second opening on 23 August in Odintsovo, a western Moscow suburb – are significant milestones in this journey.

"By using this technology, METRO is one of the most progressive companies in the sector in Russia. The recent store openings are important milestones in our global F-Gas Exit Program," Schulze says.

This is not the first time a CO₂ transcritical system has been installed in Russia's food retail sector. In 2016, Russian retailer Magnit opened a hypermarket in Voskresensk, a city 88 km southeast of Moscow, using a CO₂ transcritical booster refrigeration system.

Local manufacturer Nord-SM provided the system, with the cooperation of Danfoss and the United Nations Industrial Development Organisation (UNIDO), which undertook some preparatory work. Switzerland-based Frigo-Consulting provided technical support.

Russia is also a signatory to the global HFC phasedown under the Kigali Amendment to the Montreal Protocol.

"Following the Kigali Amendment in 2016, Russia has been tasked with reducing its CO₂ emissions by 40-45% by 2025. As a consequence, Russian retailers are now pushing the roll-out of CO₂ refrigeration systems," said Marcus Hoepfl, managing director, Frigo-Consulting.

To the knowledge of *Accelerate Europe*, the Aparinki store is the first time that a CO₂ transcritical store has been achieved in Russia without the backing of an international project.

For Schulze and his team, implementing the F-Gas Exit Program in locations unfamiliar with CO₂ transcritical technology is certainly more challenging than business as usual. "To implement these projects, we have to consider the entire supply chain, the technology, experienced installers and an efficient and safe maintenance and repair process," Schulze explains. "Our refrigeration systems are the backbone for the sale of food in our stores. We cannot afford to compromise here."

METRO Russia now boasts two transcritical CO₂ stores, 25 subcritical CO₂ stores, and one ammonia cold storage centre, according to Schulze.

Russian installer Ingenium, based in Rostov-on-Don (a town in southern

THE CALL OF THE EAST

1 / Exterior of METRO store in Aparinki, near Moscow.
2 / Cabinets inside the Aparinki store.

Photography: METRO AG

Russia), carried out the METRO installation in Aparinki. It also provided two CO₂ racks to refrigerate the 6,547 m² cash and carry store.

Aparinki is the first time that Ingenium has installed a CO₂ transcritical system in a supermarket. "For three years we have been using CO₂ in subcritical systems," Anton Rostokin, deputy director of engineering at Ingenium, told *Accelerate Europe*. "More than 10 projects (similar in size) were implemented with CO₂ subcritical."

Ingenium's first installation of a transcritical CO₂ system was at its own training centre. To familiarise itself with the technology, the Russian installer also sought training from other European manufacturers and institutes.

"We were trained on the basis of the companies Bitzer and Danfoss," Rostokin says. "Additional training was conducted at an institute in Belgium."

Ingenium would like to work more with natural refrigerants. "CO₂ is a topic of interest for many companies," Rostokin notes. "But not many companies in Russia decide to implement such projects. We think that with the development of this technology in Europe and [due to] changes in legislation, the situation will develop in a positive way."

"Our company made a bet on CO₂," Rostokin says. "But we also plan to develop in the direction of ammonia systems."

The CO₂ transcritical system in Aparinki uses monitoring controls from Danfoss, compressors from Bitzer, gas coolers from Guntner and cooling furniture from Freor. "We started in Moscow because in other Russian regions, we are still scouting for the right installer capacities for transcritical," METRO's Schulze explains.

The two Ingenium racks provide 85.77 kW of low-temperature cooling and 224.85 kW of medium-temperature cooling to the cabinets inside the store. They provide high-temperature free cooling to the tune of 262.04 kW.



2 /



1 /



2 /

1 / Güntner gas cooler on the roof of Aparinki store.
2 / CO₂ transcritical rack, Aparinki.

TIME TO SWITCH THINGS UP

METRO's second CO₂ transcritical store in Russia opened in the city of Odintsovo, the administrative centre of Odintsovsky District in the Moscow Oblast region, on 23 August 2018. The 10th METRO store in the Moscow region, with a trading area of approximately 5,800 m², is a little different from METRO's first Russian transcritical CO₂ installation in Aparinki in July.

For this store METRO decided to work with a different Russian contractor called LAND, based near St. Petersburg (in northern Russia, over 700 km from Moscow), according to Holger Guss, head of building services and engineering at METRO AG.

Danfoss provided the monitoring controls again, while this time Dorin provided the CO₂ compressors for the LAND-manufactured transcritical rack.

Frigo-Consulting was again involved in the design of the project.

The gas coolers are from Güntner and the refrigerated glass-door cabinets are from Arneg, which provided 80 cabinets (with a total length of 200 m and a display surface area of approximately 560 m²).

The latest Russian installation also features heat reclaim and parallel compression. 150 kW of reclaimed heat warms the store in the winter, according to Schulze.

The cooling capacity of this second installation is a little lower, as the Odintsovo store is smaller than the Aparinki one. The system provides 73 kW of low-temperature cooling, 202 kW of medium-temperature cooling, and 260 kW of high-temperature cooling (built with a free cooling system).

METRO is planning to open more CO₂ transcritical stores in the Moscow area. "Solntsevo [will follow] in December [...] with transcritical CO₂," Schulze told *Accelerate Europe*.

METRO'S FIRST TRANSCRITICAL CO₂ STORE IN BULGARIA

Not content with opening two stores in Russia, on 14 September METRO opened its first transcritical CO₂ store in Bulgaria.

The store, located in the Bulgarian capital of Sofia, is yet another demonstration of METRO's commitment to growing the use of CO₂ transcritical technology.

"We are committed to sustainable action. This includes the responsible use of refrigeration systems," Guss says. "We install environmentally friendly refrigeration systems wherever it is feasible to do so."

The approximately 8,400 m² Sofia store is a retrofit and was originally opened in 1999. Carrier carried out the installation with consultation from Frigo-Consulting.

METRO AG has increasingly taken on the role of a pioneer. It was the first retailer, to the knowledge of *Accelerate Europe*, to install a CO₂ transcritical system in China's food retail sector (for more on this store, check out [Accelerate China, Issue #1](#)).

It also installed a CO₂ transcritical system with innovative ejector technology in Opole, Poland in May of this year, and its ZEUS store in St. Pölten, Austria (opened in October 2017) claims to emit zero emissions.

"The transcritical system in Sofia has an ejector, similar to our system in Opole," Guss says.

"It is not our primary goal to be a pioneer in certain locations, but we are proud to promote environmentally friendly technology in new countries like China and Russia," he explains.

"Against the background of the global challenges we face today, we are also happy about every competitor who thinks and acts the same way," he adds. ■ CM



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On the rise

NatRefs in Southeast Asia

More companies in Southeast Asia are turning to natural refrigerants to reduce energy costs and greenhouse gas emissions. If these end users represent the future direction of Southeast Asia, then the region surely ranks among the world's biggest up-and-coming natural-refrigerant technology markets. *Accelerate Asia* reports.

— By Devin Yoshimoto

RIGHT

MClean Chairman
Jason Yeo.

With a population of some 650 million people and an established and fast-growing manufacturing base, Southeast Asia is shaping up to be an important market for natural refrigerant-based HVAC&R solutions amid growing demand for energy-efficient and sustainable technologies.

The adoption of the Kigali Amendment to the Montreal Protocol, meanwhile, requires the region's governments to put in place HFC phasedown strategies. Companies must begin to adopt alternative technologies that will help them to meet their growth targets and minimise their environmental impact.

Accelerate Asia reports on two Southeast Asian companies – one in Thailand and one in Singapore – that are using natural refrigerant-based technology to drive down both energy costs and greenhouse gas emissions for their businesses.

CP Foods aiming high with natural refrigerants

Thailand's Charoen Pokphand Foods (CP Foods), a subsidiary of the country's largest conglomerate, Charoen Pokphand Group (CP Group), is one of the largest food processing, distribution and retail companies in the world.

The processing of livestock such as shrimp, chicken or pork and the production of ready-made meals is at the heart of the company's business operations. Though headquartered in Bangkok, CP Foods focuses on growing its business overseas, operating food manufacturing and processing facilities in Southeast Asia, China and India, and also exporting to Europe and most recently the United States.

As one of Southeast Asia's largest businesses, CP Foods understands its leadership role when it comes to environmentally sustainable business growth and development.

The company is aiming to reduce energy consumption by 15% and greenhouse gas (GHG) emissions by 15% per production unit by 2020 (compared to the base year 2015), according to its 2017 Sustainability Report.

Thanarak Kosalwitr, CP Foods' vice-president of corporate engineering, is leading the charge on this initiative internally.

In late 2017 and early 2018, Kosalwitr oversaw the installation and commissioning of one of the first CO₂ heat pumps in Thailand.

A total of eight EcoCute UNIMO water-sourced CO₂ heat pumps, supplied by Japanese manufacturer Mayekawa, were installed at CP Foods' poultry food processing plant in Nakhon Ratchasima (also known as Korat) province in Thailand.

The UNIMO heat pumps were installed to replace a large portion of the plant's hot water supply needs, which traditionally were provided by fuel oil boilers.

Initial projections estimate energy cost savings of 38% and a CO₂ emissions reduction of 63%.

Kosalwitr notes that actual performance data is still in the process of being collected as factory staff undergo a learning curve of fully integrating the CO₂ heat pump into the factory's food processing and manufacturing processes.

"We have had some challenges, and the system's operation has changed a bit as we expanded the capacity and are using the hot water in different ways," says Kosalwitr.

There is now no issue with the system, Kosalwitr says, so the focus is on training and educating

staff on optimising the system's implementation and use as well as the process of data collection and analysis.

"We will have the real figures at the end of this year," he says.

This first installation received funding assistance from the Joint Crediting Mechanism (JCM) subsidy scheme – an agreement signed between the Thai and Japanese governments to help introduce new low-carbon technology.

MClean saves energy with NatRef heat pumps

Singapore-based MClean Technologies Pte. Ltd. (MClean), meanwhile, installed and trial-tested a CO₂ heat pump at one of its facilities earlier this year.

The company's main business is providing precision cleaning services for the semiconductor, hard disk drive and medical device industries.

The CO₂-based heat pump supplies hot water for the company's business operations and is expected to save up to 70% on the firm's energy costs as it rolls out the technology to all its facilities, replacing older traditional

electric resistance hot water heating systems company-wide.

MClean is led by Chairman Jason Yeo. Early this year, Yeo decided to move forward with a trial test for the CO₂ heat pump at MClean's facility in Singapore. The company installed one 'ECOSTAR CO₂ Solution' heat pump provided by another Singapore-based company, Energeia Technologies.

Energeia Technologies was established in 2017 by a group of engineers with significant experience of designing ammonia and CO₂-based HVAC&R systems.

Hot water is vital for MClean's precision cleaning process. The company uses ultra-clean distilled water that must be heated to 60°C to clean trays and components.

Until the trial, the company had always used electric resistance water heating.

The CO₂ heat pump trial testing period lasted several months, while Yeo and his team benchmarked basic energy consumption data. When the data was collected and analysed, the results not only confirmed but exceeded Yeo's expectations.



As per data collected in May, the 'ECOSTAR CO₂ Solution' heat pump supplied close to 800 litres of hot water per hour at 60°C at a daily average COP value of 4.2.

In other words, for every 6.3 kW of energy used, the heat pump was supplying around 27 kW of heating capacity. Inlet water temperature averaged around 27-34°C, while ambient temperatures averaged around 30-32°C.

This data was representative of the results seen in previous months of the trial-testing period, according to Energeia Technologies.

Yeo then compared these results to its internal company data on the energy efficiency of its conventional electric resistance water heaters.

"According to our calculations, we can save almost 70% [on energy costs]," says Yeo.

"We would have been happy even with 30%. But we know that we can save much more. Even with external factors like the environment, we will easily save more than 50%."

Once the testing was completed, Yeo says the decision to implement the new technology at MClean on a large scale was a no brainer.

"Basically, once I saw our potential cost savings, we decided to move forward," says Yeo.

"It is very much about the cost savings."

Asked when he estimates the installations will provide a return on investment, Yeo replies, "less than three years. It is very much worth doing for us".

Yeo says that the wheels are already in motion to begin installing the ECOSTAR system both in its planned new facilities and as replacements for the electric resistance systems in its existing facilities.

"We now have the operational data of the system, so we are now going step-by-step to get them in," says Yeo. ■ DY



Mayekawa's UNIMO water-to-water heat pump.



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NatRef innovators take to Gustav Lorentzen stage





Industry experts explain effectiveness of CO₂, ammonia and hydrocarbons as refrigerants at event named for CO₂ pioneer.

— By Andrew Williams
& Dario Belluomini

Between 1988 and 1991, Norwegian researcher Gustav Lorentzen showed how the long-dormant refrigerant CO₂ could be used again as an effective working fluid. At the biannual conference named in his honour, industry experts carry on Lorentzen's work with reports on CO₂ and other natural refrigerants.

CO₂ technology for warm climates was one of the key themes of the 13th IIR Gustav Lorentzen Conference on Natural Refrigerants, held at the Polytechnic University of Valencia, Spain, on 18-20 June.

Indeed, technology innovations such as ejectors, evaporative condensers, energy storage, parallel compression and heat recovery are helping to broaden the market for CO₂ as a refrigerant across climate zones, according to Armin Hafner, a professor at the Norwegian Institute of Science and Technology (NTNU).

Moreover, Hafner said: "Today it is possible to integrate heating and cooling into CO₂ transcritical systems to eliminate all applications of HFCs in supermarkets."

However, with more OEMs developing new technologies to improve efficiency in warmer climates, system design is becoming more complex. Training and support for installers and contractors, therefore, will be crucial in ensuring the continued success of CO₂ as a refrigerant as it takes on a greater market share, Hafner said.

"People are getting to know CO₂ systems, knowledge is being transferred, and that is very good," Hafner said.

He cited data from sheccoBase – the market development arm of shecco, publisher of *Accelerate* – indicating that there are already over 14,000 supermarkets in Europe fitted with CO₂ transcritical systems.

Echoing Lorentzen, Hafner took aim at the latest generation of synthetic refrigerants: "It does not seem very logical to try to replace HFCs with another family of related halocarbons, HFOs, which are equally foreign to nature."

The Gustav Lorentzen welcome drinks were held at the City of Arts and Sciences, Valencia.

India's first CO₂ transcritical system

Demonstrating that CO₂ technology can function in ambient temperatures of 45°C, researchers from the Department of Mechanical Engineering at the Indian Institute of Technology, Madras presented India's first CO₂ transcritical system at this year's Gustav Lorentzen.

"It's a multi-faceted system with all the modes of operation, including supermarket, air conditioning and heat recovery," Prof. Dr. Prakash Maiya from the Department of Mechanical Engineering at the Indian Institute of Technology, Madras, told *Accelerate Europe*.

"It's the first of its kind in India, and it's operating successfully in very high ambient temperatures of up to 45°C," Maiya said.

It may be able to function in even higher ambient temperatures, the professor explained. The multinational research team – which includes colleagues from SINTEF Energy Research and the Norwegian University of Science and Technology (NTNU) – is yet to try that.

1 / Didier Coulomb, director-general of the International Institute of Refrigeration, addresses the Gustav Lorentzen plenary.

2 / José Miguel Corberán of the Polytechnic University of Valencia opens the 13th Gustav Lorentzen conference.

Boosting supermarket efficiency

CO₂-based technology can provide efficient heating and cooling in Spanish supermarkets despite the country's warm climate, according to another conference paper authored by Hafner, his NTNU colleague Paride Gullo and Krzysztof Banasiak (SINTEF).

The EU F-Gas Regulation bans the use of certain HFCs with GWPs above 150 in new centralised and plug-in commercial refrigeration equipment from 2022. This presents opportunities, therefore, for natural refrigerants to replace HFCs, the researchers point out.

Yet in Spain, a number of national legislative barriers complicate the scenario: for example, Royal Decree 138/2011 prohibits the use of hydrocarbons in medium to large-sized stores for safety reasons. The researchers suggest that carbon dioxide (R744) may be a viable natural refrigerant solution.

The paper investigates the energy-efficiency performance of two alternative systems serving the refrigeration, air-conditioning and space-heating needs of a supermarket. One uses R134a in the high-temperature circuit and CO₂ in the low-temperature circuit, together with a reversible heat pump based on HFO R1234ze. The other one is a CO₂ transcritical system.

To take into account the characteristics of Spain's warm climate, the researchers collected data for six major cities. Average outdoor temperatures in the sample range from 9.9°C in Burgos to 21.1°C in Tenerife (the other cities included in the analysis are Madrid, Barcelona, Valencia and Seville).

In heating mode (between -5°C and +15°C), the CO₂-only solution proved to have a COP 83% higher than the R1234ze-based system. In air-conditioning mode (between +25°C and +40°C), the results are not as positive, given the substantial cooling demand.

As for annual energy consumption, the CO₂ systems offer energy savings of between 1% (Tenerife) and 33.2% (Burgos) compared to systems using HFCs.

Saving energy with CO₂ in ice rinks

The lifecycle cost performance of CO₂ ice rinks outperforms that of HFC-based rinks, according to research presented by ice arena specialists EKA (Energi & Kylanalys) at Gustav Lorentzen.

"Refrigeration systems based on CO₂ with optimised heat recovery seem to have a competitive advantage in ice rinks," said Cajus Grönqvist, presenting a research paper comparing different system builds and different refrigerants.

The paper, authored by Grönqvist and his colleague Jörgen Rogstam, sought to develop a lifecycle cost analysis model that is effective and capable of producing reliable results when comparing refrigeration systems in ice rinks.

Heat recovery 'greatest source' of lower energy consumption

The authors compared a CO₂-based system fitted with a heat export function to various other system builds in existing cases in Sweden, including ammonia and HFCs.

"The greatest source for lower energy consumption in ice rinks lies in the utilisation of an optimised heat recovery system," states the paper, which demonstrates that CO₂ has very good properties in terms of heat recovery compared to ammonia, for example.

"By adding heat reclaim and using the heat for an adjacent swimming pool, for example, the business case for switching to a CO₂ ice rink is compelling" in terms of the saving on total lifecycle costs, Grönqvist explained in Valencia.

"The properties of CO₂ allow some ice rinks to become self-sufficient on renewed heat," he said.



Heat export strategy

Legislation provides another motivation to switch from HFC ice rinks to CO₂. The EU F-Gas Regulation is progressively phasing down HFCs with certain GWPs in a variety of applications.

“Many ice rinks must be renovated, because R22 and R404A no longer fulfill the GWP requirements of the EU F-Gas Regulation,” Grönqvist said.

The paper asserts that the financial benefits of CO₂ technology, mainly due to its low service costs and the refrigerant’s excellent heat recovery properties, “can potentially be maximised with a well-utilised heat export strategy”.

It concludes: “CO₂-based systems should be considered when renovating or building new ice rinks, but the financial performance of a refrigeration system in an ice rink can and should only be determined on a case context level.”

Ammonia’s reinvention

The growing adoption of low-charge ammonia systems marks the “rediscovery” and “reinvention” of this most long-lived of natural refrigerants, Andy Pearson, group managing director of UK-based Star Refrigeration, told *Accelerate Europe* at the conference.

“The take-up is extremely rapid, there’s a huge level of interest,” he said. “It’s a very exciting time to be offering low-charge ammonia systems.”

He attributed this development to “a huge leap forward in terms of reliability, efficiency and safety”. “All three of them are important, and with low-charge ammonia, you get all three in a single package,” he said.

While Star is focusing on low-charge systems for existing industrial applications, Pearson noted that, “the door is also open to wider use of ammonia, for example in building services, or in chillers in ice rinks”.

Ammonia came out on top as a refrigerant for heat pumps in a paper presented at Gustav Lorentzen by Kashif Nawaz, Moonis Ally Raza and Omar Abdelaziz of Oak Ridge National Laboratory, Tennessee.

The researchers assessed the performance of selected HFCs (R134a and R410A), ammonia and propane in four different heat pump systems. These range from a simple configuration made up of four components to more sophisticated ones using flash tanks.

For all systems, the evaporating (10°C) and condensing (40°C) temperatures were fixed to produce comparable results and allow for an efficient compression process.

In terms of COP, researchers found ammonia to have the highest efficiency in all cases. The difference with R134a was particularly striking. Ammonia was also found to have the lowest mass flow rate among the selected refrigerants.

Together with its optimal volumetric capacity, NH₃-based systems were also found to be more efficient and more compact than their HFC-based counterparts under analysis.

The lab tests also highlighted the properties of propane (R290). Despite its lower coefficient of performance compared to ammonia and R410A, it may serve as a sustainable replacement for R134a. It also presents a lower mass flow rate than the two HFCs considered, implying that R290-based systems require less compressor power consumption and a lower refrigerant charge.

Thanks to ammonia’s relatively low mass flow rate, NH₃ also has the smallest overall environmental irreversibility. By contrast, when using HFCs in thermodynamic processes such as heating and cooling, it is significantly more difficult to restore the environment to its own initial conditions.



Jörgen Rogstam, Energi & Kylanalyt

Hydrocarbons: best for light commercial

The properties of hydrocarbons make them the best-performing refrigerants for light commercial applications, said Cláudio Melo, a professor at the Polo research lab, Federal University of Santa Catarina, Florianópolis, Brazil.

“Hydrocarbons have equal or better heat transfer performance and lower pressure drop compared to R22 and R134a,” said Melo in a keynote Gustav Lorentzen presentation.

In addition, “hydrocarbons mix very well with mineral oils both in the liquid and vapour phases,” he added. “The hygroscopic synthetic oils used with HFCs can thus be avoided.”

Melo pointed out that most of the materials used in HFC refrigeration systems could also be employed for hydrocarbons. These include neoprene, Viton, nitrile rubber and nylon.

There is also a strong business case for adopting hydrocarbons over HFCs, Melo said, starting with cost.

“Hydrocarbons such as isobutane and propane are substantially less expensive than HFCs,” he said.

Moreover, a refrigeration system designed for hydrocarbons will typically need “50-60% less refrigerant by mass when charged with hydrocarbons,” Melo said.

In addition, “the energy efficiency of hydrocarbon units is frequently claimed to be up to 30-40% better than comparable HFC units,” he said.

“5% to 10% of this improvement can be accredited to better thermodynamic and transport properties,” Melo said. “The rest is most likely due to component modifications such as improved compressor or heat exchanger design, as well as variable speed drives,” he added.

All this innovation with natural refrigerants, then, should help to improve their HVAC&R performance as companies begin to develop the next generation of technology. ■ AW & DB



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OPEN FOR BUSINESS IN LA VILLE LUMIÈRE

Politicians can help boost uptake of natural refrigerants by pursuing policies that support the HFC phasedown, while training initiatives can help familiarise HVAC&R stakeholders with these market-ready alternatives to HFCs. *Accelerate Europe* reports from ATMOSphere France.

– By Andrew Williams

As HFC prices skyrocket and the enforcement in France of an HFC tax draws ever nearer, policy initiatives can help HVAC&R stakeholders to bring natural refrigerant-based technologies to market more quickly, heard participants in the first-ever ATMOSphere France conference.

Following in the footsteps of other European countries such as Denmark, the French government is planning to introduce a tax on HFCs to help move the market towards more environmentally friendly alternatives – including natural refrigerants.

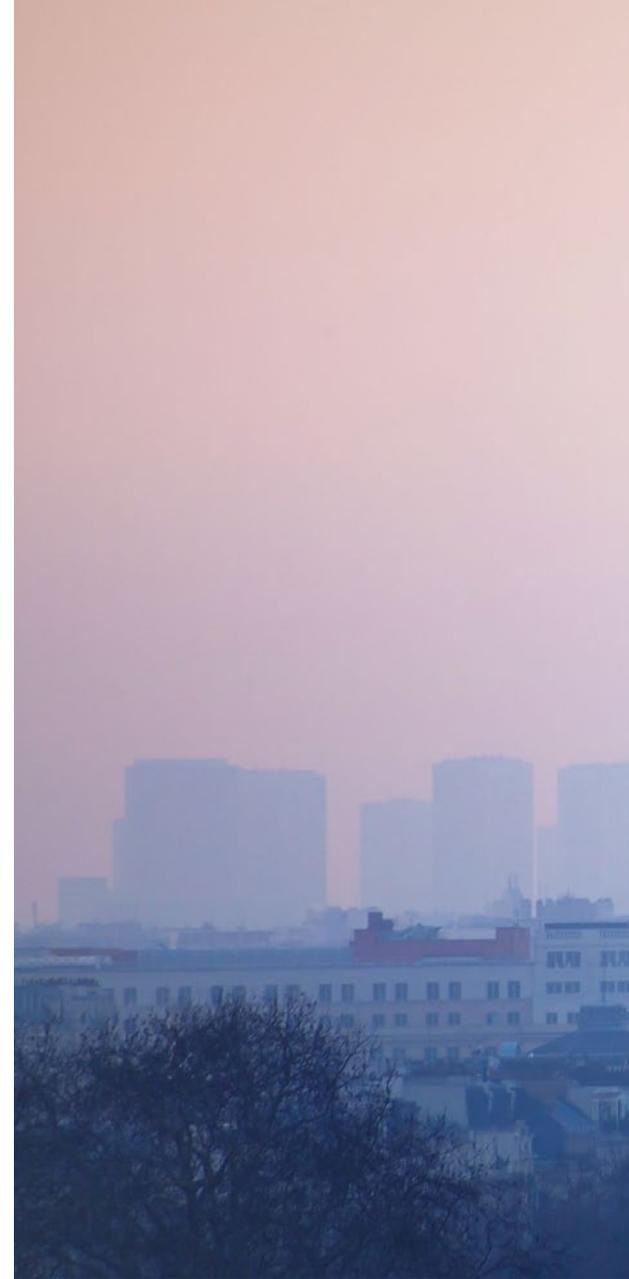
Matthieu Orphelin, a French member of parliament (MP), confirmed that the tax would most likely enter into force in January 2019. “I’m convinced that the government will include the tax

in the 2019 finance bill,” Orphelin told ATMOSphere France participants.

ATMOSphere France, held in French and organised by *Accelerate* publisher shecco, was the first edition of the global series of ATMOSphere conferences on natural refrigerants to be dedicated solely to the French market.

Held at the Intercontinental Paris Marceau hotel in the French capital on 5 July, the event brought together French HVAC&R market stakeholders from across the supply chain.

Orphelin highlighted the French government’s determination to be an environmental leader on the international scene, reminding the audience of the role that can be played by the HVAC&R industry in delivering that vision. “1 kg of HFCs released into the atmosphere





corresponds to 10,000 km of driving by car,” Orphelin said.

The HFC tax “is about giving industry a progressive signal of the trajectory that we’re on. We’re introducing this tax progressively. The technologies are already out there. It’s not about experimenting with new technologies. It’s about giving the market a signal that this is the direction we’re taking – it’s the role of the state to do this,” the MP said.

“In France’s *Plan Climat*, the carbon tax – and thereby the HFC tax – has an important role to play,” Orphelin said.

“The HFC tax is not an extra tax. It’s designed to favour the most environmentally friendly options. Look at the example of subsidies for cleaner cars. Taxes move the market.”

“We’ve got international and European agreements on HFC emissions to live up to.

We need to move faster. The HFC tax in the *Plan Climat* is about moving forward on this,” Orphelin said.

Revise standards for natural refrigerants to fulfil their potential

Marie Battesti, a policy analyst at shecco, argued that, “the progressive reduction of HFCs will increase their price worldwide, helping to develop the market for natural refrigerants. Standards revision is essential to allow natural refrigerants to fulfil their potential”.

Regarding restrictive codes in France that currently ban the use of flammable refrigerants in open-access buildings (*Établissements Recevant du Public; ERP*), Battesti said: “The ERP fire safety regulation in France restricts the adoption of hydrocarbons. In other countries, such as Denmark, regulation is actually promoting the uptake of natural refrigerants – for example via an HFC tax.”



French MP Matthieu Orphelin.

Carrefour, Delhaize showing the way

Food retailers Carrefour and Delhaize argued that natural refrigerants are market-proven, environmentally friendly and economically competitive alternatives to the HFCs being phased down under the EU F-Gas Regulation.

“Transitioning to natural refrigerants simply makes sense. By 2030, we’ll be HFC-free,” David Schalenbourg, director of department – building projects, format & maintenance at Delhaize Belgium, a leading Belgian retailer, told the event.

Commercial refrigeration is one area in which the EU’s F-Gas Regulation, which regulates the bloc’s f-gas use, is already beginning to bite. In 2022, bans on using certain HFCs with GWPs above 150 in new centralised and plug-in commercial refrigeration equipment will come into effect.

For bigger stores, Delhaize Belgium is adopting CO₂ by default. For smaller stores, the retailer is also investing in hydrocarbons.

The wider Ahold Delhaize group of which Delhaize Belgium is part encompasses 21 local brands across some 6,500 stores around the world. By 2050, the group is aiming to reduce its greenhouse gas emissions by 40-70% compared to 2010 levels.

Today 13% of Ahold Delhaize sites worldwide already use natural refrigerant-based installations (end 2017 data), Schalenbourg told the Paris audience. In Europe the figure is 33%.

Compelling business case

Making the business case for CO₂, Schalenbourg said installing CO₂ transcritical systems as a replacement for R404A in three Belgian stores had reduced their energy consumption by 40% (Fagnée store; also taking into account the energy efficiency of the building itself), 20% (Chazal store; the gain is from the CO₂ transcritical system alone) and 37.7% respectively (Dinant store, also from CO₂ only).

“Our objective is to show the way, help to transform the market, and show others what’s possible,” Schalenbourg said.

“It’s about removing any lingering doubts and fears. We’re demonstrating that natural refrigerants are the way to go,” he said.

To reduce refrigerant emissions, Carrefour is phasing out HFCs and replacing them with CO₂ for commercial refrigeration. In smaller stores, it is also investing in hydrocarbons. Factors ultimately influencing the decision to go for CO₂ or hydrocarbons include store size, equipment cost, and legislation in each country.

“Our mission to convert our stores to natural refrigerants began in 2011. It is a Group-wide engagement. In Europe and Latin America, we had over 400 sites running on natural refrigerants by the end of January 2018,” said Jean-Michel Fleury, project director – international support, Carrefour Group.

Overall the Carrefour Group is aiming to reduce carbon emissions by 40% by 2025 and by 70% by 2050 (compared to 2010 levels). There are around 12,300 stores under the Group banner in 35 countries across five continents.

“We’re targeting 100% natural refrigerants in all our installations, stores and logistics centres included, by 2030,” Fleury said. “Group-wide, we’re committed to bringing everyone on this journey.”

For new logistics centres, Carrefour works with both CO₂ and ammonia. In the commercial space, meanwhile, the future direction is clear. “For supermarkets and hypermarkets, we have no doubt that CO₂ is the best way to go.”

By the end of 2017, Carrefour had invested around €150 million in phasing down HFCs and replacing them with CO₂ systems since 2015.

“It’s almost a philosophical question – what world do we want to leave for our children?” Fleury asked.

“We’re taking the long-term view as we transition to natural refrigerants, and we’re working hard to reduce the cost of that transition,” he said.

Significant growth potential

Manufacturers, meanwhile, are optimistic that the natural refrigerant market in France is ripe for growth.

“CO₂ is becoming a very sexy industry,” José Manuel Alves from Panasonic told conference participants.

Panasonic has sold around 1.2 million compressors for CO₂ transcritical systems and some 8,500 of its CO₂ condensing units have been installed in over 3,100 stores worldwide. Most of these stores are in Asia, and the majority are in Japan.

“In Europe, we’ve installed CO₂ condensing units in 290 stores,” Alves said.

Panasonic operates four training centres in France to spread knowledge of CO₂ systems among technicians and installers operating in the field. They are located in Gennevilliers, Tours, Manosque and Nantes.

“We have a network to support and promote CO₂. 260 installers have been trained at our training centres in France so far,” Alves said.

Panasonic’s CO₂ condensing units are currently available in France at capacities of 4 kW and 15 kW. 23 kW and 33 kW models will be available from the first quarter of 2019.

‘Dynamic’ French market

ENGIE Axima is also investing in natural refrigerant technologies in France. “The French market is very dynamic. We’re doing natural refrigerant projects in increasingly large capacities,” said Jonathan Leguil, who represented the firm at the event.

Leguil presented a case study on retailer Lidl’s distribution centre in Entzheim, which uses a cascade NH₃-CO₂ system to provide cooling at temperatures ranging from -30°C to 10°C. The system, whose capacity is 2,220 kW, was commissioned in August 2017.

Meanwhile, Nicolas Pondicq-Cassou from Profroid – which represents Carrier in France – presented the CO₂OLtecEVO CO₂ transcritical system.

“The trend is to move towards new transcritical systems capable of operating efficiently in

multiple climates,” said Pondicq-Cassou. “Supermarkets are an extremely promising growth area for these solutions.”

The CO₂OLtecEVO integrates a modulating vapour ejector into a CO₂ transcritical rack in conjunction with a CO₂ pump, helping to improve the efficiency of the CO₂ transcritical cycle in warmer climates.

Paul Rivet from AF Consulting, a consultant with long experience of working with CO₂, sees potential for wider uptake of this natural refrigerant in ice rinks. “There is strong demand for hot water in ice rinks – for sanitary hot water and for hot air to dehumidify the rink,” Rivet said.

“ IT’S ABOUT GIVING THE MARKET A SIGNAL THAT THIS IS THE DIRECTION WE’RE TAKING – IT’S THE ROLE OF THE STATE TO DO THIS.”

– French MP Matthieu Orphelin on the HFC tax

Training key to boosting market

Raising awareness of natural refrigerants among technicians in the field, meanwhile, is crucial to growing the market for these technologies in France.

“Technical competence among technicians will play an essential role in growing the natural refrigerant market,” said Edouard Chalhoub from the Alençon branch of Afpa, a French training agency for adults.

“The specificities of natural refrigerants are easy to learn,” Chalhoub argued.



TECHNICAL COMPETENCE AMONG TECHNICIANS WILL PLAY AN ESSENTIAL ROLE IN GROWING THE NATURAL REFRIGERANT MARKET.

— Edouard Chalhoub, *Frigoristes Solidaires*



Chalhoub is also the face of *Frigoristes Solidaires*, a 'Makerspace' to encourage wider use of natural refrigerants, promote careers in HVAC&R, and share knowledge.

He sees growing demand for natural refrigerant training among end users, too, as these environmentally friendly solutions become more popular in view of the HFC phasedown.

It arguably takes trained technicians just a week to familiarise themselves with the peculiarities of the different natural refrigerants, Chalhoub argued. "CO₂ can be learned in two days, NH₃ in two days, and hydrocarbons in one day," he said.

The uniqueness of the French refrigeration sector can influence the type of system chosen by customers. End users go through consultants (so-called *bureaux d'études*), who recommend which system to choose before passing on the blueprint to the installer.

"The French refrigeration market is very complex," said Sylvain Gillaux of Austrian manufacturer Hauser. "We must see the *frigoristes* (refrigeration technicians) as partners, and spread the word among all actors in the market," he said.

"The *frigoristes* are vital as they're the ones on the ground. We need to give end users the advice they need to make the right decisions," Gillaux said.

Hauser's vision is to go 100% natural refrigerants within a decade. "No matter the climate or physical constraints for natural refrigerants, f gas-based systems are on the way out," Gillaux said.

Boost understanding among technicians

ENGIE Axima stressed the importance of communicating the benefits of natural refrigerants.

"It is essential to convince clients that natural refrigerants are the way to go," said Laurent Meykuchel, director-general of Axima Refrigeration. Improving component availability and reducing costs are of paramount importance in growing the market, he argued.

ENGIE Axima has a development strategy for three natural refrigerant types: NH₃, CO₂ and hydrocarbons, to cover all cold chain applications: from -50°C to +20°C and from 1 kW to 5 MW.

"We need to boost understanding of natural refrigerant systems among technicians in France to give end users the confidence to adopt them," Meykuchel said.

For ENGIE Axima, the energy transition, f-gas quotas and the increase in HFC prices are all major drivers of natural-refrigerant technology development.

Profroid, part of the Carrier/United Technologies group, reported strong growth in CO₂ transcritical system sales in France in 2016 and 2017.

"I'm convinced that standards and regulation represent a huge opportunity for our sector to put in place environmentally friendly technologies," said Profroid's Pierre Boyer.

"We are very much engaged in training because that is a crucial way of reaching new end users," Boyer said.

France's government has seen ministerial change since the ATMOSphere event. Nicolas Hulot resigned from his position as France's minister for the ecological and inclusive transition on live radio on 28 August. Hulot, a former green activist, said he had resigned because he felt "on his own" in the government, and expressed his frustration with industrial lobbies.

Speaking to *Accelerate Europe*, Orphelin expressed hope that Hulot's resignation would be an "electric shock" encouraging France's parliamentary majority and all stakeholders, "to live up to what's at stake".

It remains to be seen whether Hulot's replacement, François de Rugy, will take Orphelin's words to heart.

With the right policy and training support, however, natural refrigerants look poised to grow in France.

■ AW

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AN ADVOCATE OF CO₂-COOLED VENDING MACHINES

Despite recent progress of hydrocarbons into the vending machine market, some manufacturers continue to argue that carbon dioxide should be the industry's future refrigerant of choice. *Accelerate Europe* reports from Venditalia.

— By Dario Belluomini

At this year's Venditalia, many manufacturers reported growing market interest in hydrocarbon-cooled vending machines. Yet Marco Baron from FAS is convinced that carbon dioxide should be the refrigerant of choice in the sector, for reasons of safety and system design.

Recent market research from data gatherers Nielsen reveals strong links between a company's commitment to sustainability and its financial turnover, highlighting the strong relationship between environmental and economic performance.

Sustainability has always been at the core of the automatic distribution sector. Vending machines were born in the 1960s when factories did not use to have internal canteens in which their workers could relax. Thus they assumed an important social role.

To get additional insights into the dynamic vending sector, *Accelerate Europe* was at Venditalia, held in Milan, Italy on 6-9 June. As Europe's leading vending tradeshow, this year's edition hosted more than 300 companies from all over the world.

Today the Italian vending sector is the biggest in Europe's automatic distribution chain, serving over 25 million clients. Last year saw huge sales increases in Italy's organic snack (+30%) and drinks (+120%) markets, according to Michele Adt, chairman of Italian vending machine association CONFIDA, who spoke at Venditalia.

Cooling systems for vending machines are in the middle of an important transition. The EU F-Gas Regulation imposes a ban in 2022 on all HFCs with GWPs above 150 in new centralised and plug-in commercial refrigeration equipment, meaning that manufacturers must soon switch to more environmentally friendly refrigerants.

Competition between natural refrigerants hydrocarbons and CO₂ is picking up in the vending sector.

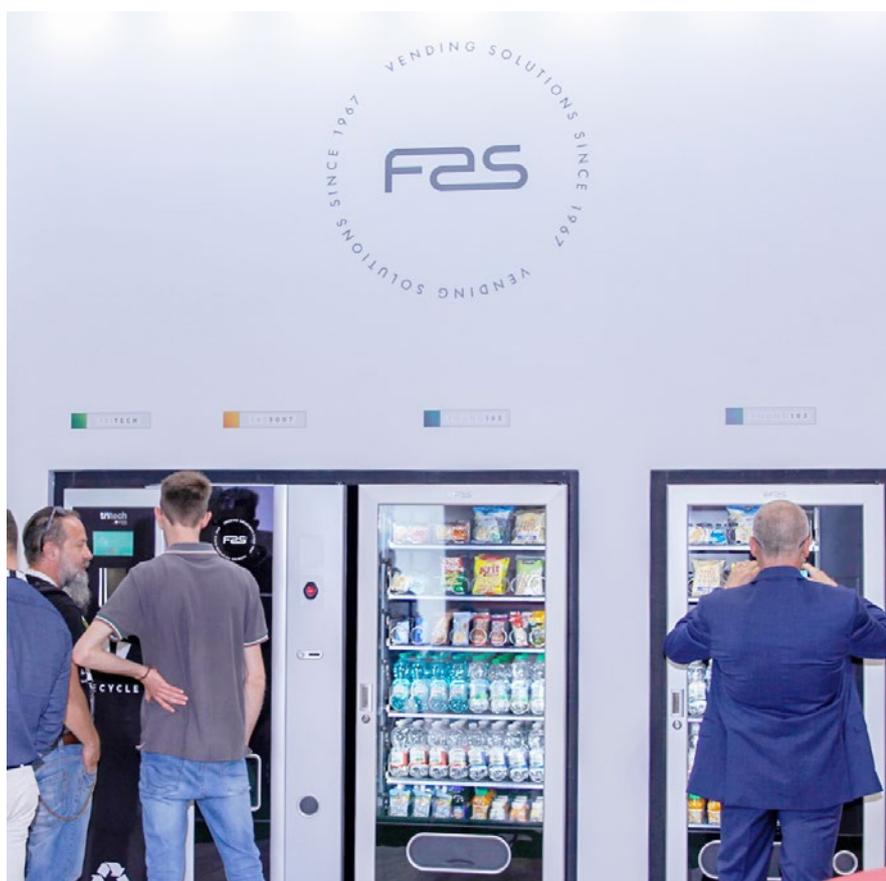
The hydrocarbon market, for its part, continues to grow. SandenVendo, for example, presented its first-ever hydrocarbon-based vending machine at the show. The G-Drink DV9 uses propane (R290) and can contain up to 504 33cl cans, at internal temperatures between +2°C and +10°C.

The key feature of the DV9 is its dual system with a heat exchanger using glycol as the cooling medium. The propane cooling system, at the bottom of the machine, is sealed off from the drinks and snacks compartment. Glycol circulates above to cool the produce. This system design keeps the flammable propane away from the electronic controller unit, reducing the risk of sparks causing an accident.

Other companies remain committed to carbon dioxide, which until recently seemed to be the uncontested refrigerant of choice.

FAS International is one such firm. The company, headquartered near Vicenza (northern Italy), is one of Europe's leading manufacturers in the vending sector and boasted one of Venditalia's biggest booths.

"Even though our production is still massively focused on R134a-based systems, we are strongly convinced that CO₂ is the future for the sector," said Marco Baron, business development director at FAS.



Despite being more expensive, Baron argues that CO₂ technology remains a better option than hydrocarbons for safety reasons. "We are aware that the European standards for hydrocarbons are currently under revision, and that recent lab tests have helped to improve the safety of these systems," he says. "Nonetheless a certain level of risk, albeit minimal, will always persist."

Should the market express a clear preference for hydrocarbons, however, FAS will be ready.

The increased interest in hydrocarbons is partly being driven by growing demand from major end users. Multinational beverage giant the Coca-Cola Company initially opted for CO₂ over hydrocarbons for its beverage coolers and vending machines, before later deciding to use hydrocarbons as well.

Taking this as a market signal, several equipment manufacturers began investing in hydrocarbon technology to avoid losing business with such titans of the snack and soft drinks industry.

LEFT

Venditalia was held in Milan on 6-9 June.

ABOVE

FAS technology on display at Venditalia.



Necta's booth at Venditalia.

Baron from FAS, however, believes this market development has been misunderstood. "Soft drinks producers are mostly interested in glass showcases, which are completely different from standard vending machines," he says.

"Glass cases have a much lower number of electric circuits, since they are basically composed of metallic shelves. The light circuit can easily be isolated, and a ventilator reduces the flammability risk from the evaporator. Vending machines are a totally different technology. We cannot use the same assumptions for products this different from one another," Baron says.

The FAS business development director also points out that the flammability of hydrocarbons can pose a challenge when storing equipment in warehouses, before it is sent to its final destination. "When putting together 200 propane-based machines in the same space, in the inconvenient occurrence of an accident, the explosion would be huge. Actually, fire-fighters may even forbid this kind of storage, given the risks related to concentrating such quantities of flammable substances in reduced spaces," Baron says.

Carbon dioxide, then, remains the priority for FAS for the time being. At Venditalia the company presented its first CO₂-cooled vending machine, the FASTER 1050. It is yet to enter full production. Only 100 units exist at the moment: they were assembled for an experimental project in collaboration with a university.

Baron proudly declares that FAS is one of the few companies in the sector to produce plug 'n' play vending machines. These slide-in, slide-out models make it easy to replace existing HFC-based machines with new CO₂ ones. Advanced software sets the internal temperature, meaning that the FAS machine is able to sell both snacks and drinks at the same time (other companies, such as SandenVendo, produce different machines according to the type of product).

To further simplify the production and distribution of its systems, FAS produces the same cooling units for all its machines ('one size fits all'). Nonetheless, particular models are available according to customer preference, such as one with an inverter cabin to reduce energy consumption, or one that is suitable for outdoor use.

Baron is a man with a vision and clear ideas. But he complains that at the European level, ideas are not clear. As chairperson of the Technical Committee of the European Vending Association, he is well aware of the challenges that bedevil the EU standardisation process. "Europe lacks a clear vision: from country to country, one can find very different positions and assumptions," he says.

Baron observes that many companies are waiting to see the direction in which standards will evolve before taking critical strategic decisions about their refrigerant of choice. Perhaps at the next Venditalia in 2020, closer to the deadline of the EU F-Gas Regulation, the scenario will become clearer. ■ DB

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What's the next challenge for the US HVAC&R industry?

At ATMOsphere America 2018 in California, participants were keen to debate how the rise of online shopping would change the market for natural refrigerants in the US commercial refrigeration sector.

— By Charlotte McLaughlin

Long Beach, California
hosted ATMOsphere
America 2018.

Photography by:
Ben Beech



Traditional food retailers are facing competition from big online shopping players like Amazon (which recently acquired Whole Foods) as US shoppers turn to online grocery shopping in ever greater numbers.

“By 2022 consumers could be spending \$100 (€85.45) billion dollars a year on online grocery” or about 20% of total yearly sales, Nielsen – a consultancy – stated in a 2018 report it wrote in conjunction with the Food Marketing Institute (which represents the US food industry).

The shift in shopping habits from in-store to online may also be having an effect on the natural refrigerant market. “Now 32% of US retailers have ‘Click & Collect’,” Andre Patenaude, director – food retail, growth strategy at Emerson Commercial & Residential Solutions, told ATMOsphere America 2018, organised by *Accelerate* publisher shecco and held on 12-14 June in Long Beach, California.

Click-and-collect often involves small locker-style storage units from which shoppers can pick up their shopping. This raises the question of how to put natural refrigerant-based HVAC&R systems into these units.

In Europe, the digitisation trend led German firm Viessmann and Austrian company Hauser to create hydrocarbon-cooled ‘Click & Collect’ systems where shoppers can easily collect shopping from an external pick-up station – such as a train station, supermarket car park, petrol station, bus stop or airport.

The Viessmann ‘Click4Food’ solution uses propane (R290) and isobutane for cooling, while goods kept at outside ambient temperature require no refrigeration at all. The system has so far been installed in Sweden and Finland. Austria-based Hauser opted for a slightly different concept with isobutane as the only refrigerant. The system is organised in descending rows of three, with each compartment using a different compressor and refrigeration system. Each row is at a different temperature: for frozen produce, for medium-temperature produce, and for ambient goods.

The Hauser system works as follows: the customer places an order online, after which they receive a QR code for their chosen pick-up station. Viessmann’s system differs here again. With the ‘Click4Food’ system, customers receive a code via SMS to enter into the system. The code grants access to lockers containing the goods.

In July 2018, French retailer E. Leclerc opted for a similar propane-based solution in a location in Anglet (near Biarritz, southern France), provided by Epta. The US does not yet have such systems with natural refrigerants.

Instead, the market trend is towards smaller stores, Patenaude told ATMOsphere America: “You will find North American retailers trying to compete with [big online] companies. [This has led to] a lot of e-commerce happening and diverts [from] other areas. [Retailers are] scaling down stores.”

Smaller stores, Patenaude noted, mean different refrigeration needs. In Europe there are a multitude of natural refrigerant-based solutions available to meet demand from small stores, such as CO₂ mini-boosters, CO₂ condensing units and hydrocarbon-based light commercial refrigeration systems, but this is yet to translate into the US market on a wide scale.

Hillphoenix (part of the Dover Corporation) has been very active in bringing natural refrigerant technology to the North American market, with help from its European subsidiary Advansor. The company has installed CO₂ transcritical technology in 139 stores in Canada and 52 in the US (2017 figures), according to Scott Martin, director of business development and industry relations for Hillphoenix.

“We [also] have a self-contained and integral line of hydrocarbon systems,” said Martin.

Emerson’s Patenaude and Embraco’s application engineer John Prall said their companies offer solutions to meet demand for natural refrigerant-based refrigeration systems in the light commercial sector, with good progress already having been made in rolling them out.

“30% of the market has already transitioned to R290,” Prall said. Yet more work needs to be done on US standards. “We have trouble with ASHRAE,” he noted, pointing out that hydrocarbon-based vending machines cannot be placed in hallways due to bans under ASHRAE standards.

US safety organisation UL did approve a charge increase for hydrocarbon refrigerants in household fridges from 57g to 150g, but the US Environmental Protection Agency (EPA) reversed its original approval for the charge limit increase earlier this year (see ‘[EPA pulls charge boost for domestic fridges](#)’, March 2018 issue of *Accelerate America*). “The EPA had not approved it because of one person’s argument,” Prall said. “I’m confident it will go back up. It’s just a matter of time.”

Prall also held out hope that international standards will change: “If we could go up to 500g we could cover a significant portion of the [commercial refrigeration] market.” The international standard for commercial refrigeration equipment is likely to increase to 500g from 150g by the end of 2018 (see ‘[Will we have a 500g charge limit in 2019?](#)’, page 64).



End users: look at total cost of ownership!

Hillphoenix's Martin highlighted the key role played by manufacturers and installers in communicating to end users the importance of looking beyond the initial cost of a system to consider total cost of ownership.

This means demonstrating to end users the installation, energy and servicing costs of using natural refrigerant-based systems, according to Martin.

Heat recovery could be one way of reducing costs. Asked if it were possible to implement heat recovery in convenience stores, Martin replied that, "even with HFC technologies, they have deployed air/water [heating technologies]. Natural refrigerant-based systems can also do this".

Marc-André Lesmerises, president of Canada-based Carnot Refrigeration, said his company had already successfully employed heat recovery in the commercial refrigeration space. "Of the more than 250 [CO₂ transcritical] systems we have [installed in the US and Canada], 90% have heat recovery capability," Lesmerises said.

A further point retailers should keep in mind, according to Hillphoenix's Martin, is the HFC phasedown – despite policy uncertainty in the United States.

"There's a \$50-60,000 (€43,000-51,400) price tag to convert from one refrigerant to the next," he said. "Look across to Europe and see what has happened there [under the new EU F-Gas Regulation]."

Europe has experienced significant HFC price increases due to the F-Gas Regulation, according to research by *Öko-Recherche* (a German organisation dedicated to environmental research and monitoring, which monitors price increases for the European Commission). Between 2014 (the date the F-Gas Regulation was finalised) and the first quarter of 2018, HFC prices increased from below €2 (\$2.34)/tonnes of CO₂ equivalent to €23 (\$26.92)/t CO₂e, or in other words by more than 1,050% (see '[HFC prices skyrocketing in the EU](#)' on page 66).

The US policy landscape still remains uncertain (see '[The Policy Quagmire](#)', June/July 2018 issue of *Accelerate America*) compared to the certainty in Europe under the EU F-Gas Regulation. Yet Martin maintains that end users cannot remain complacent. "[Non-natural] refrigerants now last [just] five years [and are a] big expense for the customer," he said. ■ CM



1 / Left to right: Derek Hamilton, shecco; John Prall, Embraco; Andre Patenaude, Emerson; Marc-Andre Lesmerises, Carnot; Scott Martin, Hillphoenix; Alvaro de Oña, shecco.

2 / Prall explaining why standards are a barrier to hydrocarbon uptake.

3 / Martin highlights the importance of total cost of ownership.

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Wynand Groenewald, CRS

South Africa gears up to leapfrog HFCs

South Africa has a unique opportunity to leapfrog straight from HCFCs to natural refrigerants, and some major end users are doing just that – with the help of home-grown HVAC&R equipment manufacturers alongside those from Europe and beyond. *Accelerate Europe* reports from Johannesburg.

– By Andrew Williams

The trickle-down effect of rising HFC prices as a result of the global phasedown being put in place in the context of the Kigali Amendment to the Montreal Protocol offers South Africa a chance to adopt natural refrigerants as replacements for HCFCs, heard participants in ATMOsphere Network Frigair 2018.

The event, hosted by *Accelerate* publisher shecco in conjunction with South African HVAC&R firm Commercial Refrigeration Services (CRS), took place on 7 June at the Gallagher Convention Centre in Johannesburg as part of Frigair 2018 – Africa's only dedicated HVAC&R tradeshow (6-8 June).

“Today our clients are posting energy savings of up to 40% by using CO₂ transcritical systems.”

– Wynand Groenewald, CRS



ATMOSphere Network Frigair was held alongside Frigair 2018 at the Gallagher Convention Centre in Johannesburg.

COMMERCIAL REFRIGERATION MARKET CONTINUES TO GROW

CO₂ in particular is making inroads into commercial refrigeration in South Africa, partly driven by the efforts of system provider Commercial Refrigeration Services (CRS) and the commitment of leading South African food retailer Woolworths.

"In South Africa, we have an opportunity to leap straight from HCFCs to natural refrigerants," Alex Kuzma from Woolworths told the ATMOSphere event.

"CO₂ is sustainable and future-proof. You put it in, and you don't have to worry about it any more," Kuzma said.

Going down the CO₂ road is a good business journey in terms of energy efficiency and reducing carbon emissions, he argued.

"Anyone putting in HFC plants now, brace yourselves, because it's going to get ugly!" he said.

Kuzma cited an initial cost premium, fear of the unknown, relative system complexity, difficulties sourcing components, and the development of local skills among the initial obstacles of adopting CO₂ transcritical technology in South African food retail.

Fast-forward to today, and such growing pains are very much a thing of the past for Woolworths.

Since opening its first CO₂ transcritical store in 2010, Woolworths now boasts between 60 and 70 supermarkets using these systems.

Among the CO₂ transcritical innovations that have improved energy efficiency vs. traditional HFC-based systems, Kuzma cited the use of electronic expansion valves, variable-speed EC fans and variable-speed compressors alongside the elimination of defrost heating.

"CO₂ is reliable and simple – our technicians are now familiar with DX technology," Kuzma said. "It's sustainable and future-proof, and almost cost-neutral."

"CO₂ transcritical works well in high ambient temperature conditions," Kuzma said. "There are excellent heat reclaim opportunities, and the cost of HFC gases is spiralling," he said.

Wynand Groenewald of CRS outlined global trends in the adoption of CO₂ transcritical systems and

expressed optimism that the market for these solutions in South Africa would continue to grow.

"Today our clients are posting energy savings of up to 40% by using CO₂ transcritical systems," he said.

SOUTH AFRICA TO RATIFY KIGALI, REGULATE HFCs

Globally, the HFC phasedown put in place by the Kigali Amendment to the Montreal Protocol represents an opportunity for alternatives such as natural refrigerants to seize a greater market share. Mindful of its international obligations, the South African government is putting in place legislation to regulate HFCs.

"Within a year, we'll have in place some kind of legislation to regulate HFCs," Obed Baloyi, chief director, chemicals management in the Department of Environmental Affairs, Republic of South Africa, told ATMOSphere Network Frigair.

South Africa intends to ratify the Kigali Amendment, which puts in place a global HFC phasedown pathway, before it comes into effect in January 2019.



“We will have legislation to make sure that we phase down HFCs in our country.”

— Obed Baloyi, Department of Environmental Affairs, Republic of South Africa (above)

“The government is putting in place a Climate Change Act, one of whose goals is to stop pumping HFCs into the South African market,” Baloyi announced.

“We’re plugging HFC management into that Act,” he said. “We will have legislation to make sure that we phase down HFCs in our country.”

The Climate Act is already in the process of being developed. “It should go into parliament soon. So we’re already looking into this,” Baloyi said.

“In less than a year, we should have something in place,” he said.

STAYING AHEAD OF THE REGULATORY CURVE

With the South African government planning to regulate HFCs in the near future, participants in the Frigair tradeshow were keen to see some of the natural refrigerant-based technologies on offer that can help them to stay one step ahead of the regulatory curve.

In another indication of the growing penetration of CO₂ transcritical systems into the South African market, SCM Ref Africa (Pty) Ltd. unveiled a CO₂ transcritical rack at Frigair.

“This is SCM Ref Africa’s first transcritical unit,” Greyling Wentzel, design and production manager at SCM Ref Africa, told *Accelerate Europe*.

Formerly known as Phoenix Racks, the company’s name changed to SCM Ref Africa at the end of 2017 following its acquisition by the Beijer Ref Group.

‘HUGE OPPORTUNITY’ IN SOUTH AFRICA MARKET

The rack has a cooling capacity of 18 kW on the medium-temperature side and six kilowatts on the low-temperature side. It is also fitted with a propane resilience unit.

“We decided to go for propane because as we’re already using a natural refrigerant, it doesn’t make sense to fit R404A or R134a on the rack,” Wentzel said.

SCM Ref Africa is confident that the South African market for CO₂ technologies is ripe for growth.

“I think there is a huge opportunity for CO₂ transcritical in the South African market,” said Wentzel.

“At the moment, there’s a bit of a skills shortage, but as soon as we can up the skills and get more people interested, then hopefully as more people use [CO₂ transcritical], the costs will come down,” he said.

Danish multinational Danfoss, meanwhile, sees the industrial sector as a promising future growth area for CO₂.

“It’s been very interesting in the last few years, with the development of CO₂ technologies in the South African market,” said Alistair Bell, technical sales engineer at Danfoss (Pty) Ltd., based in Johannesburg.

“10 or 15 years ago, the market wasn’t that accepting of CO₂ technology, but in the last 18 months, there has been a sudden acceleration of interest,” Bell said.

Growing demand for CO₂-based HVAC&R solutions from South Africa’s food retail sector will help boost the market prospects of Emerson’s product portfolio for this natural refrigerant in the near future, according to Daniel De Beer, regional manager for sub-Saharan Africa at Emerson Commercial & Residential Solutions.

“I think the CO₂ market is going to grow quite significantly in the next couple of years – specifically looking at smaller applications like convenience stores,” De Beer said.

As the Gallagher Convention Centre doors closed on these two events, the natural refrigerant market in South Africa looked set to grow. ■ AW

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Studious summer in Vienna for Montreal Protocol Parties

With the Kigali Amendment to the Montreal Protocol on phasing down hydrofluorocarbons poised to enter into force on 1 January 2019 after surpassing the required ratification threshold, the Parties met this summer in Austria to identify barriers and opportunities for its swift implementation. *Accelerate Europe* reports from Vienna.

– By Marie Battesti

ABOVE

From L-R: Ozone Secretariat Executive Secretary Tina Birmpili; Josef Plank, Secretary-General, Federal Ministry of Sustainability and Tourism, Austria; OEWG 40 Co-Chair Yaqoub Al-Matouq, Kuwait; and Paul Krajnik, Austria.

Photography: IISD/Mike Muzurakis.

Breaking news that China is continuing to produce CFC-11 dominated the agenda at a Montreal Protocol meeting in Austrian capital Vienna that was intended to prepare the ground for implementation of the Kigali Amendment on phasing down hydrofluorocarbons (HFCs).

The Parties to the Montreal Protocol met on 11-14 July 2018 for the Open-ended Working Group (OEWG), a meeting organised annually by the United Nations Environment Programme to provide the parties with scientific and technical assessments.

The Vienna meeting was also about preparing the agenda of the 30th Meeting of the Parties to the Montreal Protocol (MOP 30), to be held in November 2018 in Quito, Ecuador.

CHINA ACCUSED OF PRODUCING CFC-11

Ahead of this year's OEWG, the US branch of the Environmental Investigation Agency (EIA), an environmental NGO, published a report accusing 18 Chinese companies of illegally producing refrigerant CFC-11.

CFC-11, which has been banned by the Montreal Protocol since 2010, is a highly potent greenhouse gas that contributes to the destruction of the ozone layer.

The EIA said in the report that 18 factories in 10 provinces of China had admitted to still producing chlorofluorocarbons (CFCs) despite the international ban.

The report may offer an explanation for May 2018 findings published in *Nature* by *Montzka et al.* concluding that CFC-11 has been increasing in the atmosphere at a rate of $25 \pm 13\%$ since 2012 in East Asia.

Chinese traders admitted, during conversations with the EIA, that they are using some of the ozone-depleting substance themselves or buying it at undisclosed locations.

Production of CFC-11 in China has additionally been confirmed by an investigation led by the *New York Times*, which also spoke to CFC traders in China, and found several court documents over the last few years where companies have been fined for engaging in these environmentally harmful activities.

The EIA, in its report, notes the fines for producing, selling or consuming ODS are quite low and range from 5,000 RMB (€630) to 1 million RMB (€126,000) "depending on the violation". The *NY Times* said, in its article, that many of the CFC-producing companies it spoke to "treat fines and shutdowns as just the price of doing business".

"If China doesn't stop this illegal production, it will imperil our slowly healing ozone layer," said Alexander von Bismarck, executive director, EIA US. "CFC-11 is also a super global warmer, making this a serious threat for our climate as well. What we've uncovered is a systemic

problem, not isolated incidents. It requires a comprehensive nationwide intelligence-led investigation and higher penalties throughout the sector that fit the crime."

At their Vienna meeting, the Parties to Montreal Protocol unanimously adopted a call for definitive identification of sources. The Montreal Protocol's scientific and technical bodies (Scientific Assessment Panel and Technology & Economic Panel) were tasked with providing the Parties with a summary report on increased emissions of CFC-11, including additional information regarding atmospheric monitoring and the identification of potential sources of production and use. Comprehensive findings will be submitted at MOP 30 in November.

In an open letter addressed to the *Guardian* on 5 August, Zeng Rong, a spokesperson for the Chinese embassy in the UK, confirmed that the Chinese government had identified illegal use of CFC-11 in three factories. Rong claimed that local police had filed charges against the incriminated companies.

"China will continue cracking down on illegal production and use of ozone-depleting substances and strengthen regulation over relevant industries," Rong said.

On the industry side, the China Plastics Processing Industry Association (CPPIA) launched a new initiative to stop illegal use of CFC-11.

The EIA itself is calling for a comprehensive policy response from the government, addressing not only the factories found to be in breach of the Montreal Protocol but also identifying the loopholes that led to such practices in the first place.

"Clamping down on merely a few enterprises without systemic changes could mean that similar illegal enterprises pop up in other regions, not only gravely undermining the global ozone success, but also exacerbating the climate challenge," said EIA Climate Campaign Lead Avipsa Mahapatra.

The Kigali Amendment to the Montreal Protocol, meanwhile, is now poised to enter into force at global level on 1 January 2019 after surpassing the required ratification threshold.

IMPROVING ENERGY EFFICIENCY AND LEAPFROGGING TO NATREFS

Improving energy efficiency while phasing down HFCs was one of the main topics discussed in Vienna, with UN Environment's Ozone Secretariat organising a two-day workshop on the subject on 9-10 July 2018.

A number of representatives of signatory countries to the Montreal Protocol have shown a keen interest in evaluating the properties, availability and energy efficiency potential of natural refrigerants.

Parties are responsible for implementing their own f-gas policies, and seek to encourage the adoption of alternative low GWP refrigerant-based equipment through financial, training or awareness-raising programmes.

Better analysis of natural refrigerants' properties and their potential in terms of energy efficiency could, therefore, lead to new market opportunities.

Another key issue discussed was the potential for developing countries that are still phasing out hydrochlorofluorocarbons (HCFCs) to invest directly in low GWP refrigerant-based equipment instead of HFCs.

Representatives from Burkina Faso, Bahrain, the Gambia and Nigeria were among the parties supporting further analysis of the potential of natural refrigerant-based equipment to achieve energy gains while implementing the Kigali Amendment. ■ MB

WILL WE HAVE A 500g CHARGE LIMIT IN 2019?

The International Electrotechnical Commission's standard on commercial refrigeration equipment has reached the next stage in the process of raising the charge limit. *Accelerate Europe* asks: what are the next steps?

– By Charlotte McLaughlin, Klára Zolcer Skačanová & Michael Garry

The present international standard for hermetically sealed commercial refrigeration equipment (IEC 60335-2-89) – set by the International Electrotechnical Commission (IEC) – limits the use of flammable refrigerants to 150g.

It is commonly accepted by experts that the 150g limit does not allow manufacturers or end users to fully exploit the safe application of hydrocarbon refrigerants in the commercial refrigeration sector.

To address this, IEC Working Group SC61C/WG4 was created in 2014 with a view to raising the recommended charge limit for flammable refrigerants.

Standards from the IEC, a worldwide body that proposes rules governing how to use electrical, electronic and related technologies, influence the development of the market by providing manufacturers and customers with guidelines as to what is safe to use and buy.

During a meeting in October 2017 in Vladivostok, Russia, IEC subcommittee SC61C decided to advance the draft amendment of the IEC 60335-2-89 standard for commercial refrigeration, prepared by Working Group SC61C/WG4, to the next stage in the process (the Committee Draft for Vote; CDV).

The proposed charge increase, which would raise the charge limit from 150g to 500g, is based on 13 times the low flammability limit (LFL) of propane. To ensure safety, the draft amendment requires a minimum amount of space in which the system can be placed. Systems will also have to pass a leakage test that shows the relative absence of flammable concentrations throughout the system, besides other construction requirements.

The charge limit increase will cover all safety classes of flammable refrigerant, but with different limits.

VOTING 'YES'

National IEC committees agreed in July 2018, with a 75% 'yes' vote, to increase the charge limit to 500g.

"The IEC-89 standard CDV was voted [on and] approved with 75% 'yes'," says Marek Zgliczynski, who chairs IEC subcommittee SC61C. He is also manager of commercial refrigeration product engineering for Embraco.

The vote represents the latest stage in a lengthy standards process that will determine whether the higher charge limit is ultimately enacted as an international standard.

In the weeks preceding the July vote by the national committees, there was speculation that the new charge-limit standard might not attract approval beyond 67%. Even now, as the process nears its end game, "the battle is not over yet," warns Zgliczynski.

By voting 75% 'yes', they exceeded the minimum 67% required for the standard to advance to the final vote.

The next step is to address comments received during the CDV process at the next SC61C subcommittee meeting in Busan, South Korea, in October. The subcommittee will then decide, depending on whether the issues raised by the comments have been resolved, whether the draft charge limit change should go to a final vote phase (FDIS) by the end of 2018. If so, the revised standard could be published in early 2019, assuming a successful final vote.

"To be mandatory, [the standard] has to be adopted by region," Zgliczynski says. ■ CM, KS & MG



World Guide to CO₂ transcritical refrigeration

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HFC prices skyrocketing in the EU

Hydrofluorocarbon (HFC) prices rose from less than €2 per ton of CO₂ equivalent (/t CO₂eq) in 2014 to an average of €23/t CO₂eq at the beginning of 2018, according to a study carried out for the European Commission.

— By Marie Battesti

The new EU F-Gas Regulation, finalised in 2014 and in force since 2015, aims to reduce the European Union's use of hydrofluorocarbons (HFCs) by 79% by 2030. It has already been having a pronounced impact on prices, according to a study by *Öko-Recherche* and CITEPA.

Öko-Recherche and CITEPA, organisations dedicated to environmental research, are monitoring HFC prices on behalf of the European Commission to evaluate the effectiveness of the EU F-Gas Regulation and its quota system. 1 January 2018 heralded a 37% cut in the quota of HFCs available in the European Union.

Average purchase prices of R134a, R410A and R404A were under €2/t CO₂eq in 2014, but jumped to between €7/t CO₂eq and €23/t CO₂eq at the beginning of the first quarter of 2018, the study said.

In a webinar entitled '*Monitoring of refrigerant prices against the background of the F-Gas Regulation (EU)*', Barbara Gschrey of *Öko-Recherche* spoke of price increases for R134a, R410A and R404A throughout the supply chain (gas producers, OEMs, and service companies).

For instance, service companies' selling price for R134a has increased by €23 per kilogram (/kg) since the new EU F-Gas Regulation was adopted, while their selling price of R410 has risen by €46/kg.

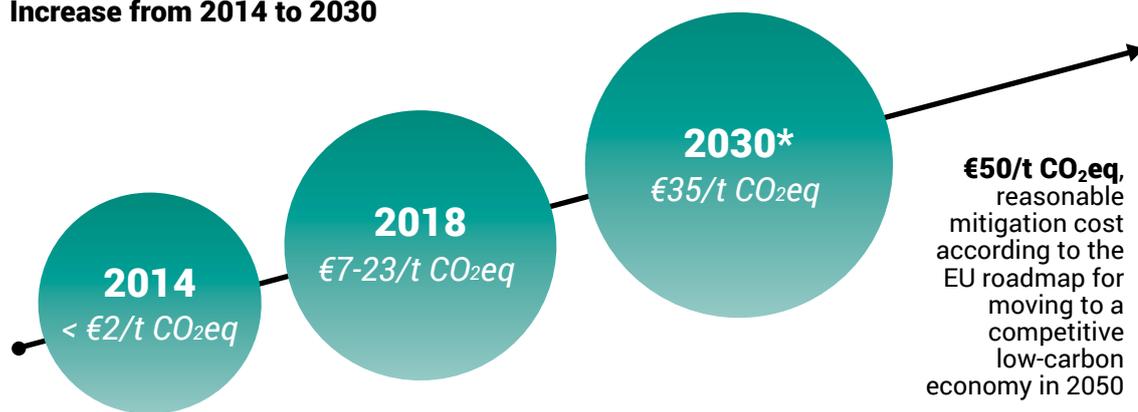
Soaring HFC prices are creating more opportunities in Europe for natural refrigerant-based technologies to serve as inexpensive, future-proof and environmentally friendly solutions for heating, ventilation, air-conditioning and refrigeration (HVAC&R).

In August, EU HVAC&R industry group AREA warned of growing illegal imports and black market trade in refrigerants in some European countries.

Higher prices and imminent shortages of these refrigerants have been attracting the attention of criminals, who are increasingly stealing HFC cylinders. ■ MB

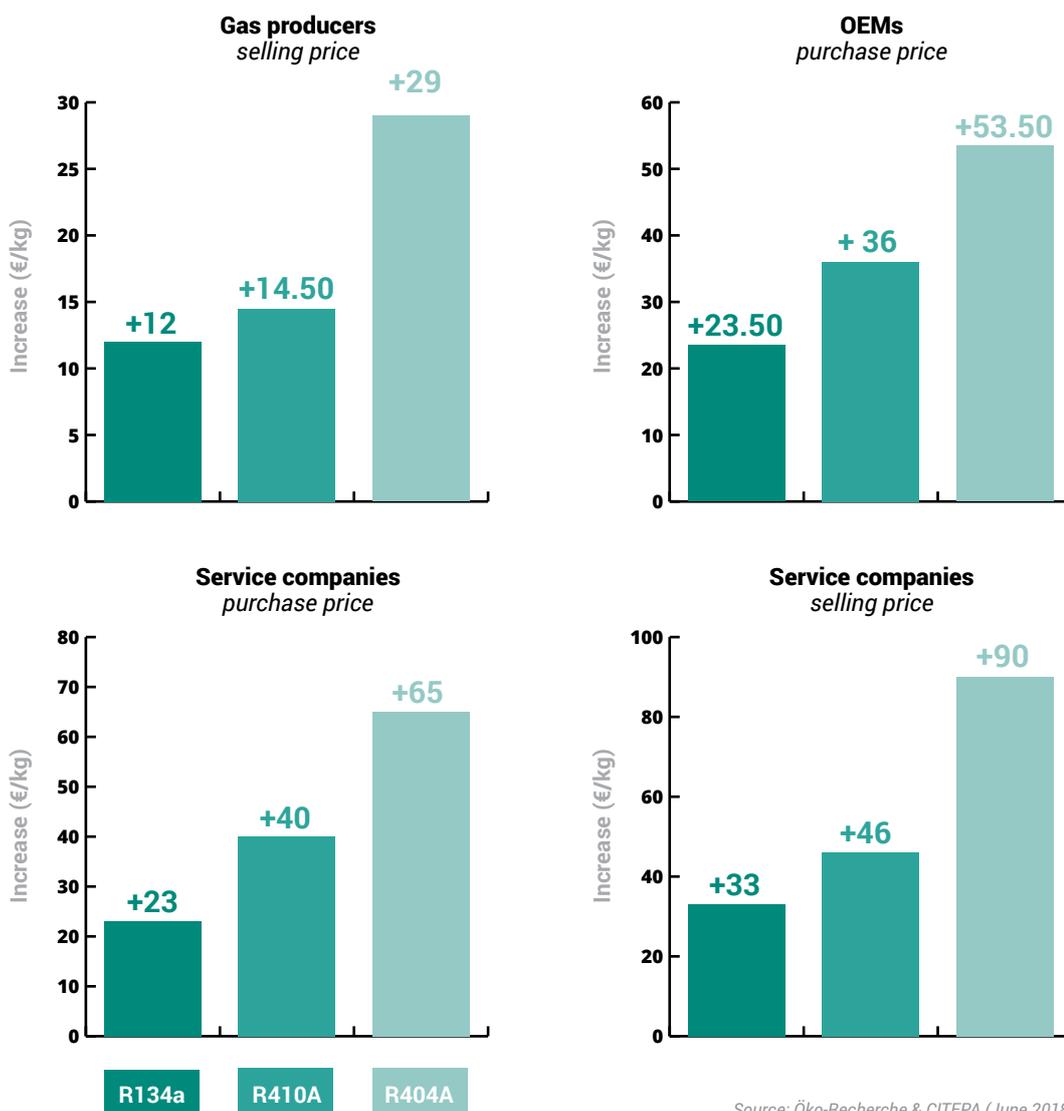
HFC PRICE DEVELOPMENT

Increase from 2014 to 2030



*Study carried out for UBA in 2015 by Öko-Recherche (forecast)

Prices of commonly used HFCs across the supply chain (2014-Q1 2018)



Source: Öko-Recherche & CITEPA (June 2018)



Pushing the boundaries

Swiss refrigeration consulting and engineering firm **Frigo-Consulting** is celebrating its 30th anniversary this year. In 15 years of working with CO₂-based HVAC&R technology, the company has brought to life over 1,000 CO₂ transcritical systems – and expects the next 30 years to be even more successful for natural refrigerants.

– By Andrew Williams

After three decades working with natural refrigerants, Frigo-Consulting is well placed to assess the current status of the HVAC&R market in Europe in 2018, its 30th birthday year.

“Our mission is to move refrigeration technology forward,” says Ernst Blatter, chairman of Frigo-Consulting’s board of directors. “We want to provide our share of innovation for the benefit of end users and installers alike.”

It was this passion for innovation that inspired Frigo-Consulting to embark on its natural refrigerants journey 15 years ago, when it first began to work with CO₂. What else made the firm decide to take the leap?

“A good portion of curiosity, and the challenge of engaging in a completely new technology,” says Blatter. “We knew what we were doing with substances like R22. So that was one thing, from the technical side.”

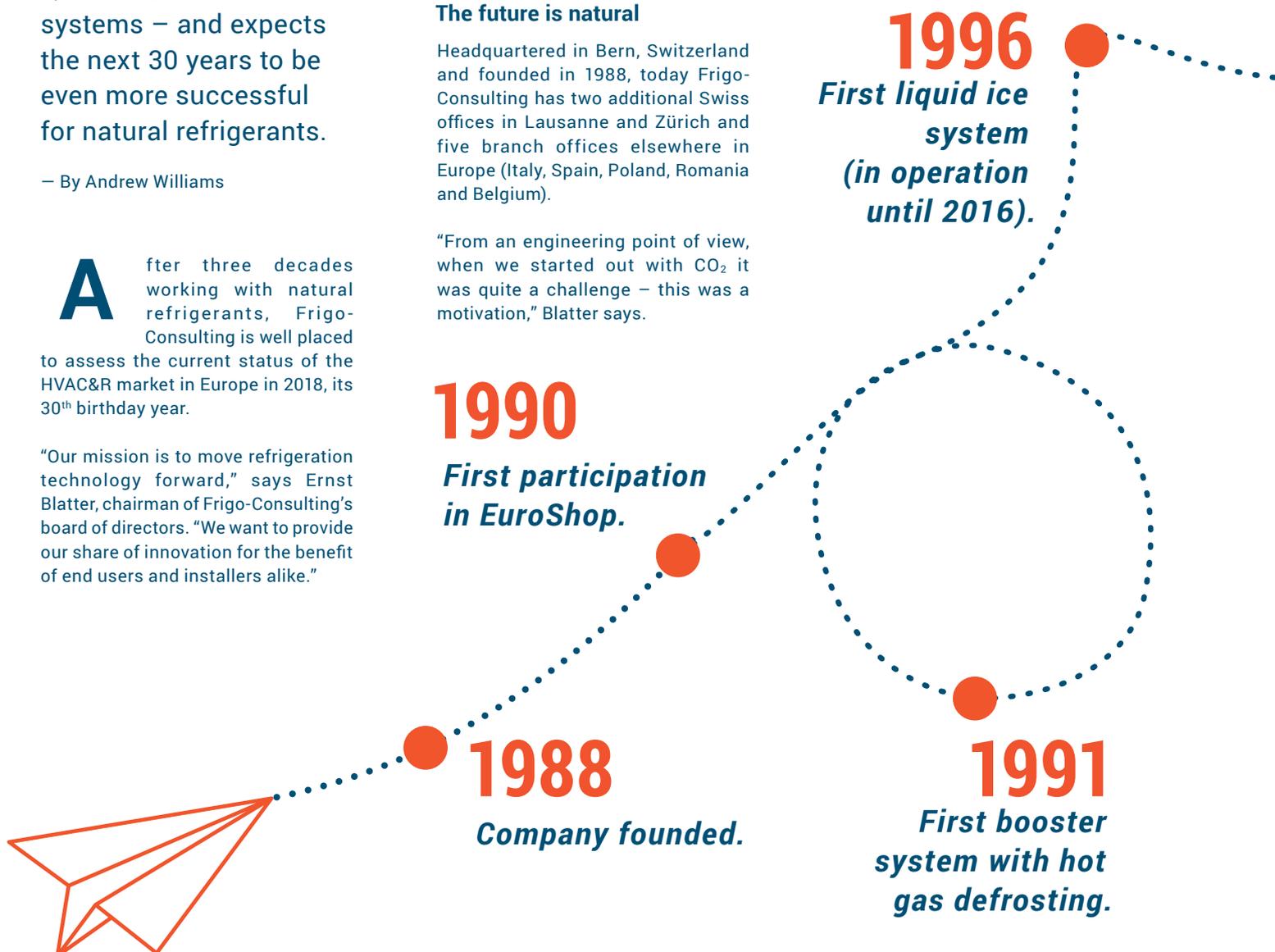
The future is natural

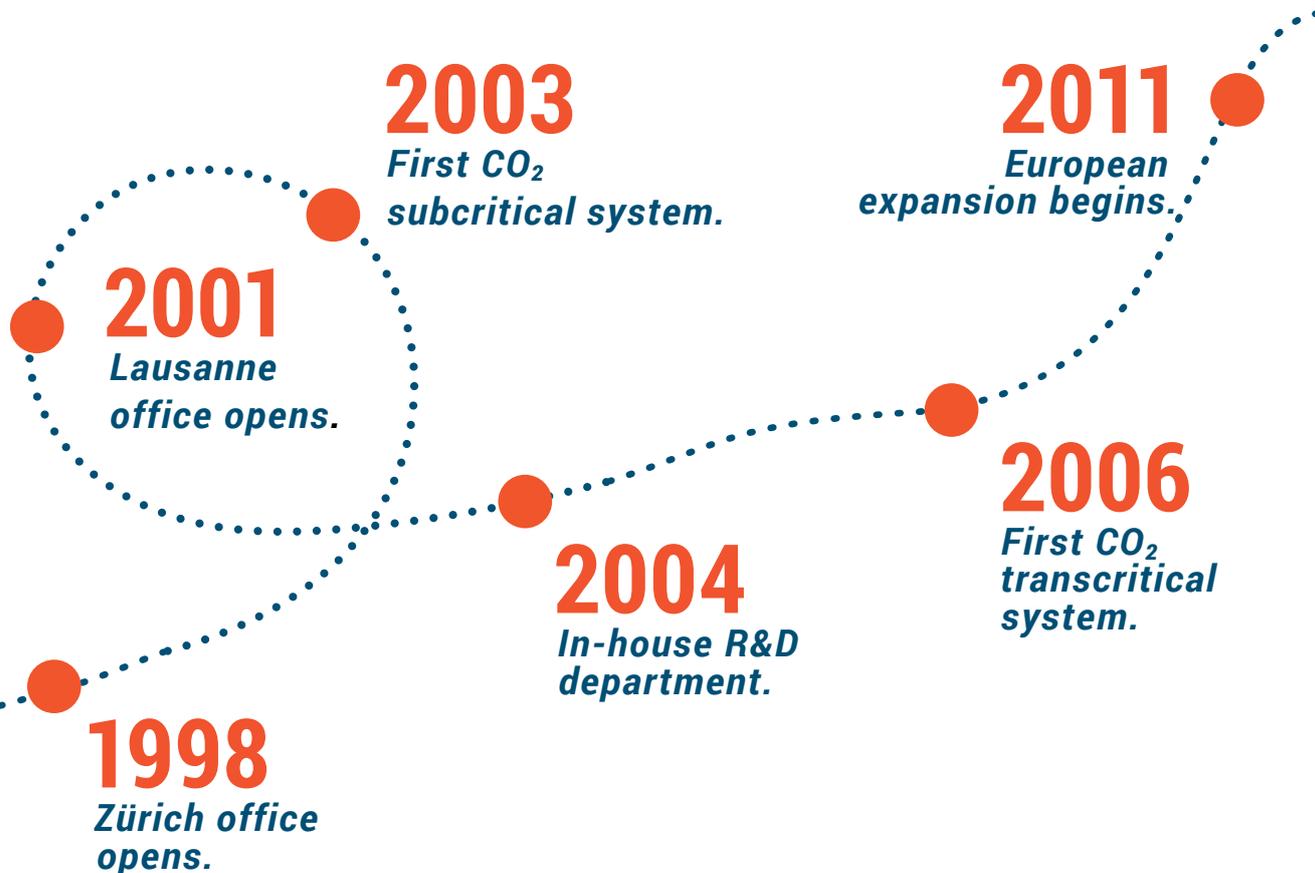
Headquartered in Bern, Switzerland and founded in 1988, today Frigo-Consulting has two additional Swiss offices in Lausanne and Zürich and five branch offices elsewhere in Europe (Italy, Spain, Poland, Romania and Belgium).

“From an engineering point of view, when we started out with CO₂ it was quite a challenge – this was a motivation,” Blatter says.

“In retrospect, it was also about our gut feeling that we’re obliged to deal with natural refrigerants – that these must be the future, rather than synthetic substances,” he says.

The regulatory incentives of the HFC phasedown taking place under the EU F-Gas Regulation and the Kigali Amendment to the Montreal Protocol came only later.





“When we first started working with CO₂, no-one was talking about f-gas phasedowns. It simply wasn’t on the agenda. But our gut feeling prevailed, in the end,” Blatter says.

Since those early days, Frigo-Consulting has worked on over 1,000 CO₂ transcritical systems. Blatter cites commissioning the first of those, back in 2006, among the highlights of the company’s 30-year history. “It still runs as smoothly as a sewing machine today,” he says.

Another was the company’s first EuroShop, a major global tradeshow for food retail, in 1990. “This is always a milestone in our company. Every three years, we get together and go to Düsseldorf,” Blatter says.

Overcoming the training gap

What were the challenges of those early days?

“There was no external training available,” Blatter says. “It was like a black box.”

Components were also in short supply. “The sourcing of spare parts was a tremendous task. For example, finding gaskets capable of withstanding the pressure of CO₂.”

All this led Frigo-Consulting to establish its own R&D department in 2004, which Blatter describes as one of the highlights in the company’s history.

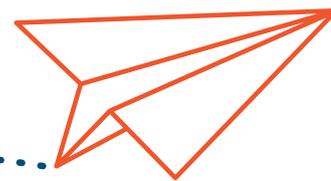
He estimates that today, around 80-85% of its installations use natural refrigerants. Of these, 90% use CO₂ and 10% use ammonia.

“*It was about our gut feeling that we’re obliged to deal with natural refrigerants – that these must be the future, rather than synthetic substances.*”

— Ernst Blatter, chairman of the board of directors, Frigo-Consulting

2018

Apprenticeships in refrigeration engineering.



2016

Pan-European ejector rollout.

Competition between different natural refrigerants in different applications has increased over the years. Frigo-Consulting sees CO₂ making greater inroads into the industrial sector, for example, where it competes with ammonia.

Blatter sees the Transgourmet installation in Hamburg as proof that for industrial applications, “CO₂ is very much an option now”.

2014

First integral CO₂ system.

“For large capacities, ammonia is still the one,” Blatter argues. Yet lately the firm has done a lot of business with logistics centres, where it sees CO₂ competing with ammonia in small to medium capacities.

“We make our own calculations between CO₂ and ammonia, and according to the total cost of ownership, we make our recommendation to the customer,” he explains. “We have no preference for one over the other.”

2013

First CO₂ system with ejectors.

In May 2018, European cash & carry giant the Transgourmet Group opened a new 120,000 m³ distribution centre in Hamburg, where a 2 MW CO₂ transcritical system designed by Frigo-Consulting serves 5,265 m² of refrigeration and 5,527 m² of deep-freezing warehouse space (see [‘Hamburg home to Transgourmet’s largest CO₂ transcritical system’](#), *Accelerate Europe*, summer 2018).

How has the firm managed to maintain such a good relationship with its customers over the years? “We’re not fundamentalists or greenies, just because we’ve committed ourselves to sustainability. Our customers understand this. They know how we work,” Blatter says.

“It’s like watering a plant. Over time, by being a reliable partner who understands what the customer wants, then if you have good, innovative solutions that create added value, you’ll keep the customer on board,” he says.

Asked what had allowed the company to move outside its home base of Switzerland, Blatter replies: “We quickly learned that you need to physically be on site.”

“You have to be present in the country concerned to understand the habits and culture, in order to provide engineering services tailored to their specific needs,” he argues.

Blatter foresees a bright future for natural refrigerants as pressure to act on the environment continues to mount.

“We’re relaxed about what the next 30 years has in store. We’re sticking to natural refrigerants,” he says. ■ AW

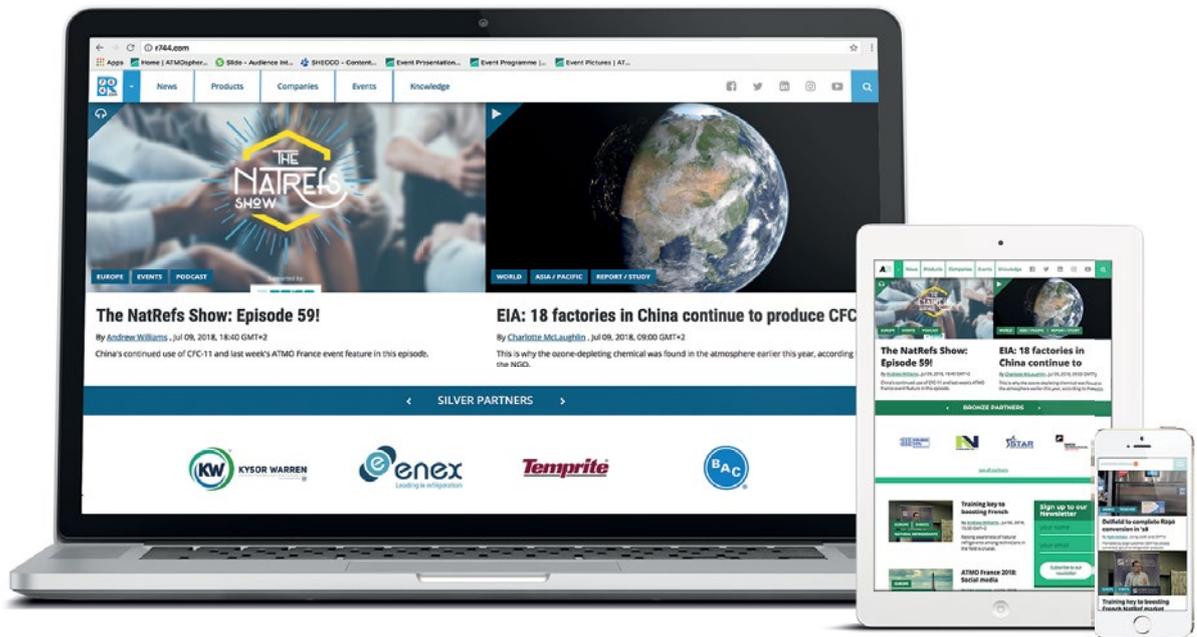


“We’re relaxed about what the next 30 years have in store. We’re sticking to natural refrigerants.”

— Ernst Blatter, chairman of the board of directors, Frigo-Consulting

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Down a winding road

Since the first prototypes were developed in the 1990s, mobile air-conditioning (MAC) with CO₂ has been favourably received by a large cross-section of the MAC industry, with some vehicle manufacturers and industry groups committed to its rollout. But it is yet to become a mainstream technology. *Accelerate Europe* looks into the reasons for this, and its future market prospects.

— By Charlotte McLaughlin

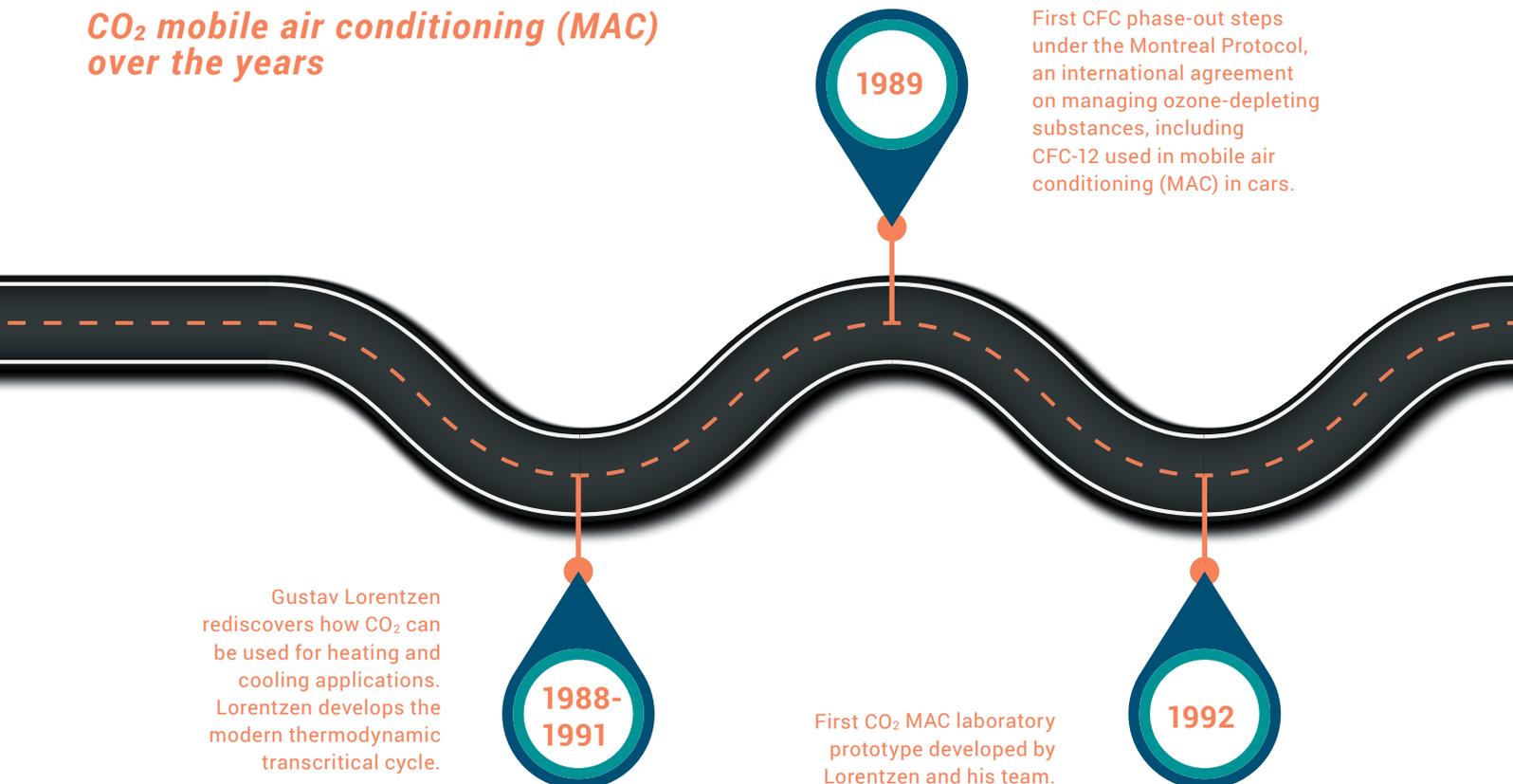
CO₂

transcritical mobile air conditioning (MAC) has a long history in the HVAC&R world. Since the rediscovery of CO₂ as a refrigerant by Gustav Lorentzen, the Norwegian professor who developed the modern thermodynamic transcritical cycle, manufacturers and researchers have been looking into whether this natural refrigerant could be a replacement for ozone-depleting refrigerants chlorofluorocarbons (CFCs) in MAC passenger vehicle systems, and later hydrofluorocarbons.

Father of CO₂ Lorentzen and his last PhD student Jostein Pettersen developed the first prototype CO₂ MAC system in 1992. Their early results revealed that it outperformed a CFC-12 MAC system, according to Pega Hrnjak, president of Creative Thermal Solutions, Inc. (CTS) and professor at the University of Illinois at Urbana-Champaign. Hrnjak has spent much of his career working on CO₂ MAC (see [cover story, February 2018 edition, *Accelerate America*](#)).

The prototype's success was well received by car manufacturers and encouraged the establishment of a research project on future MAC systems called RACE, which ran from 1994 to 1997 and was supported by the European Union (EU). The project was carried out in conjunction with carmakers, MAC

CO₂ mobile air conditioning (MAC) over the years



manufacturers and researchers, according to Professor Armin Hafner of SINTEF (Foundation for Scientific and Industrial Research at NTNU).

The RACE project looked into many alternatives to CFC-12, including R134a, R1234yf and CO₂, which demonstrated that as a high-pressure fluid, CO₂ is less sensitive to pressure drops than R134a thanks to its thermophysical properties – delivering a higher coefficient of performance (COP), according to CTS' Hrnjak.

Subsequent research over the years has confirmed that CO₂ is the best solution for MAC. Despite such thorough testing, refrigerant efficiency remains a political issue, according to Sanden International's Thomas Di Vito. "If you have a very good R134a system, you can have better efficiency overall than with CO₂," he says. "If you have a very good CO₂ system, then in some regions (e.g. Europe), you can also have better efficiency. I would say that overall, it's comparable."

The question of efficiency has not been addressed openly, according to Michael R. Ingvarlsen, incoming president of EU industry group MACPartners, which represents the MAC sector in Europe. "The companies involved in developing the CO₂ systems have been very good at keeping the technical information internal, and

therefore it is difficult for an organisation like MACPartners to [...] document the pros and cons [of] CO₂."

The first live test of a CO₂ MAC system in a car took place in the hottest place on the planet – Death Valley in the US state of California – in 1998, comparing it to an R134a system. The CO₂ system cooled down the car's interior more quickly than the HFC one.

A RACE TO THE FINISH LINE

This early testing propelled German and international carmakers and MAC manufacturers forward. Sanden, along with Luk (a MAC supplier that subsequently became Ixetic and Magna), worked on a mass-produced CO₂ MAC compressor system during the early 2000s. "Unfortunately this was stopped for several reasons. There were a lot of technical hurdles that stopped us," Di Vito says.

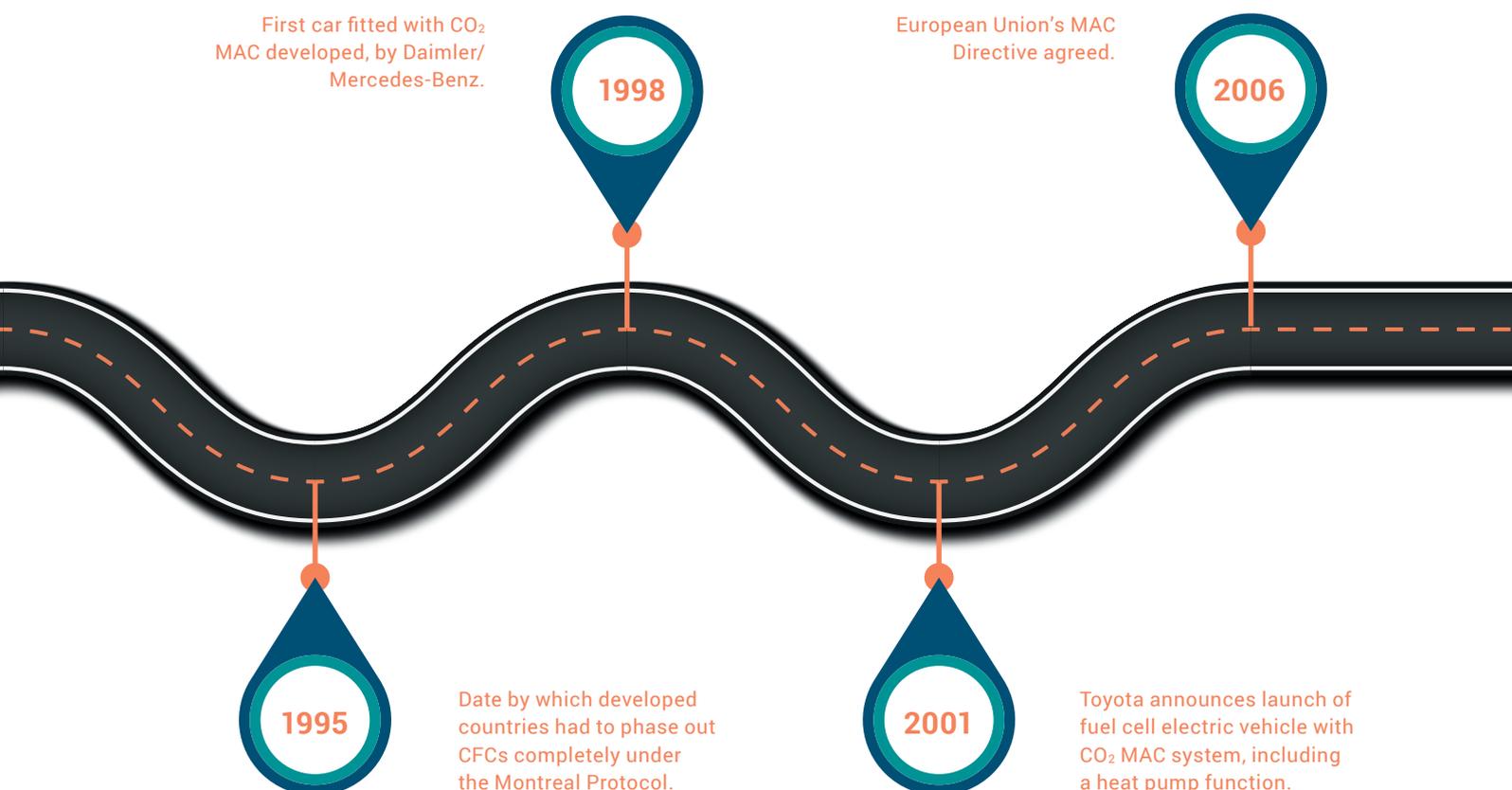
A further push came from the EU-wide MAC Directive, which entered into force in 2006, with the eventual aim of having MAC systems in passenger cars with GWPs below 150 on the EU market by 2017 (R134a has a GWP of 1,430).

Recognising that the automotive industry needed to come up with a refrigerant solution,

the German Association of the Automotive Industry (VDA), which includes major German and international carmakers BMW, Daimler, Chrysler, Ford and Volkswagen (VW), began looking into CO₂ before announcing in 2007, and reconfirming in 2008, that this was the way to go.

"With this joint step [to use CO₂ MAC], German car manufacturers are taking the global lead on climate-friendly refrigerants and putting into action their strategy for sustainable mobility," former VDA President Matthias Wissmann stated in 2007.

The light at the end of the tunnel seemed to be getting nearer. R744.com (a news website devoted to CO₂-based technology, published by *Accelerate Europe* publisher shecco) attended the 62nd



International Automotive Exhibition (IAA) on commercial vehicles in Hannover, Germany (25 September-2 October 2007), where it found many CO₂ components and systems available.

Behr, a MAC manufacturer which took part in the original Death Valley test, announced at IAA it had conducted tests with a 100+ car fleet equipped with CO₂, recording strong cooling performance and energy efficiency compared to R134a systems. Behr also stated it would start preparing for mass production, given these results and the VDA's decision.

Alongside the pronouncements of OEMs and German car manufacturers, international automaker Toyota also said it would start using CO₂ MAC. General Motors said it had placed an order for the first few tens of thousand systems.

POTHOLES GALORE!

Some of the hopeful gleam began to wear off, however, with the arrival of HFOs. "Until R1234yf was introduced in 2007, everyone expected CO₂ [would] be accepted," says CTS' Hrnjak.

In 2008, German environmental NGO *Deutsche Umwelthilfe* (DUH) began attacking the VDA for its failure to issue a concrete pledge to introduce CO₂, warning against introducing R1234yf.

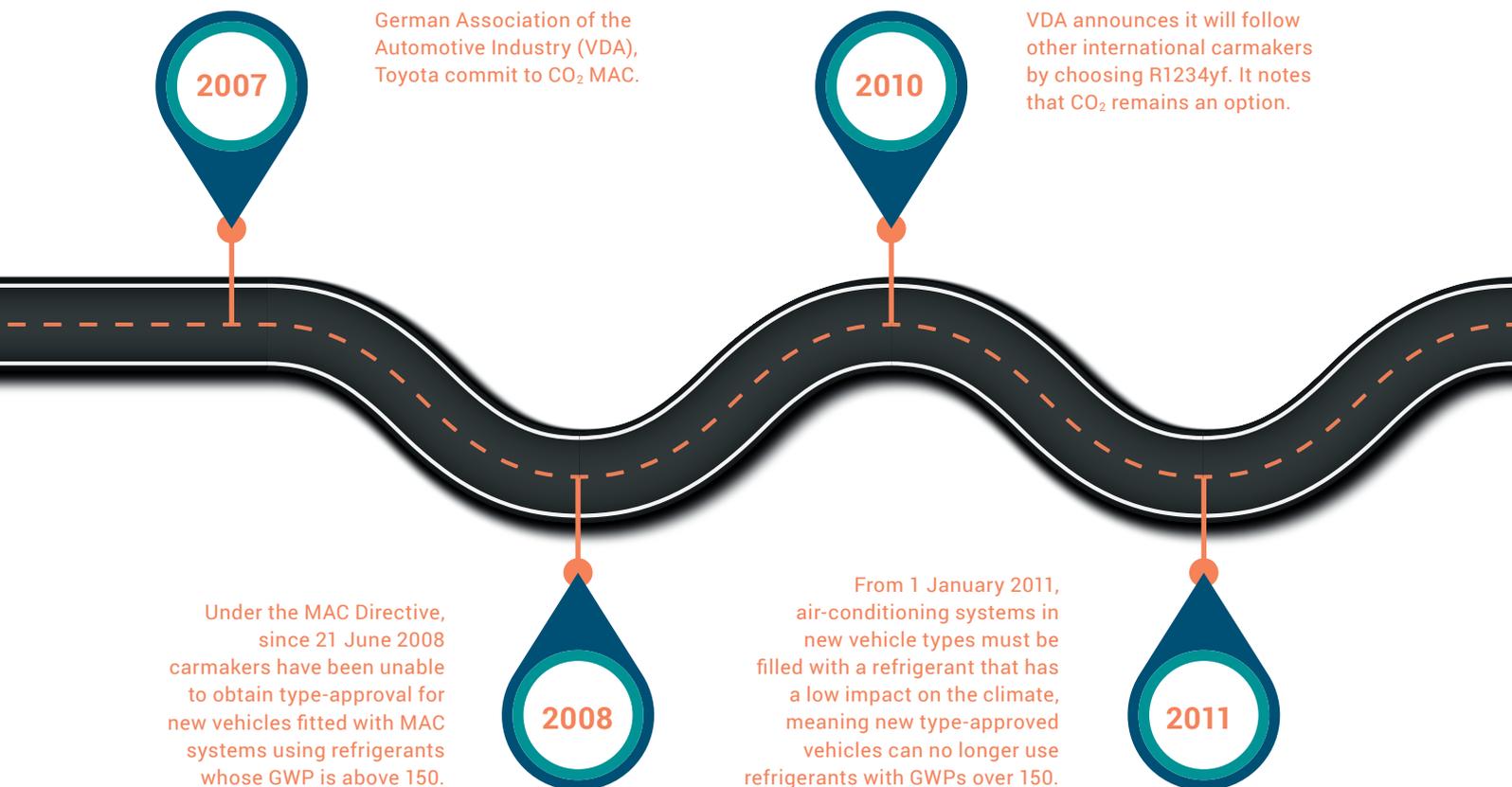
This followed a test conducted by DUH simulating a traffic accident with an HFO-based MAC system, which resulted in horrifying scenes of the car on fire throughout the whole engine compartment. The combustion of the HFO also resulted in the release of "life-threatening" concentrations of the toxic acid hydrogen fluoride, also known as hydrofluoric acid (the video can still be seen on YouTube).

Despite these concerns, and a 2010 confirmation of the safety risk posed by the HFO from the German Federal Institute for Materials Research and Testing (BAM, a chemical and materials safety institute), the VDA announced in 2010 it would use R1234yf. VDA explained its decision by saying it wanted, "not an isolated solution but a global standard" and, "second, there was [now] a new alternative with 1234yf," which was more similar to R134a and was less of a change for the industry.

System costs appear to have played a very minor role in this decision. The price difference between R134a and R744 systems was little more than \$200 (€136.80) per vehicle in 2007, Hrnjak says. At the time, both the German Federal Environment Agency (UBA) and DUH cited lobbying by the chemical industry as playing a role in R1234yf's success, while Sanden International's Di Vito told *Accelerate Europe* that at that time, CO₂ MAC was not a mature enough technology to meet the deadline of the MAC Directive.

Whatever the reasons, this decision clearly forestalled the progress of CO₂ MAC, particularly by affecting the component supply chain. "Lots of know-how was lost after the VDA's forced U-turn [...], when R1234yf was announced to be the solution for the next period," says SINTEF's Hafner.

Despite this decision, the use of R1234yf continued to be controversial. Daimler rejected the VDA's decision, and in 2012 chose to work towards introducing CO₂ MAC systems. It cited results from its own tests that had confirmed the DUH and BMA findings as one reason for its decision. Daimler has since changed its mind, amid pressure from the European Commission and the German Transport Authority – and the lack of readiness of CO₂ MAC technology. Daimler has used R1234yf in



its vehicles since 2015, with 'specific protective devices' in the event of a head-on collision.

German carmakers Volkswagen, VW brands Audi and Porsche, and BMW announced in 2013 they would follow Daimler in considering CO₂ MAC to be the long-term solution.

VICTORY FOR CO₂! OF A SORT...

In 2015, VW announced it would implement CO₂ MAC in two luxury models. Mercedes-Benz committed to rolling out the natural refrigerant in its S- and E-Class models, and pledged to eventually put it in its A, B, and C-Class models as well. The VDA also published its much delayed standards for CO₂ MAC in cars, which were heralded as creating certainty for the industry in the same year as the VW and Mercedes-Benz proclamations.

"Since the end of 2016 we have offered a model of the S-Class Coupé (S 400 Coupé) with CO₂ air conditioning," a Daimler spokesperson told *Accelerate Europe* in August 2018.

"In addition, in all variants of the S-Class (Sedan, Coupé & Cabriolet), the CO₂ air conditioning system is used in the main volume carriers S 560 and S 400 d. Also in the E-Class, the CO₂ air conditioning system is available in some variants as part of optional thermotronic equipment. To reach the necessary quality level, we will start with a slow production ramp-up of the new air conditioning systems and will decide on their further use case-by-case."

VW also followed through with its Audi model, but its other CO₂ MAC offering – in the VW Phaeton – did not come to fruition as the car was discontinued, according to a company spokesperson. "I would like to confirm that

the Volkswagen Group is continuing to announce that it will gradually equip its vehicle fleet with the refrigerant CO₂ (R744) for reasons of sustainability," she told *Accelerate Europe*. "From the point of view of environmental and climate protection, CO₂ is the preferred refrigerant for us in the long term."

BMW and VW brand Porsche appear not to have installed CO₂ in any of their car models. "Porsche continues to work on the technology within the group. At present, no Porsche models with R744 are available," a spokesperson from the German carmaker told *Accelerate Europe*. "Please understand that we cannot make any statements about future models."

BMW still believes "R744 is a sustainable solution" but stated in an email to *Accelerate Europe* that, "developing for a wide deployment takes years, not months. An area-wide rollout scenario is therefore conceivable in the medium to long term".

An estimated 30,000 cars using CO₂ MAC have been sold so far, according to Sanden. Despite this modest success, a real transition to the natural refrigerant is yet to take place.

"The transition towards CO₂ MAC requires a complete change in most of the production infrastructure," explains SINTEF's Hafner. "TIER 1 suppliers, manufacturing most of the MAC systems, need long-term contracts to be able to make this kind of investment. The OEMs do not always have a long-term perspective when it comes to investment."

"Several people developing CO₂ MAC systems still believe and understand why it would make sense to

German automakers – Daimler, Audi, BMW, Porsche and VW – state they will work to develop CO₂ MAC technology.

2013

VDA adopts new MAC standards for CO₂ technology. Daimler announces it will use HFOs while working on CO₂ MAC.

2015

2012

Daimler refuses to use R1234yf.

2014

Daimler's safety concerns about R1234yf are rejected by Germany's Federal Motor Transport Authority (*Kraftfahrt-Bundesamt*; KBA) and the Joint Research Centre of the European Commission (JRC), which undertook an additional risk analysis of the HFO that year.

perform a complete switch on a global basis. However, there are others working hard for this not to happen," Hafner warns.

Companies appearing to offer CO₂ components for MAC systems and heat pumps in cars in 2018 include Witzmann, KAORI, KONFORT, Sensata, Panimpex, AVL Ditest, Bitzer, Denso, SANDEN, Sanhua, Behr, MAHLE, Valeo, and Ixetic (Magna-branded CO₂ compressors). Eberspaecher Suetrak, Konvekta and many others have systems available using CO₂ as a refrigerant for bus air-conditioning and heat pump systems.

Despite this, CO₂ remains a challenge for the MAC industry. "The installation will of course demand a technician that is certified to work on a CO₂ system," says MACPartners' Ingvarsdén. This would require specialised training that is yet to materialise on a large scale.

DO ELECTRIC CARS OFFER OPPORTUNITIES?

Though CO₂ is yet to become mainstream, HFOs – the most likely alternative – remain an issue of concern for environmental agencies in European countries. In 2017, a report on HFOs by the Norwegian Environment Agency recommended that a number of "knowledge gaps" needed to be addressed before the chemical decomposition in the atmosphere of R1234yf into trifluoroacetic acid's (TFA) ultimate effect on the environment could be determined. It recommended a pre-emptive phase-out of the refrigerant.

Similarly in 2018, Germany's UBA warned that TFAs could contaminate the water supply as they cannot be removed after contamination has taken place. The UBA recommended adopting CO₂ for MAC instead.

Hybrid and electric cars are also set to further influence the take up of CO₂-based systems. "For the next generation of vehicles, i.e. electric and hybrid cars, there is a need for

heat pumps to increase their driving range, especially during the cold winter months," says Hafner, noting CO₂'s excellent heat pump capabilities. The driving range can be optimised by 30%, according to some studies.

"Electric cars do not have waste heat or engines with internal combustion," says CTS' Hrnjak. "For that reason, the only source of the heat in winter time is the energy from the battery. A heat pump is the best way to rationally use electric energy stored in the battery, because you need only about one third of the energy in total."

"HFOs are low pressure fluids. As such they are not appropriate for low-temperature applications for two major reasons: at ambient temperatures between -10 and -15°C, the system goes into a vacuum, with the very bad consequence of pulling air into the system. In addition, at lower pressures, the efficiency of the heat pump system with low-pressure refrigerants is dramatically lower for various reasons," Hrnjak adds.

VW has recognised this. Its new 'ID' electric car series uses CO₂, a spokesperson from the company told *Accelerate Europe*. Other carmakers are investigating the heat pump potential of CO₂, according to Michael Matthias, head of engineering at Sanden International (Europe) Ltd.'s European technical centre. "Many global OEMs are investigating the benefit of CO₂ systems," he notes.

"So there is a lot of interest and the investigation is on-going," he says.

The topic of CO₂ MAC is expected to become more popular as the electric car market grows. Yet the CO₂ story shows that market success is far from certain. ■ CM

VW to roll out CO₂ MAC in new electric car series.

2019?

2017

1 January 2017: Total ban on using fluorinated greenhouse gases with GWPs higher than 150 in all new vehicles put on the EU market enters into force. New vehicles with MAC systems using these gases cannot be registered or sold and cannot enter into service in the EU.

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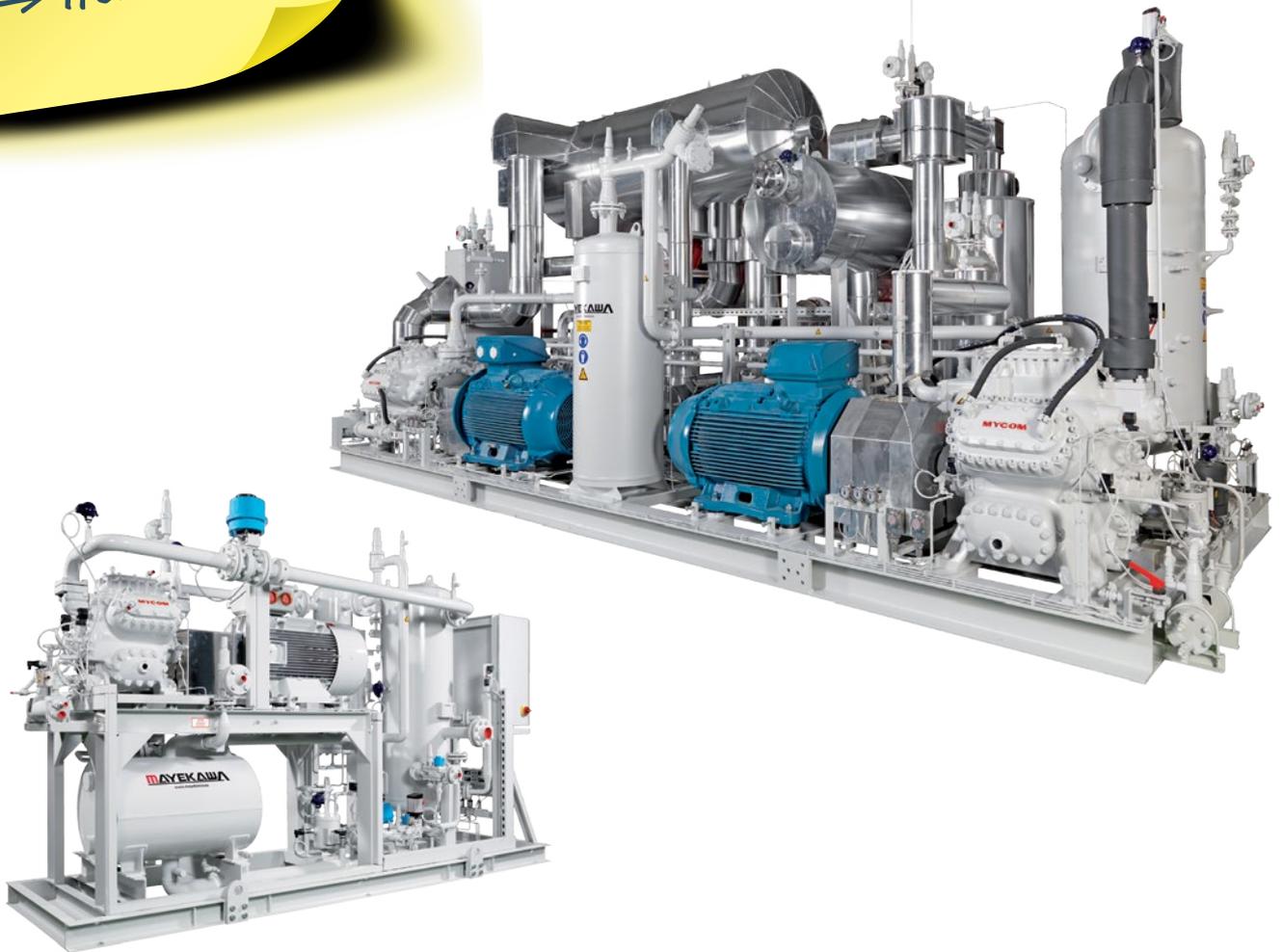
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