UNDERSTANDING THE MOST COST-EFFECTIVE WAY TO FIGHT CLIMATE CHANGE

Sharing CGF Members' Experience in Eliminating Climate Potent Refrigerants

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The Consumer Goods FORUM

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WELCOME MESSAGE BY THE CONSUMER GOODS FORUM

Back in 2010, The Consumer Goods Forum's (CGF) members made a commitment to tackle the growing impact of refrigeration systems on our climate and, in a move to sustain momentum, the CGF's Board announced a second Refrigeration Resolution in October 2016 to continue the phase out of hydrofluorocarbons (HFCs) and call for their inclusion in the Montreal Protocol. This proposed amendment to the Protocol was included in 2016: a huge step towards the global phase-out of harmful HFCs.

The 2016 Resolution focuses on four key areas; the installation of new refrigeration equipment in markets where viable, the engagement with key stakeholders to overcome barriers in markets where installation is not currently feasible, the reduction of the environmental impact of existing refrigeration systems and the development of individual targets and action plans to measure the first three points.

However, for all the industry's achievements, there is scope for consumer goods companies to be more ambitious in phasing out harmful chemical refrigerants and moving to natural alternatives. The benefits of doing so are not just environmental but economic too. When implemented at scale, a HFC phasedown will have huge impact and could prevent warming of up to 0.1 °C by 2050 and 0.5 °C by 2100, offering one of the most cost effective climate mitigation strategies available in the world today.

To support faster uptake, and as the only organisation bringing consumer goods retailers and manufacturers together globally, we have been able to bring our members together to discuss the barriers and solutions. While much has been achieved since the initial commitment was made in 2010, there is still much more that we can do. We want to see further implementation of natural refrigeration systems worldwide. We will continue to mobilise the efforts of our members and work with civil society and international organisations, with a view to promote the development, commercialisation and adoption of climate-friendly alternatives to HFCs for all relevant industry sectors and overcome barriers that limit the widespread introduction of these climate-friendly technologies and practices.

In short, no matter what industry you are in, the case for switching to natural refrigerants has never been stronger, and the time to move is now!

I am very happy to introduce this booklet created alongside shecco, a leading partner in tackling this issue with the world's largest database on natural refrigerant-based technologies. We have shared industry success stories that we hope will inspire you to take action and make the switch.

Thank you for reading, and please don't hesitate to connect with us should you have any questions about our work to phase out harmful HFC refrigerants.

Ignacio Gavilan

Director,
Environmental
Sustainability
The Consumer
Goods Forum

INTRODUCTION

Cooling is indispensable for the preservation of food, data and comfort, and demand is growing rapidly. With the rising demand in fast-growing developing economies and booming middle-class, the global demand for cooling is projected to rise steeply over the next decades.

Given the relatively long life span of refrigeration systems, decisions being made now will impact the climate for decades to come. Introduction of energy efficient HFC-free refrigeration systems without further delay would avoid locking in technologies that would negatively impact the environment.

2016 saw* The Consumer Goods Forum *(CGF) agree a new voluntary Refrigeration Resolution, committing its members, wherever viable, to immediately adopt natural refrigerants or alternative ultra-low GWP refrigerants across their estates and to work with their supply chains, governments, civil society and other stakeholders to remove any remaining barriers.

Retailers and other technology end-users have an opportunity to develop refrigeration strategies that simultaneously advance business and environmental goals. Strategic choices about system architecture and/or deeper integration with local energy networks could allow supermarkets to make use of negatively-priced excess renewable power, or develop new revenue streams by providing waste heat – or excess cold – to district heating networks, while at the same time supporting three internationally agreed goals: the Paris Climate Agreement; the Montreal Protocol's Kigali Amendment; and the UN Sustainable Development Goals.

The journey from Hydrofluorocarbons (HFCs) or Hydrochlorofluorocarbons (HCFCs) towards sustainable and future-proof technologies using natural refrigerants is often not without challenges. Lack of technicians with the right expertise, high initial cost of equipment, and availability of the suitable equipment in different conditions are among the common challenges that end-users experience when they decide to make the switch.

Learning from the experience *of those that have managed to overcome the barriers is a great way to reach the final objective faster and more effectively.*

This is exactly the aim of this booklet. It outlines the main challenges on the road towards HFC-free cooling, and highlights the benefits of using such technologies, while zooming in on experiences and lessons learnt from a number of end-users in different parts of the world.

IMPACT OF COOLING ON CLIMATE

At the environmental level, the impact of cooling technologies such as refrigeration and air-conditioning is twofold[1] due to:

- **Direct emissions** (or atmospheric emissions) of certain refrigerant gases used in refrigeration and air-conditioning installations. These emissions arise due to leaks occurring in insufficiently leak-tight installations or during maintenance-related refrigerant-handling processes, and depending on the refrigerant concerned, can have an impact on:

  - Ozone depletion;
  - And/or global warming, by exerting an additional greenhouse effect.

A loss of refrigerant may also induce a loss in efficiency, particularly in critically-charged systems.

- **Indirect emissions** (or energy-related emissions) of these installations that contribute to CO2 emissions and reduce global energy resources.[2]

According to a research paper published by the Birmingham University's Energy Institute in March 2018, the direct emissions are estimated to grow from 7% of CO_2 total emissions today to 13% by 2030. However, reduction in refrigerant emissions needs to go hand in hand with reducing energy-related emissions by adopting technologies that are energy efficient.

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1 International Institute of Refrigeration (2015), Guideline for life cycle climate performance. Available at: http://www.iifiir.org/userfiles/file/about_iir/working_parties/WP_LCCP/07/LCCP-WP_Booklet-LCCP-Guideline-V7_2015-08.pdf

2 Other indirect impacts include pollutants (SO2, nitrous oxide...), emissions related to component production and waste products associated with the destruction of refrigerants, oils and the equipment itself.

1.1. WHY TARGET HYDROFLUOROCARBONS?

Fluorinated greenhouse gases (f-gases) are powerful greenhouse gases.

Fluorinated greenhouse gases (f-gases) are powerful greenhouse gases – up to 15,000 times more powerful than CO_2 (based on a 100-year timescale measurement). HFCs are the most common f-gases, often used in refrigeration and air-conditioning equipment. Leakage of these gases during manufacturing, maintenance, regular usage, as well as during improper disposal and reclamation, results in emissions.

The phase-out of ozone-depleting substances (ODS) such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) under the Montreal Protocol propelled the adoption of HFCs as main replacements. In addition, the growth of the refrigeration and air-conditioning sector[3], especially in the food retail, building and vehicle air-conditioning sectors, has also been identified as one of the main drivers for the overall growth of HFC emissions[4].

3 Milnes J. (2014), Global refrigeration market to grow by $38bn in 2018. Available at: https://www.racplus.com/news/global-refrigeration-market-to-grow-by-38bn-in-2018/8672226.article

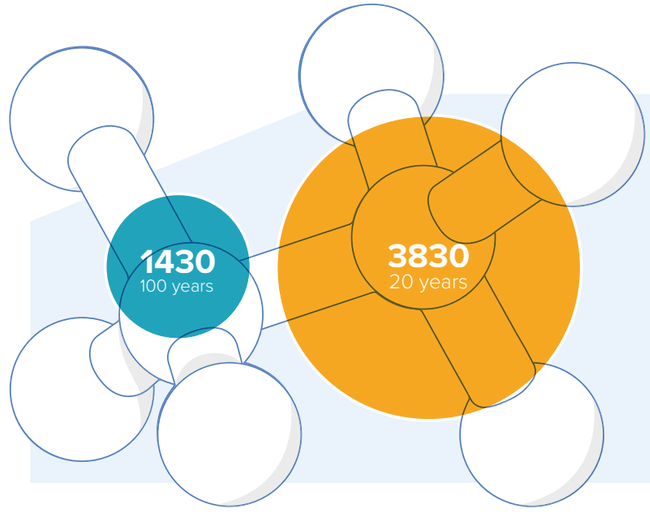
4 Gschrey B., Schwarz W. (2011), Global projection of F-gas emissions shows high increase until 2050. Available at: https://www.umweltbundesamt.de/sites/default/files/medien/publikation/short/k3866.pdf

1. IMPACT OF COOLING ON CLIMATE
1.1. WHY TARGET HYDROFLUOROCARBONS?

HFCs have become the fastest-growing source of greenhouse gas emissions worldwide[5]. In the US, HFC emissions have increased by 249% between 1990 and 2016[6]. In the European Union, the share of HFCs in total fluorinated greenhouse gas emissions rose from 41% in 1990 to 91% in 2015[7]. The drop in HFC emissions observed from 2015 in Europe is the result of EU-wide policies and measures, and complementary Member States actions.

HFCs have become the fastest-growing source of greenhouse gas emissions worldwide.

HFCs, while not ozone-depleting, do have a very high negative impact on the climate. Their global warming potential (GWP) is usually measured over a period of 100 years with reference to CO_2. Nevertheless, considering the relative short lifetime of HFCs in the atmosphere, a shorter horizon, such as 20 years, would even better reflect the effects of these gases on the climate[8]. For instance, HFC-134a, one of the most widely used f-gases in refrigeration, air-conditioning and heating, has an atmospheric lifetime of approximately 14-16 years. Its GWP over 100 years is 1,430 while the GWP over 20 years, which is much closer to its actual existence in the atmosphere, is 3,830[9].



GWP of HFC-134a
(lifetime 14-16 years)

5 European Commission (2016), EU hails global HFC phase-down as a major concrete step in delivering the Paris Agreement. Available at: https://ec.europa.eu/clima/news/articles/news_2016101401_en

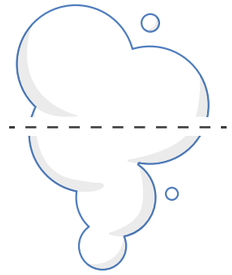
6 United States Environmental Protection Agency, Overview of greenhouse gases – Emissions of fluorinated gases. Available at: https://www.epa.gov/ghgemissions/overview-greenhouse-gases

7 European Environment Agency (2018), Emissions and supply of fluorinated greenhouse gases. Available at: https://www.eea.europa.eu/data-and-maps/indicators/emissions-and-consumption-of-fluorinated-2/assessment

8 Larkin A., Davies K. (2009), HFCs and other F-gases: the worst greenhouse gases you've never heard of. Available at: https://www.greenpeace.org/usa/wp-content/uploads/legacy/Global/usa/binaries/2009/4/hfc-fact-sheet.pdf

9 Larkin A., Davies K. (2009), HFCs and other F-gases: the worst greenhouse gases you've never heard of. Available at: https://www.greenpeace.org/usa/wp-content/uploads/legacy/Global/usa/binaries/2009/4/hfc-fact-sheet.pdf

1.2. INTERNATIONAL ACTION TO CUT HFC EMISSIONS



The Paris Agreement reached among nearly 200 countries at the 21st Conference of the Parties (COP21) to the UNFCCC aims to keep the global temperature rise below two degrees Celsius, while pursuing efforts to limit it to 1.5°C (compared to pre-industrial levels).

The Paris Agreement reached among nearly 200 countries at the 21st Conference of the Parties to the UNFCCC aims to keep the global temperature rise below two degrees Celsius.

In October 2016, the world's nations adopted the Kigali Amendment to the Montreal Protocol, a historic accord committing economies worldwide to significantly reduce consumption and production of HFCs. The reduction of HFCs globally has been identified as one of the most important actions that can contribute to avoiding 0.5°C warming by 2100[10].

HFCs are often identified as 'low-hanging fruit' in the climate challenge given that alternatives to replace these high global warming gases are readily available for a growing number of applications and regions. In addition, HFC-free technology alternatives are often more energy efficient than the systems they replace[11], which provides additional CO_2 and air quality benefits by reducing energy consumption.

Legislators in different parts of the world are taking individual and collective action to reduce the emissions of HFCs, which will only intensify as the Kigali Amendment enters into force as of 2019. The European F-Gas Regulation, which entered into force in 2015, is recognised as the most ambitious legislation to regulating HFCs to date. While aiming to limit the consumption of HFCs by 79% by 2030 (in CO_2 equivalent) in the EU countries it also has a global impact, as a large number of companies using and manufacturing cooling, heating and refrigeration equipment operate internationally. Besides that, the EU-wide legislation serves as an inspiration to other governments looking to introduce legal measures to cut HFC emissions.

The EU HFC phase-down essentially means that the average GWP of HFCs will have to fall from 2,000 in 2014 to about 400 by 2030 across all sectors. The impact might be even more severe if the adoption of refrigeration and air-conditioning equipment grows. The Regulation has also been having a pronounced impact on prices[12]. Latest data shared by the European Commission shows the average selling price of HFC-404A for service companies (i.e. the price paid by end-users, including CGF members) increased by more than 300% from 2014 to the second quarter of 2018.

10 UN Environment (2017), The emissions gap report 2017. Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/22070/EGR_2017.pdf

11 Gkizelis A. (2018), Report: better efficiency achieved with HFC-free supermarket systems. Available at: http://hydrocarbons21.com/articles/8691/report_better_efficiency_achieved_with_hfc_free_supermarket_systems

12 Tranholm-Schwarz B. (2018), F-gas policies - latest developments, ATMO.org. Available at: http://www.atmo.org/media.presentation.php?id=1476

1. IMPACT OF COOLING ON CLIMATE
1.2. INTERNATIONAL ACTION TO CUT HFC EMISSIONS

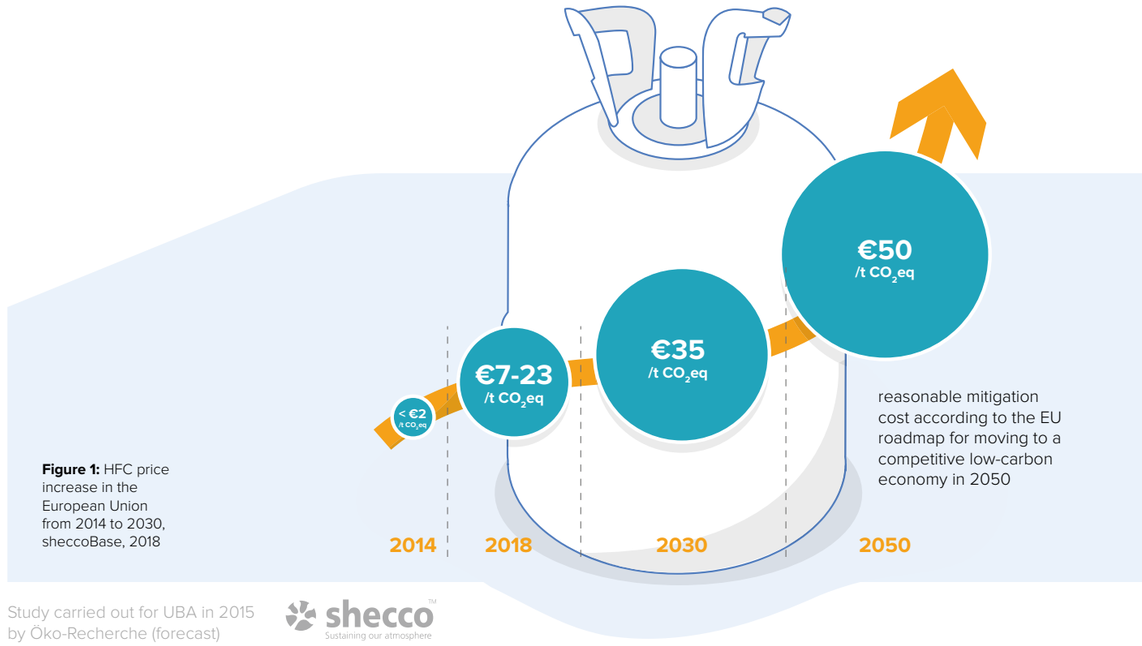


Figure 1: HFC price increase in the European Union from 2014 to 2030, sheccoBase, 2018

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

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California is another region where legislators are working on introducing strict limits on HFC use, and may outstrip the ambition of the EU F-Gas Regulation especially in terms of bans on high-GWP HFCs in new equipment. With the objective to reduce HFC emissions by 40% by 2030, policy-makers are in the process of designing legislation that would include prohibitions on new equipment using HFCs with GWP over 150 in non-residential refrigeration as of 2021, among other measures.

A growing number of U.S. states are joining efforts to reduce emissions of HFCs with concrete commitments.

The state of California is the leader when it comes to environmental legislation in North America. For the past fifty years the California Air Resources Board (CARB) has helped put California among the first US states to adopt clean air regulations for many different polluting sectors, and experience shows that the state's environmental legislation is eventually adopted nationally for the entire US. Already now a growing number of US states are joining efforts to reduce emissions of HFCs with concrete commitments. "[The] international community and business leaders have recognised HFC pollution as a serious threat and the transition to climate-safe alternatives as an economic opportunity," said Jay Inslee, Governor of Washington in his announcement of a climate action plan in December 2018, which earmarked close to $1 million to phase-down HFCs.

WHY TRANSITION TO HFC-FREE REFRIGERANTS?

2.1. HFC-FREE ALTERNATIVES

Existing lower GWP refrigerants include natural refrigerants - hydrocarbons, such as propane (HC-290), and isobutane (HC-600a), carbon dioxide (R744), ammonia (R717), air and water.

Synthetic lower GWP HFCs such as HFC-3_2 (R32), hydrofluoroolefins (HFOs) and blends are also considered as alternatives to high GWP HFCs especially in existing installations. However, the Norwegian Environment Agency[13] and non-governmental association Greenpeace[14] have been raising concerns over the necessity for further research regarding the sustainability of HFOs, conducted by independent bodies.

Natural refrigerants are therefore often considered as a future-proof solution, with well-identified thermodynamics and properties as they were used as refrigerants prior to the 1950s - before fluorocarbon refrigerants became commonplace.

The precision of the term 'natural refrigerants' is sometimes debated, given that, to be used as refrigerants, ammonia, carbon dioxide, and hydrocarbons also undergo an industrial purification and manufacturing process. However, there is today a well-established distinction between substances whose chemical properties and safety aspects have been studied in their entirety and those fluorinated gases. Given their chemical complexity and comparatively short period of usage, fluorinated gases have confirmed and/or unknown negative effects on ozone depletion, global warming and ecological safety, and therefore, are subject to continued debate.

Natural refrigerants are often considered as a future-proof solution, with well-identified thermodynamics.

13 Norwegian Environment Agency (2017), Study on environmental and health effects of HFO refrigerants (Publication number: M-917 2017). Available at: http://www.miljodirektoratet.no/Documents/publikasjoner/M917/M917.pdf

14 Greenpeace (2012), HFOs: the new generation of F-gases, Greenpeace position paper. Available at: http://ozonecenter.kg/wp-content/uploads/2014/05/HFOs-the-new-generation-of-F-gases.pdf

2. WHY TRANSITION TO HFC-FREE REFRIGERANTS? 2.1. HFC-FREE ALTERNATIVES

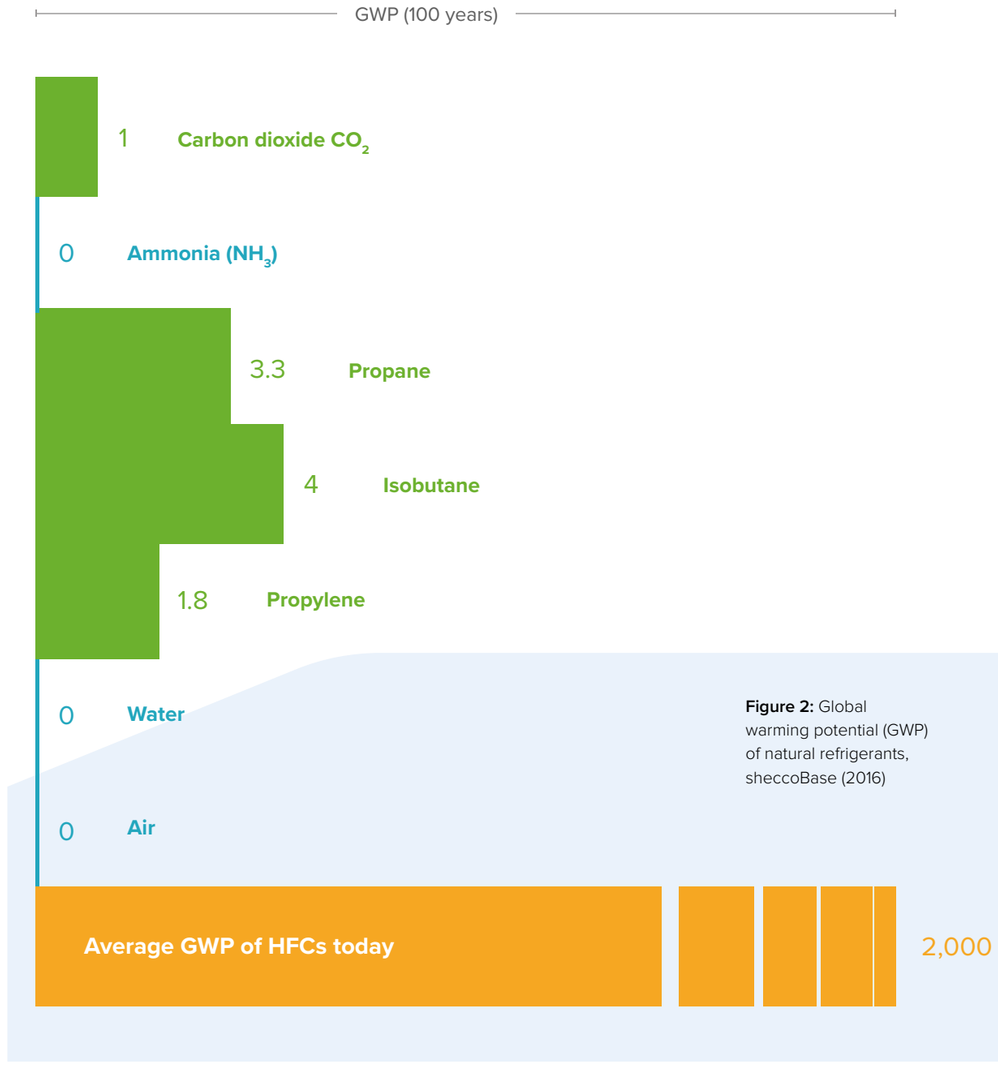


Figure 2: Global warming potential (GWP) of natural refrigerants, sheccoBase (2016)

2.2. KEY BENEFITS OF HFC-FREE ALTERNATIVES

Energy-efficient HFC-free technologies offer several benefits to retailers, consumer brands and other users of cooling equipment, including:

a. Regulatory compliance: The use of HFC alternatives such as natural refrigerants allows end-users to future-proof their operations, as they are not subject to phase-down legislative requirements.

b. Energy efficiency: Evidence[15] shows that there are HFC-free energy efficient solutions for any type of application and store format, guaranteeing reliable operation, lower operation costs, and proofing against future regulatory measures. Innovations such as parallel compression, ejectors, waterloop systems, optimised heat exchangers and others have made it possible to use energy efficient HFC-free systems in any climatic condition. The possibility to integrate heating and air-conditioning with the refrigeration system and harness the free rejected energy further increases the overall efficiency of stores.

c. Return on investment: The upfront cost of equipment using natural refrigerants (ammonia, CO_2, hydrocarbons, water and air) is often higher in certain sectors, where these refrigerants are not yet the standard technology. Nevertheless, as a result of better energy performance and lower maintenance costs end-users are able to offset the higher initial cost in a shorter period of time.

d. Environmental leadership and compliance with corporate social responsibility commitments: Natural refrigerants have the lowest possible global warming potential and no ozone depleting potential, having no or a negligible climate impact.

15 Zolcer Skačanová K., Gkizelis A. (2018), Technical report on energy efficiency in HFC-free supermarket refrigeration. Available at: https://issuu.com/shecco/docs/2018_kcep_shecco_eia_technical_repo

2. WHY TRANSITION TO HFC-FREE REFRIGERANTS? **2.2.** KEY BENEFITS OF HFC-FREE ALTERNATIVES

a. Regulatory compliance

Natural refrigerants are not subject to any legislative and/or regulatory requirements under the global HFC phase-down, including the Kigali Amendment to the Montreal Protocol and the EU F-Gas Regulation. The restrictions on fluorinated refrigerants have become stricter across the world.

Prices of natural refrigerants are not subject to inflation due to financial mechanisms such as HFC taxes in some countries or phase-down quotas. The use of natural refrigerants will become more attractive as HFC prices rise.

In addition, due to a lack of thorough independent research, it is not yet clear how the increased use of HFOs, such as HFO-1234yf in car air-conditioning and stationary refrigeration, will impact the environment due to an accumulation of trifluoroacetic acid (TFA). Several governments around the world have started to warn against potential toxicity hazards and advice to apply the precautionary principle.[16]

End-user viewpoint

"The reality is that there're always going to be constraints, changes of government, and there probably will be a reintroduction of a carbon tax at some point. The only way to try and counter-attack that is to be proactive and do what we've done. That's why we've gone down the path of natural refrigerants.

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

Petar Lujic, CEO, Kamen Group & owner, IGA Market Central

"At Carrefour, we would like to go straight to a final solution. By using CO_2 or other natural refrigerants, we are also avoiding [the risk] that in two or three years' time, there may be another update of the F-Gas Regulation, limiting other gases and decreasing the GWP even more."

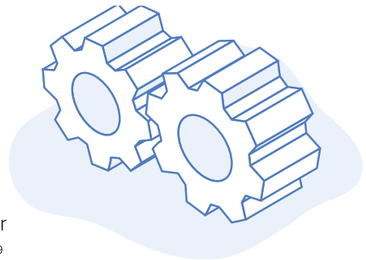
Paolo Martini, refrigeration & HVAC manager for international support, Carrefour Group

"For us, natural refrigerants are the default option. There is nothing else. If you build any other type of store now, you're building a liability."

Alex Kuzma, Woolworths

16 McLaughlin, C. (2018), Germany warns R1234yf could cause harm to drinking water, R744.com. Available at: http://r744.com/articles/8395/germany_warns_r1234yf_could_cause_harm_to_drinking_water

b. Energy efficiency



Energy efficiency has been identified as the single largest action that can be taken to limit warming to less than 2°C, representing about 40% of the additional GHG reduction potential that can be realized across the globe by 2040[17]. Refrigeration systems account for 30-60% of the total energy use in supermarkets (depending on conditions, including climate and social habits), making them the highest electricity-consuming systems in a store[18].

While natural refrigerants significantly reduce direct emissions, they can also be very energy efficient, thereby simultaneously reducing indirect emissions. For example, CO_2 condensing units typically applied in small store formats have been reported to reach up to 27% higher energy efficiency compared to their HFC counterparts, whereas HC-290 plug-in refrigeration units have been reported to deliver up to 30% higher energy efficiency.[19]

Direct systems with CO_2 are currently popular solutions for centralised commercial refrigeration with around 20,000 stores using this technology globally. The technology has evolved to overcome technical challenges and to increase the efficiency of the systems for different climatic conditions and store requirements. There are further opportunities to improve efficiency through heat recovery to meet the store's hot water and space heating needs, and integration of air-conditioning.

End-user viewpoint

"In supermarket refrigeration, it's important to have efficient and reliable refrigeration production. In our experience, CO_2 covers those two aspects very well."

Urs Berger, head of energy and building technology department at Migros Engineering Solutions

"We're always on the lookout for solutions that will allow us to operate our display cabinets and refrigeration systems more efficiently, reduce greenhouse gas emissions by using the right refrigerant and minimise our impact on the environment.

We've dedicated ourselves to operating with a focus on the future. Even if that means we have to invest more for a certain period of time. However, energy savings ultimately serve as proof of a short amortisation period and high investment security."

Jens Strassburg, director – store operations management at ALDI Süd

17 International Energy Agency (IEA) (2018), Energy Efficiency 2018 – Analysis and outlooks to 2040, Available at: https://www.iea.org/efficiency2018/

18 Minetto S., Marinetti S., Saglia P., Masson N., Rossetti A. (2017). Non-technological barriers to the diffusion of energy-efficient HVAC&R solutions in the food retail sector. International Journal of Refrigeration 86 (2018) 422-434.

19 Zolcer Skačanová K., Gkizelis A. (2018), Technical report on energy efficiency in HFC-free supermarket refrigeration. Available at: https://issuu.com/shecco/docs/2018_kcep_shecco_eia_technical_repo

c. Return on investment (ROI)

Determining ROI on commercial refrigeration systems requires considering variables such as the cost of refrigerant, energy equipment, installation, maintenance and regulation. Understanding ROI allows a grocer to make strategic, forward-thinking decisions that not only meet today's challenges but also help future-proof the business.

In Europe - where natural refrigerants-based technology has become standard in new supermarkets, giving better perspective to analyse trends - signs of falling prices are particularly registered. Industry representatives confirm that prices of compressor racks went down dramatically because of a steady increase of supply and demand; the cost of CO_2 compressors is now lower than cost of equivalent HFC compressors. Depending on the market and technology, the total installation price of a CO_2 transcritical system is currently 0% or 5-10% higher compared to conventional systems.

In addition, case studies[20] show that grocers can expect savings of 12-18% on CO_2 refrigeration installation costs.

It is also interesting to take note of the relationship between increasing energy efficiency as a result of technology advancements and dropping cost of equipment, which is due to increasing demand and production volume. One manufacturer told shecco in an exclusive interview that the efficiency of its CO_2-based refrigeration equipment increased by more than 35% between 2008 and 2018, while the cost of equipment has fallen by 40% in the same period.

End-user viewpoint

"I think [prices falling as more equipment becomes available] is a trend, and that we'll get even better prices in the future."

Paolo Martini, refrigeration & HVAC manager for international support at Carrefour Group

"Adopting systems based on natural refrigerants is in fact guided by budget and strategic decisions, rather than solely related to energy efficiency."

Olaf Schulze, director of energy management, METRO AG.

"The investment and maintenance costs of transcritical CO_2 refrigeration systems can be compared to those of f-gas refrigeration systems. However, the costs for the CO_2 refrigerant are relatively low."

Kirsten Geß, communications director at Aldi Süd

20 Zolcer Skačanová K., Gkizelis A. (2018), Technical report on energy efficiency in HFC-free supermarket refrigeration. Available at: https://issuu.com/shecco/docs/2018_kcep_shecco_eia_technical_repo

d. Environmental sustainability and compliance with corporate social responsibility commitments

Natural refrigerants are often seen as the low-hanging fruit of climate change mitigation[21], as they are already commercially available, do not deplete the ozone layer and make a negligible – or zero in the case of ammonia, water and air – contribution to global warming.

As refrigeration accounts for up to 60% in total energy use of supermarkets[22], investing in energy efficient, natural refrigerants-based technology has a significant impact on the food retail cold chain's environmental footprint and corporate social responsibility targets.

End-user viewpoint

"At Ahold Delhaize, we are a food retailer, and we aim to become a sustainable food retailer. This element is key in our technical approach, which integrates not only refrigerants but also heat recovery, energy efficiency and renewable energy. With our larger supermarkets - from 2,000 m^2 - we already opted by default for natural refrigerants and prioritise integrated installations, which recover the reclaimed heat from the refrigeration installations for heating and hot sanitary water.

Now our next challenge are our smaller convenience stores run by our affiliates: we introduced natural refrigerant-based solutions adapted to small stores. In city centre locations these compact installations require less m^2 of the precious surface.

We feel responsible to show our affiliates that there are solutions, and we aim to remove the negative clichés or arguments around the use of natural solutions for these smaller formats.

We have already equipped two small stores with CO_2 racks in Brussels, and recently we installed a fully-equipped supermarket with doors on each cabinet. We are now eager to see the results, in terms of energy efficiency, and the reaction of our customers and employees. Every day the awareness regarding the dangers of climate change is rising, and we in the food retail sector have an important role to play."

David Schalenbourg, director building projects, format & maintenance at Ahold Delhaize Group

"Environmental responsibility is a key driver in opting for natural refrigerants-based technologies. We are a world leader in the agribusiness, so we obviously have a big responsibility towards the environment and social communities. Our action with natural refrigerants is highlighted in our annual corporate social and environmental report 'Creating Shared value'."

Vincent Grass, head of refrigeration, corporate operations – engineering services, Nestlé Group.

21 Boccabella E. (2016), Kigali: what's in for natural refrigerants?. Available at: http://www.shecco.com/articles/2016-12-14-kigali-whats-in-it-for-natural-refrigerants/

22 H. Klemick, E. Kopits, A. Wolverton (2015), U.S. Environmental Protection Agency, The Energy Efficiency Paradox: A Case Study of Supermarket Refrigeration System Investment Decisions. Available at: https://www.epa.gov/sites/production/files/2016-03/documents/2015-03.pdf

2.3. BARRIERS TO ADOPT HFC-FREE TECHNOLOGY

Several barriers are slowing down or restricting the wider uptake of natural refrigerants-based technology. The barriers vary depending on the region, level of availability of natural refrigerants, climatic conditions and other criteria. The most important barriers cited by a large number of technology end-users include:

a. The initial cost of HFC-free equipment;

b. Lack of trained technicians to install and maintain the systems;

c. The challenge of warm climates to use this type of technology while ensuring energy efficiency.

However, as natural refrigerant solutions are becoming a more commonplace in certain regions and sectors the barriers become less important as industry finds ways to overcome them. Forward-thinking end-users who chose to invest in this technology to future-proof their operations remain confident it is possible to work and benefit from HFC-free solutions.

a. Initial cost

The upfront cost of equipment using natural refrigerants is often higher in certain sectors, where these refrigerants are not yet the standard technology[23]. However, the overall lifecycle cost is lower than conventional technology that relies on f-gases, thanks to improved performance, lower maintenance costs and other factors[24].

In addition, with growing production capacities[25], the cost of equipment decreases as more suppliers enter the market and components become more and more available. This is a basic economic principle that would apply to any other sector and HVAC&R is not an exception in this respect.

From the end-user perspective, especially for small and medium-sized businesses and individuals, the 'price tag' is often the decisive factor when purchasing new equipment. It is therefore an important aspect that can determine the success of a technology[26].

In sectors where natural refrigerants are a standard technology, the cost of equipment is comparable to systems using HFCs[27].

The cost of equipment decreases as more suppliers enter the market and the availability of components increases.

23 Dr. Colbourne D. (2008), Opportunities for the application of natural refrigerants. Available at: https://www.giz.de/fachexpertise/downloads/giz2008-en-natural-refrigerants.pdf

24 Eurammon (2017), Press release: Far ahead in the field of life cycle costs. Available at: http://www.eurammon.com/sites/default/files/attachments/170315_eurammon_interview_life_cycle_costs_en.pdf

25 Skačanová K. (2016), Natural refrigerants – latest trends in Europe & the world. Available at: https://www.lne.be/sites/default/files/atoms/files/10-2016-07-07-studiedag-lne-ppt-shecco-trends-inzake-natuurlijke-koelmiddelen.pdf

26 Masson N. et al. (2014), Guide 2014: natural refrigerants continued growth & innovation in Europe. Available at: http://www.zero-c.com/wp-content/uploads/2014/01/The-guide-2014-Natural-Refrigerants-Market-Growth-for-Europe.pdf

27 Skačanová K. (2016), F-Gas Regulation shaking up the HVAC&R industry. Available at: https://issuu.com/shecco/docs/f-gas_impact_shecco_october2016/47

2. WHY TRANSITION TO HFC-FREE REFRIGERANTS? **2.3.** BARRIERS TO ADOPT HFC-FREE TECHNOLOGY

End-user viewpoint

"While the initial cost of natural refrigerants-based technology is sometimes higher, there is a whole 'cost avoidance' part that drove our decision to adopt this type of technology. It is not necessarily measurable, but we believe the use of natural refrigerants will future-proof our operations for the next 20-25 years. We ensure that we won't have to remobilise teams, launch a new project, and reinvest into a new solution again. If we take the example of Europe, if we had gone from R22 to HFC-404A during the HCFC phase-down, it would have cost us a lot more than what natural refrigerants-based equipment cost us."

Vincent Grass, head of refrigeration, corporate operations – engineering services, Nestlé Group.

"There is definitely progress in removing the barriers to natural refrigeration. We see a reduction in the cost of CO_2 components, increased competition and parts availability and a better understanding of the technology with improved skills levels of our contractors. This together with the advances in energy-saving technologies and spiralling HFC costs is reducing the life cycle costing of these installations dramatically."

Alex Kuzma, head of engineering services, Woolworths

b. Lack of trained technicians

The lack of trained technicians is often identified as a key hurdle for wider uptake of natural refrigerant-based technology in the food retail sector. However, the demand and supply of proper training on natural refrigerants is steadily rising[28], due to an increasing market share of natural refrigerant-based technology worldwide, and the growing complexity of components and new system solutions, including electronic modulating ejectors, integrated frequency inverters, electronic components or compressors.

More and more companies are now also providing training to close this gap, including training institutes, system and component manufacturers, universities, research institutes, associations and other organisations, who offer training related to natural refrigerants.

Governments are also taking the lead, as part of their strategy to accelerate the uptake of alternatives to hydrofluorocarbons. For instance, Colombia, with the support of the German Corporation for International Cooperation GmbH (GIZ) – a German development agency providing services in the field of international development cooperation – is currently implementing a natural refrigerants training centre for the safe use of ammonia, CO_2 and hydrocarbons for small and medium-sized commercial refrigeration equipment," said Juliana Arciniegas, coordinator for environmental affairs at the Ministry of Foreign Affairs of the Republic of Colombia in an exclusive interview with shecco.

Companies provide training to close this gap, including training institutes, system and component manufacturers, universities, research institutes, associations and other organisations.

28 Skačanová K. (2017), Guide to natural refrigerants training in Europe 2017. Available at: https://issuu.com/shecco/docs/guidetrainingeurope2017/131

End-user viewpoint

"Regarding the installation of natural refrigerants-based equipment, we can work everywhere in the world - there is no barrier. On the other hand, we see a lack of trained technicians on the maintenance side. We need companies focusing on the maintenance of this type of equipment. In addition, we need more versatile technicians who understand the HVAC&R issues of the store as a whole. Sometimes, the best adjustments for the refrigeration system do not fit with the HVAC needs of the store. Companies that can incorporate these two elements will be key to move forward and help accelerate the uptake of natural refrigerants-based technology."

David Schalenbourg, director building projects, format & maintenance at Ahold Delhaize Group.

"With the increased training offer in refrigeration, both from the industry, but also from public organisations, we now have a good number of options for training our technicians."

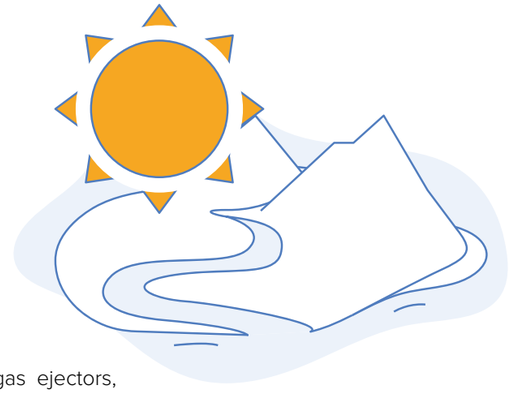
Paolo Martini, refrigeration & HVAC manager for international support, Carrefour Group.

"If end-users do not create the demand, this type of system will not evolve, because the manufacturers respond to a certain demand and develop their R&D according to market trends. The more we see end-users asking for this type of technology, the more important the developments will be. Each end-user has its responsibility to show its leadership and offer an opportunity for these technologies to be spread globally.

Yes, there are barriers, but that's not necessarily the reason why we have to give up. We should see how we can find solutions. It certainly requires more effort than taking the locally available solution on the market. For instance, we installed a propane-based chiller in Papua New Guinea in our factory. It was challenging to find trained technicians, but the project was supported by our team in Australia, which works with their local manufacturer and distributor. At least at a relatively short distance, we have an Australian distributor who does the second level service, and all the monitoring part is ensured by our own teams locally, in the plant."

Vincent Grass, head of refrigeration, corporate operations – engineering services, Nestlé Group.

c. Availability of energy-efficient solutions for warm climates



Natural refrigerants represent a "basket of solutions" with different characteristics that can cover a wide range of temperature needs for different types of applications. There is no single alternative that will replace f-gases in all applications and in all regions, just as there is no single f-gas that can be used in all applications.

The concern regarding energy efficiency of f-gas alternatives in warmer climates mainly relates to CO_2 transcritical technology. This is due to the low critical point of CO_2 (above critical temperature of 31 °C and critical pressure of 74bar) beyond which the liquid and gas phases cannot exist as separate phases (transcritical cycle) resulting in lower cooling capacity and higher energy consumption.

Nevertheless with innovations such as parallel compressors, ejectors, mechanical sub-cooling, and adiabatic/evaporative coolers, CO_2 transcritical technology is now suitable for climates up to 45°C[29].

Adding an adiabatic gas cooler to a CO_2 transcritical system in warmer climates offers additional annual energy savings of 8-12%. Parallel compression delivers 6-8 per cent savings, and in combination with gas ejectors, savings can reach 8-10% compared to a transcritical system not using these enhancements.[30] Some experts in the field believe that ejector technology is the solution to remove the CO_2 equator – a geographical line below which CO_2 systems were believed to be less energy efficient than their HFC counterparts. CO_2 systems using ejectors have been reported to offer up to 40% energy savings compared to HFC systems without ejectors.[31] With parallel compression and ejectors the CO_2 transcritical technology is suitable for warmer climates up to 45°C.

Although the advanced CO_2 technology is now more expensive than HFC-based systems in terms of initial cost, this is expected to go down as technology becomes more widespread (as has been proven for the standard CO_2 booster system[32]). Industry experts estimate that with ejector technology and parallel compression, the price of a system is a maximum 10% higher.

29 Danfoss (2016), Making the case for CO_2 refrigeration in warm climate. Available at: https://www.danfoss.com/en/service-and-support/case-studies/dcs/making-the-case-for-co2-refrigeration-in-warm-climates/

30 Schönenberger, J., Hafner, A., Banasiak, K., Girotto, S., (2014). Experience with ejectors implemented in a R744 booster system operating in a supermarket. Presented at the 11th IIR Gustav Lorentzen Conference on Natural refrigerants, IIR/IIF, Hangzhou, China.

31 EIA/shecco, (2018). Technical report on energy efficiency in HFC-free supermarket refrigeration. Available at: https://eia-international.org/report/energy-efficiency-in-hfc-free-supermarket-refrigeration/

32 Pisano, G. (2017). The use of ejectors in CO_2 technology: How to boost efficiency in warm climates – A real example from Italy. ATMOsphere America 2017. Available at: http://www.atmo.org/ presentations/ les/59374b8ce86691496796044rIFS2.pdf

Hydrocarbon-based waterloop technology is also a promising solution, especially for small and medium-sized stores as well as warmer climates. According to a leading technology manufacturer, around 16% better energy performance can be achieved with this technology compared to similar HFC models[33].

End-user viewpoint:

"The difference in climate can be mitigated by the ejector which provides the necessary efficiency boost of the CO_2 technology (in cold as well as in warm climates). In the cold climate, more heat is needed for heating [through heat reclaim], which is comparable with cooling at high ambient temperatures."

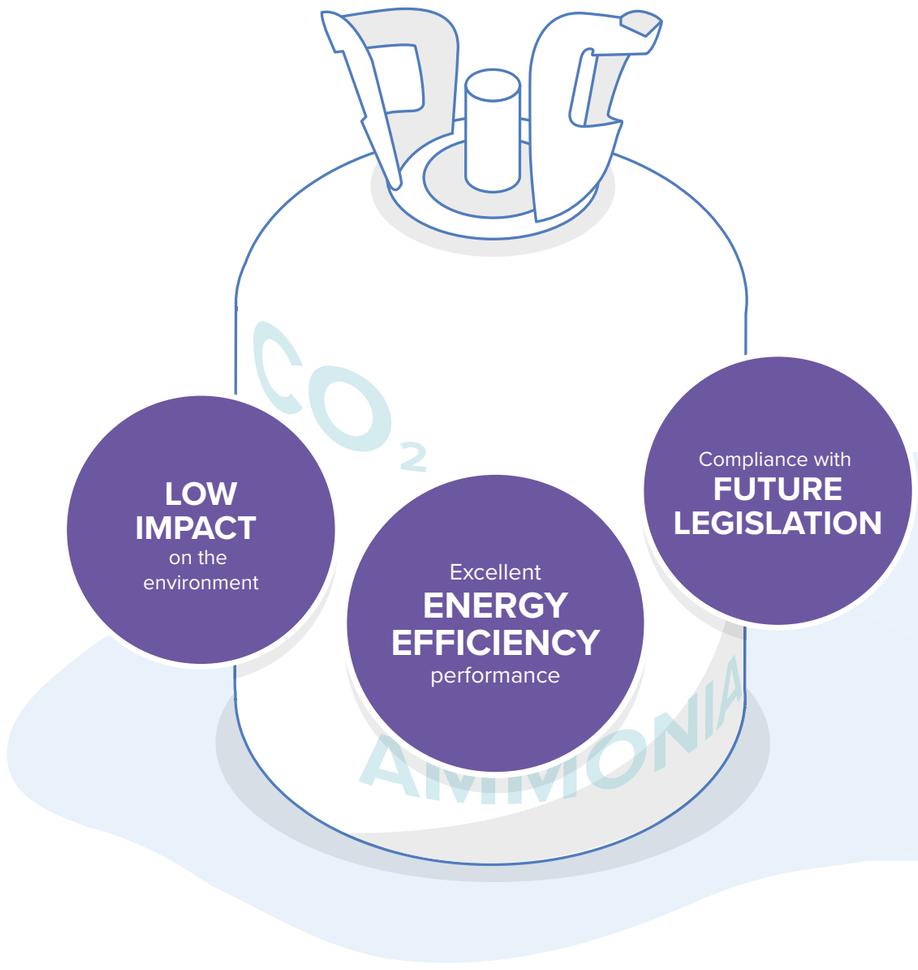
David Guthörl, head of the 'Energy/CO_2 Sustainability Unit', Coop

"We solved the performance challenges in high ambient temperatures by integrating several elements into the installations. We installed parallel compression, sub-coolers and ejectors to improve performance when the ambient temperature is high."

Ivan Díaz, refrigeration & HVAC manager, Carrefour Spain

33 Zolcer Skačanová K., Gkizelis A. (2018), Technical report on energy efficiency in HFC-free supermarket refrigeration. Available at: https://issuu.com/shecco/docs/2018_kcep_shecco_eia_technical_repo

MARKET TRENDS FOR HFC-FREE REFRIGERATION TECHNOLOGIES



3. MARKET TRENDS FOR HFC-FREE
REFRIGERATION TECHNOLOGIES

CO_2, ammonia and hydrocarbons have been used in several HVAC&R applications for many years. However, with the exception of a few sectors, their penetration in the market has been relatively low. The changing legislative landscape for fluorinated refrigerants, proactivity of influential end-users and decreasing costs of technologies are underpinning the market uptake for natural refrigerants in various sectors globally.

With their low impact on the environment, excellent energy efficiency performance and compliance with future legislation, natural refrigerants are quickly becoming the preferred option for a growing number of end-users. As the adoption of HFC-free technologies increases, the competition between different natural refrigerant-based systems grows too.

3.1. COMMERCIAL REFRIGERATION

In refrigeration, commercial refrigeration is the sub-sector contributing the most to direct and indirect emissions. The United Nations Environment Programme (UNEP) points out commercial refrigeration is the main refrigeration sector for HFC use, comprising 73% of the total.

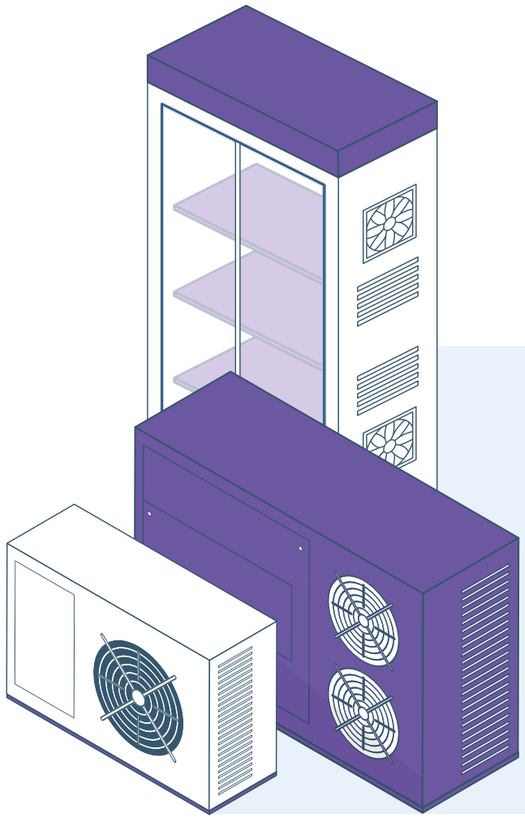
Commercial refrigeration is typically used in supermarkets, convenience stores and other applications, such as petrol stations and hotels. Technology can be divided into three main categories:

- **Centralised systems:** These consist of a central refrigeration unit located in a machine room, which is either directly connected to the evaporators in the display cases and to the condensers by long pipes containing the refrigerant (direct, DX system), or it cools a secondary fluid that circulates between the evaporator in the machine room and the display cases in the sales area (indirect system).

- **Condensing units:** Typically located outside of the sales area, condensing units are composed of one (or two) compressor(s), one condenser, and one receiver. Condensing units are connected to one or more display cases in the sales area.

- **Plug-in units:** Self-contained plug-in display cases typically used in small and medium-sized supermarkets include multidecks, vertical and semi-vertical freezers and coolers, islands, counters and more.

Commercial refrigeration is the sub-sector contributing the most to direct and indirect emissions.



CO_2 transcritical technology: a key trend in the food retail sector

Globally, HCFC-22 and HFC-404A continue to represent the largest refrigerant bank within commercial refrigeration and is used at all temperature levels. Traditionally, commercial refrigeration equipment is prone to significant refrigerant leaks. Although there has been a lot of progress in terms of refrigerant management with a view to control and reduce the leaks, much more effort is needed. Switching to refrigerants with very low GWP is the most effective way to reduce the impact of refrigerants on the retailer's footprint.

Commercial refrigeration is indeed the sector that has seen the most dynamic technology developments with low climate impact. This trend has been apparent across various regions, but at a different pace. CO_2 has become one of the most interesting technologies for new systems and refurbishments for a number of major retailers who are leading this trend.

sheccoBase, the market intelligence arm of shecco, estimates there are at least 20,000 stores globally using CO_2 transcritical technology. The majority of these, around 16,000, are located in Europe, where they represent about 14% of the food retail market (food retail stores in the EU, Norway and Switzerland bigger than 400m^2). Following the adoption of the EU F-Gas Regulation in 2014, the market for CO_2 has seen annual growth rates of 25-40%. The biggest momentum for natural refrigerants in this sector in Europe is expected within the 2020-2022 timeframe.

Accelerated by a subsidy scheme run by the Japanese Ministry of the Environment, Japan is the second largest market for CO_2-based stores globally, boasting more than 3,530 stores by October 2018. In contrast to other regions, the technology in Japan has been adopted predominately in convenience stores, using condensing units. Canada and the United States are following the global trend with the number of CO_2-based stores currently at 245+ and 370+ respectively. The growth of CO_2-based stores in South Africa, currently at 110+, has been mostly driven by end-user demand. CO_2 technology has been adopted in other challenging environments, including in warm climates, such as in Jordan, Malaysia, Indonesia, Chile, Ecuador, Mexico and others.

CO_2 transcritical stores in the world

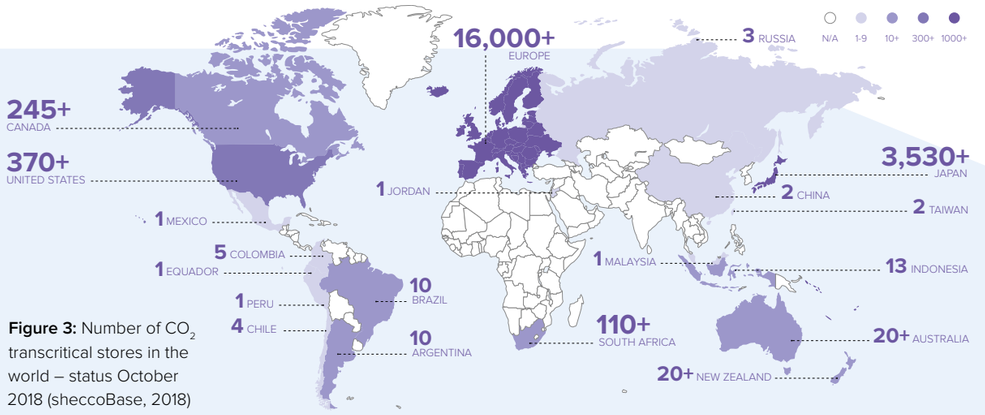


Figure 3: Number of CO_2 transcritical stores in the world – status October 2018 (sheccoBase, 2018)

Although the market is still insignificant in China, it is expected to grow soon with international supermarket chains, such as Carrefour and METRO AG, looking to increase penetration of CO_2 technologies in the country. The first CO_2 TC system in China was installed at a METRO Beijing Lishuiqiao store in 2018.

While CO_2 is gaining grounds in new centralised installations and major retrofits that require changing the refrigeration equipment, many store owners are choosing to retrofit their existing equipment with hydrofuoroolefin (HFO) blends. These have usually comparable energy performance as high GWP HFCs, but reduce the impact of direct refrigerant emissions on the overall footprint. Rather than simply dropping in the lower GWP refrigerants, equipment needs to be modified and optimised after the refrigerant retrofit before it can be safely used. In addition, certain HFO blends have been developed to replace certain HFC refrigerants. For example, HFC-448A (GWP = 1273) and HFC-449A (GWP = 1397) are designed to replace HFC-404A (GWP = 3922). While the HFO blends help to reduce the negative impact on the environmental footprint in existing equipment, their global warming impact is still relatively high and they are not seen as an optimal solution for new installations.

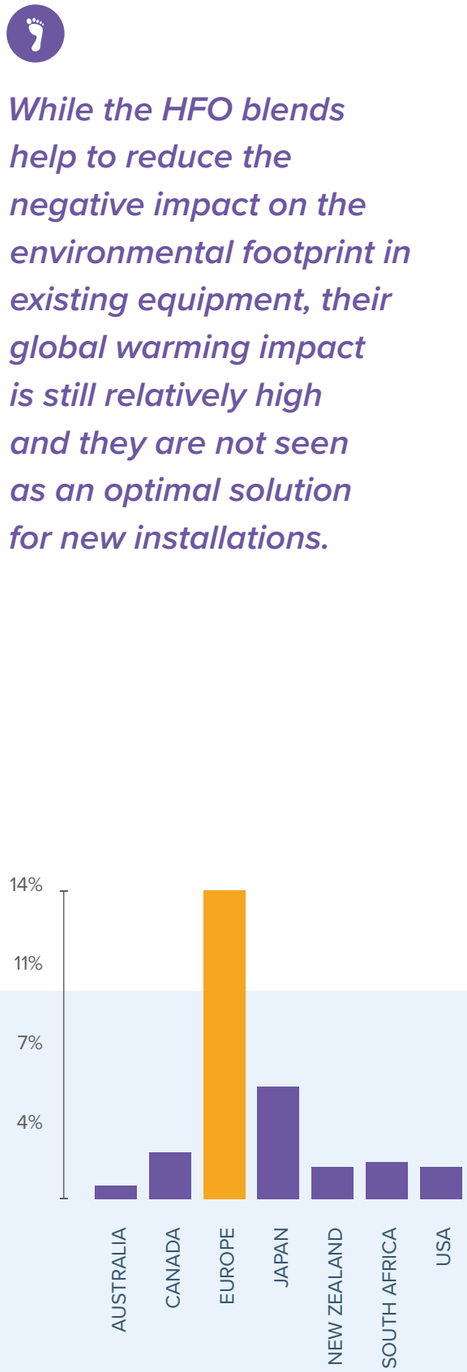


Figure 4: Share of CO2 transcritical stores in selected markets – status October 2018 (sheccoBase, 2018)

3. MARKET TRENDS FOR HFC-FREE REFRIGERATION TECHNOLOGIES **3.1.** COMMERCIAL REFRIGERATION

While the HFO blends help to reduce the negative impact on the environmental footprint in existing equipment, their global warming impact is still relatively high and they are not seen as an optimal solution for new installations.

FOCUS

CO_2 transcritical making inroads in South Africa

Woolworths' journey

Woolworths operates 1,556 stores, serving 15 million customers in 14 countries across the southern hemisphere.

Woolworths first turned to natural refrigerants in October 2009, when it opened its first subcritical CO_2 store. It now has nine. It opened its first transcritical CO_2 store in November 2010, and currently boasts 69.

"Our CO_2 transcritical stores are working very well. We've kept our system design very simple, and it's incredibly reliable," said Woolworths' Alex Kuzma in an exclusive interview with shecco.

Kuzma spoke of South Africa's "unique opportunity" to leapfrog HFCs by adopting natural refrigerants as alternatives to HFCs instead.

He cited high initial cost premiums versus f-gas-based systems, fear of the unknown, relative system complexity, difficulties sourcing components, and the development of local skills among the initial obstacles of adopting CO_2 transcritical technology in South African food retail.

Among the CO_2 transcritical system innovations that have saved on energy consumption vs traditional HFC-based systems, Kuzma cited the use of electronic expansion valves, suction demand, variable speed EC fans, floating head pressures and variable-speed compressors alongside the elimination of defrost heating, for a total energy saving of 48%.

woolworths

1,556
stores

15,000,000
customers

14
countries

"Our CO_2 transcritical stores are working very well. We've kept our system design very simple, and it's incredibly reliable" said Woolworths' Alex Kuzma.

CO_2 integrated solutions delivering additional energy savings

Instead of having separate HVAC and refrigeration systems, retailers are increasingly looking at combining them into one HVAC&R solution to improve energy efficiency and ultimately electricity costs.

CO_2 transcritical booster systems provide excellent opportunities for heat recovery that can be utilised to cover the store's needs for hot water and space heating. By increasing the discharge pressure of CO_2 and switching from subcritical to transcritical, the amount of available heat increases considerably in CO_2 systems. The heat recovered from a CO_2 refrigeration system is free and reduces retailer's capital and operating cost otherwise accrued from using additional energy systems.

In addition, parallel compression in a CO_2 system allows integration of energy efficient air-conditioning with the refrigeration system.

Delhaize Belgium, part of the Ahold Delhaize group, is using heat reclaimed from a CO_2 rack installed in a Brussels supermarket to warm the greenhouse of a rooftop 'Urban Farm', as well as to provide heat and hot water for the store below.

A German supermarket using heat recovery with a gas cooler by-pass managed to increase the total coefficient of performance (COP) of the CO_2 system by 20%.[34] Another German supermarket using a CO_2 system with a parallel compressor connected to ground thermal storage as the auxiliary heater in parallel with heat recovery from the refrigeration system, reported that up to 50% of the heat rejected by the de-superheater was recovered in the cold months.[35]

A case study from a Danish supermarket has shown that by replacing the gas heating system with heat recovery from a CO_2 transcritical booster system, they were able to provide the entire heating demand of the supermarket (160kW cooling capacity). The payback period for the heat recovery was less than five months.[36] Another store in Bulgaria operated by METRO AG, which uses CO2 transcritical technology with heat recovery has delivered savings of 8,3% in energy demand for heating in the winter 2018/2019.

The heat recovered from a CO_2 refrigeration system is free and reduces retailer's capital and operating cost otherwise accrued from using additional energy systems.

34 Tambovtsev, A., Olsommer, B., Finckh, O., (2011). Integrated heat recovery for CO_2 refrigeration systems. Presented at the International Congress of Refrigeration, IIR/IIF, Prague, Czech Republic.

35 Rehault, N., Kalz, D. (2012). Ongoing Commissioning of a high efficiency supermarket with a ground coupled carbon dioxide refrigeration plant, in: International Conference for Enhanced Building Operations (ICEBO). Manchester, England.

36 Funder-Kristensen T. (2012). Refrigeration and Heat Recovery with CO_2 in Food Retail stores. Danfoss, ATMOsphere Europe 2012. Available at: http://www.atmo.org/presentations/files/199_2_ CLEAN_Kristensen_Danfoss.pdf

Solutions for small stores

Condensing units or plug-in refrigeration equipment usually fulfil the refrigeration needs in smaller stores, typically reaching cooling capacity up to 30kW. The condensing unit market is largely dominated by high-GWP HFCs, primarily supplied by Asian manufacturers.

CO_2 is the most environmentally friendly alternative for condensing units, applied already in a large number of convenience stores. In Japan, CO_2 condensing units have been a well-established technology for many years with more than 8,500 units running in the market by the end of 2017. In Europe and other parts of the world, retailers that have gained experience with CO_2 in supermarket refrigeration push the manufacturers to commercialise and decrease the cost of CO_2 condensing units and mini boosters. The result of this is a growing offer of commercially available CO_2-based products to fulfil the cooling needs in small stores.

Besides CO_2, hydrocarbons are also making headway in the condensing unit sector. Although the offer is currently limited, the potential for the technology is vast, with expected energy savings of about 30% compared to HFC-based equipment.

In the small store segment, plug-in refrigeration equipment is often a preferred option for end-users as it does not require any installation effort apart from plugging the cabinet into electricity. HFCs, especially HFC-134a and HFC-404A, have been dominating this market segment in different parts of the world. Nevertheless in new equipment, hydrocarbons and to a smaller extent CO_2 have been making inroads in the last few years. According to recent market data, hydrocarbons are in use in more than 2.5 million refrigerated showcases globally. The industry expects the uptake of hydrocarbon plug-in equipment to accelerate in the near future. This is especially due to excellent energy efficiency performance of hydrocarbons in this type of equipment, which helps to meet gradually stricter energy performance standards while contributing to reduction of the overall environmental footprint.

One of the key barriers in the wider uptake of hydrocarbon-based refrigeration technology is the restrictive standards that limit the charge size per refrigeration circuit to 150g of propane (the most popular hydrocarbon used in this segment). The international standard IEC60335-2-89, which is currently at final stages of review, could increase the charge limit to 500g of propane if voted positively by national standardisation committees at the beginning of 2019. Such an increase is expected to have a massive impact on the adoption of hydrocarbons in commercial refrigeration.

Plug-in refrigeration equipment is often a preferred option for end-users as it does not require any installation effort apart from plugging the cabinet into electricity.

IN FOCUS
Jaya Grocer installs Malaysia's first CO_2 condensing unit[37]

The first CO_2 condensing unit in Malaysia was installed and commissioned in May 2017 at one of Malaysian retailer Jaya Grocer's supermarkets. The project was carried out under the framework of Stage 1 of Malaysia's HCFC Phase-out Management Plan, which included assistance from the Multilateral Fund for the Implementation of the Montreal Protocol.

Two Panasonic 15 kW CO_2 outdoor condensing units were installed at the supermarket, providing cooling for a total of 23 medium temperature CO_2 display cases.

Though cost challenges remain, feedback from the end-user has so far been positive, according to installation contractor Coolcare. The representative from Coolcare announced that energy savings have been about 12.8% (in energy consumption costs compared to HFC- based systems).

2017
CO_2 condensing unit in Malaysia was installed

12.8%
energy savings

37 McLaughlin, C. (2017). Panasonic installs its first CO_2 condensing unit in Malaysia, R744.com. Available at: http://r744.com/articles/7616/panasonic_installs_its_first_co2_condensing_unit_in_malaysia

Hydrocarbon waterloop technology

Hydrocarbon plug-in systems combined with waterloop technology are gaining presence in the global market. The waterloop technology, developed to work mainly with propane and propylene, is designed to remove the heat generated from the plug-in units outside the store, thereby reducing the air-conditioning needs. This technology is therefore especially suitable for regions with warmer climates.

The data collected by sheccoBase from system manufacturers and retailers indicated there are more than 1,900 stores globally in 2018 using the hydrocarbon waterloop technology, with growing interest in Asia. The industry representatives anticipate that the review of standards to allow higher hydrocarbon charge limits per refrigeration circuit would accelerate the market uptake of this technology.

Manufacturers report around 16% better energy performance with hydrocarbon waterloop technology compared to similar HFC models[38].

According to one end-user interviewed, the most efficient HC-290 waterloop systems, for which they had at least one year of measurements, used around 2,500 kWh annually per meter of cooling unit. Measurements indicate that the annual energy consumption of the new waterloop systems currently being installed will be around 2,000 kWh[39].

16%

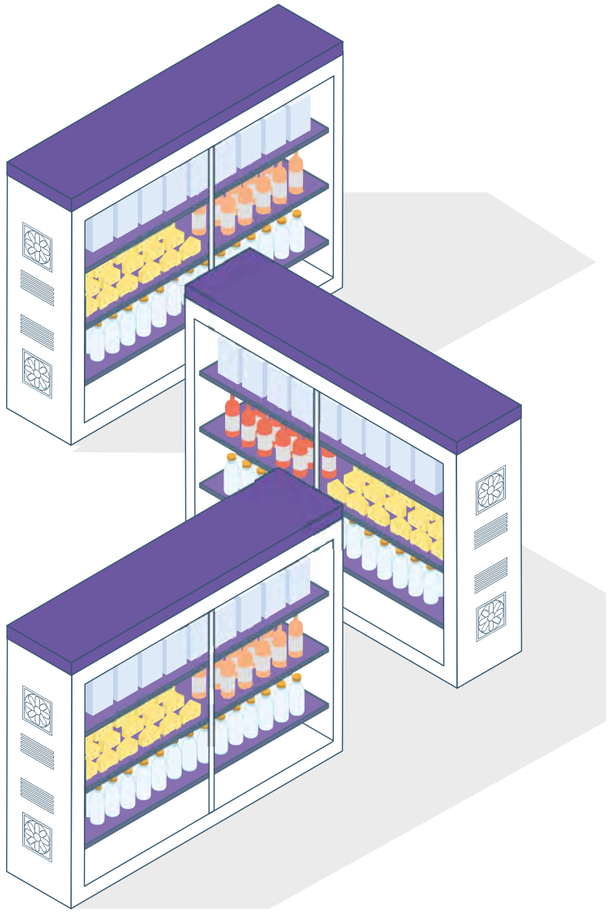
Manufacturers report around 16% better energy performance with hydrocarbon waterloop technology compared to similar HFC models.

38 William A. Ranson J. (2016). Carter descenting on Australian shores, hydrocarbons21.com. Available at: http://hydrocarbons21.com/articles/7302/carter_descending_on_australian_shores

39 Meters are corrected according to the dimensions of the cooling cabinets.

3.2. LIGHT COMMERCIAL REFRIGERATION

Light commercial refrigeration is a sub-category of commercial refrigeration and includes equipment, such as bottle coolers, vending machines, ice-cream freezers and water coolers. Light commercial refrigeration equipment is typically owned and installed by food and beverage companies and placed predominantly in supermarkets, offices, hotels, restaurants and bars.



3. MARKET TRENDS FOR HFC-FREE REFRIGERATION TECHNOLOGIES **3.2.** LIGHT COMMERCIAL REFRIGERATION

Global consumer brands driving natural refrigerant adoption in the light commercial sector

The replacement of HFCs with natural refrigerants in millions of glass-door merchandisers is one of the most direct ways to achieve an improved carbon footprint for companies as point of sales equipment accounts for up to one-third of a company's carbon footprint. It is also seen as low-hanging fruit, as not only is it in line with a more global understanding of the negative effects fluorinated gases bestow upon the environment; the use of natural refrigerants also improves energy efficiency, with up to 45% energy savings quoted by major consumer brands.

With environmental friendliness and increased energy efficiency making the case for natural refrigerants, natural refrigerants CO_2 and hydrocarbons have come to the forefront to be the substance of choice for global consumer brands in their commercial refrigeration equipment.

Several major global companies have already significantly reduced their HFC consumption and are reporting significant gains in energy efficiency (The Coca-Cola Company, PepsiCo, Red Bull and Unilever).

These groups are part of Refrigerants, Naturally!, a non-profit initiative bringing together several multinationals in the food and beverage, food services and consumer goods sectors. The network has been recognised as a "Partnership for Sustainable Development" by the United Nations Commission on Sustainable Development. Refrigerants, Naturally! is also supported by the non-governmental organisation Greenpeace and the UN Environment.

By the end of 2017, members of Refrigerants, Naturally! (The Coca-Cola Company, PepsiCo, Red Bull and Unilever) collectively installed 7.25 million units of natural refrigerants, avoiding the emission of about 43.5 million tonnes of CO_2 equivalent. This equates to the annual emissions of more than 8.86 million vehicles.

At the same time, three of the member companies had achieved their goal of only purchasing new equipment based on natural refrigerants. The last company is about to achieve this goal in 2020.

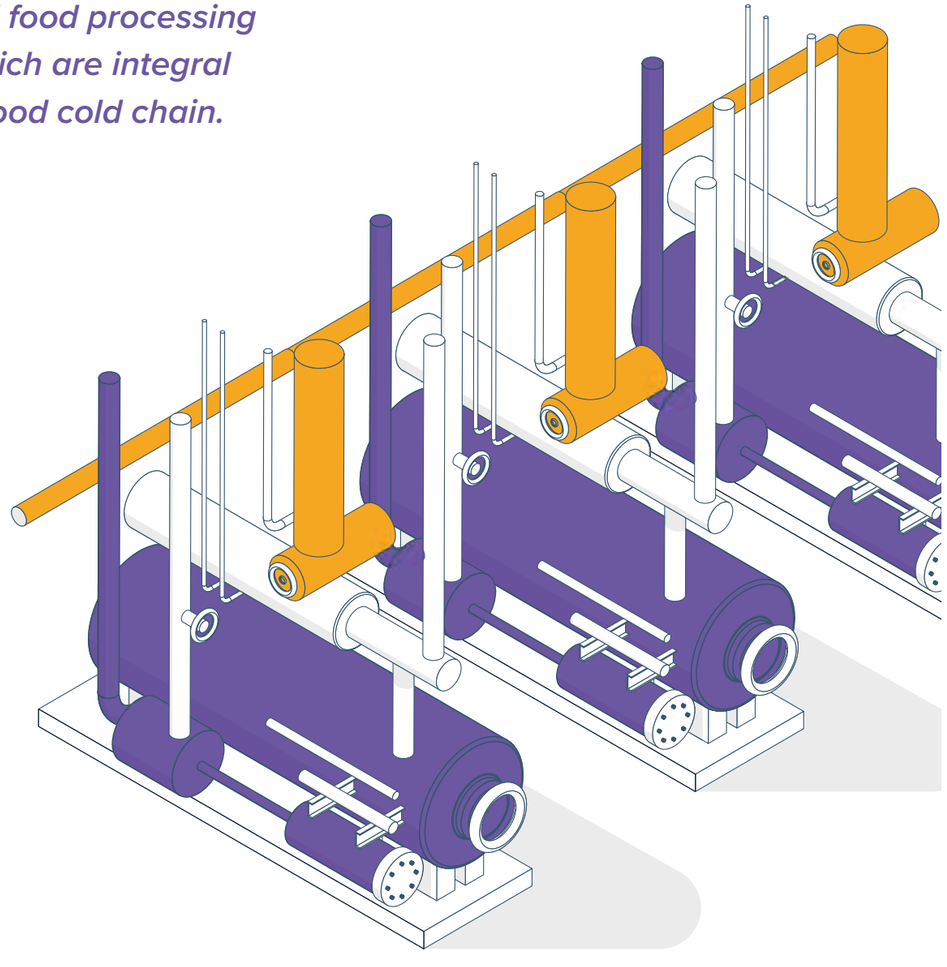
In terms of energy efficiency, the Unilever Group purchased 1.28 million hydrocarbon-based freezer cabinets. The company reported energy gains of about 10%.

Similarly, since 2009, The Coca-Cola Company has deployed 1.1 million refrigeration units without HFCs. 75% of them are more energy efficient than their HFC counterparts.

A side effect of the use of two different refrigerants is the impact on training. Consumer brands have had little problem in training their engineers to handle the equipment, noting that the training for hydrocarbons and CO_2 is based on knowledge of conventional systems. This is encouraging for other markets as it shows that with time, perceived entry barriers such as higher initial costs and training requirements can be surmounted, allowing the market to flourish.

3.3. INDUSTRIAL REFRIGERATION

Industrial refrigeration equipment is used in a wide range of applications, including warehouses, distribution centres, and food processing facilities, which are integral part of the food cold chain.



3. MARKET TRENDS FOR HFC-FREE REFRIGERATION TECHNOLOGIES **3.3.** INDUSTRIAL REFRIGERATION

Growing market for low-charge ammonia

Competition between different types of natural refrigerant-based systems is expected to intensify. This will help improve performance and reduce costs. In industrial refrigeration, the low-charge trend is attracting new customers to ammonia, while new technology is bringing CO_2 to higher capacities. All this innovation is helping industry to phase down synthetic refrigerants and improve energy efficiency.

Competition between different types of natural refrigerant-based systems is expected to intensify. This will help improve performance and reduce costs.

Ammonia has been widely used as the refrigerant of choice in industrial refrigeration for more than a century; however, the technology used has not undergone any major changes during that time.

Recently, growing pressure to improve safety and increase energy efficiency has led many to embrace low-charge ammonia systems. Having less of the ammonia refrigerant in the system is a great advantage for a system's safety and its susceptibility to regulatory standards.

While the concept of low charge is not new, it represents the leading disruptor in the traditional industrial refrigeration market. This new technology is also leading to ammonia being considered for applications where it has traditionally not been used, such as HVAC and food retail.

On a component level, the development of optimised heat exchanger designs, advanced controls and novel system architectures are driving innovation in this newly formed and competitive market. Manufacturers are taking advantage of this new technology by developing modular, packaged ammonia systems as well as optimised, distributed systems with a variety of designs.

The proliferation of low-charge ammonia systems in North America is evident. In the US market in particular, the advent of low-charge, packaged ammonia systems is seen as the ideal solution to the on-going HCFC-22 phase-out. For the many facilities still using HCFC-22 rooftop packages, switching to modern, low-charge ammonia packages can provide a solution that is efficient, cost-effective and reliable. Most importantly, the

Recently, growing pressure to improve safety and increase energy efficiency has led many to embrace low-charge ammonia systems.

use of ammonia means that facility owners can bypass the intermediate step of using HFCs, which are already being phased out, and go straight to a natural refrigerant, which will not be subject to future restrictions due to environmental concerns. This makes low-charge ammonia a very attractive option for the replacement of HCFC-22 systems.

Moving to another part of the globe, Australia's uniquely remote landscape and strong agricultural sector have produced a long history of large-scale industrial plants using ammonia. In modern times, the focus has been on optimising energy efficiency and reducing the ammonia charge, and as a by-product, carbon emissions, by harnessing cutting-edge technology. It is no surprise that the convergence of these two goals has given rise to the proliferation of low-charge ammonia technology in Australia.

In China, the development of NH_3/CO_2 secondary and cascade refrigeration systems that reduce ammonia refrigerant charge has been gaining popularity since 2013, when the technology was developed and tested by a Chinese manufacturer. Today, it is estimate that there are more than 150 such projects. The installations vary from ice making facilities and cold storages through to meat, aquatic products and prepared food processing, to ski halls and ice cream production facilities.

3. MARKET TRENDS FOR HFC-FREE REFRIGERATION TECHNOLOGIES
3.3. INDUSTRIAL REFRIGERATION

FOCUS

Ammonia/CO_2 system in Carrefour distribution centre in Argentina[40]

An ammonia/ CO_2 system has been running in a Carrefour distribution centre in Isidro Casanova Partido de la Matanza in Buenos Aires province since January 2017. The installation is one of the biggest in the region at 14,000m^2.

The safe low-charge ammonia system is in the machine room. No ammonia is in the evaporators.

The cold room has no need for CO_2 compressors and only requires a CO_2 pump for the brine/CO_2 system. The pumps have a low brake horsepower (BHP) and small tube diameters. The cost of installing CO_2-brine is also lower due to the small tube diameters.

According to the system manufacturer, the low-pressure system is very efficient with a high coefficient of heat transfer.

Carrefour

14,000 m^2
ammonia/CO_2 system installation in Buenos Aires

According to the system manufacturer, the low-pressure system is very efficient with a high coefficient of heat transfer.

40 Atea. (2017). Mayekawa Installs Argentina's First Ammonia/CO_2 System. R744.com. Available at: http://ammonia21.com/articles/7570/mayekawa_installs_argentina_s_first_ammonia_co2_system

CO_2 transcritical's growing potential in industrial refrigeration

Next to commercial refrigeration, CO_2 is also becoming popular and increasingly competitive in industrial refrigeration applications, especially in small and medium-sized installations. Especially in the smaller-sized installations, HFCs and HCFCs have been the dominant refrigerant option.

New technological developments, particularly for compressors, have allowed CO_2 trancritical systems to reach higher capacities and capture a part of the industrial refrigeration market. This market is moving towards CO_2-only systems, partly due to the safety and technical challenges of using traditional ammonia systems with high refrigerant charge. According to expert engineers, CO_2 compressors can have an equally long life as the ammonia ones without the need for special components.

The use of CO_2 in industrial applications gives more flexibility on the regulatory compliance side compared to traditional HFC-based equipment as well as other natural refrigerants. In addition, the low maintenance costs and the possibility for heat reclaim make this an attractive option for end-users.

FOCUS

South African food processing facility opts for CO_2 transcritical technology[41]

In2Food decided to install the biggest CO_2 transcritical system in Africa to date. The facility in Boksburg has a cooling capacity of 3MW.

In2Food, based between Johannesburg and Pretoria, provides a broad range of food products to retailers and wholesalers, such as Woolworths.

The new cutting-edge processing facility for In2Food in Boksburg will help the company to expand their operation whilst being more efficient and sustainable. The 15,250m² plant will feature various areas, including a meat and vegetable processing section, and requires several blast chillers and freezers.

The installation will include four CO_2 packs — two booster packs and two medium-temperature CO_2 transcritical packs. The technology also allows for heat recovery, delivering 18,000 litres of hot water per hour.

41 Aleu, P. (2018). In2Food opts for CO_2 in South Africa, R744.com.
Available at: http://r744.com/articles/8214/in2food_opts_for_co2_in_new_facility_in_south_africa

3. MARKET TRENDS FOR HFC-FREE REFRIGERATION TECHNOLOGIES **3.3.** INDUSTRIAL REFRIGERATION

Hydrocarbon chillers offering energy savings for industrial processes

The use of hydrocarbons is also employed in industrial processes within Europe and to a lesser extent in other regions. Propane and propylene chillers deliver substantial energy savings helping to rapidly recover the initial cost of technology, which is usually higher than for HFC-based equipment.

FOCUS

Propane cold storage facility in Colombia reached 20% energy savings[42]

Asocolflores, the association representing flower exporters in Colombia, has replaced an HCFC-22-based system with propane (HC-290) in a cold storage facility for flowers, achieving energy savings of 20%.

Asocolflores used to cool their cold rooms in the Savanna of Bogota with HCFC-22. Seeking to minimise their environmental impact while maintaining high product quality, they converted their cold room for post-harvest processing to HC-290.

In converting the system, technicians ensured that electrical and refrigeration systems complied with existing regulation in order to eliminate risks associated with refrigerant flammability and changing the compressors to semi-hermetic compressors suitable for hydrocarbons.

Despite the success of the project, Asocolflores encountered challenges during implementation such as a lack of standards and funding mechanisms, a shortage of qualified technicians and difficulties finding local equipment and component suppliers working with HC-290.

42 Aleu, P. (2016). Cold storage facility converted to R290 in Colombia, R744.com.
Available at: http://hydrocarbons21.com/articles/7338/cold_store_converted_to_r290_in_colombia_

END-USER ACTION TO CUT HFCs

METRO

RECHEIO

Campbell's

HEINEKEN

LAWSON

While every end-user is facing unique challenges when phasing out damaging refrigerants there are some common issues and lessons that can be learnt from each other.

This section zooms in on the experiences of five end-users operating in different sectors and world regions.

They explain their journeys towards HFC-free refrigeration, challenges they faced, and opportunities they see for the future.

4.1. METRO AG

Number of stores	**773**
Location of stores	**36 countries** (Europe and Asia)
Share of stores using natural refrigerants	**Around 25%** (incl. 9 storages with ammonia)
Type of natural refrigerant technology used	**CO_2 transcritical, CO_2 subcritical**

METRO AG, operating with more than 750 METRO/ MAKRO Cash & Carry Stores in 36 countries across Europe and Asia is a German-based wholesale and food specialist headquartered in Düsseldorf. METRO AG has built a global reputation as a committed player in environmental protection efforts by committing to reduce its CO2 emissions by 50% per m2 of net operating area by 2030 (baseline: 2011).

source: https://www.metroag.de/en/media-centre/image-gallery

METRO's journey towards HFC-free refrigeration

The company piloted its first CO_2 refrigeration installation in its METRO store in Hamburg-Altona, Germany in 2008. Two years later, METRO publicly committed to The Consumer Goods Forum's pledge to begin phasing out climate-warming hydrofluorocarbons (HFCs) as of 2015. To that end, the company (incl. local boards of METRO countries) published plans to use only natural refrigerants in new refrigeration equipment installations.

METRO's f-gas reduction & avoidance programme consist of three pillars:

- Standard operating procedure (SOP) for repair & maintenance
- Logbook cooling system (all leakage rates are transparent)
- F-Gas Exit Programme

The leakage database (logbook) monitors leakage rates (in %) and relevant emissions in relation to m2 of net operating area connected to the METRO Energy Management Systems (MEMS), which also monitors electricity, heat and water consumption.

METRO considers energy key performance indicators (KPIs) - electricity and f-gas status (leakage rate). In 2015, the group's internal target was of 11.6% maximum leakage rate across all stores. In 2018, it is 8.35%. In addition METRO aims to reduce electricity demand of its stores by 24% in 2018 per m^2 net operation area vs the base year 2011.

In place since 2013, the F-Gas Exit Programme 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. The F-Gas Exit Programme evaluates all refrigeration installations taking into account certain criteria, including the refrigerants used (ODP and GWP), system depreciation, age, leakage rate and quality of technology, location (EU or non-EU) and local legal requirements. Based on this evaluation, the systems are ranked to set the order for the remodelling of refrigeration systems.

State-of-the art refrigeration technology using natural refrigerants is introduced when current equipment is reaching its end-of-life-cycle (between 18 and 25 years after its initial start-up).

Deciding where to begin exchanging refrigeration systems, however, was a difficult task. Olaf Schulze, METRO AG's director of energy management told shecco how his team addressed the challenge: "We undertook extensive internal research, looking at all our equipment, and in the end we came up with a five-level ranking system." Schulze explained. As of mid-2017, METRO AG has replaced f-gas based systems with natural refrigerant-based systems in more than in 199 stores of the existing stores. Additionally, every year, the retailer installs around 30 subcritical or transcritical CO_2 systems worldwide.

In place since 2013, the F-Gas Exit Programme aims to phase out f-gases in all METRO stores worldwide by 2030.

FOCUS
METRO China's strategy with natural refrigerants

METRO is also committed to expanding natural refrigerants technology in its stores beyond Europe, including in China.

"METRO China is aiming to eliminate HCFCs entirely by 2019/20," Alan Lin, head of facility management at METRO China told shecco. In 2020, it will stop introducing R22 systems and fully divest from them by 2025. In 2025, it will stop introducing HFC-404A systems and fully divest from them by 2030.

In China, the company has already installed 44 subcritical CO_2 systems. It is now beginning to transition towards using transcritical CO_2 technology as well. The installation of China's first transcritical CO_2 system in the retail sector, in a METRO wholesale store in the Lishuiqiao area of Beijing, is just the first step in a journey to adopt CO_2 transcritical systems in all its new Chinese stores by 2025.

Lin explained that while the initial cost of CO_2 transcritical system in the Lishhuiqiao stores – which opened in January 2018 - was about 30% higher compared to a subcritical system, the technology is showing at least 10% better energy performance. For Lin the higher initial investment costs is not a deterrent. "As the market opens up and new players enter the Chinese market, the initial costs will come down," he said.

The successful rollout of CO_2 transcritical cooling in all new METRO stores in China will depend on training. "In China, these are totally new systems. So we need to train our employees," Lin said. In 2019, METRO China will install new CO_2 transcritical systems in two existing stores, in Beijing and Chongqing.

> ***METRO China is aiming to eliminate HCFCs entirely by 2019/20.***
> *Alan Lin, head of facility management at METRO China.*

> ***As the market opens up and new players enter the Chinese market, the initial costs will come down.***

METRO

Overcoming the "CO_2 Equator" barrier

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

"In China, most urban areas have different temperature ranges," says Lin. "Yet during summer, 80% of the cities will reach over 35°C". Lin and his team flew to Europe last year to inspect at first hand the latest transcritical CO_2 systems already in operation. "We learned some real cases, like in Spain, where temperatures in some cities reach over 40°C," says Lin. "When we saw that the transcritical CO_2 systems were functioning there, we thought to ourselves, 'OK, we can go this way', and got the confidence to move forward," Lin added.

Message from METRO AG to other end-users: "We all have the same responsibility to customers and the environment. Therefore we encourage you to adopt natural refrigerants. You need to accept a long period of learning and experiences. You can learn from our example, and we would like to do the same from your experiences.

We believe CO_2 transcritical technology is technically reliable and can provide more than 20% energy efficiency improvements compared to HFCs, while the usage of heat recovery will lead to 30% less heat demand. We are fully independent of HFC price development for refrigerant refills. We are convinced that CO_2 transcritical will make us fit for the future and will contribute to our climate targets." Olaf Schulze, director of energy management, METRO AG

> ***We all have the same responsibility to customers and the environment. Therefore we encourage you to adopt natural refrigerants. You need to accept a long period of learning and experiences. You can learn from our example, and we would like to do the same from your experiences.***

4.2. **RECHEIO**

Total number of stores and distribution platforms	**44**
Location of installations	**Portugal**
Share of installations using natural refrigerants	**≈ 20%**
Type of natural refrigerant technology used	**CO_2 transcritical, propane plug-in cabinets***

*Plug-in equipment (freezer cabinets) using propane (HC-290) began to be installed in 2010 and represent over 90% of all units used in Recheio stores

Recheio Cash & Carry, S.A. is the leading cash and carry chain operating in Portugal, with over 40 sites, among stores and Distribution Centres, in its portfolio.

Founded in Figueira da Foz, centre of Portugal, in 1972, Recheio is owned since 1988 by Jerónimo Martins, a Portugal-based international retailing Group. Established in 1792, the Group's core business is Food Distribution, which represents over 95% of consolidated sales. Jerónimo Martins' asset portfolio includes supermarkets, cash and carries, convenience stores, health and beauty stores and coffee shops. Jerónimo Martins operates over 4,100 stores in Portugal, Poland and Colombia. In addition to Recheio, its food retail banners include Pingo Doce (Portugal), Biedronka (Poland) and Ara (Colombia).

4. END-USER **ACTION** TO CUT HFCs **4.2.** RECHEIO

Recheio's journey towards HFC-free refrigeration

Recheio first implemented its CO_2 subcritical low temperature (LT) solution in 2013, at the Leiria store. The biggest challenge was to control the pressure of the CO_2-based equipment during winter as it is a cascade system and often medium temperature does not have enough load to start medium temperature (MT) compressor racks.

Recheio opened its first CO_2 transcritical store in 2016 in Sines – south of Lisbon – marking a major milestone in its refrigeration strategy. The inspiration to install a CO_2 system came from best practices adopted by peers, which installed such technology in countries with warmer climates.

As a leader in the wholesale market in Portugal, Recheio is aware of the positive impacts it can imprint in the Portuguese society. "Our actions are important for our country and for our planet," says Ângela Soares, the company's Chief Operations Officer (COO).

By committing to becoming HFC-free with the adoption of 100% natural refrigerants, Recheio is certainly playing its part by aiming to anticipate by five years the legal framework – which sets 2030 as the deadline.

> ***Our actions are important for our country and our planet.***

Main drivers for adopting natural refrigerants

Environmental leadership and culture of innovation

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

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

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

Return on investment

Although initial investment costs may still be higher for state-of-the-art CO_2 transcritical systems, when compared to their HFC-based counterparts, Recheio is confident that this reality is changing as HFC quotas and phase-down schedules begin to kick in under the terms of the EU F-Gas Regulation.

In addition, in terms of costs savings, natural refrigerants show higher efficiency over equivalent HFC-based systems.

Energy efficiency

Energy efficiency has been an important factor for Recheio when deciding on the introduction of CO_2 transcritical technology in its stores. Despite initial concerns over CO_2 performance in warmer climates, the reality demonstrates that the systems work well in the Portuguese climate.

Next on the agenda is the imminent commissioning of Recheio's first CO_2 transcritical system to be fitted with an ejector in a store located in the Greater Lisbon, south of the city centre.

We're innovating. It's about finding the best technology solutions, both for the environment and for our customers.

FOCUS

CO_2 transcritical installation in Recheio's store in Sines, Portugal

The opening of the Sines store in 2016 – the first to be fitted with a CO_2 transcritical system – was a milestone on the path for Recheio to achieve its commitment to anticipate the EU F-gas regulation by 5 years.

In Sines, the CO_2 transcritical rack serves the large, free-standing cabinets and all the wall-mounted ones. It is a fully integrated system, providing cold water for the air conditioning. 'Free' heat recovered from the rack provides hot water to clean the store. To increase the efficiency of the system in climates with higher temperatures, the system makes use of three parallel compressors.

The total investment cost of the system was about 15% higher compared to a traditional solution. However, the wholesaler has recorded about 15% higher energy savings compensating for the higher initial cost and providing further benefits over the equipment's lifetime. Overall, the financial return on investment is expected to be around two years.

Just try it. Motivation to innovate and working with experienced business partners are key drivers for the successful execution of these installations.

4.3. CAMPBELL SOUP COMPANY

Number of installations (production plants)	**36**
Location of installations (countries)	**U.S., Denmark, Australia, Malaysia, Indonesia, the UK and the Netherlands**
Share of installations using natural refrigerants	**39%**
Type of natural refrigerant technology used	**Low-charge ammonia and CO_2 refrigeration**

Campbell's food production facilities are separated into two categories: Meals & Beverage, which include soup, sauces (Prego), salsa (Pace) and beverage (V8), among other products; and Snacks, which encompass Pepperidge Farm (cookies, crackers, bread) plants, and Snyder's-Lance (chips, crackers, nuts) facilities and Kelsen Group cookie plants in Denmark" End sentence after "facilities. As of March 2019, the company also has production plants in Australia, in Denmark, Malaysia and Indonesia.

4. END-USER **ACTION** TO CUT HFCs
4.3. CAMPBELL SOUP COMPANY

Campbell Soup's Journey Towards HFC-free Refrigeration

Campbell has, for more than two decades, been one of the industry leaders in shifting from large ammonia or R22 systems to low-charge ammonia systems.

Low-charge ammonia systems have emerged in the past few years as a growing trend in industrial refrigeration, as cold storage and food processing companies seek to reduce the amount of ammonia in their systems well below the 10,000-pound mark that in recent years has triggered high levels of regulatory scrutiny and insurance costs. The environmental impact associated with HFC-based refrigerants has been another reason the company has shifted towards natural refrigerants.

Camden, New Jersey-based Campbell started implementing low-charge ammonia systems as far back as the late 1980s, long before the Environmental Protection Agency started paying closer attention to ammonia plants.

Under its current strategy that emphasises low-charge ammonia chiller packages circulating glycol, most of Campbell's thermal facilities now use less than 10,000 pounds of ammonia and minimise the circulation of ammonia in refrigeration applications.

Bing Cheng, Campbell's senior manager of utilities, environmental and sustainability programmes manages the strategy towards adopting low-charge ammonia systems, with the focus on the company's Pepperidge Farm bakeries using refrigeration in process cooling, freezers/coolers and HVAC.

Since 2011, Campbell has converted four Pepperidge Farm bakeries (Downingtown, Pennsylvania; Lakeland, Florida; Richmond, Utah; and Willard, Ohio) from R22 to low-charge ammonia, with another facility in Denver, Pennsylvania, scheduled for completion in early 2019.

Certainly, the enhanced safety of the low-charge systems helps to settle the nerves of the uninitiated. "We're talking less than 300-500 pounds of ammonia in these skids," said Cheng. "If you get a leak or release, it's not catastrophic or life-threatening, so it's manageable and not frightening compared to a large ammonia system."

Campbell commissioned a CO_2 refrigeration system at its corporate headquarters in Camden, New Jersey. The CO_2 system supports a new centralised storage cooler and freezer facility in the corporate R&D pilot plant. In addition, Campbell installed a CO_2 system for a spiral blast freezer for a new frozen bread line in Downingtown, Pennsylvania, which was commissioned in January 2018.

"We have systematically addressed most of our R22 and large HFC users throughout our facilities," Cheng said. A number of small charge (less than 10 tonnes of refrigeration) HVAC units use HFCs, which Cheng plans to replace over time with a natural refrigerant option (low-charge ammonia and/or CO_2 systems). "We are currently developing a programme to address our large HFC users at the sites of our most recent acquisition Snyder's-Lance. This will be our next big challenge," he noted.

4. END-USER **ACTION**
TO CUT HFCs

4.3. CAMPBELL
SOUP COMPANY

FOCUS

Low-charge ammonia chiller delivers air conditioning at Napoleon facility in Ohio

The manufacturing facility in Napoleon, Ohio makes more than two-thirds of Campbell's beverage volume and over a third of soup volume in North America.

In 2014, the facility was named Green Plant of the Year by Food Processing magazine. The award was based on energy efficiency, innovative or alternative sources of energy, water use, green building construction, innovative design and economic sustainability.

Since 2017, the facility uses a self-contained air-cooled low-charge ammonia package chiller that generates cold glycol used by an air handler in the product labelling area – one of the first such chillers used for this application in North America.

The chiller/air handler delivers comfort cooling to a labelling and packaging section of the building where the red-and-white labels are applied to soup cans – and where a cool environment is needed to ensure proper adherence of the labels to cans. This project replaced an inadequate and dated system.

The advantage of the self-contained packaged chiller is that it eliminates the need for long ammonia distribution piping in the production arealn addition, the risk of ammonia release is eliminated as the refrigerant is contained in a package. In addition, the risk of ammonia release is eliminated as the refrigerant is contained in a package. This also avoids an efficiency penalty due to a suction line pressure drop and extra heat gain into the system. The standalone feature of this chiller package allows Campbell to provide refrigeration capacity in remote areas of the plant or in areas where glycol supply is not available.

In addition, the industrial construction of the package chiller, incorporating steel piping and steel condenser tubing, allows it to run for 30+ years. By contrast, an HFC chiller may need to be replaced after 10-15 years. This package chiller uses an air-cooled condenser, which does not require chemical water treatment and offers savings on water and sewer bills.

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

Message from Campbell Soup to other end-users:
"Moving away from HFC refrigerants to natural refrigerants is the better long-term strategy from a capital investment and maintenance costs standpoint, as well as impact to the environment. Education on the use of natural refrigerants and its benefits was critical in our successful conversion programme." Bing Cheng, senior manager of utilities, environmental and sustainability programs, Campbell Soup

4.4. **HEINEKEN**

Number of refrigeration equipment (fridges)	**Over 1 million fridges**
Location of installations (countries)	**Worldwide**
Share of equipment using natural refrigerants	**More than 80%**
Type of natural refrigerant technology used	**Hydrocarbon** (HC-290, HC-600a) plug-in coolers

Founded by Gerard Afriaan Heineken in 1864, today Heineken is the second-largest brewer in the world by revenue. It operates more than 170 breweries, malteries, cider plants and other production facilities in over 70 countries and its beers are available in 192 nations.

Heineken's overall climate strategy is driven by the 'Drop the C' programme, which by 2020 aims to reduce emissions from production by 40%, lower emissions from fridges by 50% and cut emissions from distribution in Europe and the Americas by 20%.

In early 2018, 'Drop the C' was extended to renewable energy, with the target of growing renewable energy usage to 70% by 2030. Surpassing the 2020 commitment, Heineken achieved a 41% reduction in relative CO_2 emissions in 2017 (2016: 37%). Emissions have also decreased in absolute terms; even though production volumes were 57% higher in 2008, emissions were down 7%.

source: https://www.heineken.com/es/credentials/the-product-behind-the-star

Heineken's journey towards HFC-free refrigeration

In 2010, Heineken CEO Jean-François van Boxmeer gave his team the target to reduce the energy consumption of beer fridges. Thus began Heineken's hydrocarbon journey.

The brewer defines 'green' fridges according to the following four principles: the use of hydrocarbon refrigerant, LED illumination, an energy management system, and energy efficient fans. Targeting 50% lower emissions from fridges by 2020, Heineken provides 'green' fridges whenever a fridge needs replacing and tests fridges against the Heineken Energy Efficiency Index (HEEI).

"We discovered hydrocarbons as part of our 'Brewing Better World' programme. We adopted them for two reasons – one, because they help to deliver the energy efficiency that we want; and two, because of their significantly lower GWP compared to the existing refrigerants we used in our fridges," Graeme Houghton, Global Category Leader, Commercial Equipment and Servicing at Heineken told shecco.

"So that was the pairing of it. We work with a number of cooling partners. We use an independent cooling advisory group, which helps us with the technology side of things, plus our cooling partners – the fridge manufacturers," Houghton says. "It's a lifecycle thing. The policy is 'all new fridges'," he added.

To facilitate the optimal serving of Heineken and the other brands, whether in cans, bottles or draught, the company itself provides the infrastructure. "In the majority of cases, we own the fridges and draught beer equipment. We place it with our customers to help them serve the perfect Heineken," Houghton said.

"Because of the lifecycle of fridges, which we expect to be around about eight years, we anticipated that in order to reach our target in 2020, we needed to start immediately," he added.

With operations in so many countries, Heineken is mindful of the large contribution that adopting greener cooling practices can make to reduce its overall climate impact. "Cooling is a significant part of our CO_2 footprint. We've got over a million fridges out there in the field. We're reducing their energy consumption by half," told Hans Donker, Global Category Buyer, Fridges & Draught Beer Equipment at Heineken to shecco in an exclusive interview. He added that every year the brewer buys roughly 140,000 fridges, all of which use hydrocarbons.

Today, Heineken uses hydrocarbon equipment all over the world. Initially, the maturity of the service organisations posed challenges in some parts of the world such as Central Africa. Heineken first introduced the equipment in Europe, followed by the Americas and later in Asia and Africa. While they were familiar with the suppliers present in those markets from working with them in Europe and the Americas, it took time to develop servicing infrastructure.

The equipment suppliers themselves provide Heineken's customers with training on how to work with hydrocarbons. "We went through a change process, to get our clients and our sub-contractors on board," Houghton said. "We were pleasantly surprised by the robustness of the technology."

Asked about the cost of hydrocarbon-based technology, Houghton explained: "We have not seen much of an impact on the cost to convert our equipment to hydrocarbons. To meet our ambitious energy efficiency targets, we had to invest in a specific suite of technology. By reducing the energy requirements, we have seen less strain on the components, which has shown to increase the useful lifetime of the fridge, meaning a longer time between replacement purchases."

Main drivers identified for adopting hydrocarbons

Energy efficiency

Adopting natural refrigerants is helping Heineken to improve the energy efficiency of its fridge portfolio. When they started, they made enquiries with their fridge suppliers, asking them how much energy savings introducing hydrocarbon refrigerant, LED illumination, and a smart thermostat (energy management system) would deliver.

"They said, 'if you do hydrocarbons, you'll get 7% more efficient fridges; if you do LED, you'll save 15%; and the energy management system gives another 15%'. That's how it was described to us," he explains. "It's about the overall tuning of the system, all of the components coming together to produce energy savings," added Houghton.

In Mexico this year, Heineken launched fridges with variable-speed compressors for the first time in order to achieve that next step in improving energy efficiency. "We need to know where the next energy efficiency boost will come from, and we look to the market for the latest innovations that will do that," he explained.

Future-proofing its investment

Some users of HVAC&R technologies are adopting HFOs, the new generation of synthetic refrigerants, as a means of complying with the HFC phase-down. Heineken did not consider going down that road. "I looked at HFOs, but they're mixed gases," says Donker. "In my experience, mixed gases make life difficult." "Frankly speaking, I don't think HFOs are here to stay," he said.

Adopting natural refrigerants is helping Heineken to improve the energy efficiency of its fridge portfolio.

4. END-USER **ACTION** TO CUT HFCs **4.4.** HEINEKEN

FOCUS

Heineken's hydrocarbons-based draught beer dispense state-of-the-art technologies

The firm's use of natural refrigerants is not restricted to fridges. Since 2012, all Heineken's new draught beer dispensers in Europe have used hydrocarbons (and in Mexico since 2014).

The Blade – Heineken's latest draught beer dispense innovation – has a keg volume of eight litres and is capable of chilling beer to 2°C, delivering beer at 3°C in the glass. It uses isobutane (R600a) as the refrigerant. "It's already live in selected markets and will go further," Houghton said.

The propane-based David XL Green draught system, meanwhile, stores and chills 20-litre kegs in a fridge directly below the counter so the beer does not have to travel far to the tapping point. Over 12,000 of the systems have been installed in 25 markets across Europe, Africa & the Middle East, Asia and the Americas.

David XL Green (double tap of beer) is the line extension of David Green (single tap of beer), the world's first 'green' draught beer system. Last year Heineken celebrated placing its one hundred thousandth David Green on the market.

Message from Heineken to other end-users: "This is a win-win for any company and the environment. We reduce the refrigerant GWP, we save on electricity as hydrocarbon-based technology is energy efficient, there are no extra costs to achieve this and the fridges last longer. In my view, it's hard to explain why you should not change. " Graeme Houghton, Global Category Leader, Commercial Equipment and Servicing, Heineken

***Since 2012, all Heineken's new draught beer dispensers in Europe have used hydrocarbons** (and in Mexico since 2014).*

4.5. **LAWSON**

Number of stores	**14,500+**
Location of stores	**Japan**
Share of installations using natural refrigerants	**22%**
Type of natural refrigerant technology used	**CO_2 condensing units**

Lawson, a convenience store business that runs on a franchise system, operates 14,500+ stores in every region in Japan, from Hokkaido to Okinawa. Today, it is the country's number one retailer in terms of adopting natural refrigerants. CO_2 refrigeration has been standard in all new Lawson stores since September 2014. By February 2019, the retailer is aiming to have at least 3,400 stores using CO_2 refrigeration systems, representing 23.5% of total installations.

Lawson's journey towards HFC-free refrigeration

LAWSON

It was a focus on energy savings that first led Lawson, on the path to climate-friendly refrigeration. After reaching their goal of reducing energy consumption by 10% in 2012 as compared to 2008 levels, the retailer found itself looking for the next environmental challenge. Having heard about the environmental benefits of CO_2 refrigeration, Lawson decided to try the technology.

"Realising that we could make a far more positive impact on the environment by replacing f-gas refrigerants than taking energy saving measures, we launched a study group to further look into CO_2 as a refrigerant," said Lawson's energy manager, Shinichirou Uto. Exploring how to introduce CO_2 refrigeration technology to Japan, Mr Uto's study group - made up of engineers and associations, alongside various system and component manufacturers - turned their sights to Europe, where CO_2 transcritical refrigeration was beginning to make inroads. After several visits, Mr Uto returned deeply impressed and determined to promote CO_2 refrigeration technology.

By adopting highly energy-efficient CO_2 systems, the company set the goal of reducing annual power consumption for refrigeration by 14% compared to existing standard stores; and by combining these systems with energy-saving equipment for air-conditioning and lighting, it also aimed to cut down on overall store energy use, which is equivalent to energy reductions of 21%.

Standard Lawson CVS (convenience stores) rely on two types of CO_2 systems, a 10HP (horse power) and 2HP CO_2 transcritical condensing units. The CO_2 units contribute to average energy savings of 21% compared to conventional HFC units in subtropical climates. It is the energy savings that are most important to the franchise operators. Facing difficult sales and soaring electricity costs, the savings help keep Lawson CVS's profitable.

"If there had been more efficient technology to reduce energy consumption than CO_2 refrigerant, we may have opted for it. After implementing various energy-saving equipment, we needed to choose a new means to save energy, and CO_2 technology turned out to be the only option with high cost efficiency," explained Mr Uto.

Overcoming initial challenges thanks to government support and broad stakeholder engagement

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Lawson initially had to address concerns about how to construct and manage CO_2 systems. Mr Uto looked to Europe to find out what, if any, special standards applied to CO_2 technology. Whilst he found that CO_2 was not subject to any specific regulations, he learnt that unlike in Japan, where the type of gas to be carried through a pipe is given little importance and where refrigerant leakage is considered unavoidable during equipment installation, in Europe piping is designed and installed based on a sound understanding of the properties and pressures of the gas to be carried. Following Europe's lead Lawson thus designs and constructs pipes to suit the high-pressure properties of CO_2. "It is absolutely critical to have construction practices established. Without this, we would be unable to introduce CO_2 technology."

Another challenge was the fact that although CO_2 refrigeration systems are very energy efficient - the up-front costs are almost double those of traditional refrigeration systems. Looking for support to lower these costs Lawson turned to the Ministry of Economy, Trade and Industry (METI), who in 2010 granted Lawson a subsidy for its first 50 stores. Based on the results of these pilot stores Lawson received funding for further CO_2 installations.

The subsidies also helped the CVS operator overcome a second potential hurdle: lack of technician training. Working closely with system manufacturer Panasonic, Lawson has provided training in the installation and maintenance of CO_2 refrigeration technology to a large network of refrigeration technicians throughout Japan.

Lawson's latest goal is to help reduce the cost of the technology by encouraging more competition among manufacturers in the market. It is doing this by actively testing natural refrigerant equipment from a number of different suppliers.

Though Panasonic supplies the majority of Lawson's CO_2 equipment, in May 2018 Lawson began testing CO_2 equipment supplied by two other manufacturers – Fukushima Industries and Mitsubishi Heavy Industries Thermal Systems (MHI). In addition, the retailer has been testing CO_2 equipment supplied by Sanden Retail Systems in three of its stores since 2015.

4. END-USER ACTION TO CUT HFCs 4.5. LAWSON

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Adopting innovative energy saving measures in CO_2 stores

Lawson has acknowledged that its effort to help spread the uptake of CO_2 technology plays a key role in its wider energy-use reduction efforts. In fact, the company has set out to open its first "zero-energy store" in a few years. To do this, Lawson is introducing a number of innovative energy generating and saving measures at a number of model stores where it is gradually reducing power consumed each year.

For example, in January 2018, Lawson opened one of its latest environmentally-friendly model stores in Gunma prefecture where in addition to using solar panels, highly heat insulating "cross laminated timber", and other such energy saving measures, the store has installed a thermal storage tank which is connected to Panasonic's CO_2 condensing units.

Another Japanese manufacturer named Yamato Co. Ltd supplies the thermal storage tank, dubbed the "Ultra Eco-Ice" thermal storage system. The system helps reduce peak period energy consumption by the refrigeration system by creating and storing brine-ice at night and using it to cool brine circulated through the store during the day.

It is yet another example of how Lawson is pushing the development of CO_2 commercial refrigeration technology in Japan as it continues to actively seek and test out various new technologies in the country.

Message from Lawson to other end-users: "In regard to both newly-installed and existing equipment, we need to reduce the number of equipment that uses HFCs. If we do not start using natural refrigerants now, we will not be able to comply with laws and regulations and will have risks in the future with respect to replacement of equipment."

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