

ATMOsphere Europe 2015

**I N T E R N A T I O N A L W O R K S H O P
S U M M A R Y R E P O R T**

16 - 17 March 2015 — Brussels, Belgium



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ATMOsphere Europe 2015

Summary Report International Workshop

published by shecco®

www.atmo.org

Rue Royale 15

1000, Brussels

Belgium

www.shecco.com

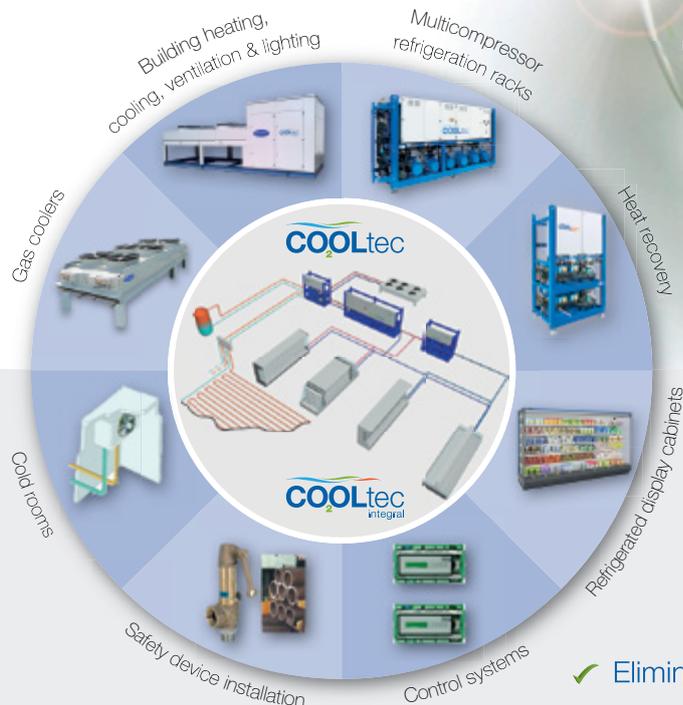
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THIS IS ONLY THE BEGINNING

ATMOsphere Europe 2015 was held in Brussels 16-17 March. This was the first ATMOsphere after the introduction of the updated European F-gas Regulation.

To be honest, we were curious to find out whether people would come. Because, maybe there was no need to talk about natural refrigerants now that the Regulation is in place and the market is moving towards low-GWP refrigerants anyway.

Well, in fact: this was the biggest and best ATMOsphere Europe ever, with more than 230 experts attending. We had the who's who of European industry in Brussels for two days. And if some people felt that the pace of market penetration of natural refrigerants-based technologies was slowing down, I have some news for you; it is quite the contrary. We saw lots of innovations across all sectors using a variety of natural refrigerants both for air conditioning and refrigeration.

ATMOsphere Europe helped put all these discussions into context. It provided clarity for policy makers, end-users and suppliers. In the summary report that follows you will get a good overview of what was discussed as well as links to all the presentations given during ATMOsphere Europe. I hope you enjoy reading this report and we all very much look forward to meeting you again next year in Barcelona.



MARC CHASSEROT

CHAIRMAN, ATMOSPHERE EUROPE 2015
MANAGING DIRECTOR, SHECCO

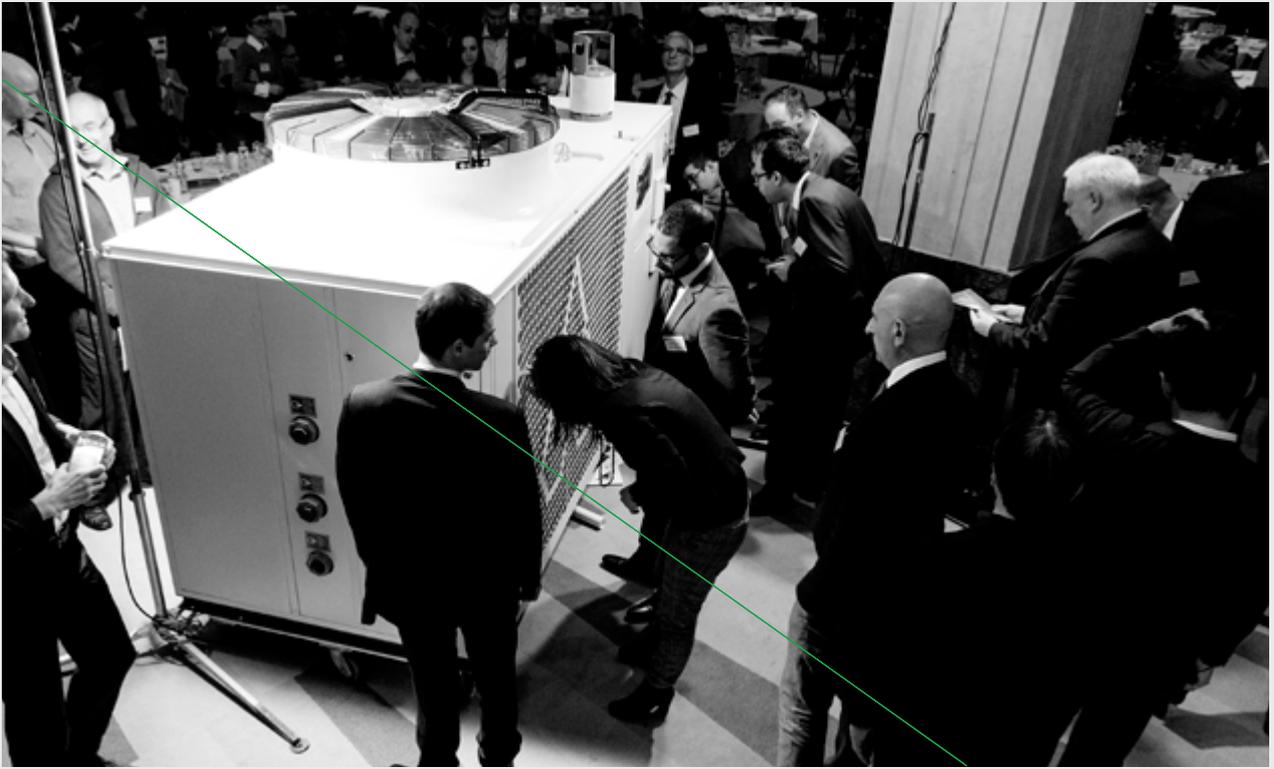
A TMOsphere Europe returned to Brussels on 16 & 17 March 2015 for its 6th, and largest edition. Attended by 230 participants, the event featured 60 international speakers, including government representatives, technology providers and end-users, who presented on the very latest natural refrigerant trends in and around Europe. The conference covered a mix of applications from commercial, light commercial, industrial and transport refrigeration to heat pumps.

The Food Retail Panel underlined the confidence many leading European retailers have in CO₂ commercial refrigeration technology, with Metro AG, the Delhaize Group, and Ahold laying out plans to install CO₂ systems in all new stores and refurbishments. Whether or not this trend becomes Europe-wide will depend on the performance of technologies designed to increase the efficiency of CO₂ in warm ambient climates, and as such these featured heavily throughout the ATMOsphere programme.

For industrial applications case studies were presented on ammonia heat pumps for hot water production and refrigeration in food processing applications, whilst the increasing popularity of hydrocarbons in the food retail & food service sector was brought to the fore by compressor manufactures and end users like Red Bull.

Complementing the main sessions, ATMOsphere Europe 2015 featured a series of Technomericals, including a world premier - the unveiling of the TripleAqua, a patented natural refrigerant heat pump using hydrocarbon propæne as the refrigerant.

With the new EU F-Gas Regulation favouring those that already work with natural refrigerants, ATMOsphere Europe 2015 defined the path that the European HVAC&R market must follow to adapt to the restricted use of HFCs.



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AIR



H₂O



NH₃



CO₂



HC



CHAPTER 1

POLICY DEVELOPMENTS



BENTE TRANHOLM-SCHWARZ

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UNEP

W

With the new EU F-Gas Regulation in effect since January 2015, ATMOSphere Europe 2015 provided a timely platform for key policymakers, industry representatives and stakeholders to exchange views and updates on its implementation. Government representatives from France, Germany and Denmark presented about the next steps foreseen in the national legislation that will further restrict the use of HFCs and promote the use of natural refrigerant solutions. Looking beyond Europe, the event also featured a Global Policy Session, which highlighted the importance of including developing countries in the debate regarding phasing down f-gases. Whilst the European Union is currently well on the way to reducing f-gases by 79% by 2030, with containment measures and market prohibitions currently being implemented, there still exists a critical need for international action to complement these steps.

EU F-GAS REGULATION PROVIDES SIGNALS TO INDUSTRY TO MOVE AWAY FROM HFCs

Kicking off the first of the policy sessions, Bente Tranholm-Schwarz, Deputy Head of Unit of DG Climate Action at the European Commission provided a snapshot of the key measures under the EU F-Gas Regulation that entered into force in January 2015. The HFC phase down, which will require reducing the average GWP of refrigerants from 2000 to 400 by 2030, gives a clear signal to the manufacturers and buyers of refrigeration and AC equipment to avoid the use of HFCs as much as possible.

“For those who use natural refrigerants, you need not worry about this, as you are not covered by the F-Gas Regulation” – Bente Tranholm-Schwarz, European Commission.

The positive effects of the F-Gas Regulation on increased demand and availability of equipment using natural refrigerants will need to be accompanied by an update to national codes and standards. To help eliminate any regulatory barriers to the introduction of natural refrigerants, Tranholm-Schwarz noted that the European Commission has initiated work on a study that will identify codes, standards and legislation that limit or prevent the use of HFC alternatives at EU and national level.

In a similar vein, in the summer of 2015, the French government will update certain regulations to alleviate the burden on ammonia installations, to allow for a wider introduction of such technology in France.

“We need to support companies so that they are aware of the goals,” said Florian Veyssilier, Policy Advisor for the French Ministry of Ecology, Sustainable Development & Energy.

Besides updating national regulations, the French government is also actively involved in data collection, including an ongoing study on leak rates and involvement in price monitoring of HFCs. Veyssilier explained that based on information provided to the government, a sharp increase in the price of HFCs has already been recorded since the publication of the F-Gas Regulation. He pointed out that France continues to support the idea of paid quotas, a topic that will be re-discussed before 2017, when the European Commission shall assess the impact of free quota allocation and propose changes, if deemed appropriate.

The German government is currently in the process of identifying

all the aspects of national legislation that need to be aligned with the EU F-Gas Regulation. According to the presentation by Katja Becken, Policy Advisor for the German Federal Environment Agency (UBA), the Climate Action Programme 2020, adopted in December 2014, indicates that Germany aims to take a pro-active approach to promoting natural refrigerants. While the details of the programme are yet to be published, Becken highlighted that activities will focus on the strengthening of technical advisory services, training and education on natural refrigerants, as well as continuous and extended promotion of non-halogenated refrigerants, such as CO₂ and hydrocarbons, in commercial refrigeration and other applications such as transport. In addition, the UBA has recently published a report that identifies areas where hydrocarbons could be used more extensively, a strategy that could translate into further policy measures in the future.

In Denmark, the effects of the EU F-Gas Regulation will likely be less pronounced due to the strong domestic regulations that have already been in place for several years. As noted by Mikkel Sørensen, Head of Section at the Danish Environmental Protection Agency (EPA), the decline in use of HFCs, which Denmark has already achieved, is similar to what is expected in the European Union as a whole by 2030.

As such, Denmark is considering other options to further restrict the use of HFCs. One of the options presented by Sørensen relates to the national ban on HFCs, which applies to all equipment except systems with a refrigerant charge between 150g and 10kg. The Danish EPA is currently considering changing this rule and setting a limit in terms of CO₂ equivalent instead of kg, which would better reflect the environmental impact of refrigerants. The limit of 5t CO₂eq would result in emissions savings of 3.95 million t CO₂eq over 30 years, while the calculated tax loss would amount to €130 million. Sørensen noted that a drawback of such a measure could be the negative consequences this could have on small businesses.

In order to enhance information and advisory activities, Sørensen mentioned that almost €1 million has been set aside to support companies to move voluntarily to natural refrigerants in applications where the use of HFCs is still legal.

INCREASED FOCUS ON TRAINING ON NATURAL REFRIGERANTS IS NEEDED

Alongside the lack of end-users' experience with natural refrigerants, outlined by Juergen Goeller, Director Sustainability at Carrier Transicold & Refrigeration Systems, another key challenge to the transition away

from HFCs foreseen by the EU F-gas Regulation is training. As a result, the European Commission, together with Member States, is looking into the availability of training for alternative technologies, as well as green public procurement at the national level.

Marco Buoni, Vice President of the European Association of Refrigeration, Air Conditioning and Heat Pump Contractors (AREA) presented a brief assessment of the current level of competence and training in natural refrigerant HVAC&R technologies. He said that three years ago roughly 10% of technicians were educated to handle different natural refrigerants.

To address this issue, Stuart Webb, Carrier Commercial Refrigeration Europe, Sales Support CO₂ (International) announced the launch of the company's new CO₂ training academy, the CO₂OLacademy, in March 2015. Based in Germany, the CO₂OLacademy will provide a 400m² mock-up supermarket with functioning CO₂ systems, which will help train people to use these systems safely and knowledgeably.

Italian system supplier EPTA has also invested in training, operating an academy for cascade and transcritical systems in the UK since 2009. A success since it opened, the academy has been fully booked most weeks.

Danfoss's Head of Public Industry Affairs for refrigeration and air conditioning controls, Torben Funder-Kirstensen, echoed this point.

FAIR DEAL NEEDED FOR DEVELOPING COUNTRIES IN PHASING OUT HFCS

At the international level, the EU has made the case for a phase out of HFCs, which was presented in a discussion paper in 2014. According to Philip Owen Head of Unit Transport and Ozone, DG Climate Action, European Commission, the discussion paper seeks to address the "political stalemate", which currently exists under the Montreal Protocol. The proposal seeks to firstly challenge countries in stimulating innovation, and secondly, urge a fair deal for developing countries in phasing out ozone-depleting substances.

"With the adoption of the 2014 F-Gas legislation, it moved the European Union to the forefront, it made Europe a global leader," said Philip Owen.

For developed countries, the EU suggests a phase-down of production and consumption of HFCs to 15% of current levels by the mid-2030s, while a distinction between consumption and production is proposed for developing countries. Low-cost mitigation is central to the proposal, both in ensuring the freezing of consumption of HCFCs and HFCs by 2019, as well as phasing down the production of HFCs to reach 15% of average 2009 to 2012 levels, by 2040.

The United States, Canada and Mexico have also put forward an amendment proposal to the Montreal Protocol for six consecutive years. Philippe Chemouny, Manager,

“ Training is an essential asset for the whole industry, as we have the possibility to overcome doubts and point customers in the right direction.

FRANCESCO MASTRAPASQUA

EPTA

Montreal Protocol Programme, Environment Canada, said in his presentation that they are currently working on the 2015 version, which should be submitted for a meeting later in 2015.

For Chemouny, the challenges that need to be addressed in order to come closer to an agreement on a global HFC phase down include the vast differences in consumption levels in developing countries, in addition to differing opinions with regard to the technical feasibility of alternatives to HFCs. Besides this, questions relating to adequate financial support for developing countries and the role of the Multilateral Fund (MLF), need to be clarified.

Motoyuki Kumakura, Director, Office of Fluorocarbons Control Policy, Climate Change Policy Division, Japanese Ministry of the Environment (MOE), highlighted the need to support developing countries in transferring alternative technologies to HFCs. Given that they are relatively expensive, the Japanese government supports energy saving projects in the private sector with subsidies via the Joint Crediting Mechanism (JCM). Additionally, Japan offers some US\$20million (€18,214,088) to the Multilateral Fund (MLF), under the Montreal Protocol.

UNEP's Programme Officer, Ezra Clark, presented on the practical assistance that UNEP's DTIE OzonAction Branch, provides to countries to help them phase out HCFCs. UNEP is involved in the implementation of 100 HCFC Phase Out Management Plans (HPMPs), through which there is the opportunity to influence the technology choice and move towards natural refrigerant solutions, thanks to Decision XIX/6 and XXI/9.

UNEP however faces considerable challenges in explaining the different technologies. "If I was speaking to a group in developing countries, in some cases when you mention natural refrigerants the immediate reaction is 'no these are dangerous, we can't use them'," said Ezra. To overcome this type of blanket refusal, developing countries need corporate models from developed countries, local champions of natural refrigerants, proof of commercial viability and use, and capacity building and training.

These efforts will help developing countries play a more important role when it comes to phasing-down fluorinated refrigerant use, which is critical according to Clare Perry Senior Campaigner at the Environmental Investigation Agency (EIA).

Whilst the Montreal Protocol has been successful in many ways, Perry said that data on HFC use and consumption needs to be improved in order to strengthen negotiations. Additionally, she highlighted that a more balanced debate needs to come to the fore; the Montreal Protocol discussions are currently dominated by industry supporting HFC-based technology. The natural refrigerant industry in Europe thus has a key role to play in revising standards and balancing the debate.

“ Ambition is key to ensure a swift market uptake of climate-friendly solutions.

CLARE PERRY

EIA



JAPAN & CANADA TAKE ACTION AT HOME TO REDUCE EMISSIONS OF HFCs DOMESTICALLY

As a country that has been pro-actively working towards a global HFC phase down under the Montreal Protocol for several years, Canada is also taking action to reduce the emissions of HFCs domestically. In September 2014, the government issued a notice of intent to regulate the import and use of certain HFCs and is currently considering a variety of options in consultation with the industry. Chemouny hinted that possible measures could include an HFC phase down, sector specific bans as well as a combination of both approaches.

Kumakura also provided a promising update on Japan's initiatives to promote natural refrigerants. Japan enacted a law to phase-out f-gases in 2001, but recently strengthened the regulation, a move strongly influenced by the EU's decision to reinforce f-gas controls. As Kumakura emphasised, however, cost still remains a drawback. For this reason the Japanese government provides support to facilitate their introduction. For instance, the MOE has provided five billion Japanese Yen (€38,119,916) of subsidies to around 60 companies in Japan.

GREENPEACE WARNS OF NEW DANGERS FROM NEW F-GASES

Providing an NGO perspective, Wolfgang Lohbeck presented Greenpeace's initiatives against f-gases since 1992, a campaign primarily aimed at demonstrating the redundancy of fluorinated refrigerants. One of Greenpeace's greatest successes was their involvement in the development of the Greenfreeze, hydrocarbon refrigerator, the first CFC and HFC-free fridge, which demonstrated the needlessness of f-gases in household refrigeration.

Looking at why there is a need to eliminate f-gases, Lohbeck commented that HFCs are the fastest growing greenhouse gases (GHGs) and it is estimated that in 2050, HFC emissions could be equivalent to 20% of CO₂ emissions, under a business as usual scenario (BAU).

Lohbeck added that on the measuring of CO₂ equivalents the chemical industry clearly won a political victory because the lifetime of HFCs is relatively short compared to CO₂. "The lifetime of most HFCs used today is around 20 years, nevertheless the time we are calculating their impact on is 100 years," Lohbeck said.

Since 2006, the new f-gases, called HFOs, have been introduced to the market. On this topic Lohbeck pointed to the growing resistance in the car industry to the quasi-monopoly of the f-gas industry, talking about the positive results some OEM (original equipment manufacturers) have achieved using CO₂ in mobile air conditioning.

“ The Montreal Protocol has been successful in phasing out CFCs, it has been equally successful in phasing in f-gases. ”

WOLFGANG LOHBECK
GREENPEACE

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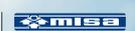


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CHAPTER 2

MARKET TRENDS



STUART WEBB

CARRIER COMMERCIAL REFRIGERATION EUROPE

TORBEN HANSEN

ADVANSOR



FRANCESCO MASTRAPASQUA

EPTA

NINA MASSON

SHECCO



OLAF SCHULZE

METRO AG

GEORGIOS PATKOS

DELHAIZE GROUP



MICHEL DE ROOIJ

AHOLD EUROPE

ERIC DELFORGE

MAYEKAWA EUROPE

A TMOsphere Europe 2015 presentations made it clear that the natural refrigerant market is going from strength to strength. The supply of CO₂ transcritical systems continues to grow, with new players entering the market, and new technologies increasing efficiency in warm ambient climates. Hydrocarbons too, are experiencing significant market growth, spurred on by green procurement strategies in the food service and retail sectors. Leading end users McDonald's and Red Bull for example, have invested in over half a million units of propane refrigeration equipment.

CO₂ COMMERCIAL REFRIGERATION TECHNOLOGY IS AVAILABLE, IN DEMAND AND HEADING SOUTH

Speaking first in the Market Trends Session, Carrier's Stuart Webb provided an overview of the CO₂ commercial refrigeration market in Europe. He noted that year-on-year growth of cascade systems was an impressive 51%, but that this increase was being outstripped by transcritical refrigeration systems, which have increased by 63% from 2013 to 2014. The once 'alternative refrigerant' has now become a mainstream solution. Webb quoted a recent report by Carrier and shecco, which stated that CO₂ refrigeration systems in commercial refrigeration have a penetration rate of 64%.

Advansor's Director Torben Hansen also reported an upturn in business for CO₂ systems, stating that "Advansor have had a tripling in enquiries" over the last two years. This shows that the growth is not just in the north of Europe but also the south. In fact, the advancement in CO₂ technology for southern European countries, where higher-ambient temperatures previously had an undesired effect on the efficiency of R744, was a key focus of many presentations. CO₂boosters, gas ejectors and parallel-compression were just some of the solutions predicted to sound the death knell for the so-called 'CO₂ equator'.

This promise of continued growth of CO₂ - especially in the south - was reinforced by Adrian Forastier, Carrier Commercial Refrigeration Europe, in a keynote dinner speech:

"Carrier is committed to take this CO₂ standard to the South, by taking the technologies that were mentioned such as ejectors, economizers and sub-coolers and combining these to create efficient systems."

Francesco Mastrapasqua, Marketing Manager, Refrigeration Systems with EPTA, was equally optimistic about the future of CO₂ systems. He picked out hypermarkets as an emerging adopter of transcritical systems, outgrowing the discount retailer sector. Mastrapasqua believes that in the future the greater adoption of these systems, due to the banishing of efficiency concerns and positive EU policy will lead to cheaper system costs, thanks to economies of scale.

Confirmation from Antoine Azar, Global Program Director at The Coca Cola Company that R744 and hydrocarbon technology now comprises 96% of their global fleet of vending machines and drinks dispensers shows that this is no longer a small operation, but that R744 is a mainstream solution.

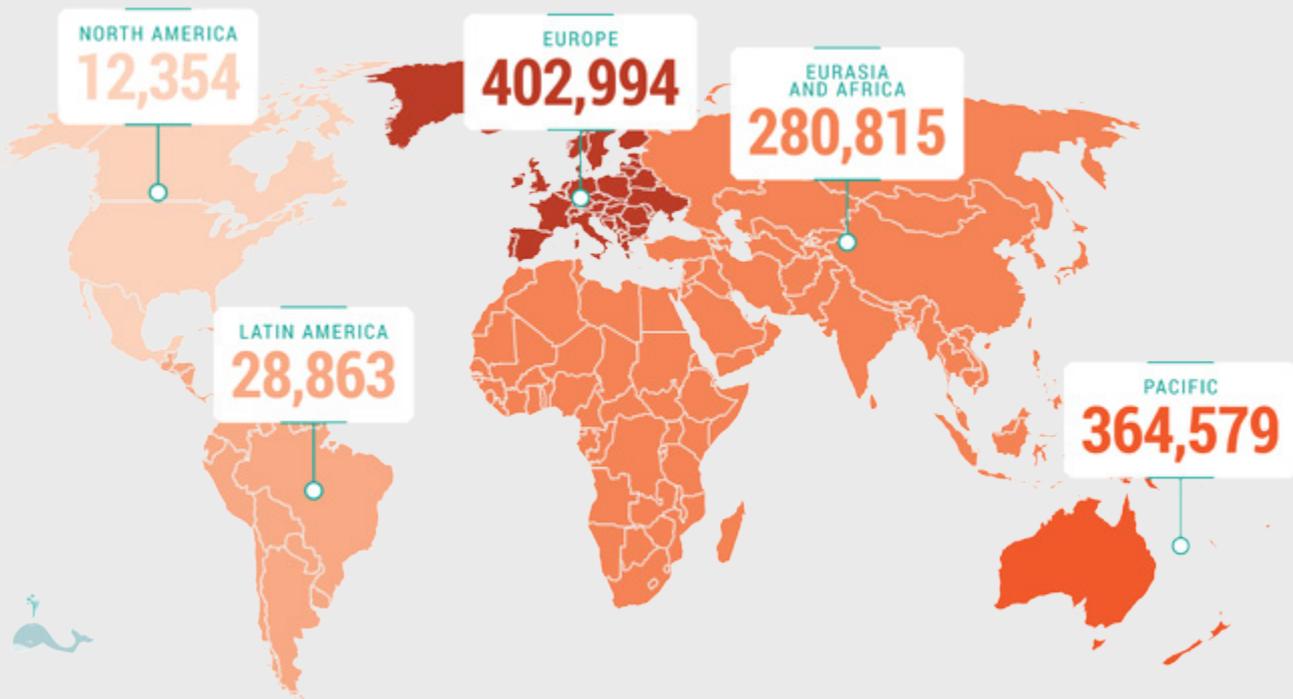
This transition was reaffirmed by Nina Masson, shecco's Deputy Managing Director, who showed that the developments in Europe are reverberating all around the world, with an increase in uptake of CO₂ in North America, China and Japan presented alongside a sneak peek into shecco's upcoming publication, 'GUIDE to Natural Refrigerants in China - State of the Industry'.

“ This is no longer a northern European thing, with growth in central and east European countries and the gradual lowering of the CO₂ equator. ”

TORBEN HANSEN
ADVANSOR



HFC-FREE PLACEMENTS BY COCA-COLA OPERATING GROUP*



*As of June 2014

According to data presented by Masson, in Canada for example, retailer Sobeys has 72 stores using CO₂ transcritical systems, and is opening 15-20 CO₂ stores every year. China has eight CO₂ stores, one of which is transcritical, as well as 25,000 CO₂ bottle coolers & vending machines.

MAJOR RETAILERS OPT FOR CO₂ AS STANDARD REFRIGERANT

The Food Retail Panel, which featured end users opting to invest in natural refrigerants for all new stores, such as Metro AG, the Delhaize Group, and Ahold, provided further proof that the CO₂ market is maturing.

Olaf Schulze, Director of Facility, Energy and Resource Management, Metro AG, which has more than 700 cash and carry stores, as well as more than 300 real hypermarkets, explained the retailer's move away from f-gases and plans to reduce greenhouse gas emissions by 20% by 2020. As of 2015, the retailer is introducing natural refrigerants in all new stores, where technically possible.

The shift to natural refrigerants is one of the three pillars of Metro's F-Gas Exit program, which also includes leakage prevention, requiring a stringent maintenance and repair program, and a logbook for cooling systems (LOCS).

Currently, the retailer has 36 CO₂ refrigerated cash and carry's, representing around 2% of their stores. Based on an assessment of their current HVAC&R installation base, 40-70 stores per year will get a new commercial refrigeration system. This means that in addition to their first CO₂ store in China, Metro will open new CO₂ stores in Russia, Turkey, Italy, Germany, Denmark, the Netherlands and Belgium in 2015.

By 2025, 1,478 Metro cash and carry HVAC&R units will need to be converted.

"This investment is higher than one billion Euros and is the biggest investment program outside of our expansion program. We are inviting the suppliers and consultants to accompany us and support us in this journey," explained Schulze.

The Delhaize Group, which has also set itself the goal of reducing CO₂ emissions by 20% by 2020 (compared to 2008), plans to reduce cooling needs, improve management of leakages and implement new technologies. Today, the Group has deployed 28 CO₂ transcritical refrigeration systems and 71 CO₂ cascade systems throughout Belgium, Greece and the US.

Georgios Patkos, Director Technical Department, Delhaize Group, explained that in Belgium, the Group has realised a decreasing price gap between natural solutions and those using HFC refrigerants. However, Patkos made it clear that for Delhaize, choosing a refrigeration system depends on much more than just initial price, with the retailer's decision to make CO₂ refrigeration technology the standard for new stores based on close monitoring and calculation of performance. With the plan to continue

“ For me it is very important to know that we will start more CO₂ transcritical stores in other countries and to be confident that this is the definitive solution - that we won't have to change refrigerant again in a few years. ”

GEORGIOS PATKOS

DELHAIZE GROUP

implementation of CO₂ refrigeration systems, Patkos highlighted that particular focus will be attributed to optimising heat recovery and integrating hot water heating.

What does Delhaize plan next?:

- Belgium: 5 CO₂ transcritical installations planned per year
- Greece: 10 more cascade CO₂/R134A systems installed in 2015

Representing Ahold, which has 3,200 stores in Europe and North America, Michel de Rooij Senior Manager Technology & Process Innovation, Ahold Europe Real Estate & Construction explained how the retailer plans to reduce CO₂ emissions by 20% by 2015, thanks to investments in natural refrigerants. Currently, the number of Ahold CO₂ stores is as follows:

- US: stores in the USA have now started testing natural refrigerant CO₂, a process that began in Europe around five years ago
- CZ: the Czech Republic now has 20 hybrid CO₂ installations, up from 10 stores two years ago
- NL: the Netherlands now has 362 hybrid CO₂ installations, compared to 257 two years ago, out of a total of 850 stores. What is more, the R744 technology is used for both refrigeration and store heating. Ahold is reducing emissions by 30%, with a leakage rate of 5.5%.

In 2014, Ahold completed seven CO₂ transcritical pilot stores, which have compared favourably to the large base of hybrid CO₂ installations. Ahold found that the CO₂ transcritical (TC) stores were cheaper to run and performed better.

“We add 60-80 stores a year, so we can easily calculate when we will be green, and all our stores are refrigerated using CO₂,” said de Rooij.

In 2010, Ahold switched over to natural refrigerants in plug-ins as well as creating CO₂ hybrid installations with heating. The retailer also developed a framework for system development that stipulates the installed base must operate within EU and local legislation. “The EU F-Gas Regulation of 2015 helped us enormously as it provided a clear direction of what we have to do,” explained de Rooij. The framework also stipulates that the promises and targets of Albert Heijn must be fulfilled. These include improving life cycle climate performance (LLCP), reducing total cost of ownership (TCO), and respecting what Ahold calls ‘next week open’, whereby stores are refurbished in one week.

From de Rooij’s perspective, in order for the rollout of natural refrigerant systems to be as smooth as possible, standardised systems and store layouts must be adhered to.

“ For us, it is very simple mathematics, for us it means that we will switch over to CO₂ TC.

MICHEL DE ROOIJ

AHOLD EUROPE

In the future, Ahold will invest in adsorption cooling to take advantage of the waste heat. A trial installation in Eindhoven, the Netherlands, is currently being tested. When it comes to their CO₂ technology, Ahold will start to invest in parallel compression and ejectors.

HYDROCARBONS GAINING MOMENTUM IN THE FOOD RETAIL & FOOD SERVICE SECTORS

Much like CO₂, shecco's Nina Masson also predicted a 'growing appetite' for hydrocarbons (HCs), in the North American food service industry. The approval of HCs in six AC&R applications, including stand-alone commercial refrigerators and freezers, will certainly help to cement this trend.

In China, the national government strategy for natural refrigerants in Room Air Conditioning (RAC) foresees the deployment of hydrocarbon technology. Further east, in Japan, since 2014, R290 cabinets have been available and placed in 30 stores, by convenience store operator SAVE ON.

Other hydrocarbon data presented by Masson included the following:

- US: Unilever's Ben & Jerry's had placed 4,588 propane (R290) freezers by the end of 2013, Red Bull has committed to 100% HC procurement, and PepsiCo to only HFC-free coolers, vending machines and fountain dispensers.
- China: has 400,000 hydrocarbon stand alone cabinets, 320,000 hydrocarbons ice cream freezers, and 2,500 HC bottle coolers and vending machines
- Europe: McDonald's has deployed the following propane refrigeration equipment: 3,811 meat freezers, 2,802 frozen fry dispensers, and 1,614 blended ice machines

Alongside McDonald's, leading end user Red Bull, which is active in 166 countries, has more than 543,000 ECO Coolers already using R600a. In his presentation, Red Bull's Global Purchasing Manager, Jürgen Brenneis, said that annually Red Bull procures around 200,000 coolers and in 2014 purchased only hydrocarbon coolers, except in Japan, where Red Bull faces a number of difficulties. These include the negative perception of hydrocarbons and problems sourcing hydrocarbon compressors and components, cooler service partners, hydrocarbon refrigerant, and training.

Italian water chiller manufacturer Blupura reported approximately 200 units installed in Italy, and, Luca Constantini, Blupura Founder & CEO, said the company continued to receive international enquiries about their technology.

These numbers clearly show a growing demand for hydrocarbon technology. In fact, Huayi Compressor Barcelona predicted a 42% increase in demand in 2016 alone.

“ What we can expect is that with upcoming regulations and standards, the number of light commercial hydrocarbon systems will increase. ”

NINA MASSON

SHECCO

“ We need compressor suppliers to help us to get enough availability of hydrocarbon compressors for Japan. ”

JÜRGEN BRENNEIS

RED BULL



MCDONALD'S PROPANE REFRIGERATION EQUIPMENT DEPLOYED IN EUROPE, 2010-2013



MEAT FREEZERS

3,811



ICE MACHINES

688



FROZEN FRY DISPENSERS

2,802



BLENDED ICE MACHINES

1,614



JUICE DISPENSERS

503



BEVERAGE SYSTEM CHILLERS

9

*Source: McDonald's Corporate Social Responsibility Report, 2012-2013

According to Vicente Guilabert, R&D and Technology Director of Huayi Compressor Barcelona, the main challenge related to the use of hydrocarbons remains the base 150g charge limit, in some applications in Europe. Discussions regarding extending the maximum charge are not expected to result in changes in the short term, but perhaps in the medium term. The European Commission continues to consult Member States on what national legislation is creating barriers for the uptake of natural refrigerants.

In the domestic refrigeration sector, Lohbeck was proud to say that to date over 700,000,000 hydrocarbon units using Greenfreeze technology, have been placed worldwide.

DRIVERS FOR CHANGE AND BARRIERS TO OVERCOME IN INDUSTRIAL SECTORS

In the industrial sector, taxation on emissions, customer demand for sustainability and accountability, as well as high operational efficiency, are all driving the uptake in natural refrigerants, such as ammonia and CO₂. Technology providers are responding with wider equipment availability, less complexity and greater accessibility. "There are many more industry players on the market today, and an increased variety of applications for natural refrigerants," said Eric Delforge, Corporate Business & Policy Officer, Mayekawa Europe. "Because there is more competition and equipment on the market, the capital costs of these systems can decrease."

Challenges for technology providers in industrial applications remain. Principally, they are: minimising refrigerant charge; making operation more simple, reliable and safe, and eliminating leakage. Delforge concluded that what is needed for the evolution of industrial natural refrigerant technology is, "inclusive technology incorporating heating and cooling, and local and cross-sector collaboration/ integration."

“

We are forecasting a growth in propane solutions. At the beginning, when we started working with propane it was not accepted in all world regions, nowadays we can say it is a global refrigerant solution.

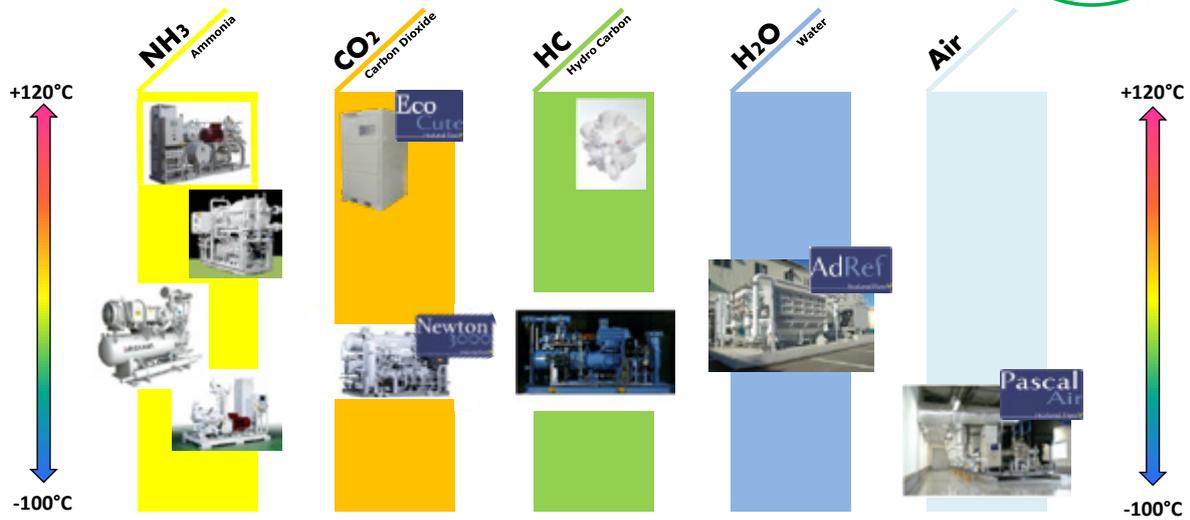
”

VICENTE GUILABERT

HUAYI COMPRESSOR BARCELONA, S.L.

Industrial Refrigeration & Heat Pump solutions provider

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CHAPTER 3

CO₂ COMMERCIAL

REFRIGERATION INNOVATIONS



ERIK WIEDENMANN

FRIGO-CONSULTING

DIEGO MALIMPENSA

CAREL INDUSTRIES

UDO GÖRNER

EPTA DEUTSCHLAND



TORBEN FUNDER-KRISTENSEN

DANFOSS

CHRISTIAN HEERUP

DANISH TECHNOLOGICAL INSTITUTE

ARMIN HAFNER

SINTEF

SYLVAIN GILLAUX

SANDEN EUROPE



JEAN-MICHEL FLEURY

CARREFOUR

GABRIEL ROMERO

AUCHAN SUPER SPAIN

AMAD HAFEZ MODELO

CONTINENTE HIPERMERCADOS, S.A

DAVIDE REFOSCO

SCM FRIGO



SERGIO GIROTTTO

ENEX

TORBEN HANSEN

ADVANSOR

MICAEL ANTONSSON

GREEN & COOL

FRANCESCO MASTRAPASQUA

EPTA

The continually diminishing CO₂ efficiency equator was a hot topic at ATMOsphere Europe 2015. Several system manufacturers presented the methods by which CO₂ transcritical system efficiency can be improved, with ejector technology and parallel compression stealing the spotlight. According to several presenters, the end of the so-called 'CO₂ equator' is in sight. Building on these case studies, several presenters in the Food Retail Panel shared first results on the implementation of the new methods designed to improve the efficiency of CO₂ in warm ambient climates. Alongside these solutions, integrated CO₂ refrigeration systems for CVS layouts from Carel and EPTA Deutschland, CO₂ condensing units, and the need to scale down solutions for smaller formats, were all discussion topics.

PARALLEL COMPRESSION AND EJECTOR TECHNOLOGY TAKE CENTRE STAGE

Presenting in several sessions, Torben Hansen, Commercial Product Director of Advansor, focused on defining the hot climate challenge, mainly, how to remove flash gas at higher temperatures, and presented a number of solutions for improving efficiency of transcritical CO₂ commercial refrigeration systems in high ambient temperatures, including high-pressure subcoolers, water spray systems, adiabatic cooling curtains, parallel compression systems and gas ejectors.

According to Hansen, combining parallel compression with ejector technology achieves the highest performance. In fact, he believes it could remove the CO₂ equator all together. Combining parallel compression and gas ejector technology is expected to be able to achieve peak savings of 22-27% and annual savings of 12-16%; the data will be validated during 2015.

Davide Refosco, Export Area Manager, SCM Frigo, also highlighted parallel compression, citing the company's successes with the technology in improving the performance of CO₂ systems. SCM Frigo has 20 CO₂ transcritical units in operation using parallel compression and heat recovery to achieve efficiency increases of 15% and higher throughout Belgium, Spain and France. Boosting efficiency of CO₂ systems in warmer climates is of particular focus for the company, which prides itself on its continuous product development.

Torben Funder-Kristensen, Head of Public Industry Affairs for Refrigeration and Air Conditioning Controls at Danfoss, confirmed that with parallel compression, CO₂ systems are able to keep up with R404A systems up to approximately 38°C.

He also discussed the application of ejector technology, which moves gas from the medium temperature suction to the parallel compressor. In some cases all the gas can be moved, resulting in increased performance in high ambient temperatures or 100% heat recovery. In particular, Funder-Kristensen noted the positive performance of enEX systems using gas ejectors.

For liquid ejector systems, which allow the medium temperature evaporator to be flooded, Funder-Kristensen explained that savings are achieved thanks to the higher suction pressure, rather than from the parallel compressor or the ejector itself. Trials running since 2013 have shown good results; on average the evaporation temperature is raised by 5-10°C. The savings of the liquid ejector can even be used in parallel with a gas ejector to further improve efficiency. In a comparison of systems using gas and liquid ejectors to systems using R404A, the ejector technologies show superior performance to R404A, even at high ambient temperatures.

"Efficiency doesn't depend so much on the ambient temperature anymore," said Funder-Kristensen, "This is very encouraging because it means the limit for CO₂ basically disappears."

“ There is a bright future for enhanced CO₂ solutions in hot climates. ”

TORBEN HANSEN

ADVANSOR

“ This technology [ejectors] has been around for more than 100 years; we're not reinventing the wheel here. ”

TORBEN FUNDER-KRISTENSEN

DANFOSS



Armin Hafner, a Research Scientist at SINTEF Energy Research, presented an innovative expansion work recovery system with multiple ejectors. The organisation's MULTIJET project, which is a collaboration with enEX and Danfoss, has been underway since 2013. It includes two supermarket test campaigns, one in Trondheim, Norway, and one in Spiazzo, Italy, and the long-term objective is to make ejector-equipped CO₂ refrigeration systems thermodynamically, operationally and economically competitive with HFC systems over the entire range of operating conditions, namely, high ambient temperatures.

The multi-ejector block is compact and utilises two liquid ejectors and four vapour ejectors, allowing for a wide range of capacity control. Meanwhile, the gas cooler is divided into two parts and acts as a heat pump for winter operation. The system maintains flooded evaporators all year round and the evaporating temperature is around 3°C.

In his summary, Hafner commended the high level of flexibility ejector technology can achieve and said that the market is quite competitive, allowing end users to make choices that best fit specific situations. In addition, Hafner highlighted that the use of ejector technology is a cost effective and efficient way to integrate AC in CO₂ commercial refrigeration applications.

enEX is another company that has been developing solutions for warmer climates for many years now. Using parallel compression and ejectors in unison, the company has realised significant efficiency gains and cost (first cost + energy cost) reductions. enEX President Sergio Giroto said in his presentation that while the initial cost of the Multijet ejector solution is higher than an R404A system, the lifetime cost is significantly lower. The company's 'full saving' system consumes 25-30% less energy than a standard CO₂ solution. Giroto also highlighted that refrigeration needs of end users vary on a case by case basis, to which enEX is able to cater to maximise return on investment of a system. enEX has installed more than 20 systems with its ejector technology since 2012.

Last to speak on the topic of ejectors was Erik Wiedenmann Engineer at the Frigo-Consulting Research & Development Department. Wiedenmann presented a comparative study of two CO₂ booster refrigeration installations using ejector technology in Migros supermarkets in Switzerland. An installation in Bulle has been in operation since summer 2013, while one in Ibach was inaugurated in November 2014. In both cases, liquid in the suction allows for the reduction of superheat in the cabinets, which increases heat exchanger efficiency and the evaporation temperature. Based on the evaluation of these installations, Wiedenmann predicts similar systems in central Europe could achieve a 20% reduction in energy consumption and 25% less in southern Europe.

“ Commercial refrigeration is in a very innovative period. ”

ARMIN HAFNER
SINTEF

“ The CO₂ equator is moving... actually, it's gone. We will see this in the US and Asia, I'm sure of it. ”

ARMIN HAFNER
SINTEF

END USERS TEST SOUTHERN WATERS AS CO₂ TECHNOLOGY OVERCOMES EFFICIENCY BARRIERS

Retailers are gradually becoming aware of the new components discussed above that make CO₂ transcritical refrigeration a viable option in warm ambient climates.

After talking about Carrefour's CO₂ emissions reduction commitments, Jean Michel Fleury, Director International Support at Carrefour, emphasised the viability of CO₂ transcritical solutions for warm climates, mentioning in particular two pilot Carrefour stores in Valencia, Spain.

Carrefour first began its move to implement natural refrigerant solutions with a CO₂ cascade system in 2009. The retailer is now gradually deploying 100% CO₂ transcritical (TC) systems, with a CO₂ TC pilot hypermarket in Alzira, launched in 2013, which uses parallel compression, achieving 13% net savings. Another launched in 2014 in Castellon, that combines parallel compression with an ejector, promises even higher savings. The success of these two projects so far has prompted plans to expand the use of the optimised CO₂ technology to the south of France, Italy and Brazil.

Gabriel Romero, Technical Director, Auchan Super Spain, also presented a pilot CO₂ transcritical booster system installation, this time at a Simply supermarket in Bilbao, Spain, where the average maximum ambient temperature is 26°C and the average minimum temperature 4°C. According to Romero, a major factor in opting for natural-refrigerant-based solutions is the Spanish tax on high GWP refrigerants. The retailer analysed the high GWP gases at its existing installations, calculating a potential risk of more than €3,000,000 in f-gas taxes.

The technology piloted is an EPTA ECO₂ Small power rack transcritical booster system integrating refrigeration and air conditioning as a completely green solution. The air conditioning is integrated with a direct expansion (DX) system using CO₂. During winter, the system is able to recover enough heat to maintain a comfortable inside temperature. The store in Bilbao also incorporates an adiabatic cooling system to improve overall efficiency and to reduce the operating temperature of the gas cooler by first cooling down the ambient air. Consequently, the system operating pressures are reduced from 107 bar to 70 bar, resulting in reduced electricity usage of the system. In terms of energy performance, the CO₂ performs similarly or better than systems in similar supermarkets.

Not yet convinced about CO₂ transcritical technology for warm climates was SONAE MC's Equipment Manager, Amad Hafez, who shared the experiences SONAE has had with its use of CO₂ cascade systems. Today, the retailer has in operation 13 stores using CO₂ cascade systems, two of which are "100% green" using CO₂/NH₃ refrigeration systems. At this stage, SONAE is evaluating the performance of these stores to decide the direction its green strategy will take. The results so far reveal that for SONAE, the CO₂/NH₃ systems consume similar amounts of energy to HFC systems;

“ We have concluded that CO₂ transcritical systems are a viable option in temperate climates, and we are exploring the possibility of introducing it in warmer climates. ”

GABRIEL ROMERO
AUCHAN SUPER SPAIN

while the low temperature side shows promising results, the medium temperature side actually consumes more energy. Naturally the retailer is looking to deploy systems that provide higher energy savings at both the low and medium temperature levels. According to Hafez, the retailer plans to continue rolling out CO₂ cascade stores, though it is hoping to find a better alternative to R134a.

SUPPLIERS WISING UP WITH CO₂ CVS SOLUTIONS AND FULL SYSTEM INTEGRATION

Looking beyond the 'CO₂ equator' during one of the ATMOsphere Europe 2015 lunchtime Technomericals, Carel presented a CO₂ solution for the CVS market. Carel's compact solution the 'C-Store' is divided into these three different areas: one refrigeration area with racks made with three to five compressors (low temp and medium temp), while for air conditioning, Carel uses split units. Lastly, the alarm and energy monitoring room is used to monitor the optimisation of the store

Nicola Pieretti, Application Specialist – Retail Solution Marketing Department at Carel, explained that synchronisation of the system is an optimal way to run the store's energy management, with Carel's pR300T controller providing complete rack control. It has the capacity to control and monitor the E3V-C high-pressure valves, gas cooler, intercooler, parallel compression and double heat recovery. He also highlighted Carel's MPXPRO controller for complete management of single multiplex showcase and cold room units.

Moving on to the company's BLDC water loop for commercial refrigeration, Diego Malimpensa Business Unit Manager, Retail Solutions at Carel, presented its application in CO₂ plug-in units with heat management, using a brushless, inverter-driven DC compressor. Unlike conventional systems, which commonly use the standard AC compressor, the cabinets contain water condensers onboard, no copper pipes, no compressor racks and are charged with around 1-2kg of refrigerant.

Carel's cabinets are factory tested and avoid welding. Malimpensa said they change the format for CVS from more complex systems and provide considerably improved refrigerant leakage rates and a 25% energy saving. The system provides flexibility, allowing stores to change their layouts and the possibility to change the position of the cabinets. "This creates the possibility to have a wider sales area because there is no need anymore to have a machine room," Malimpensa said.

Also presenting on the topic of small format stores was Sanden Environmental Solutions' Sales & Marketing Manager Sylvain Gillaux, who explained that Sanden's business model is perfectly suited to smaller format stores as they concentrate almost exclusively on heating and cooling components and systems with a capacity under 25kW. With experience in Japan, where there is a high density of CVS, Sanden is now looking to translate that experience to the European market and increase their penetration with commercial and plug-in units.

“

The key factors for the convenience stores are the integration of the components of the systems – from refrigeration to air conditioning to lighting.

”

NICOLA PIERETTI

CAREL

“

The originality of Sanden is that we are making our own key devices; compressors or heat exchangers. In order to accelerate this transition, and not just say, 'we're going all CO₂' we took the decision last year to open a new office. We are not only talking about distributing products but defining the market by coming up with innovative product plans for the next years.

”

SYLVAIN GILLAUX

SANDEN EUROPE



Sanden's approach is unique in that they have their own compressors and can maximise the efficiency of their own products. "In 2015 Sanden will be the biggest CO₂ compressor manufacturer in the world. We are aiming at selling more than 1 million small CO₂ compressors," Gillaux said.

In his third presentation at ATMOshere Europe 2015, Hansen discussed the need for compact energy systems in small supermarkets and his belief industry should be focusing more on overall building efficiency and CO₂ system integration.

Udo Görner, Technical Director of EPTA Deutschland presented one such solution. The company's EPTA Clima is a green, innovative, refrigeration, air-conditioning and heating system. The integrated solution has one main control system and the company is currently investigating its cost advantages and energy consumption compared to conventional systems.

Görner explained the system in winter operation, whereby if heating is needed the high-pressure offset uses the useful energy in the system. The cooling positions are assigned to specific cabinets/chillers and if the energy of heat recovery, which is normally able to cover the heating need until 0 to -5°C (outside temperature), the system can use the heat recovery of the cooling system to cover the heating need. "Below this temperature (-5°C) we need an additional heating source which is in this case a heat pump and compressor," Görner said.

On the other hand, if the outside temperature is high, the water flow temperature starts from 30°C, while at 15°C ambient temperature the water reaches up to 40°C. The system can reach a COP of 3.6, which is very favourable compared to other high-pressure systems.

Christian Heerup, Product Manager Refrigeration of the Danish Technological Institute (DTI), addressed his organisation's long-term plans for developing a viable CO₂ condensing unit for small format stores.

Heerup said Danish national legislation limiting the use of HFCs had long shaped DTI's manufacturing philosophy with natural refrigerants and the impact of the broader European F-Gas and Ecodesign Directives always at the forefront of DTI's R&D. He noted that the F-Gas Regulation had targeted small commercial systems (CDUs), forcing suppliers to think outside the box to develop new solutions.

With funding support from the Danish EPA, Green & Cool (and later Advansor) were the first companies to place CO₂ CDUs on the market, specifically designed to meet the Ecodesign Directive. DTI and other suppliers are still working to improve the stated capacity and energy efficiency of these units.

“ There is room for more integrated solutions, which save money and energy. ”

TORBEN HANSEN
ADVANSOR

“ The first generation CDU exceeds Ecodesign requirements, but we can improve, I believe we have the ability to match best in class. We need the (market) pressure to produce more efficient systems. ”

CHRISTIAN HEERUP
DANISH TECHNOLOGICAL INSTITUTE.

As with all manufacturers of water coolers connected to the mains water supply, our products save on the use of plastics and the subsequent release of CO₂ into the atmosphere during transportation of the bottles.

But what makes us different from all of the other manufacturers of water coolers is that we were the first (and so far the only) to use natural gas. SO WE REFRIGERATE YOUR WATER WITHOUT HEATING UP THE PLANET!

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80%
refrigerant charge reduction

25%
energy saving

carel.com

CHAPTER 4

HYDROCARBON COMPRESSORS

AND TECHNOLOGIES FOR

THE FOOD SERVICE SECTOR



ANTOINE AAZAR

THE COCA-COLA COMPANY

GARRY BROADBENT

GREEN COOLING



DAVE BLINKHORN

GREEN COOLING

JÜRGEN BRENNEIS

RED BULL GMBH



VENU KANDI

EMERSON CLIMATE TECHNOLOGIES

VICENTE GUILBERT

HUAYI COMPRESSOR BARCELONA, S.L



MAREK ZGLICZYNSKI

EMBRACO

LUCA CONSTANTINI

BLUPURA

In the Commercial Refrigeration sessions and technomericals, hydrocarbon technologies from Emerson Climate Technologies, Embraco, Huayi Compressor Barcelona, S.L, and Blupura showcased the high efficiency of today's R290 solutions, while in the Consumer Goods Panel, end user Red Bull lauded the efficiency of HCs in warm climates. With regards to the food service sector, UK-based Green Cooling presented a case study about a CO₂ food service refrigeration system installed at London landmark Canary Wharf, while The Coca-Cola Company shared their success in introducing natural refrigerants in point of sale equipment.

HYDROCARBON COMPRESSORS FOR MEDIUM AND LOW TEMPERATURE REFRIGERATION APPLICATIONS

Emerson Climate Technologies Product Manager Refrigeration Marketing, Venu Kandi, endorsed the excellent thermodynamic properties of hydrocarbons, presenting two separate installation case studies: a project with partner A1 Engineering in the UK and an AHT self-contained case using Emerson's R290 scroll compressors.

At the first location, Emerson installed an EU/ATEX certified hermetic R290 scroll compressor. Kandi said it was the ideal solution for flammable refrigerants. Used in a secondary system with R290/water-glycol for mid temperature, the system can produce cooling capacities of 10-63kW at a -6°C supply temperature. With a heat recovery capacity of 12-42 kW at a 50°C supply temperature, the system has 3-6 compressors and a refrigerant charge of 12-16kg. With up to six leak detection sensors at critical locations, the solution displays superb safeguarding measures and proves Emerson is at the forefront when it comes to meeting strict regulatory requirements.

The second project was an AHT self-contained case - a fully hermetically sealed refrigeration system - with a 4.8-7kW cooling capacity. Using a higher refrigerant charge (500-700g), Kandi extolled the unit's benefits. "It's factory made, easily installed, and because the leakage of refrigerant is low, the 10-year cost of the system is very low," he said.

In his presentation, Embraco's Manager of Commercial Refrigeration Product Engineering, Marek Zgliczynski, highlighted the company's use of hydrocarbons for ultra-low temperature cascade applications. Used mainly in the medical and pharmaceutical industry, specifically for lab purposes, the systems must operate in temperatures of -70°C to -90°C. Embraco produces around 200,000 cabinets per year across a range of markets.

Under a theoretical cycle comparison, Embraco found the efficiency of propane/ethane cabinets to be higher than HFC systems, given the latter typically use the same compressor for both the first and second stage of cascade operation, which is not very effective because power consumption is typically much higher in the second phase. Zgliczynski compared a cascade hydrocarbon system with an HFC (R404A/R5088) unit and found the system COP to be higher for HC (0,82) compared to HFC (0,7), with the power usage of the HC compressor (1st stage – 0,72 kW/2nd stage - 0,50 kW) lower than the HFC cabinet (0,88 kW/0,55 kW).

Embraco also manufactures a special compressor series for ultralow cascade systems using R170. With a special valve design and optimised torque electric motor, the compressors are the first of their kind optimised for this type of application. Zgliczynski noted that the US has already proposed a protocol for energy consumption for these ultralow applications, presenting a market opportunity for Europe that doesn't currently exist under the Ecodesign Directive.

“ Local regulations vary between European countries and addressing national restrictions will be one of the keys to advancing this market. ”

venu kandi

EMERSON CLIMATE TECHNOLOGIES.

“ If we compare the HFC cascade system efficiency to propane and ethane cascade systems with the same conditions, we can see even from a theoretical point of view the benefit of hydrocarbons over HFCs. ”

MAREK ZGLICZYNSKI

EMBRACO.

Vincente Guilbert, R&D and Technology Director Huayi Compressor Barcelona, spoke about the benefits of his company's small, hydrocarbon, hermetic compressor. The company manufactures plug-in systems where the maximum refrigerant charge is usually not a consideration. Highlighting a typical ice maker case study, the analysis of energy consumption between cabinets shows that with the company's new U compressor there is an improvement of 26.64% and 6.23% compared to Huayi's previous best model - NLY60Cab - and the second best product on the market, respectively.

In Huayi's lunchtime technomercial, the U compressor range was showcased under the trademark 'cubigel compressors', from the smallest capacity D range (2.4-4.03 cc), for small applications like water coolers, right up to the S range (18.0-34.4 cc), for large refrigerators/freezers and blast chillers. Huayi compressor Barcelona manufacturers all of its products in Barcelona, with 90% of their compressors and hermetic condensing units exported around the globe.

BLUPURA HYDROCARBON CHILLERS GARNERING INTERNATIONAL ATTENTION

It was another hydrocarbon technology, Blupura's charged stainless steel chiller, that supplied the water at the ATMosphere Europe 2015 welcome dinner. The innovative Italian company supplies four European market segments with its filtered water chillers: hospitality, water vending machines, outdoor fountains and high-end offices.

Using natural refrigerants R290 and R600a, Blupura's product range includes the Blue soda – a compact, powerful, and entirely stainless steel chiller. The chiller also uses Blupura's signature DRY COOLING technology.

There are approximately 200 units installed already in Italy and Constantini said the company continued to receive international enquiries about their technology. Constantini highlighted two public installations – one in Sirolo (Italy) and another in San Francisco (U.S.) - both of which eliminate the need for plastic bottles and generate water closer to the source (creating less pollution).

"The water can be taken with a pre-paid card," Constantini said. "For example in Italy there are companies that sell pre-paid cards for €5, charged with 100 litres, so the water is sold at five cents per litre, which means it is four or five times cheaper than bottled water in a supermarket. It's a very good service for the community to supply cool water at an affordable price."

RED BULL'S ECO COOLERS SUITABLE FOR ALL CLIMATES, EVEN THE TROPICS

In his presentation, Red Bull's Brenneis looked at the performance of hydrocarbons in point of sale equipment, in order to address concerns that HCs are not as efficient in tropical conditions. Working in conjunction with Liebherr, Red Bull tested the energy consumption of an R600a, 370L, Mega Glass Door Cooler using an Embraco EMT644Y

“ With this product we have proven that for us, for important placements like Greece, the Middle East, south of Croatia or even Spain, that it is definitely no issue at all to place hydrocarbon coolers, also in non-air-conditioned places. ”

JÜRGEN BRENNEIS

RED BULL.

compressor. The unit was tested at different temperatures and compared to R134a the units performed as follows:

- 25°C: R600a used 16% less energy than the R134a unit
- 38°C: R600a used 20% less energy than the R134a unit
- 43°C: R600a used 21% less energy than the R134a unit

A FIRST FOR CO₂ IN FOOD-SERVICE REFRIGERATION IN THE UK

Green Cooling Commercial Director Garry Broadbent and Technical Director Dave Blinkhorn presented a case study about a CO₂ food-service refrigeration system, provided and installed for KPMG at Canary Wharf, London - a project which encompassed a restaurant with a seating capacity of 1,500 people. The project highlights the practical nature of utilising CO₂ refrigeration within a centralised system as an alternative to conventional designs, while satisfying the UK BREEAM sustainable building standard.

The system features a twin refrigeration enEX CO₂ pack design with six Dorin compressors. A 4,500-litre hot water production system was incorporated within the CO₂ system design, in order to reuse the waste heat and provide higher overall system efficiency. The catering facility benefits from higher efficiency and a sustainable cooling system that matches the flexible and variable load conditions that are found within a busy restaurant environment. This CO₂ system represents a step forward within the HORECA (Hotel, Restaurant, Cafe) market in the UK, expanding the scope of R744 beyond the more traditional, large capacity retail sector.

COKE'S JOURNEY TO ACHIEVE 100% NATURAL REFRIGERANT PROCUREMENT

In his presentation, Antoine Azar, Global Program Director of The Coca-Cola Company, was proud to announce that Refrigerants, Naturally!, of which they are a founding member, has placed over 3.5 million HFC-free refrigeration units worldwide. The Coca-Cola Company itself currently has 1.4 million HFC free units, representing an improvement of 20% compared to 2013. Among those models, 230 use CO₂, 78% of which are more energy efficient than HFC versions.

Nevertheless, challenges remain and The Coca Cola Company will narrowly miss their target to achieve 100% natural refrigerant procurement by the end of 2015, due to a lack of suitable CO₂ compressors solutions for small equipment. Instead, for very small applications, Coca-Cola has developed a thermoelectric cooler.

“ This year, about 600,000 commercial compressors will not be bought using R134a, but we buy 1.2 million pieces of equipment every year, so I am making a call to compressor manufacturers to help us.

ANTOINE AZAR

THE COCA-COLA COMPANY.

cubigel[®]
compressors

Live
the **Cooling**
Experience

As leaders in the production of compressors for commercial refrigeration, Cubigel Compressors[®] products offer remarkable efficiency ranges of compressors and condensing units. The solutions of Cubigel Compressors[®] are supported by European development and focus on product innovation strategy with comprehensive industry experience. The company has been in the market for more than 50 years and it is part of the Huayi Group, the world's leading manufacturer of hermetic compressors.

As a result, our customers can enjoy an ultimate experience in which quality, service, technology and innovation come together.



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COMPRESSOR
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10+

years of extensive
experience in
natural refrigerants

Engineering a greener tomorrow

Your expert in natural
refrigerants

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ENGINEERING
TOMORROW

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CHAPTER 5

DOMESTIC & COMMERCIAL

HEAT PUMP TECHNOLOGIES



SYLVAIN GILLAUX

SANDEN EUROPE

SHIGERU YOSHIDA

mitsubishi heavy industries



MICHAEL MIRANDA

BOOSTHEAT

RANIERO TRINCHIERI

ENEA



JOSÉ MIGUEL CORBERÁN

UNIVERSITAT POLITÈCNICA DE VALÈNCIA, SPAIN

MENNO VAN DER HOFF

UNIECHEMIE

A TMOSphere Europe 2015 provided a platform for some of the latest heat pump innovations, including ENEA's joint case study on a heat pump with a unique two-cylinder compressor, designed to cater for the European market. boostHEAT showcased its integrated heat pump/boiler solution, while Mitsubishi Heavy Industries (MHI) and Sanden outlined the increased migration of their products from Asia to Europe. In an exclusive world premier, Menno Van der Hoff unveiled for the first time the TripleAqua, a patented natural refrigerant heat pump system using propæne as the refrigerant. Designed for heating and cooling of medium and large size buildings, this cutting-edge technology allows for reductions in energy consumption of up to 50% and can achieve a label A+++ for building energy efficiency, the highest attainable level.

COLLABORATION ON DHW (DOMESTIC HOT WATER) HEAT PUMP BROADENING AMBIENT BOUNDARIES

One of the highlights of the Heat Pump Session at ATMOSphere Europe 2015 was ENEA's (Italian national agency for new technologies) ongoing four-year case study of CO₂ and hydrocarbon heat pumps for domestic and commercial applications in European conditions. The European project, including three universities (Stockholm, Napoli and Valencia) and several manufacturers, including Alfa Laval, Dorin, Danfoss and Lu-ve, was designed to test three R290 heat pumps and two CO₂ heat pumps.

To date, ENEA has performed around 80 tests set to international standards. Raniero Trinchieri, ENEA Research Scientist, outlined the project, which commenced in December 2012, and included the development of a new 30kW CO₂ heat pump for residential heating of hot water as well as a 50kW commercial heat pump. As part of the joint project, enEX is supporting the design and construction of heat pumps and control of the machine, Dorin is supplying the compressor, Lu-ve the CO₂ heat exchangers, Alfa Laval the gas cooler and internal heat exchanger, and Danfoss the electronic expansion valve.

The heat pump for domestic applications has proven to work in winter (-10°C to 10°C) and summer conditions (20°C, to 35°C) producing 60°C hot water (up to 80°C capacity). The 50kW heat pump for commercial purposes produces 80°C hot water when operating in an ambient temperature range (-10°C to 35°C).

"After testing we have evaluated the global performances of the heat pump," Trinchieri said. "For example for compressors and gas cooler the performances were good for most conditions. We had some problems with the internal heat exchanger and evaporator; the internal heat exchanger had efficiency problems due to the high temperature of the evaporator, which was higher than expected, in particular when the ambient temperature increases."

Trinchieri noted that performance in terms of COP is greatly improved when the ambient temperature is higher than 2°C. To improve further in this area the project partners are focusing on three key areas:

- Optimisation of gas cooler pressure by internal control
- Optimisation of the internal heat exchanger efficiency
- Optimisation of work conditions of the evaporator

Dorin is working on improving the compressor, which is already showing 'high mass flow and high input power in many operating conditions' but the electric motor, suction reeds, valve plate and discharge port all have to be improved as well as the controller of the gas cooler pressure.

“ This 30kW [heat pump] can work in a range of ambient temperatures, which is not conventional for a CO₂ heat pump as it utilises a two-cylinder compressor. ”

RANIERO TRINCHIERI

ENEA

“ The innovation of the heat pump boiler is really the fusion of the boiler and the heat pump into one fully integrated unit and this is achieved by our patented thermal compression technology. ”

MICHEL MIRANDA

BOOSTHEAT



"This is because in some conditions, when the ambient is higher than 20°C and water inlet temp is higher than 30°C, the controller does not work in an automatic condition," Trinchieri said.

BOOSTHEAT'S INTEGRATED HEAT PUMP/BOILER, A 'GLOBAL SOLUTION'

Michael Miranda, Business Developer at boostHEAT presented a new type of natural gas-fuelled residential CO₂ heat pump. The heat pump has been shown to increase efficiency by up to 200% in light of the fusion between the boiler and heat pump.

At the heart of the technology is the new thermal compressor, which uses the heat from the burner instead of mechanical energy, to efficiently compress the natural refrigerant. The compressor activates the thermal compression cycle at a high temperature. The pressure cycle is the direct result of the thermal cycle, which has the added benefit of causing minimum wear to the equipment.

French gas distribution company GDF SUEZ helped with testing the product and the results showed an efficiency of 200%, with COP 5.2, and producing 35°C water. Impressively, even at a very high water temperature (65°C), the efficiency was 165% with a COP of 4.29. The unit reaches a capacity of 22kW at -10°C ambient and 33kW at 7°C. Here, the boostburner can add additional output if needed; it runs at the efficiency of a condensing boiler, which is integrated into the thermal compressor.

"We see [the heat pump] as a solution for the global residential heating and hot water market," Miranda explained. "We've been able to achieve a real leap forward in efficiency, really by taking advantage of the full benefits of our natural refrigerant carbon dioxide."

The second generation of the 'combination boiler' is already underway, with at least five units to be installed in France in 2015. boostHEAT will conduct further testing in the UK, which it sees as a viable market for the product.

Q-TON MAKING INROADS IN EUROPE WITH INDUSTRY HIGH COP OF 4.3

Shigeru Yoshida, Engineering Manager for the Heat Pump Designing Group at Mitsubishi Heavy Industries (MHI), presented a number of case studies on its Q-ton CO₂ heat-pump water heater. The Q-Ton has been successfully installed in a range of applications in Japan and Europe, achieving efficiency gains and operation at an ambient temperature as low as -25°C, with an industry-high COP of 4.3. As was outlined at ATMOsphere Asia 2015, the transcritical heat pump initially faced

the same challenges as its predecessors in cooler temperatures, but MHI has been able to improve its performance in very low ambient temperatures.

The Q-Ton is a specialty heat pump for domestic hot water applications and Yoshida noted the differences in installation between Japan and Europe.

"The tank system is completely different in Europe than it is in Japan, where they typically use open tanks, but the Q-ton can be used for both (open and closed). It tries to work in a similar fashion to a gas water boiler where it can work at low ambient temperatures," he said.

Yoshida presented case studies from two hot spring inns in Matsumoto and Kanazawa, Japan. At the two locations a hybrid system with boiler was used. The set-up included an imbedded cylinder tank, and a faucet utilising the existing tank and boiler, with the purpose to facilitate bathroom and shower facilities.

Other Q-Ton installations include:

- An office block in Germany utilising three Q-Ton units with closed tank 1000L capacity.
- Hotel retrofits in the UK and Spain, both using two Q-Ton units
- Student accommodation in the UK supplying domestic hot water for 48 students, using a 6kW immersion element

HEAT PUMPS CENTRAL TO SANDEN'S ALL-CO₂ PLAN

Earlier at the conference, Sanden confirmed plans to steer away from HFCs in the coming years and adopt 100% CO₂ technology. With new headquarters opening up in Brittany, France, Sylvain Gillaux of Sanden's European division said the company hoped to boost sales of its heat pump range for household and light commercial applications as part of the accelerated transition.

"Wherever we have a need for heating or cooling, we want to meet this need with CO₂," Gillaux explained. "Providing some CO₂ modules we want to concentrate on what we do, be it heating, hot water or space heating, and work with the specialists of this market with already strong brand names and use our CO₂ modules."

Sanden's heat pumps for hot water come in two models: the first with 4kW capacity and a COP of 3.0 for domestic applications, and the second with 6kW capacity and a COP of 3.3 for light commercial needs.



Sanden plans to bring its experience in Japan to Europe with a particular focus on increasing penetration in the commercial sphere.

OPTIMISATION OF THERMAL STORAGE ENERGY ACHIEVED WITH TRIPLEAQUA

ATMOsphere Europe 2015 was the chosen location for the unveiling of a very unique natural refrigerant heat pump technology using hydrocarbons. The outdoor heat pump, presented by Menno Van der Hoff, Research & Development HVAC Manager at Uniechemie, operates with the climate-friendly refrigerant propæne 433A (a mix of R290 propane and R1270 propene), with a charge of less than 5kg, and three pipelines for hot (28 – 36°C) and cool (12 - 18°C) water, and a return pipe for water at ambient temperature. Thanks to its water-based loop design, no coolant enters the building, ensuring system safety. Inside the building, heating and cooling is provided by slim-line horizontally and vertically installed units equipped with self-regulating water control valves.

The TripleAqua has an external unit that autonomously controls all tasks with its own arithmetic processor. The full package of controls (provided without purchasing additional options) include functions such as speed and capacity control, energy measurements, sensors, door surveillance, CO₂ measurement input, clock, day/night/weekend, emergency heating, communication with GBS, VING card, fresh air, CO₂ control, and more.

Van der Hoff said that the TripleAqua combines the advantages of VRF fan coil systems and allows for reductions in construction costs of 25%. It also reduces operation costs by at least 50% compared to traditional heat pumps. What is more, the TripleAqua is easy to install, easy to use and uses standard components that are readily available on the market.

“ Tripleaqua has thermal internal storage for cooling and it can simultaneously heat and cool to double the efficiency with water moving the energy around.

MENNO VAN DER HOFF

UNICHEMIE



EU-FUNDED PROPANE WATER-TO-WATER HEAT PUMP BOOSTER

José Miguel Corberán, Professor at the Universitat Politècnica de València, gave an additional presentation on hydrocarbon heat pump technology. He outlined the University's EU-funded project to test a propane water-to-water heat pump booster for sanitary hot water production.

The university is working with different units - the compressor is supplied by Danfoss and Alfa Laval supplies the hydrocarbon heat exchanger. Corberán said he considered the excellent properties of CO₂ for this application, given the high gas cooler efficiency it supplies at a low temperature input to high water output. However, he noted that when compared to the CO₂ cycle, propane represented a good candidate for producing hot water at high temperatures. This is due in part to propane's low discharge temperature.

"We're trying to significantly increase the subcooling on the heat pump and trying to maintain good efficiency for the set condenser and subcooling," Corberán said.

"We did some modelling to see if the COPs we could expect were high and the results were good. We were able to analyse what the COP was at different condensation and subcooling pressures. When we took the water temperature of 10°C at the unit of the condenser and we changed the condensation pressure (amount of subcooling), we saw the optimum for each temperature at the inlet:

- At 15°C (inlet water temperature to condenser) a COP of 5 was attained
- At 25°C (water inlet temperature to evaporator) a COP above 5 was attained

"We are asking about the potential market for this," Corberán said. "We think that it is not huge but there is at least a niche market for low temperature heat recovery – in buildings at the industrial level, low temperature hot water processing, commercial moulds, and smaller places like supermarkets where there are condensation loops."

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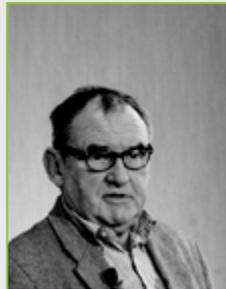
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CHAPTER 6

INDUSTRIAL REFRIGERATION, COOLING & HEATING



JÖRGEN ROGSTAM

ENERGI & KYLANALYS

KENT HOFMANN

GREEN & COOL WORLD REFRIGERATION

PAUL RIVET

AF CONSULTING



JUAN CARLOS RODRÍGUEZ

JOHNSON CONTROLS ESPAÑA

GARRY SHAW

JOHNSON CONTROLS

JAN BOONE

MAYEKAWA EUROPE



JOHN BURDEN

JOHNSON CONTROLS INDUSTRIES

PAUL DE LARMINAT

JOHNSON CONTROLS INDUSTRIES

JÜRGEN SÜSS

EFFICIENT ENERGY

For industrial applications, ATMOsphere Europe 2015 featured case studies on both ammonia and CO₂, including the first CO₂ ice rink in Europe. For the food-processing sector, Mayekawa and Johnson Controls presented ammonia heat pump case studies that have enabled end users to reduce their energy costs by as much as half, whilst AF Consulting presented on a CO₂ transcritical installation at a frozen fish factory in France. For high temperature needs in the industrial market, attendees experienced an ATMOsphere first with water vapour heat pump technology discussed.

FIRST CO₂ TRANSCRITICAL ICE RINK IN EUROPE BY GREEN & COOL

A first in Europe in 2014 was the implementation of a CO₂ transcritical ice rink installed in Gimo, Sweden. Kent Hofmann, Sales Engineer at Green & Cool and Jörgen Rogstam, Managing Director of Energi & Kylanalys, presented a case study on the initial efficiency results since the system's implementation in September 2014.

The renovation stemmed from the collapse of the ice-rink's roof in 2013, which was replaced, less than a year later, with a new roof and upgrade of the energy management technology. At the heart of the new system is a transcritical CO₂ unit with a 250 kW nominal cooling capacity. The system is able to recover a large portion of the waste heat from the cooling process to use for site heating and hot water. Any excess heat is transferred to geothermal energy storage, enabling subcooling of the CO₂ process and saving heat for use during colder periods, thus providing both a 'warm climate' and 'cold climate' solution. No supplementary heating such as gas, electricity or district heating is used.

In addition, the low pumping power suits the vast distribution system in the rink floor and CO₂ can be used directly (i.e. no secondary fluids are required) on both the cold and the warm side, which cuts losses in heat exchangers and reduces parasitic energy usage by pumps and fans. Reduced energy usage, mainly due to heat reclaim, is an important saving for the ice rink owner together with lower service costs.

Thanks to the CO₂ system, the daily average energy usage of the ice rink was reduced to 1,500 kWh, from 4,200 kWh, which suggests that the seasonal energy usage will be about 350,000 kWh, about a third of the energy usage of a standard ice rink. This is an energy savings for the municipality of about 600,000 kWh a year, corresponding to over 60% energy cost reductions.

CO₂ TRANSCRITICAL FREEZING FACTORY IN FRANCE

Manager of AF Consulting Paul Rivet presented on a CO₂ transcritical system in a frozen fish factory in France. The system is made up of two continuous freezers with capacities of 350 kW at -40°C, as well as frozen storage rooms with a 100 kW capacity at -25°C, and working areas of 150 kW at +8/+10°C. Usually, a project of this nature would use ammonia as the refrigerant, but in this case a complete CO₂ transcritical system was installed, after comparisons with direct pumped NH₃, direct pumped HFC, a hybrid CO₂/NH₃ system, and also due to the strict constraints on ammonia refrigeration in France. The aspects taken into account were: investment costs, running costs, safety, service and heat recovery possibility.

The freezing equipment installed included:

- 8 semi-hermetic compressors on HT and 5 on LT (2 with inverter)
- 2 continuous freezers fed with CO₂ pump with variable flow
- CO₂ charge of 13,000 kg

“ CO₂ has become a successful refrigerant in the food retail industry and now has the potential to revolutionise the ice rink industry. ”

KENT HOFMANN

GREEN & COOL



Even if the performance of using air to remove discharge heat is not as effective as ammonia, Rivet concluded that this CO₂ transcritical system has proven to be a good alternative with its evaporative condenser during hot periods, individual running room programme for day/night operation, reduction of distribution piping at -40°C, and heat recovery.

CENTRALISED CO₂ SOLUTION FOR MEAT PROCESSING FACILITY IN SPAIN

Juan Carlos Rodríguez, Engineering Manager at Johnson Controls España described the installation of a centralised CO₂ industrial refrigeration system to improve the quality of production and reduce long-term operational costs at the FRIBIN meat processing facility in Spain. The solution provides a saving up to 2,600,000 kW per year, which translates to 32% and €380,000 in energy and cost savings respectively.

Before renovation, the plant had four machine rooms dating back to the 70's, 80's and 90's. This project was implemented in two phases, with no disruption to production, and allowed for better performance, consumption and control. One of these machine rooms was renovated in 2004 with three new Sabroe screw compressors, which provide 5,245 kW at temperatures of -13°C, -29°C and -48°C. As part of phase one of the project, the remaining three machine rooms were unified in the recently installed NH₃ machine room, thus limiting the number of compressors and maintenance costs. The existing tunnels and cold rooms were replaced with CO₂ (all piping and evaporators were renewed), the system was fitted with high-pressure reciprocating compressors, while glycol was implemented for the working rooms.

During phase two, Johnson Controls installed a Sabroe heat pump to generate hot water for cleaning, whereby the thermic energy delivered in the process is reused to produce hot water and keep the working space clean and secure.

A NEW INDUSTRY STANDARD FOR ENERGY OPTIMISATION – CRANSWICK COUNTY FOODS

Also from Johnson Controls, Senior Sales Executive Garry Shaw and Sales Manager John Burden presented a case study on an ammonia industrial heat pump installation at Cranswick County Foods, located in Watton, Norfolk, in the UK.

Cranswick is one of the main suppliers of pork products to supermarkets in the UK. In order to phase out its R22 and HFC dependency, improve its product yield, and reduce costs, personnel at the pig abattoir decided to overhaul the refrigeration system. It accepted bidders for the refurbishment of its plant in 2012 and since November 2013 the abattoir has been running Sabroe industrial refrigeration heat pump reciprocating compressors.

The case study revealed that the company was able to reduce the energy costs by £500k (€686k) per year, increase productivity by 30% and decrease the weight loss of the carcasses from 2.3% to 1.4%.

“ The CO₂ transcritical solution with pumped circulation is a much better solution than HFC technology, and it is also an interesting alternative to the usual ammonia solution.

PAUL RIVET
AF CONSULTING

“ By centralising the refrigeration and heating system, and working with the customer, we have been able to achieve a 30% reduction in electricity and gas consumption, zero dependency on heavy oil, 10% reduction in water consumption, and a 45% reduction in their CO₂ emissions.

GARRY SHAW
JOHNSON CONTROLS

The newly installed four-stage ammonia/ glycol system comprises:

- Low temperature ammonia at -33°C x 1,700 kW
- Medium temperature ammonia at -12°C x 600 kW
- Secondary water/glycol at -8°C x 1,000 kW
- High temperature heat pump at $+60^{\circ}\text{C}$ x 950 kW

The cooling COP is 2.3 (LT) and 3.9 (HT), while the heating COP is 14. The new system includes five frequency driven SABROE screw compressors, two SABROE heat pump compressors, a multi-stage heat recovery system, 65 air coolers, nine distribution heat pumps, two evaporative condensers and a SCADA control system.

NH₃ HEAT PUMP FOR HOT WATER PRODUCTION IN BELGIAN BAKERY FACILITY

Mayekawa's Executive Director Jan Boone presented a case study describing an industrial bakery plant located in Mouscron, Belgium, requiring a hot water heat pump for an extension of its production capacity. The installation was designed to reduce energy consumption and energy costs in order to contribute to the company's sustainability program.

The specific demands of the bakery plant were:

- Production of 1000 m³/day of hot water at 65°C with a heating capacity of 300 kW per hour
- 70 m³/day of warm water at 25°C for dough-proofer, with a heating capacity of approx. 65 kW
- Cooling of 2,5 MW at -30°C and 1 MW at -10°C
- -30°C freezing, for which an ammonia pump circulation and direct expansion was used

To produce hot water at 65°C Boone explained that an ammonia heat pump was fitted, with a condensing temperature at 67°C , corresponding with a pressure of 29.5 barg. The system also recovers the condenser heat of the NH₃ refrigeration system, resulting in a positive impact on the condenser load and the recovery of residual heat for hot water production. This provides ideal warmth and humidity for the rising of the bread products in the plant.

The heat pump equipment uses a piston type compressor equipped with frequency convertor for capacity control. The compressor has mechanical cylinder banks, which can be unloaded, and a 375 kW heating capacity. The final design coefficient of heating performance corresponds to 7.7 at a 30°C evaporating temperature.

According to Boone, the bakery achieved annual energy savings of €56,200 and a return on investment of three years. He also noted the heat pump's long lifetime of more than 25 years and low maintenance costs.

“ If we compare the two systems, a conventional gas boiler and an electric heat pump, then for a hot water quantity of 375 kW per hour, a gas boiler will have energy costs of €109,500 and a heat pump will have energy costs of €53,300. The heat pump thus provides a cost saving of 51% and a CO₂ savings of 378 tons or 42%.

JAN BOONE
MAYEKAWA

WATER CHILLERS AND VAPOUR TECHNOLOGY MAKING WAVES AT HIGH TEMPERATURES

A little used refrigerant in many applications, water's high efficiency in a vapour compression heat pump and in the pioneering eChiller, was highlighted in presentations by Jürgen Süß, Chief Technical Officer of Efficient Energy, and Paul de Larminat, Director Advanced Technologies at Johnson Controls Industries.

Süß began his presentation by promoting R718 as containing a 'list of properties a good refrigerant should comply with' from its physical make up (environmentally benign, sufficient pressure, low viscosity etc); its chemical properties (chemical stability, low flammability etc.); physiological properties (no toxicity); and economical properties (high COP, volumetric refrigeration capacity etc.).

Taking advantage of these properties, Efficient Energy has developed a two-stage, centrifugal compression module - the eChiller. The unit contains a heat exchanger as well as another device taking the cooling water, and operates in a vacuum to achieve the temperatures needed for refrigeration. The system 'decides' whether it runs in free cooling mode, or one stage or two-stage compression.

"When the temperature outside increases, the machine slowly begins to start the compressors and increase the temperature from the heat source so that it can dump the heat, so it's like a lazy human being with the minimal level of applied effort," Süß explained.

Following testing in Frankfurt, Süß found the eChiller could achieve an exceptionally high COP of 26 with 22°C cold water at the inlet/16°C at the outlet, at an ambient temperature of 40°C (refrigerant capacity 45kW). At this temperature, the eChiller is a suitable alternative for facilities like data centres. "This is not really even refrigeration, or cooling, but is a temperature that you would need for say a data centre," Süß said. "Plastic moulding would be another application, a lot of industry cooling would be in that range."

Preliminary testing over Christmas affirmed Süß's remarks: "When the ambient temperature cooling water is below 14°C, which in a normal European climate is quite often the case, then the machine only needs about 300-400W to take 45kW out of the server room, so this is a COP in the range of 100," he said. "The competitor technology is doing that job with about 9kW, which is not too bad either but definitely far away."

In another industrial refrigeration application, Paul De Larminat showcased the test results of Johnson Controls' (JCI) heat pump using water vapour as the working fluid. Like Süß, de Larminat extolled the many virtues of using water vapour: its low cost, excellent efficiency at high temperatures and ability to be used in closed and open loops.

“ If everything is green then you have the opportunity to apply the refrigerant globally and also in a viable way. As we can see with water, all that a good refrigerant should comply with is fulfilled. ”

JÜRGEN SÜß

EFFICIENT ENERGY



ATMO
ATMOSPHERIC THERMAL MONITORING ORGANIZATION

Some challenges and issues to consider

<p>• Regulatory compliance: Meeting the requirements of various international and national standards and regulations, such as ISO 14001, ISO 9001, and ISO 45001.</p>	<p>• Market competition: Identifying and addressing the needs and expectations of a diverse customer base, while maintaining a competitive edge in a global market.</p>
<p>• Operational efficiency: Streamlining processes, reducing costs, and improving the overall quality of services provided to clients.</p>	<p>• Technological innovation: Investing in research and development to stay at the forefront of atmospheric monitoring technology.</p>

Aimed at bridging a gap in the market, JCI teamed up with Electricité de France (EDF) to develop high pressure heat pumps, with capacities of around 600kW and 90-130°C, for the industrial market. De Larminat said that currently the majority of heat pumps are limited to around 85°C, where there is a lot of waste heat, but said there was huge demand in larger applications for heating between 100-150°C.

“The study (with EDF) was driven mostly by market needs and showed heat demand by industry in France per temperature level,” explained de Larminat.

Prior to JCI's entrance to the market there were no suitable systems using mechanical vapour recompression (MVR), which works by raising a product's temperature above its boiling point to remove liquid and concentrate the fluid. This technology produces thermal energy, mainly steam, for heating.

Using MVR, JCI's aim was to achieve a temperature lift of 30°C with a relatively large volumetric flow. To do this they used a two-stage centrifugal compressor (magnetic bearings/oil free) to compress, which is now a standard fixture in JCI products.

Results from a prototype that has been running for about one year at an EDF test block showed that the MVR solution achieved a COP of 5.4 at design conditions of 90°C (evaporation), 130°C (condensation) and 40°C lift. The average electrical energy consumption of the MVR solution is 130kWh.

JCI is now looking to develop bigger prototypes (2.5MW) and de Larminat noted that this is a market trend to look out for in the future.

SOLUTIONS COVERING THE NEEDS OF CO₂ REFRIGERATION SYSTEMS



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CHAPTER 7

TRANSPORT REFRIGERATION



LIONEL POURCHERESSE
CARRIER TRANSICOLD EUROPE

ANTHONY BOUR
THERMO KING

The introduction of new F-Gas measures in the EU as of 2015, and in particular the bans on HFCs in certain sectors, have opened up new market opportunities for a wider uptake of climate friendly natural refrigerants, including CO₂ in the transport refrigeration sector. Two case studies on the topic were presented, one focusing on the use of CO₂ in a closed loop system and the other an open loop system.

Lionel Pourcheresse, Senior Manager Sustainability & Product Solutions, Carrier Transicold Europe presented the world premiere of the company's new E-Drive Natural Refrigerant Trailer prototype, which was launched in 2014. The refrigeration unit is dedicated to road transport and uses CO₂ in a closed loop system. It is fully autonomous and driven by an independent diesel engine.

The prototype aims to demonstrate the future for refrigerated transportation systems in compliance with the EU F-Gas Regulation. The trailer is charged at the factory with a defined amount of CO₂ refrigerant. The CO₂ inside the refrigeration circuit is compressed, then expanded, and compressed again in a closed loop system.

"The benefit for the user is that there is no need to recharge the system everyday and no need for heavy infrastructure to store the natural refrigerant," said Pourcheresse.

The cost of the system, initially higher than current or partially improved systems, is countered by the elimination of leakage check costs, taxes on refrigerant and refrigerant price versatility.

Pourcheresse's presentation was followed by that of Thermo King's CryoTech Product Manager Anthony Bour, on CryoTech transport refrigeration technology using liquid CO₂ in an innovative open loop system. The recovered R744 used for cooling is obtained as a by-product from industrial processes, which would otherwise have been released into the atmosphere. As such, there are no new CO₂ emissions during the operation of the CryoTech system.

The CryoTech system functions in the following ways:

- Heat is absorbed by passing liquid CO₂ through an evaporator
- CO₂ does not enter the load compartment
- Max noise level 58dBA

There are nearly 1000 CryoTech equipped trailers on European roads, including 10 in Delhaize Belgium's fleet – Delhaize was the first retailer to equip themselves with the technology in an effort to help reduce greenhouse gas emissions (GHG) by 20% by 2020 (as compared to 2008). Estimations show that during delivery the CryoTech-equipped Delhaize trailers use only 25% of the total energy and generate 75% fewer emissions than a domestic refrigerator of equal size.

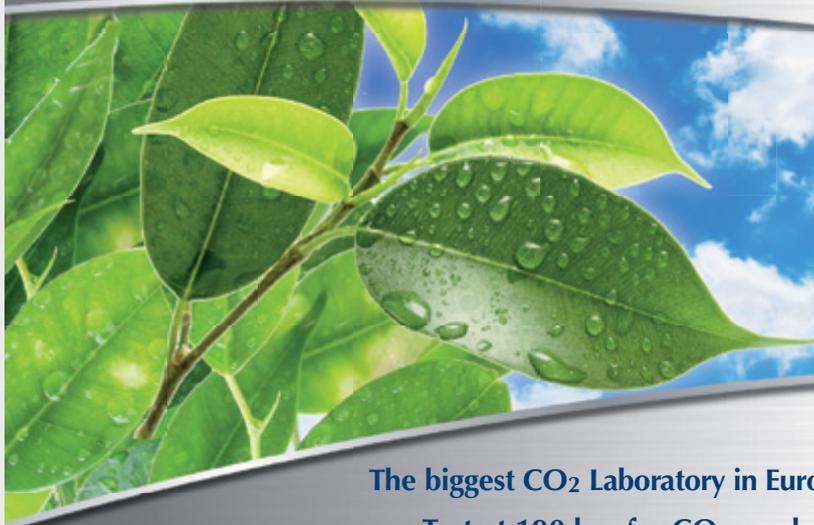
According to Bour, CryoTech units are capable of faster recovery temperature compared to conventional diesel driven refrigeration, and allow for faster temperature pull-downs. "This is crucial where the cooling unit is often interrupted as drivers deliver goods at multiple locations," said Bour.

“ This new design reduces potentially harmful effects on the environment, without compromising reliability or performance, creating a desirable balance between efficiency and sustainability. ”

LIONEL POURCHERESSE

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GLOSSARY

AC	— AIR CONDITIONING OR ALTERNATIVE CURRENT
AREA	— AIR CONDITIONING AND REFRIGERATION EUROPEAN ASSOCIATION
BAU	— BUSINESS AS USUAL
BLDC	— BRUSHLESS DIRECT CURRENT
CDU	— CONDENSING UNIT
CGF	— CONSUMER GOODS FORUM CO ₂ - CARBON DIOXIDE
CO₂	— CARBON DIOXIDE
COP	— COEFFICIENT OF PERFORMANCE
CVS	— CONVENIENCE STORE
dBA	— A-WEIGHTED DECIBELS
DG	— DIRECTORATE GENERAL
DHW	— DOMESTIC HOT WATER
DTI	— DANISH TECHNOLOGICAL INSTITUTE
DX	— DIRECT EXPANSION
EC	— EUROPEAN COMMISSION
EDF	— ÉLECTRICITÉ DE FRANCE
EIA	— ENVIRONMENTAL INVESTIGATION AGENCY
EPA	— ENVIRONMENTAL PROTECTION AGENCY
ETS	— EMISSIONS TRADING SYSTEM
EU	— EUROPEAN UNION
FGB	— FLASH GAS BYPASS
GHG	— GREENHOUSE GAS EMISSIONS
GWP	— GLOBAL WARMING POTENTIAL
H₂O	— CHEMICAL NAME FOR WATER
HC	— HYDROCARBONS
HCFC	— HYDROCHLOROFLUOROCARBON
HFC	— HYDROFLUOROCARBONS
HORECA	— HOTEL, RESTAURANT, CAFE
HP	— HORSE POWER
HPMP	— HCFC PHASE OUT MANAGEMENT PLANS
HT	— HIGH TEMPERATURE
HVAC&R	— HEATING, VENTILATION, AIR CONDITIONING & REFRIGERATION
JCI	— JOHNSON CONTROLS
JCM	— JOINT CREDITING MECHANISM
JRAIA	— JAPAN REFRIGERATION & AIR CONDITIONING INDUSTRY ASSOCIATION

KWH	— KILOWATT HOUR
LBP	— LOW BACK PRESSURE
LLCP	— LIFE CYCLE CLIMATE PERFORMANCE
LT	— LOW TEMPERATURE
METI	— MINISTRY OF ECONOMY, TRADE AND INDUSTRY
MHI	— MITSUBISHI HEAVY INDUSTRIES
MLF	— MULTILATERAL FUND
MOFA	— MINISTRY OF FOREIGN AFFAIRS
MOE	— JAPANESE MINISTRY OF THE ENVIRONMENT
MW	— MEGAWATT
MVR	— MECHANICAL VAPOUR COMPRESSION
NCV	— NET CALORIFIC VALUE
NGO	— NON-GOVERNMENT ORGANSATION
NH₃	— AMMONIA
NR	— NATURAL REFRIGERANT
ODP	— OZONE DEPLETION POTENTIAL
OEM	— ORGINIAL EQUIPMENT MANUFACTURER
PC	— PARALLEL COMPRESSION
R718	— REFRIGERANT NUMBER FOR WATER IDENTIFICATION FOR PROPANE
R290	— R-NUMBERING IDENTIFICATION FOR PROPANE
R600A	— R-NUMBERING IDENTIFICATION FOR ISOBUTANE
R744	— R-NUMBERING IDENTIFICATION FOR CARBON DIOXIDE
R717	— R-NUMBERING IDENTIFICATION FOR AMMONIA
ROI	— RETURN ON INVESTMENT
R&D	— RESEARCH & DEVELOPMENT
TC	— TRANSCRITICAL
TMG	— TOKYO METROPOLITAN GOVERNMENT
TOC	— TOTAL COST OF OWNERSHIP
UBA	— GERMAN FEDERAL ENVIRONMENT AGENCY
UEI	— ULTRA ECO ICE
UNEP	— UNITED NATIONS ENVIRONMENT PROGRAMME
UNEP DTIE	— UNEP DIVISION OF TECHNOLOGY, INDUSTRY AND ECONOMICS
UK	— UNITED KINGDOM
U.S.	— UNITED STATES
VRF AC	— VRF AC - VARIABLE REFRIGERANT FLOW AIR CONDITIONING

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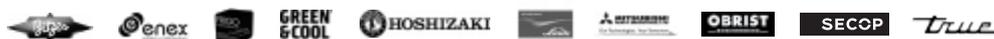
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