natural refrigerants

solutions for europe

ATMOsphere Europe 2013

Summary Report
International Workshop

Brussels, Belgium
15-16 October 2013

ATMO EU sphere
solutions for europe
natural refrigerants

ATMOsphere Europe 2013

Summary Report of International Conference

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MARC CHASSEROT
Chairman ATMOsphere Europe 2013
Managing Director shecco

This is the decade for natural refrigerants…

… we already have over 400 European companies across Europe working with all natural refrigerants (using CO_2, ammonia, hydrocarbons, air and water) in the refrigeration and air conditioning sectors.

100 of those companies either attended or presented their solutions at the biggest ever ATMOsphere Europe conference in Brussels, 15-16 October 2013. This is a sign that natural refrigerant alternatives to HFCs exist today. There is an undeniable momentum behind this trend and it is growing every day.

An ambitious EU F-Gas Regulation will only accelerate this trend rewarding innovative companies across the whole of Europe and creating 'green jobs' that will attract the next generation of European talent.

A phase down of HFCs over the next 15-20 years is too weak and will not reward the leaders and innovators that want to make the HVAC&R industry more sustainable. It will maintain the status quo and has been referred to as the 'business as usual scenario'. It will not provide the clarity that industry really needs.

Clear deadlines, bans, training for natural refrigerants will. HFC-free solutions for Europe exist today. By giving clarity to industry, more and more companies will compete in this growing market thus further improving efficiencies and driving down costs. This is what Europe needs.

Leading Food Retailers and Consumer Brands are already anticipating tough EU F-Gas legislation by implementing these natural refrigerant-based solutions today. They benefit from being 'greener' towards their consumers but also because they are saving money with natural refrigerants. It's a win-win.

The clear message to EU policy makers: "Be ambitious" and industry will deliver.

Marc Chasserot

About ATMOsphere Europe 2013

For the fifth consecutive year the International Workshop on Natural Refrigerants was held on 15-16 October 2013 in Brussels. The event opened with presentations and discussions regarding the status of the EU's F-Gas Regulation Revision, during which attendees heard from representatives of the European Parliament, the European Commission, and Member State Governments, and voiced what they believe a revised and strengthened Regulation can achieve. The latest market trends were also reviewed as well as latest technology developments, such as high temperature ammonia and hydrocarbon heat pumps, and solutions to make CO_2 commercial refrigeration viable for convenience stores and in hot climates. This largest ever ATMOsphere conference gathered over 220 decision makers from all major stakeholder groups, and heard from 54 speakers over the course of 11 sessions and lunchtime Technomercials, a popular new addition to the programme. Prior to the two-day conference a pre-event F-Gas workshop was organised, and for the first time, a site visit to see a CO_2 installation in the field was arranged, at the Delhaize Supermarket store in St.-Pieters-Leeuw, Brussels.

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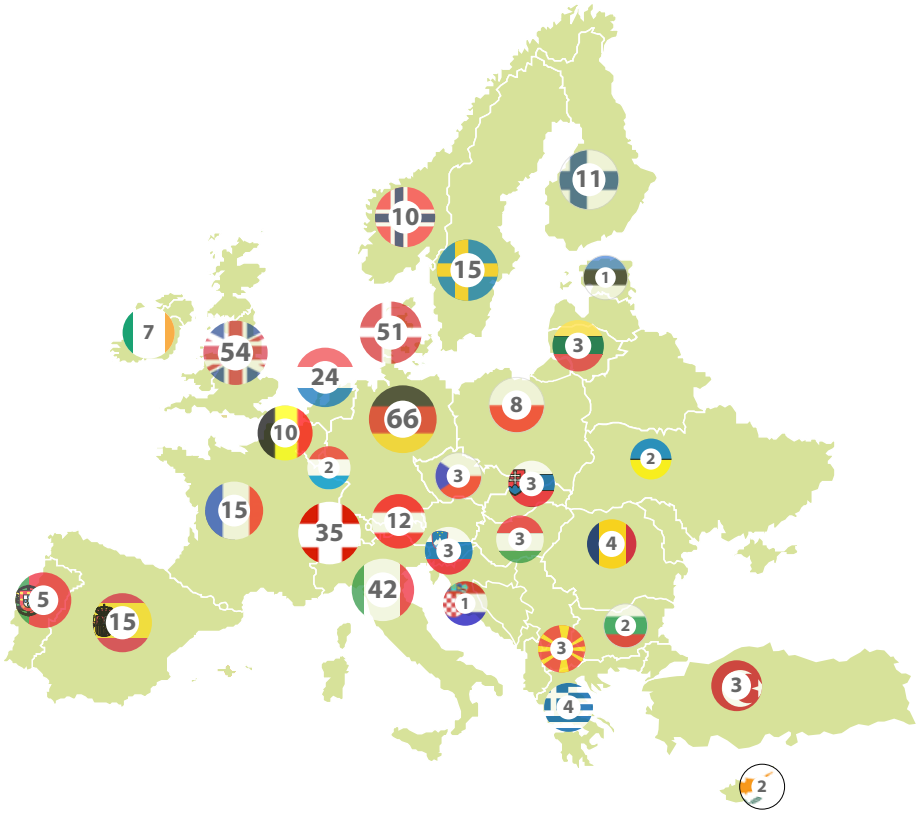
Growing natural refrigerant industry eager for stricter EU F-Gas rules

Taking place in the midst of the negotiations on the new EU F-Gas Regulation, the draft legislation and the measures considered by different EU institutions were at the centre of discussions during the ATMOsphere Europe 2013 conference on natural refrigerants.

the future EU F-Gas Regulation

Already today there are over 400 European companies working with natural refrigerants, highlighted Marc Chasserot, shecco's Managing Director in his opening speech. The map he presented indicates that these companies are present not only in the North, but also in Southern European countries, hence a strong regulatory framework would also benefit the economies and increase the competitiveness of Southern European countries.

400+ COMPANIES IN EUROPE WORKING WITH NATURAL REFRIGERANTS TODAY



"Most natural refrigerant experts will argue and tell you that all of this can be done with natural refrigerants."

Marc Chasserot,
shecco

To provide policy-makers with an answer about the commercial availability of refrigeration and air-conditioning equipment using natural refrigerants, shecco, with input from a large number of industry experts, put together a table indicating the level of commercial availability for the variety of sectors in Europe between today and 2025.

The table shows that in most refrigeration and air-conditioning sectors, natural refrigerants are already commercially available to some extent and will be available with sufficient production capacities in all EU countries in the short-term. "We are seeing more and more trends towards commercialisation of natural refrigerants, whether it is ammonia, CO_2, hydrocarbons, air or water across the board," says Chasserot.

Natural Refrigerant Commercial Availability 2013 - 2025

Commercially available across EU with sufficient production capacity

Semi commercially available (low volume production)

Not yet commercialy available (R&D / demonstraction projects)

Refrigeration	Today	2015-2020	2020-2025	2025
Domestic refrigeration				
Stand-alone units				
Condensing units		2018		
Centralised systems				
Small industrial refrigeration				
Large industrial refrigeration				
Road transport refrigeration		2017		
Container refrigeration		2017		

Air-conditioning	Today	2015-2020	2020-2025	2025
Movable room AC				
Split AC		2018		
Multisplit / VRF AC				
Rooftop AC				
Displacement chillers				
Centrifugal chillers		2018		
Heat pump water heaters		2016		
Heat pumps for space and water heating		2018		
AC in cargo ships				

Industry needs regulatory pressure and clarity

Jo Leinen, Member of the European Parliament and shadow rapporteur on the EU F-Gas Regulation points out that "[the Parliament has] changed the logic of the approach of the European Commission from phasing down to bans with clear dates" so as to give a clear signal to the market to shift to alternative technologies. "Market forces are quite dynamic and innovative to adjust to the regulatory measures," he says.

According to Clare Perry, a senior campaigner at the Environmental Investigation Agency (EIA) unless there is regulatory pressure, the industry will not invest in alternative technologies and only sector-by-sector bans can stimulate innovation - this is the main missing element in the European Commission's proposal and the Council's approach.

"Regardless of your view on whether the phase-down can do the job alone or not, I think we should all agree here that overallocated phase-down will certainly not exert any pressure on the market to change the business-as-usual scenario."

Clare Perry,
EIA

Andrea Voigt, representing the European Partnership for Energy and the Environment (EPEE) contradicts this view. "The Commission has proposed a very ambitious phase-down. EPEE and our members support this very ambitious phase-down as a way forward and we firmly believe that this is going to make the change happen," she says. However, the EIA points out that the massive overallocation of HFC quotas, as shown in the Commission's, Council's and Parliament's phase-down proposals will not deliver the necessary pressure on the industry to motivate them to invest in natural refrigerants.

Looking at the experience from other regulations, such as the EU Emissions Trading System (ETS), Bas Eickhout, European Parliament's rapporteur on the F-Gas Regulation also stresses: "We see that if you have a lot of overallocation in the beginning you are keeping problems for later on," which is why the European Parliament would like to see a stricter phase-down schedule. Another lesson from the ETS relates to allocation of quotas upon a fee so as to avoid windfall profits from grandfathered allowances. According to Eickhout an allocation fee would in addition stimulate the work of companies on the decrease of f-gases.

The Council however has been very reluctant so far to support a price related to quotas, with the exception of a few Member States that have been in favour of an auctioning system as a preferred option. According to Samuel Just, Policy Advisor at the French Ministry of Ecology, Sustainable Development and Energy, an allocation mechanism is fair and non-discriminatory with the possibility for any producer or importer to participate. Such a mechanism would limit the market distortions and provide revenues to fund the global reduction of HFCs, Just notes.

European companies are ready for the change

During the two-day conference, several industry representatives voiced their support for an ambitious F-Gas Regulation with clear timelines for different sectors. While there is already a lot happening in the European refrigeration and air-conditioning sector even without regulatory measures, European companies are asking for political support to bring their innovative natural refrigerant-based solutions faster to market.

The industry recognises the importance of regulatory action as it gives strong signals to the market. "The F-Gas Regulation matters. Since there was the vote in the Environment Committee in the Parliament we have a significant increase in our activities. […] It doubled just overnight and it continues to be there," underlines Torben Hansen, Director of CO_2-based system manufacturer Advansor, as an example of how fast the market can react to clear regulatory measures.

"We believe the industry and its customers can be ready for the transition from 2018 for supermarkets and from 2025 in mobile refrigeration. […] We continue to support a ban of HFCs for stationary and mobile refrigeration applications in the new F-Gas Regulation. This will avoid unnecessary and costly intermediate solutions for our customers and the industry."

Thierry Jomard,
Carrier Commercial Refrigeration

"Industry is able to develop the technologies and make them cost-efficient, as long as we give the signal [to companies]. Let's not talk about ambition, but just accept the change."

Sylvain Gillaux,
SANDEN Europe

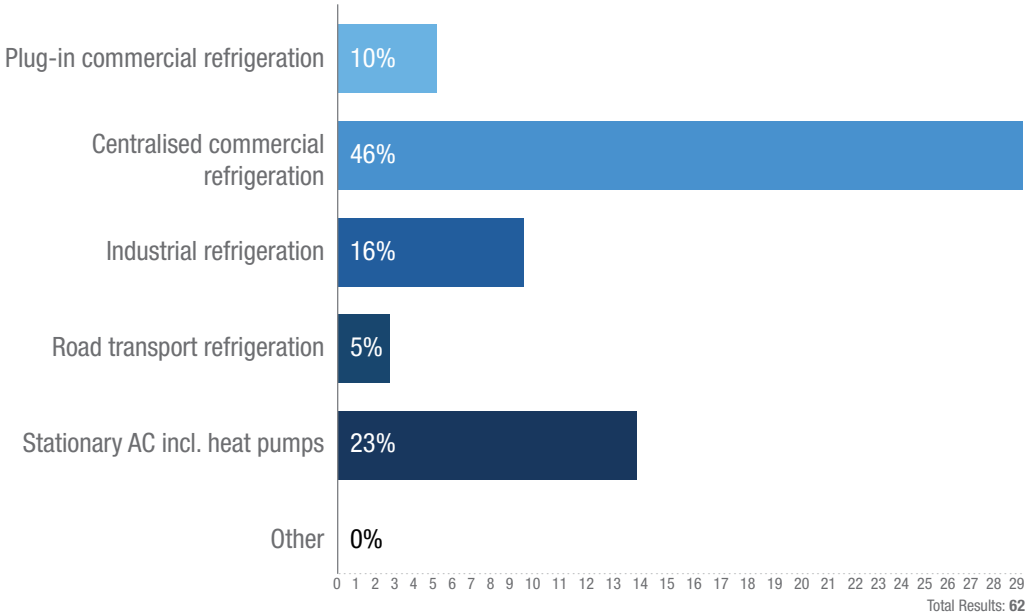
The strong signals by the European Parliament were welcomed by Thierry Jomard, Vice President and General Manager Mechanical Systems at Carrier Commercial Refrigeration: "We warmly welcome the strong push by the European Parliament to use natural refrigerants for refrigeration."

Similar messages were voiced by experts from the air-conditioning and heat pump sector: "We are not afraid of competition, but we need some support in the first months or years to move forward to natural refrigerants," insists Sylvain Gillaux, European Sales & Marketing manager at SANDEN Europe, a company that has taken a strategic decision to build their future business around the natural refrigerant CO_2 for both light commercial refrigeration and heat pumps.

HFC bans are also considered as the only way to greater and faster adoption of natural refrigerants, especially by smaller end users. There is still a significant potential for broader scale adoption of natural refrigerants, as far as smaller end users are concerned, who unlike food retailers typically do not have sustainability strategies. This is the case for example for plug-in refrigeration equipment used at kiosks, and on premise accounts (bars, restaurants, hotels). "If we would have in our [EU F-Gas] regulation a 100% HFC ban, we could also tackle some of the accounts and some of the placements which are not so much in focus right now […] We see that the only potential to have also these accounts fully aligned with the natural refrigerant strategy, would be to have the legislation in place requiring their use," highlights Jürgen Brenneis, Team Leader Electrican Appliances & POS at Red Bull.

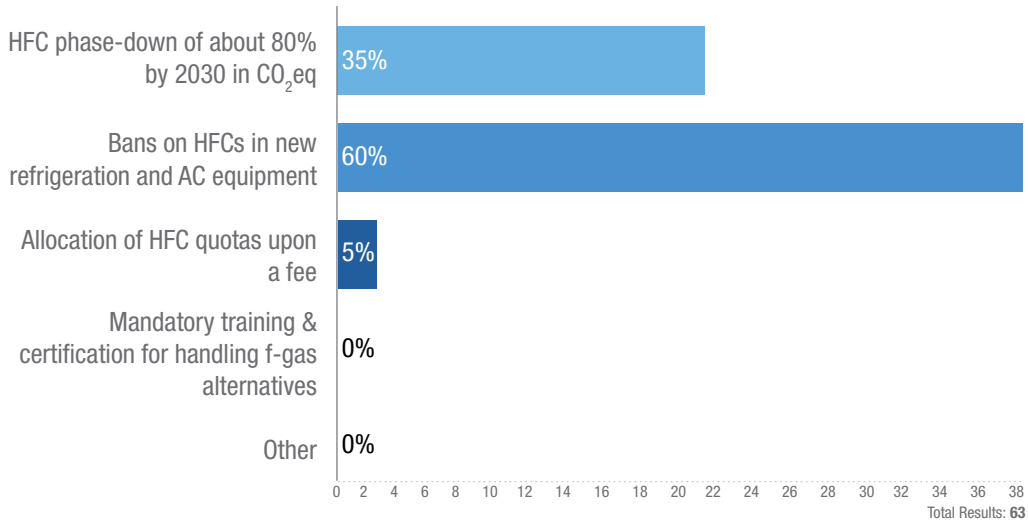
Conference participants from around 100 innovative European companies working with natural refrigerant technologies had an opportunity to contribute to the debate through live polling. Nearly two thirds of those that participated in the polls communicated that they are eager to get clarity and support from the policy-makers in the form of sector-specific bans on HFCs in new equipment as the most important measure that will drive the uptake of natural refrigerant technology.

In which sector do you consider an HFC ban to be the most relevant in terms of driving innovation and ensuring growth of EU companies?



In addition, participants consider the commercial refrigeration sector, followed by stationary AC, including heat pumps, and industrial refrigeration, as the three most relevant sectors for which HFC bans would drive innovation and ensure growth for European companies.

Which type of measure considered in the F-Gas review do you regard to be of key importance in driving the uptake of natural refrigerant technology?



"As far as industrial refrigeration is concerned, it is very important for politicians to understand that the industry needs a stable legislative environment. [..] An HFC ban on new industrial refrigeration equipment can be applied today without a problem because natural refrigerants are proven technology in industrial refrigeration and we hope that all the other subsectors of refrigeration will follow very soon."

Eric Delforge,
Mayekawa Europe

"From the Parliament's perspective it is very important to have more clearly defined sectoral bans in order to give very clear market signals to everyone in this room and outside this room. This is really one of the key aspects, because until now the Council has been very reluctant to take anything on board so this is one of the key discussion topics that we are going to have."

Bas Eickhout,
European Parliament

F-Gas rapporteur Eickhout reassure industry representatives as well as end users that HFC bans will be one of the key aspects that the Parliament will advocate for. Member States, however, have been very reluctant so far to give the green light to additional HFC bans, and discussions on this measure will remain one of the key topics to be addressed in the negotiations among the three EU institutions.

EU could become frontrunner in the global market

Looking at the recent international developments, such as the agreement between the Chinese and American presidents to work together on addressing HFCs or the announcement of the G20 countries to support the phase-down of HFCs under the Montreal Protocol, a number of speakers highlight that with an ambitious F-Gas Regulation, European companies could become frontrunners in the global market.

"Many observers believe that as soon as next year we could have a global deal on HFCs. […] If we get it right and empower legislation that actually supports our alternative businesses and enterprises, it will put them at the forefront of a huge green technology revolution. So it is hugely important not just for the environment, but also to EU business and enterprise," says Perry of the EIA.

"The EU can play a leading role if we get the proposal out as soon as possible. However, it must have an appropriate ambition level, otherwise it is not going to show any leadership."

Bente Tranholm-Schwarz,
European Commission

The timing of the agreement on the F-Gas Regulation also plays an important role as nations from around the world are expected to discuss the curbing of HFCs at a global level in multilateral meetings slated for October and November.

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market trends

NINA MASSON
shecco

LOTHAR SERWAS
Carrier Commercial Refrigeration

ERIC DELFORGE
Mayekawa Europe

REINHOLD RESCH
AHT Cooling Systems

Natural refrigerants trends in Europe and beyond reveal rapid growth in green technology market

Nina Masson, Head of Market Research at shecco presents the changing industry environment and the latest market trends for natural refrigerants in Europe. In terms of the market potential of natural refrigerant solutions in Europe, Masson predicts that carbon dioxide will enjoy a stronger increase in use among system suppliers than most other natural refrigerants, especially in the commercial and industrial refrigeration industry. However, whilst CO_2-based systems will significantly increase in popularity, Masson also believes that ammonia will continue to play a dominant role in industrial refrigeration, and that hydrocarbons will become or remain a preferred option in the light commercial refrigeration sector.

Continued European growth for natural refrigerants in commercial refrigeration sector

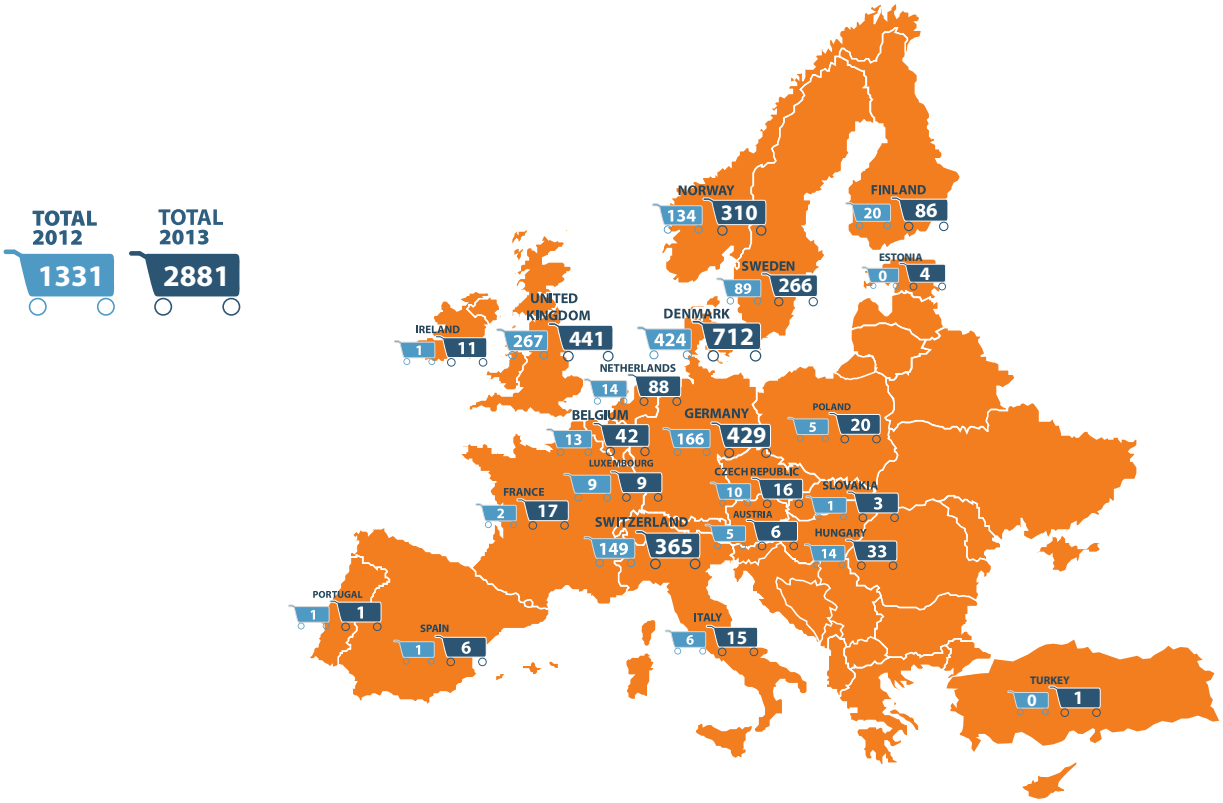
"Europe will continue being the market leader for the coming years and European-based suppliers can benefit from their experience gained, also in other parts of the world."

Nina Masson,
shecco

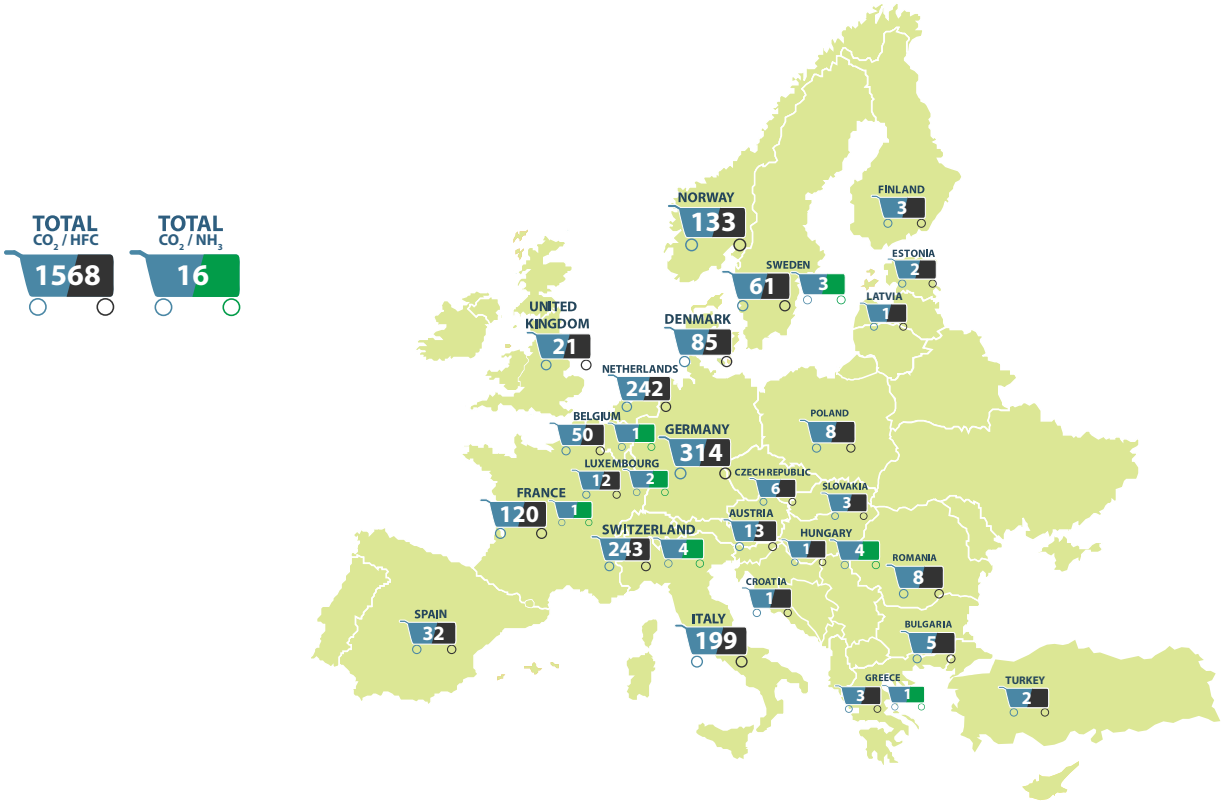
The combination of market, policy and technology drivers have led to an impressive increase in the number of European stores using CO_2-based commercial refrigeration systems in just 2 years. According to shecco's research, compared to the end of 2011, the number of CO_2 transcritical supermarkets in Europe has more than doubled, reaching a total number of 2,881 stores (as of September 2013). At least another 1,568 European supermarkets use CO_2/HFC cascade refrigeration systems, with some other food retailers having tested and applied CO_2/ammonia solutions or hydrocarbon-based commercial refrigeration systems.

From a global perspective Europe leads the world in the use of natural refrigerants in the commercial refrigeration sector.

CO_2 TRANSCRITICAL SUPERMARKETS IN EUROPE



CO_2 CASCADE SUPERMARKETS IN EUROPE



Out of the total 2,881 CO_2 transcritical supermarkets in Europe, UK retailer Sainsbury's, considered a transcritical refrigeration pioneer, revealed at the conference to now have 167 stores using the climate friendly technology, whilst German retailer Edeka Südwest has 106 transcritical CO_2 refrigeration systems and 59 subcritical hybrid cascade systems. Belgian food retailer Delhaize stated that it has 56 stores using natural refrigerants, including 15 CO_2 transcritical stores.

Presentations made by many system manufacturers and suppliers throughout ATMOsphere Europe 2013, provided further confirmation of Masson's analysis that the share of CO_2 refrigeration for commercial refrigeration has grown very fast in recent years.

For instance, according to Lothar Serwas, Manager CO_2OLtec Sales at Carrier Commercial Refrigeration, CO_2 refrigeration for supermarkets has gradually become the market standard in the European food retail sector. Across Europe Carrier has already installed 677 CO_2 transcritical systems, and 409 subcritical CO_2 /HFC systems.

Whilst CO_2 solutions represent more than a 30% share of Carrier's total turnkey in 2013, for Italian manufacturer SCM Frigo, CO_2 represents 50% of the company's production, which includes a range of CO_2 subcritical systems, transcritical packs, CO_2 pump circulation systems, CO_2 condensing units, and CO_2 "Plug-'n Cool" units. To date SCM Frigo has installed over 800 CO_2 units.

"Every time I see the work of end users and the industry I see a great commitment, much greater than politicians are asking of them…"

Torben Hansen,
Advansor

Leading CO_2-only system supplier Advansor says it has supplied close to 1,000 transcritical units, 90% in supermarkets, and spread across 15 countries. Key markets are in Switzerland, Scandinavia and the United Kingdom, although Advansor reports growing interest in Central Europe, and emerging interest in Southern Europe. Torben Hansen from Advansor says that more than 50% of the top 20 retailers in Europe are now trialling or going full-scale CO_2 in their existing stores or new stores, further evidence that this technology is being taken seriously.

market trends

Another important CO_2 system supplier, Green & Cool, has around 500 CO_2 systems installed in Europe and in the United States. According to Green & Cool's Marketing Director Stig-Göran Lind, key market drivers for CO_2 solutions are legislation, cost, efficiency, and green policies.

Swiss consultancy Frigo-Consulting has around 330 CO_2 systems in operation, in Switzerland and surrounding countries, with around 250 of them transcritical installations.

CO_2 refrigeration takes to the global stage

In other regions retailers have also started to adopt natural refrigerants. In North America at least 48 stores use CO_2 transcritical refrigeration technology, with the majority in Canada, and in Japan there are more than 100 using the climate friendly technology. Added to these are CO_2 transcritical stores in New Zealand and South Africa, which bring the estimated global number of CO_2 transcritical stores to over 3,050.

When it comes to CO_2 cascade supermarkets Masson estimates the total global number is over 1,965 stores, with installations in Argentina, Brazil, Canada, China, Colombia, Japan, New Zealand, Singapore, South Africa, South Korea, Thailand, the USA and Venezuela.

In terms of the competitiveness of natural refrigerant-based solutions, Masson believes that new & optimised components and system designs have shifted the efficiency equator further south and will ultimately remove it. Today and in the coming years, she expects that we will see a variety of technological solutions that further close efficiency and price gaps.

Ammonia will defend its market-leading position while CO_2 and NH_3/CO_2 systems will become increasingly competitive

In the industrial refrigeration sector, despite slow overall growth rates in the food industry and industrial refrigeration sector, the move towards a still broader adoption of natural refrigerants is expected to continue. Results from shecco's latest market survey of key industrial stakeholders indicates that ammonia will maintain its market-leading position in the next 7 years, but that NH_3/CO_2 solutions, and to a lesser extent hydrocarbons (HCs), will become increasingly competitive.

"96% of industrial applications use ammonia. It is to be expected that chemical refrigerants will diminish in years to come."

Eric Delforge,
Mayekawa Europe

These predictions are confirmed by Eric Delforge from Mayekawa Europe, who says that ammonia based systems account for about 95% of the market share of the sector in Europe. CO_2 systems have about 4% market share while hydrocarbon (HC) and HFC-based systems account for the rest. Delforge believes that new products and services offered specifically for industrial refrigeration in Europe with natural refrigerants will continue to have a high share of ammonia but will also increasingly focus on the use of CO_2.

The latest technology trends says Delforge, include cascade systems, brine systems and innovative heat exchangers to minimise charge, as well as frequency control, indirect cooling and cascade cooling to increase efficiency. When it comes to industrial heat pumps, ammonia heat pumps that are capabale of producing hot water up to 90ºC, using condensing waste heat and stable thermal heat sources, are gaining favour. Hydrocarbon heat pumps that can produce water with a temperature exceeding 120ºC could also become strong competitors to conventional fossil fuel steam boilers.

Delforge's conclusion is that the industry needs a stable legislative environment. He wishes to see an HFC ban for new industrial refrigeration equipment, stressing that natural refrigerants are a proven technology in industrial refrigeration. Deadlines for phasing out HCFC-22 are already stimulating demand for new industrial refrigeration equipment, creating important transition opportunities for natural refrigerants, a fact also put forth by Masson.

With regards to what end users want to see in the industrial refrigeration sector, Masson argues that whilst they place a strong emphasis on charge reduction and a system's capital cost, in recent years this has been superseded by an even stronger emphasis on safety, reliability and legislative compliance. According to Masson, the influence of policy drivers in the European industrial refrigeration sector will increase in importance, even as compared to technology or cost factors, in the years to come.

Buoyant market for hydrocarbons in stand-alone refrigeration units

"R290 is the best refrigerant for use in ice cream cabinets, bottle coolers and commercial freezers."

Reinhold Resch,
AHT Cooling Systems

Leading hydrocarbon manufacturer AHT Cooling Systems has used hydrocarbons in their ice cream cabinets since 2004, in addition to which it is now producing bottle coolers and supermarket cabinets with R290. AHT has supplied more than 600,000 hydrocarbon units worldwide, including 480,000 in Europe and 3000 in Thailand. AHT delivers more then 50,000 of its hydrocarbon cabinets in Europe every year, with an average of 28 units used in each store.

In 2006 when AHT introduced hydrocarbons and the variable speed compressor to the company's cabinets there was a major step downwards in the energy consumption. With other improvements like optimised fans, and a general improvement of all the components in the cabinet from the sensors to the electronic control, a reduction in the energy consumption in kWh/24h of 50% has been achieved.

Outside the market for stand-alone equipment hydrocarbons have a big market potential for adoption in process cooling in industrial refrigeration sectors in the coming years. Mayekawa's Delforge says that hydrocarbons have favourable thermodynamic properties and material compatibility, and are regarded as one of the most promising working fluids in heat pumping systems. Hydrocarbons are already widely used in the petroleum industry, in domestic refrigerators/freezers and more sporadically applied in residential heat pumps in Europe.

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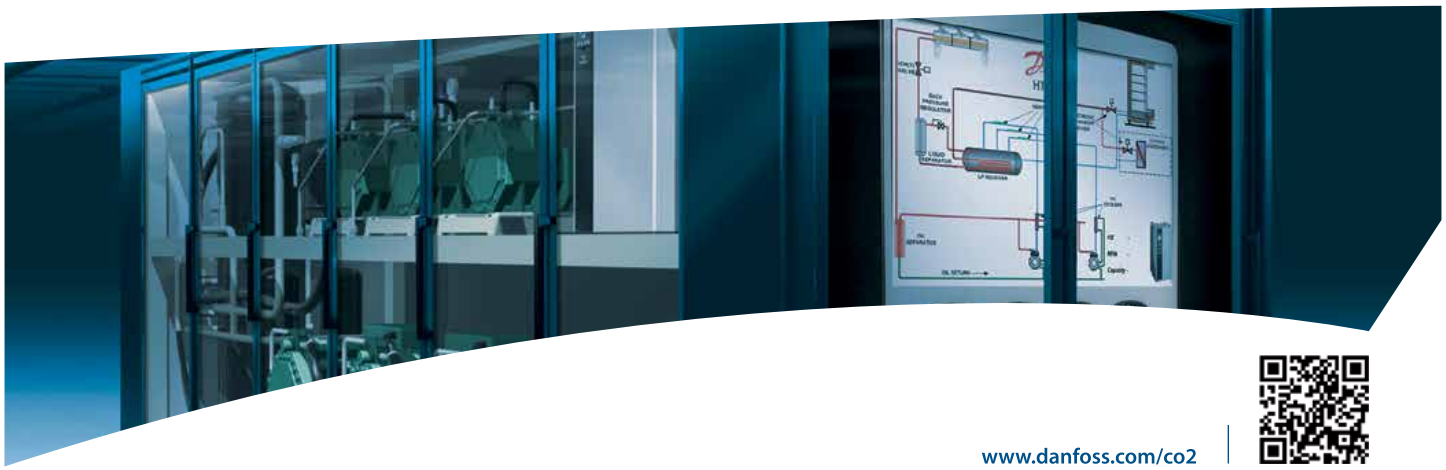

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food retailers & end users

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MICHEL DE ROOIJ
Ahold Europe

PAUL ALWAY
Marks & Spencer

JOHN SKELTON
Sainsbury's Supermarkets

AMAD HAFEZ
Modelo Continente Hipermercados Portugal

GEORGIOS PATKOS
Delhaize Group

MEGAN HELLSTEDT
The Consumer Goods Forum/ Delhaize Group

JÜRGEN BRENNEIS
Red Bull

MAARTEN TEN HOUTEN
Heineken

ANTOINE AZAR
The Coca-Cola Company

Natural refrigerant heating and cooling technologies are future proof solution for end users

The most diverse end user panel organised at an ATMOsphere conference for the first time featured German and Portuguese retailers Edeka and Sonae, alongside leading Belgian, Dutch, and British retailers Delhaize, Ahold, Marks & Spencer and Sainsbury's. Despite retailers not knowing which direction the F-Gas Regulation will go, it was clear that European retailers have decided to go HFC-free, and that CO_2 is the preferred option for many. Company-wide sustainability policies are a key driver of this trend, along with a desire to show environmental leadership.

With a clear shift towards CO_2 refrigeration in large-format stores, a hot topic of discussion for several retailers was the need to achieve cost parity of large commercial CO_2 refrigeration systems with traditional systems, and to find cost effective natural solutions for convenience stores, and also to develop all-natural solutions for hot climates, such as in Portugal. (These latter two points are discussed in separate chapters).

food retailers & end users

Preference for CO_2 transcritical systems confirmed by major Northern European retailers

"Delhaize Group is committed to increasing the number of natural refrigerant systems where they are feasible and cost-effective."

Georgios Patkos,
Delhaize Group

Andreas Nolte, Managing Director of Nolte aktiv-markt, a company that owns several supermarkets under the Edeka Group which is one of the largest food grocers in Germany, set the pro-CO_2 refrigeration tone of the ATMOsphere Europe 2013 Retailer Panel that was to be echoed by fellow presenters. According to Nolte's presentation, since 2009 transcritical CO_2 systems and subcritical hybrid cascade systems have been the preferred choice at Edeka Südwest. As a result, today Edeka Südwest has 106 transcritical CO_2 refrigeration systems and 59 subcritical hybrid cascade systems in operation. The brand's newest CO_2 store will open at the end of November in Koenigstein, and will feature a CO_2 booster refrigeration system with a refrigerant that has been calculated to provide 10% yearly energy cost savings for refrigeration and 35% yearly energy cost savings for heat recovery.

"The big motivator for us [Delhaize Group] is our overall CO_2 emissions goal, which we have had since 2008, and which is a 20% reduction in emissions per m^2 by 2020."

Megan Hellstedt,
Delhaize Group

In his presentation Michel de Rooij, Senior Manager of Technology and Process Innovation at Ahold Europe, draws attention to the key drivers pushing investment in CO_2 technology at Albert Heijn, (a supermarket chain, owned and operated by Ahold) such as the commitment to reduce CO_2 emissions by 20% per m^2 sales area by 2015. He also talks of the extensive in-house research into energy and CO_2 flows undertaken at their 257 hybrid R134a/CO_2 stores and three pilot transcritical stores, research which will enable the retailer switch to natural refrigerants at the end of 2014.

As with the other retailers, reducing GHG emissions is a central part of the Delhaize Group Sustainability strategy, a commitment that has led the retailer to invest in natural refrigerants in 56 stores in Belgium and Luxembourg, including 15 CO_2 transcritical systems in affiliated stores.

"We rose to the challenge of CFCs, HCFCs, HFCs. My business can't believe that we can come up with so many different refrigerants that cost so much money. But hopefully CO_2 is going to put us in a place where we will have some future proofing."

John Skelton,
Sainsbury's Supermarkets

In the UK, Sainsbury's, which operates over 1,000 stores, is considered a pioneer of CO_2 transcritical refrigeration, with 167 stores using the climate friendly technology. These CO_2 installations proved their worth during the hot summer of 2013, helping to show that CO_2 transcritical systems can cope with hot weather peaks.

Incentives to reduce costs will accelerate investment in naturals by retailers

Cost is a key factor in the speed of natural refrigerants uptake and in particular for CO_2 technology systems. Michel de Rooij from Ahold Europe highlights this fact when he says that the retailer's job is to "make money". Investment in CO_2 systems has to make financial and according to de Rooij, the price level of CO_2 installation parts still presents retailers with a significant challenge.

"Feeling as an end user the frustration of everybody of not knowing where the F-Gas Regulation is going to go."

Paul Alway,
Marks & Spencer

Costs were also a focus of Georgios Patkos' presentation, in which he looks at a comparison of three stores to understand the total cost of construction of a store. He concludes that there is work to be done to fine tune and improve the performance of CO_2 transcritical stores, such as reducing accidental leakage, but that the difference in initial investment cost between CO_2 transcritical and traditional systems (about 15%) is coming down.

"Cost still drives business decisions today, but cost is coming down, and I can assure you that in three years time, in our case, this issue changed for us from us thinking that we could not do this, to thinking instead yes, let's go!"

Antione Azar,
The Coca-Cola Company

Patkos believes that subsidies or tax breaks could help CO_2 systems achieve cost parity with traditional systems, but that these are lacking. In cost calculations of new refrigeration installations presented to the Delhaize management for example, a potential future tax on HFC refrigerants is already being taken into account, and Patkos says that this would most certainly accelerate retrofits and investment in naturals.

Paul Alway from Marks & Spencer points out that once a tax on HFCs is introduced then trying to get cost parity between R404A and CO_2 systems becomes a moot point. The argument that retailers cannot invest in a CO_2 refrigeration system because they are too expensive ceases to be relevant. In Denmark, for example, the tax on HFCs has pushed retailers to invest in CO_2 because using HFCs has become prohibitively expensive. Although Alway believes taxes will push retailers to go to naturals, he argues that retailers are moving in that direction anyway.

Experiences with pumped CO_2 systems

UK retailer Marks & Spencer (M&S) has 82 food halls operating with a pumped CO_2 cascade system, out of a total of 542. The retailer has trialled several different CO_2 cascade systems, including pumped CO_2 systems using CO_2/hydrocarbons, CO_2/R404a and CO_2/R134a. According to Alway, the current pumped systems are rather complicated: the HT primary has four compressors, and each one of those compressors has an individual discharge line to its own heat exchanger, condenser, and suction, so there are four 25kW condensing units.

As the retailer's goal is to become HFC-free and to integrate heat reclaim, the question facing M&S today is whether to develop an HFC-free front end for the current installed base of CO_2 pumped systems, or transition to CO_2 transcritical. To test the behaviour of transcritcal CO_2 refrigeration as an alternative to their pumped systems, Alway is building a cold room with 8 to 10 cases inside and a transcritical pack on the outside.

Will CO_2 refrigeration system heat reclaim end natural gas consumption?

As a result of their in depth studies Ahold Europe has learnt how to optimise CO_2 refrigeration to suit their needs, and will now be able to end natural gas consumption, with all heating coming from the cooling system. Sainsbury's on the other hand, remains undecided about whether to source all its heat from heat reclaim from the refrigeration system, due to the success of its 78 biomass boilers, which are saving Sainsbury's around 20,000 tons of CO_2 per year.

More certified people needed to work on natural refrigerant systems

"We have a bigger issue in the whole industry when it comes to the refrigeration competency levels of our engineers."

John Skelton,
Sainsbury's Supermarket

Outside of system costs, another issue slowing the market uptake of CO_2 refrigeration technologies is lack of training. Because John Skelton believes there is still a gap in CO_2 training in the UK, and that there is an industry-wide lack of competency in refrigeration among engineers, he has taken the initiative to invest significantly in training. To begin with, he helped to shape the British Refrigeration Association short course on CO_2, prior to which no such course existed for engineers in the UK. Moreover, Sainsbury's has paid for 90 engineers to go through that course, and has also paid for engineers to go through familiarisation training with different pack manufacturers and with the retailer's control supplier.

Georgios Patkos, from Delhaize also argues that the lack of skilled companies and individual technicians is a barrier to the immediate adoption CO_2 transcritical refrigeration. To move forward Patkos argues for turnkey project contractors that can help overcome the psychological reluctance amongst retailers to start using a new technology. In the meantime the Delhaize Group has committed to sharing and applying best practices on refrigeration and identifying good training programmes.

Maarten ten Houten from Heineken says he has also experienced a lack of trained personnel able to safely service and maintain their hydrocarbon coolers, in particular in developing countries.

As Southern European retailers start their CO_2 journey, will we soon see a European-wide CO_2 future for commercial refrigeration?

In another ATMOsphere first, Amed Hafez, Equipment Manager for Modelo Continente Hipermercados, presents efforts by Portuguese retailer Sonae to eliminate the use of R22 and find natural refrigerant solutions, such as the use of R290 in frozen stand-alone cabinets. Sonae is also investigating the use of hybrid systems.

CO_2 refrigeration the preferred technology of The Coca-Cola Company

Presenting for the second time at ATMOsphere Europe, Antoine Azar highlighted The Coca-Cola Company's preference for CO_2 technology which it will use to replace HFCs, which are being phased out. Today the company has over 1 million HFC-free units on the market.

"It is not a legend, HFC-free systems perform well, their price is going down and there is more and more natural refrigerant training available, so I think with time we are addressing all those elements that posed an initial concern."

Antoine Azar,
The Coca-Cola Company

The view from the end users on stand-alone hydrocarbon refrigeration units

Emulating what is happening in the commercial CO_2 refrigeration market, it seems that company-wide sustainability policies and a desire to show environmental leadership are also driving investment in hydrocarbons, which are well suited to light commercial and plug-in refrigeration applications. The ATMOsphere Europe 2013 presentations by leading end users, such as Heineken and Red Bull, and retailers such as the Delhaize Group, and Sonae, are evidence of this growing trend towards hydrocarbon refrigeration.

For example, Heineken, a global company with over 250 international beers and ciders in its portfolio, has as one of its priorities to embed and integrate sustainability and to reduce their carbon footprint, 28% of which is linked to cooling. As a result, Heineken has set itself as a target to reduce the specific CO_2 emissions from fridges by 42% by 2015 and by 50% by 2020. This has led to a "Global Fridge" policy whereby Heineken "Green Fridges" have to meet five key criteria, including the use of hydrocarbons (R290 or R600a) as the refrigerant, where legally or technically possible.

"Our strategy is 100% HC procurement starting in, starting from the last year already. One exception for us is Japan where we are facing issue to get components, and to get the right sized compressor with hydrocarbons available."

Jürgen Brenneis,
Red Bull

According to Maarten ten Houten as a result of its Green Fridge policy in 2012 Heineken purchased 130,000 fridges, about 65% or these equipped with hydrocarbons. Heineken has also developed the world's first green draught system that uses R290 as the refrigerant and uses 50 to 70% less energy than regular beer coolers. Lastly, the company is also phasing in hydrocarbons for its large draught beer installations, which use 50% less energy than equivalent alternatives.

Another leading end user, Red Bull, has around 457,000 "ECO Coolers", half of its total cooler fleet, which use hydrocarbons as the refrigerant.

In Romania, Delhaize Group has 66 stores working with R290 plug-ins, whilst retailer Sonae is using R290 cabinets in 14 of its new stores.

"They [the retailers] feel they have a future proof equipment with natural refrigerants."

Reinhold Resch,
AHT Cooling Systems

In addition to this, according to Head of Research and Development at AHT Cooling Systems Reinhold Resch, AHT has since 2006 installed 480,000 R290 cabinets in European supermarkets, including at several stores belonging to leading discount retailer Lidl. According to Resch the feedback from retailers has been very positive. Retailers have experienced significant energy savings, and a very low failure rate, whilst product temperature is always maintained lower than -18°C.

Collaborative approach driving the natural refrigerant revolution forward

A central theme throughout both the ATMOsphere Europe 2013 Consumer Goods Forum and Retailer Panel was the collaborative effort by end users and industry to work together to accelerate the market uptake of natural refrigerants in the commercial and light commercial refrigeration sectors.

"I want the support to do more stores, I want the support to do the right thing with convenience stores. I want to know what are the technologies that are coming round the corner? I want people advising me and helping me to make sure that we have the best refrigeration system in our stores. The Sainsbury's door is always open."

John Skelton,
Sainsbury's Supermarket

For example, Sainsbury's attributes its success with speedily rolling out CO_2 transcritical refrigeration, to its close collaboration with its supply base, and thanks to knowledge sharing, which has enabled them to get as much support as possible.

In addition, end users are also joining forces through associations such as Refrigerants Naturally! and The Consumer Goods Forum, each of which is also playing a critical role in encouraging investment in natural refrigerants.

Megan Hellstedt from Delhaize Belgium presents an overview of The Consumer Goods Forum (CGF), which has over 400 members in 70 countries, and is the world's leading association of retailers and manufacturers and their business partners. CGF has five strategic pillars, one of which is sustainability, within which refrigeration is a component.

The CGF board in 2010 passed a resolution, "To begin phasing out HFC refrigerant as of 2015 and replace them with non–HFC refrigerant (natural refrigerant alternatives)". The CGF has a three-pronged approach to reach this goal, one of which is to create a compendium of best practice from which the industry as a whole can learn.

In 2013, the CGF organised their third Retail Refrigeration Summit with the aim of bringing together retailers and suppliers to discuss barriers and solutions to the wider uptake of natural refrigeration systems. Hellstedt summarises the key outcomes of the summit as the following:

- In store proven natural refrigeration solutions are available for larger and smaller businesses, working across different countries and climates
- The cost of natural refrigeration systems is coming down
- The CGF commitment to start phasing out HFCs is widely recognised as the right long term approach
- More work is needed to develop cost-effective systems that work as well in hotter climates
- The industry needs to grow a skills base to build and maintain natural refrigerant systems

Unlike The Consumer Goods Forum, Refrigerants Naturally! has only four members right now: The Coca-Cola Company, PepsiCo, Red Bull and Unilever. However, they have a similar goal to the CGF, ”taking action to combat climate change by replacing fluorinated gases in refrigeration equipment with climate-friendly natural refrigerants”. Collectively, the group has placed 2.5 million HFC-free refrigeration units in major countries around the world. This effort has avoided 1 million tons of CO_2 equivalent emissions.

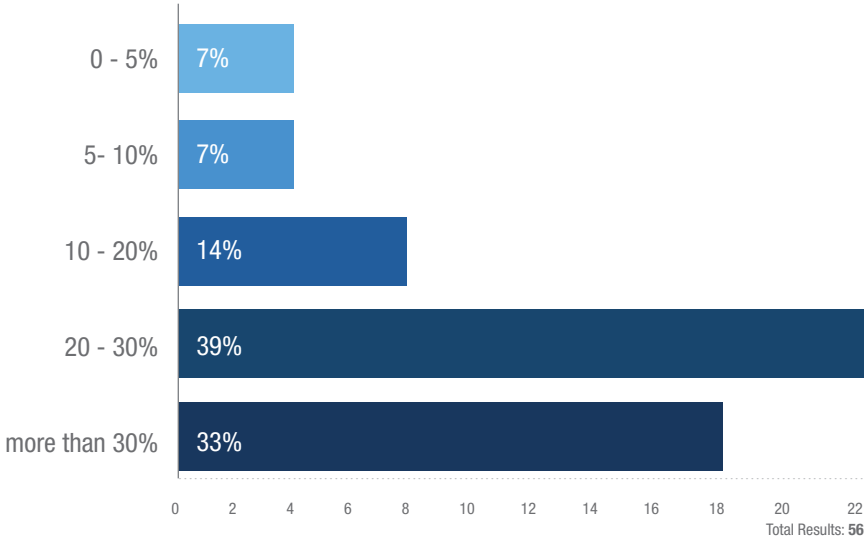
“As of 2015, we [Refrigerants Naturally!] will not buy any more HFCs.”

Antoine Azar,
The Coca-Cola Company

According to Antoine Azar, the main focus for Refrigerants Naturally! member The Coca-Cola Company is to develop the supply chain, to which aim they are working with different companies to make different components available, such as heat exchangers.

Overall, both Refrigerants Naturally! and The Consumer Goods Forum are working to share knowledge, and to spread best practice to accelerate the phase out of HFCs.

What do you predict will be the average percentage of natural refrigerants used in refrigeration by 2015 by The Consumer Goods Forum members as a result of The Consumer Goods Forum pledge?



market innovations

commercial refrigeration for warm climates

TORBEN HANSEN
Advansor

DIEGO MALIMPENSA
Carel Industries

STIG-GÖRAN LIND
Green & Cool

JONAS SCHÖNENBERGER
Frigo-Consulting

SERGIO GIROTTO
Enex

MIRKO BERNABEI
SCM Frigo

"The majority of problems have been solved. I think that is a very important message to take back to policy makers."

Torben Funder-Kristensen,
Danfoss

"We know there are companies testing their solutions for warmer climates, and they are testing effective systems, and they will share their learnings quickly, and we will be able to adopt it. So we believe there is a momentum on that issue and that we have some solutions that are emerging. The question is how to quickly make them cost effective for the industry."

Megan Hellstedt,
Delhaize Group

Improving efficiency of CO_2-only refrigeration for warm climates

With a clear shift towards CO_2 refrigeration by European retailers, a key theme at this year's conference was the need to find a cost effective natural solution for hot climates and push the "CO_2 equator" further south, discussed by both retailers and system suppliers and manufacturers. With 85% of the world's population living in warm ambient climates, for CO_2 heating and cooling solutions to become mainstream, the technology must be adapted to a wide range of ambient conditions, including those with short-lived, high peak temperatures and those with high temperatures for long periods of time.

Technical case study presentations by Advansor, Carrier, Carel, Enex, Frigo-Consulting, Green & Cool and SCM Frigo, indicated promising results from the use of parallel compression, ejectors and mechanical subcoolers, in helping to push this "CO_2 equator" further south towards the Mediterranean.

Retailers call for CO_2 solutions for warmer climates

"All the development work seems to be around transcritical CO_2, parallel compression, ejection etc."

Paul Alway,
Marks & Spencer

"We have the technology for you, and we are ready to help you."

Jonas Schönenberger,
Frigo-Consulting

During the second day's Retail Panel, Hafez told the audience that Modelo Continente Hipermercados are trialling their first hybrid CO_2/R134a cascade system. However, given the shift towards using all-natural refrigeration systems, he asked industry how confident they were that efficient CO_2 transcritical solutions for warm climates would be available soon, and asked what the expected energy consumption of such systems would be compared to hybrid CO_2/R134a systems.

In answer, several suppliers talked about a number of projects and technologies that can make all-natural systems efficient even in high ambient climates. For example, Juergen Goeller, Director Sustainability of UTC Climate, Controls & Security Europe, Middle East, Africa (EMEA) says:

"We are working to move this so-called CO_2 equator line towards the Mediterranean and even across the Mediterranean Sea. We have three pilot projects on the Iberian Peninsula, one in the North East, one in Madrid, and one in the South East of Spain, which is not yet running. From what we have seen in the two stores that are already running, we are very confident in this new design of the transcritical system."

Hansen from Advansor says, "Our experiences are not in the Iberian Peninsula, but in the US, where we also had 44°C this summer, and in Central European climates where temperatures reach 40°C, and we are very confident that we get efficient operation".

Promising initial results from Carrier for CO_2 transcritical in warm climates using mechanical subcoolers

Carrier is working on the following innovations to eliminate the "CO_2 equator":

- Economizers: installed in Germany, Switzerland, Italy and Spain
- Mechanical subcoolers: the first hydrocarbon mechanical subcooler has been installed in Spain, with two more planned
- Ejectors: currently being lab tested in Carrier's R&D centre, and for which field trials are planned in the coming year
- Expanders: have also been modelled, but not yet been further investigated due to other more promising solutions

Data from the field trial of their CO_2 transcritical booster and roof-top mounted hydrocarbon mechanical subcooler installation in Spain show measured energy consumption is equal to HFC systems in southern European climates. Goeller says the installation, which has an MT refrigeration capacity of 310 kW, has been operating successfully for one year in a supermarket in the North West of Spain. Moreover, the CO_2 MT rack gains more than 30% in capacity, the installed cost €/kW MT is equal to the existing CO_2 range and the serviceability is equal to established CO_2 technologies. Also highlighted by Goeller is that an electrical power saving of 14% can be achieved at an ambient temperature of 38°C.

Warm climate solutions in the form of high-pressure subcoolers and parallel compression, from Advansor

According to Torben Hansen, Advansor is working on warm climate solutions for central European countries such as Romania, developing high-pressure subcoolers. These systems involve the addition of a heat exchanger to get more sub-cooling, connected to a chilled water system that improves efficiency in comparison to having to compress CO_2 from -7°C. Other warm climate solutions proposed include removing flash gas by parallel compression, and water spray adiabatic systems, which also help to reduce flash gas.

Carel Industries and Green & Cool tehnologies that can provide comparable efficiencies with CO_2 hybrid systems in warm climates

Diego Malimpensa, Application Manager at Carel Industries, in his presentation on CO_2 integrated systems for warm climates, looks at using parallel compression and flash gas valve synchronisation to improve CO_2 efficiencies in warm climates.

Looking at the performances of systems only with the flash gas valve or with a parallel compressor Malimpensa shows that the system efficiency improves at higher ambient temperatures. In fact, the parallel compressor can only run when the outside air temperature is 15°C or higher.

To evaluate the performance of these adaptations, Malimpensa says Carel tested their booster system with flash valve and with parallel compression, in systems installed across three different cities: Munich, which has an average temperature of 8°C, Venice, which has an average temperature of 13°C and Palermo, which has an average temperature of 18°C. Using these systems he says that a 5% energy saving was achieved in Munich, a 7% energy saving was achieved in Venice, and a 10% energy saving was achieved in Palermo. Comparing these results to those of a cascade CO_2/R134a system, Malimpensa concludes that in Palermo the energy saving results of a booster with parallel compression is comparable with those of a cascade CO_2/R134a system, which a few years ago was unthinkable.

Stig-Göran Lind from Green & Cool also mentions the company's CO_2 R&D undertaken to make sure their "ECO" products achieve a high COP even under high ambient temperatures. These developments include flash gas removal and parallel compression.

Frigo-Consulting's advanced CO_2 booster system using ejectors

Jonas Schönenberger, working with Swiss consultancy Frigo-Consulting, presented a case study of a CO_2 transcritical installation in a Migros Bulle store in Neuchâtel, Friboug, which has a surface area of 5,000 m^2. The system has an MT cooling capacity of 120 kW and a LT cooling capacity of 55 kW. The CO_2 system installed is equipped with ejectors, and has one of the medium temperature compressors shifted to a parallel compressor, and a low pressure receiver added.

This is unlike a standard transcritical booster system with parallel compression, says Schönenberger, where all the cabinets are operating at dry expansion, and where the refrigerant is superheated, which leads to an evaporation temperature of -8°C.

According to Schönenberger the use of ejectors, which recover throttling losses in the system, allow liquid or vapour to be sucked out of the low pressure receiver and fed back into the medium pressure receiver. This in turn means the flooded evaporators show a much higher heat exchange efficiency and the evaporation temperature can be increased to approximately -1.5°C, a considerable difference from the standard booster system -8°C evaporation temperature.

There are two key benefits of the ejector system when compared to the standard booster system: the evaporation temperature can be increased, and a part of the vapour is shifted from the medium temperature compressors to the parallel compressors, to reduce the work on the other compressors.

"I doubt that there is something like a CO_2 equator."

Jonas Schönenberger,
Frigo-Consulting

Thanks to these factors the measured efficiency increase of using the ejectors to recover throttling losses was 12% compared to a CO_2 booster system with a parallel compression unit. Schönenberger concludes that by travelling further south, the recovery of these throttling losses increases, as does the potential to increase efficiency.

Combining auxiliary compressors, evaporator overfeed and expansion energy recovery to improve efficiency of CO_2 transcritical by up to 25% in warm climates, by Enex

Enex president, Sergio Girotto, highlights three key solutions that have been identified by his company to improve the energy efficiency of CO_2 in warm ambient temperatures:

"We believe that the solution presented with overfeeding can be used anywhere, with a significant advantage. In warm countries we believe that to have a performance system we need to implement all the best solutions, and in this way compete, and overcome the efficiency gap."

Sergio Girotto,
Enex

- Systems with auxiliary compressors for flash vapour compression
- Systems with evaporator overfeed
- Energy recovery from throttling process

What energy savings can be expected using these solutions in a climate such as that found in Southern Italy? According to the results presented by Girotto, using evaporator overfeeding a 12 to 15% improvement in energy efficiency can be achieved in Southern Italy. Adding auxiliary compressors to this improves energy efficiency by 15 to 20%, and adding expansion energy recovery on top of this improves energy efficiency by 20 to 25%.

SCM Frigo presents CO_2 pump circulation system for high temperature efficiency

"CO_2 is a reality for the European retail market, and the technology will continue to improve."

Mirko Bernabei,
SCM Frigo

SCM Frigo's development efforts to widen the application range of CO_2 systems to warm climates were presented by Technical Director Mirko Bernabei. He says one of the applications SCM Frigo have developed is a CO_2 pump circulation system for MT, with a direct expansion LT, featuring the possibility to use CO_2 or NH_3 for condensation. The CO_2 pump circulation system is easy to manage and is also more efficient in high temperature climates.

commercial refrigeration for convenience stores

MARC CHASSEROT
Chairman ATMOsphere Europe 2013, shecco

MICHEL DE ROOIJ
Ahold Europe

JOHN SKELTON
Sainsbury's Supermarkets

SYLVAIN LAMY
Emerson Climate Technologies

CHRISTIAN HEERUP
Danish Technological Institute

TORBEN HANSEN
Advansor

STIG-GÖRAN LIND
Green & Cool

CO_2 solutions for convenience stores, the next big challenge

The Commercial Refrigeration Panel, chaired by Marc Chasserot, Managing Director of shecco and Chairman of ATMOsphere Europe 2013, focused on both end users, and suppliers of natural refrigeration solutions. Whilst the panel showed strong commitment to using natural refrigerants, and discussed the advantages of CO_2 systems like increased energy efficiency and reduced operating costs, the use of natural refrigeration systems for smaller stores was presented as a challenge, but one with a growing number of solutions.

Due to limited space and higher costs resulting from the slower pay off from energy savings, retailers are calling for cost efficient CO_2 solutions for small stores. ATMOsphere Europe 2013 presentations showed that suppliers have already developed several low capacity range natural refrigerant solutions to reach a whole new market segment: smaller sized stores.

Skelton from Sainsbury's was one of the most vocal retailers on the need for smaller capacity solutions: "Probably the reason we only have the one convenience store using CO_2 is because at the moment we are finding it easier to get to the right cost point with supermarkets, and more difficult in convenience store applications. That is something that we need to change, and rather quickly. Whether it is CO_2 or another natural, we made a commitment back in November 2009 that all of our refrigeration systems would be natural by 2030, and the piece that is holding me up delivering that, at the moment, is our convenience estate."

"For the smaller stores, it is really too expensive. Not being able to solve this problem is really annoying as we have a lot of small stores in Holland."

Michel de Rooij,
Ahold Europe

Michel de Rooij, from Ahold Europe, also stresses the importance of finding cost effective natural solutions for their high number of small stores in operation, needed in order for the retailer to achieve its environmental targets.

Panel discussions did however reveal that suppliers are aware of the need to offer efficient and cost effective natural refrigeration systems for lower capacity ranges.

Earlier in the day, Sylvain Lamy, Marketing Manager, Refrigeration Compressors, Emerson Climate Technologies, talked about their latest innovations to help retailers to adopt CO_2 refrigeration systems in their convenience stores. Lamy says system compactness has already been reduced and that energy efficiency is 3-6% higher than for standard HFC systems. New CO_2 scroll and digital scroll technologies will also help to make systems more cost competitive in the near future. His conclusion: CO_2 refrigeration technology for small stores is readily available and convenience store operators can afford to make the transition to CO_2 now.

Scandinavian refrigeration system suppliers Advansor and Green & Cool also confirmed that solutions for smaller capacities have already been developed and are available on the market. Green & Cool has designed a small CO_2 pack to meet the requirements of convenience stores, whilst Advansor offers condensing units with CO_2 as the only refrigerant for medium and low temperature, in one system. Advansor's systems from 3-10 kW are available for indoor and outdoor installation.

Christian Heerup, a Senior Consultant at the Danish Technology Institute (DTI) also talked in his presentation about measures to improve the efficiency of small transcritical CO_2 supermarkets. He referred to Danish retailer Fakta, which already has around 150 CO_2 transcritical stores in operation today, amongst which is a small discount store. A comparison by Heerup of the average energy consumption of conventional HFC refrigeration systems and second generation CO_2 transcritical systems in different supermarkets of the Fakta chain showed that huge improvements in energy consumption have already been achieved. Compared to conventional HFC systems, the second generation of environmentally friendly CO_2 transcritical systems have lower energy consumption in winter and equivalent energy consumption in summer. What is more, further improvements in energy consumption can be achieved by systems with heat recovery.

commercial refrigeration using integrated systems

JENS KALLESØE
Advansor

DIEGO MALIMPENSA
Carel Industries

All of a supermarket's needs wrapped up in one system

One of the major CO_2 innovations featured during the Commercial Technology Case Studies session was integrated systems with parallel compression, which can provide refrigeration, air conditioning, and heat reclaim. With a single system, all of a supermarket's thermal needs can be met.

The latest CO_2 innovations; integrated systems that are able to provide refrigeration, air conditioning and heat reclaim were introduced by Advansor and Carel Industries. Using parallel compression, the systems showed higher energy savings compared to a traditional CO_2 booster system, also in high ambient temperatures.

"We can combine all thermal demands of the supermarket now in one system."

Jens Kallesøe,
Advansor

Jens Kallesøe, Advansor's Nordic Sales Manager, presented Advansor's Sigma system, which combines the supermarket's entire thermal needs (refrigeration, AC and heat recovery) in one unit and was installed in a new Coop Maxi store in Tocksfors, Sweden. It incorporates new technologies such as parallel compression and heat pump function with artificial loads on the cabinets.

One of the main specifications of the new store was that it needed to be self-reliant for heating in the winter, as there was no opportunity to install district heating. This meant that during the winter, all heat from the system would need to be reclaimed. To meet this challenge, Advansor installed two heat recovery units in the total system. Efficient heat reclaim is achieved with parallel compression, which takes the gas directly from the receiver to the high-pressure side without using a gas bypass valve, and a false load evaporator. Since the parallel compressor is being used to gain heat, it has a better COP factor (heat COP of 3.2) compared to the LT or MT compressors. Kallesøe says that with the artificial load, the store produces more heat than it needs and delivers the surplus heat for a local community district heating system.

The two systems operating in Sweden have shown 700kW of AC production capacity, which should fit the needs of every store, even in southern Europe, says Kallesøe. Today, Advansor has installed nine of these systems in Europe, seven of which include the AC evaporator and two of which only have the parallel compressor for high ambient temperatures.

"We have an entire system that is managed by one single device. That means: lower installation costs; increased usability (one point of access); faster commissioning; and improved efficiency."

Diego Malimpensa,
Carel Industries

Diego Malimpensa, from Carel Industries, introduces a similar innovation: systems that provide refrigeration, AC and heat recovery controlled by a single controller. Such a system was installed in a medium-sized supermarket in southern Germany, and is also applicable in southern Europe.

The integrated Carel controller controlled system features two MT (medium temperature) compressors with a capacity of 60kW, one LT compressor with a capacity of 8kW, one parallel compressor with a 12m^3/h flow rate, one heat recovery heat exchanger with 75kW, and one air conditioning heat exchanger of 30kW.

The integration of refrigeration, air conditioning and heat reclaim in one system provides the simplicity of one unit for several applications, but needs a single controller to provide information on the power consumption of each of the components: refrigeration, AC and heat reclaim.

industrial refrigeration

ALEXANDER COHR PACHAI
Johnson Controls

ROBERT SOSSI
Mayekawa Germany

KENT HOFMANN
Green & Cool

Increasingly competitive low energy consumption CO_2 and NH_3 solutions

Mayekawa and Green & Cool presented two innovative industrial refrigeration case studies featuring a bakery production plant in Germany and a brewery in Norway. Both projects noted significant energy savings.

Robert Sossi, Technical Manager from Mayekawa Germany, presented on a project involving a CO_2/NH_3 cascade system deployed in a bakery production plant. The project was undertaken to fulfil a customer's need for nearly 3 MW for the direct freezing of bakery products at -35°C. According to Sossi the system designed has:

- A low temperature at useful pressures, which can be used for defrosting
- Can maximise the COP
- Can be used directly in freezing applications
- Is low cost
- Poses less risk for food safety
- When used in a CO_2 cascade system it reduces the ammonia charge, which can reduce insurance costs
- Saves energy and reduces CO_2 emissions

"Natural refrigerants are the main trend for refrigeration in the food industry and it will increase."

Robert Sossi,
Mayekawa Germany

The Mayekawa system employs different high-pressure compressors, including screw compressors and piston compressors. The hot gas defrost is accomplished by the CO_2 system. One piston compressor has a design pressure of up to 66 bar. The rest of the plant consists of one screw compressor achieving a freezing capacity of 740kW at -40°C, and 606kW for defrosting at 8°C, and 4 piston compressors, each with a capacity of nearly 1.2 MW at -40°C for freezing and nearly 700kW for defrosting. The high temperature side is realised by an ammonia system with 3 screw compressors, which have a capacity of 3.5 MW watts at -12°C evaporation temperature.

The total freezing capacity of the CO_2 system is roughly 2.9 MW at -40°C with a COP of 4.1. The total capacity of the ammonia system is 3.5 MW and it has a COP of 3.5. Combined, the cascade system has a total COP of 1.68. Sossi's analysis shows that the condensing temperature of the system could be further reduced to 25.9°C, which would save 180kW energy on the high stage side, resulting in a COP of 1.88, an increase of 12%. When calculated for one year of operation time, 870,000 kWh of energy could be saved per year. At 70 cents per kW, this would result in savings of more than €600,000 per year.

Another presentation by Kent Hofmann, from Green & Cool, focuses on process cooling with CO_2 at a Mack Brewery in Norway, which produces mineral water, lemonade and beer. The goal of the project Hofmann describes was to double the production capacity while increasing energy savings by 50%. The most important aspects of the project were the efficiency of the chillers and the heat recovery.

The brewery chose to install two transcritical CO_2 chillers with a total capacity of 500kW at a brine temperature of -8°C. In addition, outdoor gas coolers and heat recovery for tap water and air ventilation were needed. The project received some government funding, in total around 2.5 million Norwegian krones (€300,000), for being the first CO_2 installation in a Norwegian brewery. Since installation, the project has recovered 170,000 kW/h for tap water and 300,000 kW/h for the ventilation system. The system has proven low energy consumption and high energy recovery.

transport refrigeration

SÉBASTIEN LEMOINE
Carrier Transicold Europe

MADS SIGSGAARD
DSI (Dybvad Stål Industri)

PAULO CEBOLA SANTOS PEREIRA
Thermo King

Natural solutions throughout the cold chain, including the transport sector

As the emission targets of corporations are becoming more ambitious, natural refrigerants have a vital role to play in achieving these targets throughout the cold chain. Several presentations at ATMOsphere Europe 2013 demonstrated the various natural refrigerant applications available for transport refrigeration, which represents 2% of European emissions.

Sébastien Lemoine, Director of Products & Sustainability, Carrier Transicold Europe, presents Carrier's CO_2 container, which is now commercially available after two years of testing, and which could help to lower the environmental impact for marine shipping. Lemoine highlights that in terms of energy efficiency, training, reliability and performance the new systems have exceeded the expectations and are ready for the market. He also points out that CO_2 is the preferred refrigerant for Carrier in terms of safety and achieved energy efficiency. According to Lemoine, retailers such as Sainsbury's, which is currently trailing CO_2 trailers, are pushing suppliers to find consistent solutions across their entire cold chain.

Mads Sigsgaard, Regional Sales Manager at DSI, a Danish company specialised in the niche market of plate refrigeration offers vertical and horizontal plate freezers for fishing vessels using CO_2 and ammonia. Today the technology is well proven and 80% of freezers use either ammonia or CO_2. DSI has developed a special plate freezer with a reduced volume of CO_2. Sigsgaard says that the freezing capacity with CO_2 is increased by 4-8% compared to ammonia at -40°C and is further increased to 30-40% at -50°C temperature level. In total, DSI has delivered more than 500 CO_2 plate freezers for European fishing companies.

Paulo Cebola Santos Pereira, CryoTech Business Leader from Thermo King presents a new technology trend in the transport refrigeration sector, the open cycle CO_2 refrigeration system. In this system liquid CO_2 is obtained as a by-product from industrial production and stored in a tank mounted to a truck. When released it cools the air through an evaporator coil located in a refrigerated space. Retailer Spar in the Netherlands has already converted 100% of its fleet to the new technology achieving a 27% lower logistic carbon footprint.

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ait-deutschland

THORE OLTERSDORF
Fraunhofer ISE

MATHIAS SAFARIK
ILK Dresden

Natural refrigerant heat pumps are widely available

As Europe moves towards low-carbon and low-energy buildings, investments need to be made in sustainable energy sources and things like solar shading, ground source heating and heat pumps. Despite the European recession, the heat-pump market continues to rise about 8% per annum, equalling about €3 million per year in the EU. The problem is that the synthetic refrigerants applied in many of these systems use high global warming potential (GWP) HFC refrigerants. As was demonstrated by presentations during the heat pump technology case study session at ATMOsphere Europe 2013 however, there are many low GWP natural refrigerant alternatives already available today.

Efficient ice slurry generation with water as a refrigerant

In the air-conditioning sector, the use of water as a refrigerant, ice slurry generation by vacuum freezing and ice storage is being demonstrated in a pilot project at the University of Applied Sciences in Zwickau, Germany.

"Hydrocarbons, ammonia or CO_2 units are widely available all over Europe, so I can't accept that people say the technology isn't there yet. They are widely available and this is something we really should focus on."

Menno van der Hoff,
KNVvk & NVKL

In his presentation Menno van der Hoff, from KNVvk & NVKL concludes that natural refrigerant technology is ready to help satisfy demands for zero-energy buildings, high COP, and higher comfort (often demanding mutual heating and cooling). His presentation displays, merely as a starting point, ten natural refrigerant heat pump brands commercially available in Europe in the 40kW - 400 kW range. Van der Hoff says that in Denmark alone there are over 1000 such natural refrigerant heat pump units in operation.

Regarding smaller installations such as de-central heat pumps, van der Hoff predicts that China will sell quite a lot of propane-based systems. For large buildings, natural refrigerant in-direct systems connected to both warm and cold-water output will be useful in supporting both heating and cooling loads. Thermal storage can be used to keep what is not immediately needed in terms of hot- or cold-water output, which can be used at a time when it is really needed. Doing so can double COP, says van der Hoff.

"The message I'm telling you is that these technologies are available, we just have to pick them up," said van der Hoff.

"Can't afford to ignore what we call this river of gold, which is flowing past their doorstep."

Andy Pearson,
Star Refrigeration

Large ammonia heat pumps more advantageous than CHP and can produce hot water up to 90°C

Andy Pearson, Group Engineering Director at Star Refrigeration, who opened up the ATMOsphere Europe 2013 Technology Case Study Session dedicated to heat pumps, highlighted the large potential for ammonia heat pumps to deliver district heating, by tapping into rivers for heat for example. To illustrate this point he refers to the main river in Glasgow, which has a flow rate of about 100 m^3 per second. If the total flow of this river were chilled by 2°C (from 10°C to 8°C) this would produce 840 MW of heat capacity, "absolutely gigantic potential". Pearson notes that even cities like Brussels, where the ATMOsphere conference was being held, have a river hidden beneath the city's vast road network that can be tapped into for heat.

According to Pearson, there are four things that need to come together to generate a good return on investment for a district heating project. For a start a heat source needs to exist and there has to be a need for that heat, and these two factors need to be reasonably coincident. In addition to this, the end user needs to have the vision to believe that that they can undertake a district heating project, and lastly the equipment capability needs to exist.

Having outlined these key criteria Pearson goes on to look at Glasgow University, which has a high heating requirement, and currently spends £4.3 million (€5.04 million) on electricity, £1.9 million (€2.23 million) on gas, £1 million (€1.17 million) on water and £0.2 million (€0.23 million) on heating oil. Glasgow University is near the river Kelvin, which has a flow rate of about 0.5m^3/s. If the river flow was cooled by 2°C it is estimated that about 28 MW of heating could be provided, and this just by heating the river with a heat pump.

Pearson's comparison of a centralised heat pump with a gas district heat heating system and a gas combined heat and power (CHP) system for a 10MW district heating project in the UK, assesses the heat pump as the technology with the most benefits. This is because a centralised heat pump has a COP of 4 where as for gas district heating this is only 0.85, since only 85% of the heat is recovered by the boilers from burning gas. For gas CHP the efficiency is only 0.37 for electricity and 0.43 for heat.

Whilst the operating cost of the centralised heat pump is £0.9 million (€1.05 million) per year, for gas district heating this is £1.6 million (€1.88 million) per year and for the CHP it is £0.62 million (€0.73 million) per year. What is more, although the installation costs for the heat pump are higher, approximately £4 million (€4,69 million) compared with £0.5 million (€0.57 million) for the gas boiler, for the CHP system installation costs are estimated to be £7 million (€8.21 million). With regards to return on investment, those for the heat pump and CHP are calculated to be on par - 17.5% for the heat pump and for the CHP 14%.

"There is strong evidence that heat pumps work, that they are low carbon, that they are economical, that the river provides a good source of heat and that the University heat demand is significant. But the key thing here is that ammonia is the key to the economics, we would not get this COP of 4 if we were using HFCs."

Andy Pearson,
Star Refrigeration

Overall therefore, Pearson's conclusion is that the heat pump is the better option due to operating costs, and because as the electricity grid becomes cleaner, the heat pump also has lower CO_2 emissions, which is not the case for the CHP system. Added to this, the renewal heat incentive in the UK would supply £1.4 million (€1.64 million) per year to a heat pump operator but nothing to the operator of the CHP system, meaning there is a strong imperative for going for the heat pump instead of the CHP.

In light of this, Pearson calls upon the decision makers in Brussels to take legislative action. "If people want heat they should be forced to get it from heat pumps, that would be a sensible piece of legislation."

In the industrial heal pump sector, Mayekawa's Eric Delforge also presents ammonia (NH_3) as the refrigerant of choice. Delforge's presentation explains that by using condensing heat or by having a stable thermal heat source, it has never been a problem to produce hot water up to 90°C using ammonia as a refrigerant.

"Today we can announce that we are running field tests with an industrial heat pump with hydrocarbons exceeding 120°C and therefore we are actually creating competition for fossil fuel steam boilers, which is getting very exciting,"

Eric Delforge,
Mayekawa Europe

Propane heat pumps can produce hot water up to 120°C

Looking at the use of other natural refrigerants such a hydrocarbons in heat pump applications, Mayekawa's Delforge talks about the field tests his company is conducting, which are proving the viability of propane as a refrigerant to produce water up to 120°C in industrial heat pump applications. Mayekawa's combined chiller and heat pump cools water down from 10°C to 1°C, and on the other side produces 1 MW 90°C hot water.

Propane heat pumps for family homes

"The safety concept was approved by VDE and TÜV from the very beginning, and we performed several tests to show that in case of a leak nothing happens. There is no ignition at any point in the refrigerant cycle."

Joachim Maul,
ait-deutschland

Looking at decentral heat pumps for smaller installations van der Hoff says that he has made an award winning propylene prototype of a water source heat pump system, which is actually a cascade system. In his system a fan coil with an internal heat pump is connected to a central heat pump. As previously mentioned, he thinks that China will soon supply the market for split heat pumps with systems charged with propane, for which production started up in the summer of 2013.

Joachim Maul, Director of R&D at ait-deutschland, affirms as well that heat pumps with propane are a good technology for the renovation market to substitute gas or oil boilers. For this market ait-deutschland has an R290 heat pump designed to achieve a flow temperature of up to 70°C, without any additional heater, and using a proven low GWP refrigerant with a long history of use.

Maul says that most of the components in the R290 heat pump will be familiar to heat pump manufacturers, with the exception of the double heat-exchanger and sealing of the electrical box, and that none of the components incur significant additional costs.

Given its thermodynamic properties, R290 is considered by Maul to be a good refrigerant for outdoor air-to water heat pumps. For indoor heat pumps there are additional costs for safety devices such as gas alarm systems and ventilation that make it less favourable.

European Commission funding for propane "green Heat Pump"

"This project promises to have a high impact for heat pumps in Europe during and after the project […] But it needs a clear strategy to link activities and results to manufacturer needs."

Thore Oltersdorf,
Fraunhofer ISE

As part of the European Commission's Seventh Framework Programme for Research (FP7) a project titled "green Heap Pump", has been funded, presented at ATMOsphere Europe 2013 by the Head of heat pump development within the Group, Thore Oltersdorf, from Fraunhofer ISE.

The project was set up to develop next generation components and heat pumps with natural refrigerants for retrofitting buildings in Europe. It includes many partners and organisations, working together to develop a 30kW air to water heat pump system for multi-family houses, which represent 35% of the residential building market in the EU-27. The decision to use propane as the refrigerant was based on life cycle cost performance.

The system is being designed to be roof-mounted, so it is suitable for urban areas, and to have a refrigerant charge of 20g per kW heating capacity. Preliminary charge calculations indicate the system will have a total charge of 500g. It will feature novel, state-of-the-art designs, such as a minichannel evaporator whose fin design has been optimised for stable operation in frosted conditions, a novel fluid distributor, and new scroll compressor.

CO_2 heat pumps for commercial and residential sector now available across Europe

Oliver Campy, CEO of SANDEN Europe introduced the ATMOsphere Europe 2013 audience to SANDEN's CO_2 heat pumps, which have been available in the European market since 2011. During his presentation he also emphasised a need to focus on the return on investment, rather than on upfront costs.

Labelled under the brand acquaECO_2, SANDEN's CO_2 heat pumps are available for residential hot water production, and professional or large capacity water production. Based on the Japanese technology, the product was re-engineered by French technology centers to suit European conditions in terms of hot water temperature, water storage volume, control logic and installation (indoor vs. outdoor).

Since 2012, residential space heaters running on CO_2 were also made available in Japan, with hot-water output temperatures of 40°C to 70°C and a COP of 4.0.

In 2013 SANDEN also made available in Europe the first combi-type CO_2 heat pump for residential space heating and domestic hot water production, with a COP of 3.64.

Thermal compression of CO_2 to reduce boiler consumption by 50%

"Like you said [Andy Pearson, Star Refrigeration] to use gas and to burn gas to deliver heat in a house is more or less a thermodynamic crime."

Luc Jacquet,
boostHEAT

Also talking about CO_2 heat pump technology was Luc Jacquet, the co-founder of boostHEAT, who presents a pioneering business model to push forward an innovative new heat generator based on the basic principle of thermal heat compression technology.

The focus of this heat generator is its efficiency, and delivering the same level of service, with lower usage of energy. This is achieved by fusing two technologies: the gas-burning boiler, and the heat pump. These two technologies are combined by thermal compression, creating a new heat generator that is neither a hybrid boiler, nor a sorption cycle.

The idea behind thermal compression is that if you heat a limited space both the temperature and the pressure will increase. The technology, which has a four-stroke cycle is quite simple, using a piston, a cylinder system, and a regenerator. CO_2 is used says Jacquet, because "we are heating CO_2 at a level of 600-700 degrees we need to have a refrigerant that is completely stable at this level of temperature."

The boostHEAT system has a seasonal average efficiency rating on the net calorific value (NCV) of fuel of 200%. This is more efficient than most other available technologies, such as condensing boilers, hybrid boilers, mini cogeneration, gas absorption heat pumps and fuel cells. What is more, since there is no mechanical power transmission there are fewer losses, and low wear. The global efficiency observed through a prototype running since January 2013 is about 50,000 hours with no need for maintenance.

As well as explaining how the technology works, Jacquet talks about the unique business model, whereby this new heat generator is rented to the consumer for a low price by an energy service provider, an idea developed to counter the rising cost of today's heating solutions such as condensing boilers.

Vacuum ice technology

"Water is one of the refrigerants of the future."

Mathias Safarik,
ILK Dresden

ILK Dresden is developing the "vacuum ice technology" using a centrifugal compressor adapted to the special requirements of water as refrigerant. The pilot installation at the university campus, which is expected to be commissioned in November 2013, will demonstrate the advantages of vacuum ice slurry storage over conventional block ice storage, resulting in efficiency increases of about 30%. Ice storage can be charged over night when ambient temperatures are low. Therefore, condensation temperatures of the chiller are low, increasing the efficiency of the cooling cycle. Compared to on-time generation of chilled water, the overall efficiency of the chilled water supply using vacuum ice storage can be higher. This solution is expected to be very economical, especially in regions with greater differences between peak and off-peak electricity tariffs. In addition, ice slurry can also be used as a secondary refrigerant in an indirect system. Compared with a direct evaporation system, costs are lower due to the use of smaller pipes and because there is no need for wearing parts for the slurry production.

glossary

CGF - Consumer Goods Forum
CO_2 - Carbon dioxide
COP - Coefficient of Performance
EC - European Commission
EU - European Union
ETS - Emissions Trading System
HC - Hydrocarbons
GWP - Global Warning Potential
HCFC - Hydrochlorofluorocarbon
HFC - Hydrofluorocarbons
HVAC&R - Heating, Ventilation, Air conditioning, and Refrigeration
kWh - Kilowatt hour
NCV - Net calorific value
NH_3 - Chemical name for ammonia
ODP - Ozone Depletion Potential
R744 - Chemical name for carbon dioxide
R&D - Research and Development
UK - United Kingdom
VRF AC - Variable Refrigerant Flow Air Conditioning
USA - United States of America

more information

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