

1996-2026
30 Years of Championing

Refrigerants by Nature





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EDITORIAL



Rob Vandenboer,
Chair eurammon e.V.



Michael Freiherr,
Deputy chair eurammon e.V.

In 2026, eurammon commemorates its 30th anniversary - a fitting occasion to pause and assess the current situation in the Refrigeration, Air conditioning and Heat Pump (RACHP) sector. We warmly invite you to join us on a brief journey through the past, present and future of eurammon: a look back at three decades of promoting natural refrigerants, and a look ahead at what still lies before us.

When eurammon was founded thirty years ago, working with natural refrigerants was anything but self-evident. Ammonia, CO₂ and hydrocarbons were regarded with considerable scepticism, and their use remained a niche across most application areas. Those who advocated for them often found themselves explaining, defending and reassuring. How different the picture looks today: anyone walking the halls of RACHP trade fairs now will find natural refrigerant systems presented not as the exception, but as the standard. Proven, efficient and increasingly expected.

This transformation did not happen by chance. Significant developments have taken place at both European and international level. With the revised F-Gas Regulation, a major step was taken towards the European phase-out of F-gases, while the Kigali Amendment set the phase-down framework at global level. Together, these instruments have reshaped the regulatory landscape and confirmed what our members have long known: that natural refrigerants are not a temporary answer, but a lasting one.

And yet, eurammon's mission is far from accomplished. It has, rather,

evolved: from overcoming resistance towards natural refrigerants to helping the sector fully embrace them across all RACHP applications. The relevance of that shift has never been greater. The need for cooling is rising sharply. Reliable cooling has become a precondition for keeping much of our critical infrastructure operational. In this context, the choice of refrigerant is no longer a purely technical matter; it is a question of resilience, efficiency and long-term responsibility.

Looking ahead, our main challenges are clear. eurammon aims to grow into a trusted education base in Europe, and to serve as a reliable contact point in policy decision-making and implementation processes, translating technical expertise into practical guidance for industry and regulators alike.

Finally, and most importantly, we wish to thank our founding members, our current members and our partners. Thirty years of progress rest on your long-standing commitment to natural refrigerants, your conviction, your patience and your willingness to lead the way. It is thanks to people like you that naturally cool has become not an ambition, but a reality.

Here's to the next thirty years.

With warm regards,

Rob Vandenboer,
Chair eurammon e.V.

Michael Freiherr,
Deputy chair eurammon e.V.

ADVANCING NATURAL REFRIGERANTS

Founded in 1996, eurammon is a leading association of companies, institutions and individuals dedicated to advancing natural refrigerants in the refrigeration, air conditioning and heat pump industry.

Our Vision

eurammon envisions a world where the refrigeration, air conditioning, and heat pump (RAC&HP) industry fully embraces natural refrigerants as the reliable and sustainable pathway to net zero emissions.

Our Mission

eurammon's mission is to empower policymakers, industry stakeholders, and educational institutions with the knowledge, tools, and technical know-how necessary to accelerate the adoption of natural refrigerants in the RAC&HP sector.

Building on more than three decades of experience, eurammon provides:

- **Expert guidance** on transitioning to thermodynamically superior natural refrigerants in compliance with global and national phase-down regulations.
- **Accessible resources** such as publications, case studies, and educational events showcasing innovative solutions.
- **Clear advocacy** for implementing natural refrigerants in all viable RAC&HP applications, crucial for meeting a net zero carbon emissions target latest by 2050.

Global Presence & Impact

eurammon is a global network with member companies operating across all regions:

Europe

Belgium, Denmark, Finland, France, Germany, Hungary, Italy, Romania, Switzerland, The Netherlands, UK, Spain, Sweden, Turkiye

Americas

Argentina, Brazil, Canada, Chile, Mexico, USA

Asia-Pacific

Australia, China, India, Indonesia, Japan, Malaysia, Thailand

Middle East & Africa

Egypt, Saudi Arabia, South Africa, UAE

Value Chain Coverage

- Component Manufacturing
- System Assembly
- System Design
- Installation & Service
- End Users & Application
- Research & Education

Highlights

- Natural Refrigerants Symposium
- More Than 60 Case Studies
- eurammon Annual Student's Day
- Cooperation with International Organisations

EUR 40B
Combined
Annual Turnover

170K+
Total Workforce

100+
Countries
Reached

35+
Member Entities

Find out more at www.eurammon.com; connect with us on LinkedIn

BECOME A MEMBER



HISTORY:

30 YEARS OF EURAMMON

In 2026, eurammon celebrates three decades of pioneering advocacy for natural refrigerants in the refrigeration, air conditioning, and heat pump industries. Founded in July 1996 as a European initiative with 18 founding members, eurammon has grown into a global network of more than 50 members active in over 100 countries, fundamentally reshaping the perception and adoption of ammonia, CO₂, hydrocarbons and air as environmentally sound, efficient, and future-proof refrigerant solutions.

What began as an advocacy group addressing misconceptions surrounding ammonia as refrigerant has evolved into a recognised authority and leading source of evidence-based technical expertise on all natural refrigerants in the ongoing dialogue on their properties, applications, and technological advancements. In this role, eurammon has contributed decisively to the paradigm shift from synthetic refrigerants to natural alternatives in the global phase-down of ozone-depleting substances and climate-harmful HFCs, positioning natural refrigerants as a credible and reliable pathway to net-zero emissions in the cooling and heating sector.

1996: The foundation of eurammon

“eurammon has set itself the main goal of increasing awareness and acceptance of ammonia as an alternative refrigerant among consumers, residents of metropolitan areas, politicians and experts in Europe who have had little to do with ammonia to date, and of overcoming resistance to the use of this natural refrigerant.”

eurammon-Information Nr.1, 07/1996

In the early 1990s, the refrigeration and air conditioning industry faced a pivotal crossroads. The Montreal Protocol (1987) had mandated the phase-out of chlorofluorocarbons (CFCs), and increasingly stringent regulations were targeting hydrochlorofluorocarbons (HCFCs). While this created an opportunity for natural refrigerants - particularly ammonia, which had been successfully used in industrial refrigeration for over 100 years - a significant barrier stood in the way: public perception.

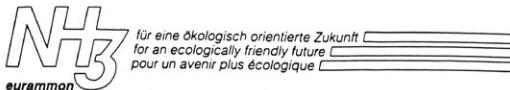
The chemical industry had a vested interest in promoting synthetic alternatives, often characterizing ammonia as acutely poisonous and harmful.

Meanwhile, countries like Luxembourg, Scandinavia, and Switzerland were already successfully using ammonia in supermarkets due to their high environmental awareness - demonstrating that the technology was proven, safe, and effective.

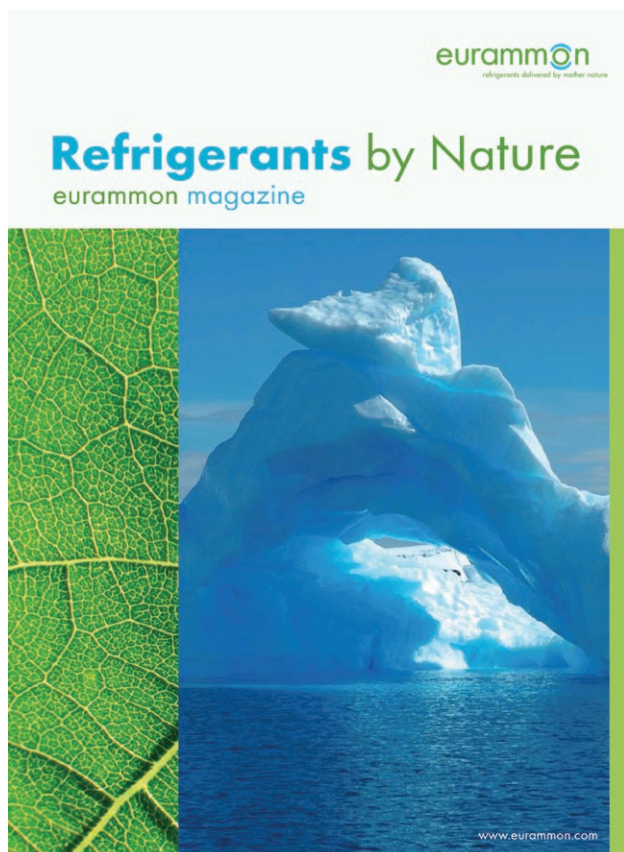
“For more than a century, Europe’s dairies, breweries, slaughterhouses and freezer halls have run on ammonia. And ammonia still does the job with less energy than any alternative.”

eurammon-Information Nr. 11, 02/1998

Founded in Frankfurt in July 1996, eurammon was established as a membership association (verbandlicher Zusammenschluss) of European companies with expertise in ammonia refrigeration. The name itself signals the mandate: “Europe” combined with “Ammonia,” anchoring both the geographic scope and technical focus. From the outset, eurammon pursued a tightly defined mission — bringing together the continent’s leading companies

		
	Mitglieder	
○ home	ABB Kälteanlagen GmbH	Mainz-Kastel
	Bock GmbH & Co. Kältemaschinenfabrik	Frickenhausen
	DANFOSS Wärme- und Kältetechnik GmbH	Heusenstamm
○ Aufgaben / Ziele	Energie Food Town GbR	Duisburg
	FRIGOPOL Kältemaschinen GmbH	A-Graz
	Fuchs Mineralölwerke GmbH	Mannheim
○ Mitglieder	GEA Grasso GmbH Refrigeration Technology	Berlin
	Hans Güntner GmbH	Fürstenfeldbruck
	M. G. Herl Armaturenfabrik GmbH & Co. KG	Köln
○ Informations-schriften	KWN Engineering-Gesellschaft mbH	A-Seekirchen
	ILKA MAFA Kältetechnik GmbH	Halle
	Gustav Mohrmann GmbH & Co. KG	Geesthacht
○ E-Mail	Reinhard Raffel Metallwarenfabrik GmbH	Bonn
	SABROE + Söby Kältetechnik A/S	DK-Horslet
	SABROE Industriekälte GmbH	Flensburg
	Sulzer-Escher Wyss GmbH	Lindau
	Th. Witt Kältemaschinenfabrik GmbH	Aachen
	YORK International GmbH	Mannheim

The eurammon founding members



eurammon magazine, launched in 2008

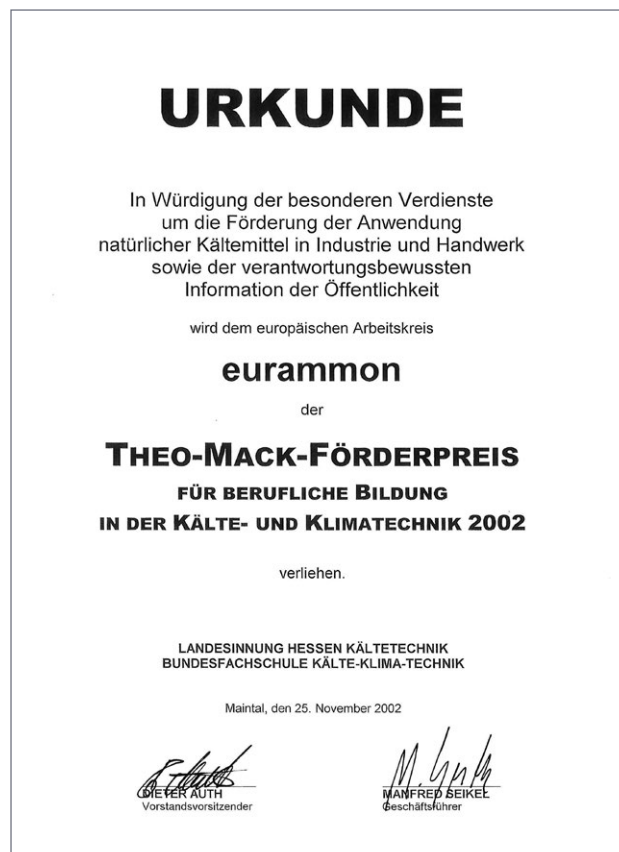
active in ammonia refrigeration and turning collective knowledge into practical, accessible output. This meant compiling technical regulations on ammonia use across European jurisdictions, building a structured literature base on ammonia topics, and producing technical papers on safe handling for operators, regulators, and the broader public.

1996–2026: Three decades of impact

What began as a technical forum for ammonia specialists has developed into a leading advocacy network for natural refrigerants - a transformation shaped by regulatory pressure, climate urgency, and a growing industry consensus that refrigerants with high



eurammon members meeting Verona 2008



Theo-Mack-Förderpreis, 2002

global warming potential have no long-term future.

Building the knowledge base (1996–2006): From its earliest years, eurammon converted expert knowledge into accessible reference material. By 1996, information papers on ammonia properties, safety regulations, TEWI concepts, and emergency procedures were already in circulation - establishing the publication model that would define the organisation for decades: identify knowledge gaps, produce technically sound guidance and case studies, and disseminate it broadly. In 2002 eurammon received the Theo-Mack-Förderpreis für Berufliche Bildung in der Kälte- und Klimatechnik from the Hessen State Guild and Federal Technical School - an early validation of its educational role.

The strategic decision to expand from ammonia to all natural refrigerants took shape around 2000 and was formally adopted in 2006 - the same year the EU F-Gas Regulation came into force, creating regulatory pressure on synthetic refrigerants and sharpening the rationale for the shift.

Institutionalising the network (2007–2016):

eurammon strengthened its internal structures in 2010 with the establishment of a Technical Committee. That same year saw the launch of the annual eurammon Symposium in Schaffhausen and the creation of two awards: the Natural Refrigeration Award - a biennial prize for pioneering research, co-hosted with universities and industry publications - and the eurammon Honour Award for exemplary industry

projects, recognizing sustainable, energy-efficient refrigeration and air-conditioning systems.

International reach expanded in parallel: by 2012, eurammon had formalised partnerships with the International Institute of All-Natural Refrigeration IIAR (USA), Le Club Ammoniac (France), the Indian Ammonia Association, NVKL (Netherlands), and the Green Cooling Association (Australia). A formal Memorandum of Understanding with IIAR followed in 2016, by which point eurammon maintained active partnerships with 14 international organisations and had been registered as a non-profit association in Germany.

Consolidating a global voice (2017–2026): The revised EU F-Gas Regulation and the Kigali-Amendment to the Montreal Protocol reinforced the urgency of the transition to natural refrigerants that eurammon had long advocated.

In 2024, eurammon merged with Refrigerants, Naturally! e.V., consolidating two complementary advocacy platforms into a single global voice. By 2026, eurammon counts 35+ member organisations across the full value chain, with reach extending to over 100 countries - and a scope now encompassing heating alongside cooling, reflecting the convergence of heat pump and refrigeration technology.



eurammon Natural Refrigeration Award, 2015



Registration of eurammon as association, 2018



eurammon symposium 2019



Memorandum of Understanding eurammon IIAR, Renewal 2022

30 YEARS OF EURAMMON AT A GLANCE

Knowledge Platform & Publications

eurammon Magazine

- “Refrigerants by Nature” - biannual publication

Case Studies

- 60+ case studies showcasing successful applications across all industry sectors

Information Papers Series

- 20+ technical papers & factsheets on natural refrigerants

eurammon Symposium on natural refrigerants

- International forum on current developments in the RACHP sector

Education & Training

Theo-Mack-Förderpreis

- Acknowledgement for eurammon’s educational role

eurammon Natural Refrigeration Award

- eurammon award for pioneering research, co-hosted with universities and industry publications

eurammon Honour Award

- eurammon award for exemplary industry projects, recognizing sustainable, energy-efficient refrigeration and air-conditioning systems

eurammon Student’s Day

- Annual exchange between industry and young professionals on latest technical developments, co-hosted by universities



eurammon Student’s Day, 2019 at Bundesfachschule Kälte Klima Technik



eurammon Student’s Day 2025 at Hochschule Karlsruhe



eurammon Student’s Day 2026 at UCLL Belgium

VOICES FROM THE EARLY YEARS

Founding and early members look back on milestones, obstacles and defining moments

Roland Handschuh /Güntner GmbH & Co. KG:

"Inspired by practitioners who had decided well ahead of the wider industry that natural refrigerants were the only way forward, I brought eurammon to Güntner's attention. From 2006 onwards, the company was a member of eurammon at my initiative, and I had the privilege of supporting its work on the Steering Committee until 2016.

Whether at my first meeting as a member in Glinde near Hamburg, the conferences in Schaffhausen on the Rhine or my last Annual Meeting at Burg Schwarzenstein in the Taunus, the eurammon events were always excellently organised by Dr Jahn and her team, offering valuable technical exchange in a genuinely collegial atmosphere.

Throughout my time with eurammon, I found the collaboration within the network to be consistently constructive. The shared goal of advancing natural refrigerants technologically and strengthening their acceptance among the public and within the industry brought together a great many committed experts. Looking back, involvement in eurammon supported our sales work and was a success for Güntner - and for me, a highly rewarding experience both professionally and personally."

Rainer Brinkmann/York International Corporation, today part of Johnson Controls International

"When I first heard about the founding of eurammon at YORK International in October 1995, bringing together leading companies seemed to me a necessary response to the growing debate around ODP and GWP. In my view, the Institute of Air Handling and Refrigeration (ILK) research report provided an important impetus to eurammon's early years. The experience of ammonia being introduced too hastily and subsequently withdrawn from the supermarket sector in the 90s showed that sustainable innovation must always be accompanied by sound judgement, effective communication and mature safety technology. Creating these conditions for other natural refrigerants remains a key responsibility for eurammon, and I wish the association every success in this important work."

Thomas Spänich, GEA Refrigeration Germany GmbH

"I attended the very first eurammon meeting in around 1997, in my role as Product Manager for chillers. At that time, ammonia was still an unusual choice in chiller applications, and eurammon offered the perfect platform to build wider awareness of its benefits.

In those early days, no other organisation was advocating for natural refrigerants. Over the years, eurammon came to be regarded even by the EU and its authorities as a centre of competence for natural refrigerants. For more than two decades, eurammon was hosted and managed by VDMA. Dr Karin Jahn in particular, through her tireless commitment and outstanding networking, gave eurammon a face recognised around the world and kept the initiative moving forward.

Although natural refrigerants have since become established across almost all applications, there is still room for improvement, especially in heat pumps. Heat pumps play, and will continue to play, an important role in decarbonisation over the coming years, particularly at temperatures above 100 °C.

Many end users have never worked with ammonia or other natural refrigerants before, which is precisely why eurammon's experience and expertise are still needed."

Monika Witt, TH. WITT Kältemaschinenfabrik GmbH

“eurammon was founded at a time when the chemical industry was pushing hard to force ammonia out of the market, portraying it as unacceptably dangerous despite decades of good experience in practice. In the early days it was hard to argue against those claims, but the case was always there to be made: ammonia is the best refrigerant available in terms of efficiency and environmental impact. This is why industry wanted to keep using it. eurammon’s answer was fact-based information, and the very first activity of the newly founded organisation was Information Leaflet No. 1, “Ammonia as a Refrigerant”, which is still available today. From the beginning Dr. Karin Jahn was the driving force as managing director of eurammon and it was a pleasure to work with her for more than 25 years.

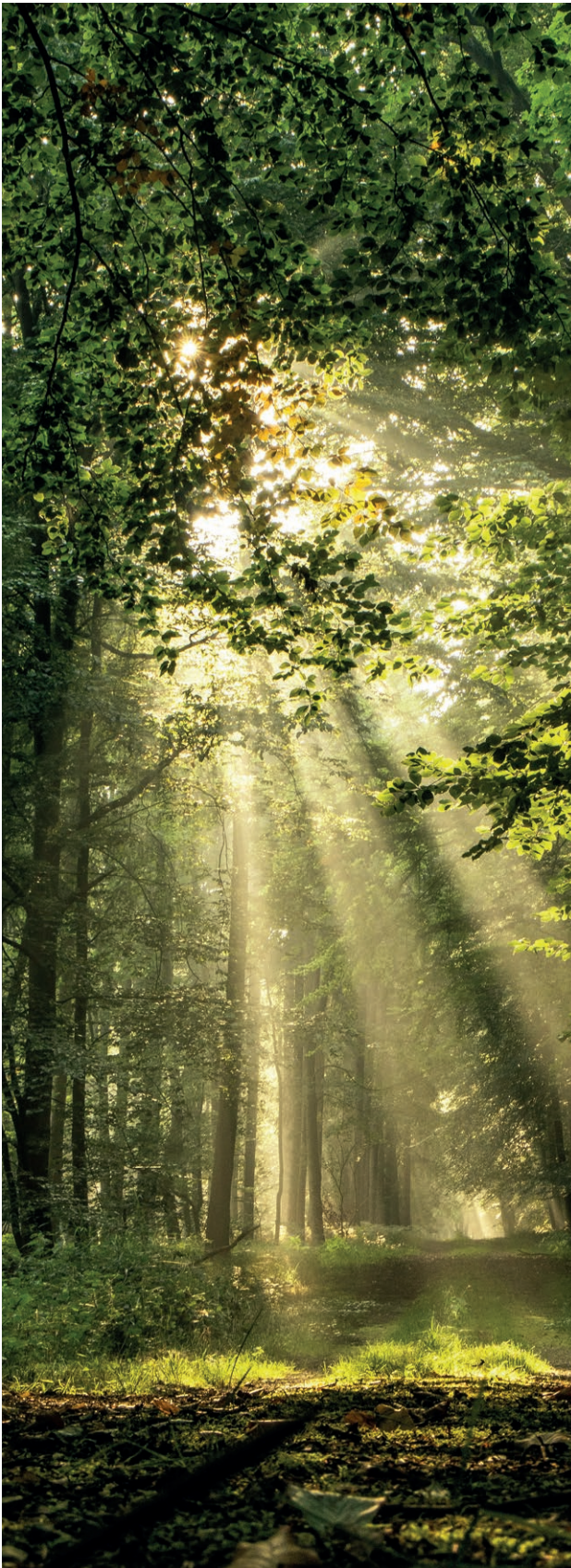
We always made clear that we were fighting for natural refrigerants rather than against other refrigerants, and that we worked alongside organisations pursuing similar goals. This is why I considered it a great achievement when we signed our first memorandum of understanding with the IIR. eurammon championed carbon dioxide early on too, and together with the hydrocarbons, natural refrigerants can now cover almost every refrigeration and heat pump application. Today no one questions that the future belongs to natural refrigerants. What matters now is passing on our experience and ensuring safe plant operation. I hope eurammon will keep contributing to that.”

Prof. Dr. Michael Kauffeld

“30 years eurammon is a great achievement! In the early 1990s natural refrigerants were far from established. In 1996 I joined the UNEP Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee (RTOC), and we hosted the second international conference on natural refrigerants for the International Institute of Refrigeration (IIR) in Aarhus, Denmark. The conference logo caused quite a stir at the time: Three brown arrows disappeared off to the right, labelled CFC, HCFC and HFC; a broad green arrow pointed up into the blue sky, bearing the words ‘Ammonia’, ‘Carbon Dioxide’, ‘Hydrocarbons’, ‘Water’, ‘Helium’, ‘Air’, ‘And other non-artificial substances’. Today, I would definitely label the third brown arrow ‘HFO’. Yet the conference triggered relevant developments: Denmark became the first country in the world to ban HFCs.

I personally joined eurammon as a member in January 2009, starting with a meeting in the mountains with the Kaltenbrunnern. Over the years the discussion of the use of natural refrigerants has changed, with new topics such as TFA and PFAS. I was very glad when eurammon broadened its scope from ammonia to all natural refrigerants, reflecting the development of technical solutions. Another milestone, in my opinion, was the merger with Refrigerants, Naturally! e.V. in 2024, as it broadened the membership and the outreach. Unfortunately, there are far too few young people entering our industry. At Karlsruhe University of Applied Sciences, we’re trying to remedy this through the ‘Inspiring®’ programme. We send our students to local schools to carry out experiments together with the children. Many of these experiments are related to refrigeration technology. Whenever I run one of these experiment events myself, there’s always ice cream made using liquid air produced with our Helium Stirling refrigeration machine. That’s usually the highlight of the experiment session.”

LOOKING AHEAD: VISION AND STRATEGIC PRIORITIES



Vision 2026

Following the merger with Refrigerants, Naturally! e.V. in 2024, eurammon revised its vision and mission to reflect both the expanded scope and the urgency of the transition to natural refrigerants in the RACHP sector:

“eurammon envisions a world where the refrigeration, air conditioning, and heat pump industry fully embraces natural refrigerants as the reliable and sustainable pathway to net zero emissions.”

Strategic Priorities

To advance this vision, eurammon will continue to promote the wider use of natural refrigerants in both cooling and heating. Over the next decade, a particular focus will be on growing applications in heat pumps and on supporting the market with clear, up-to-date technical knowledge on RACHP technologies using natural refrigerants. A central priority will be sharing practical expertise in a way that is relevant and accessible to different audiences. This includes providing expert guidance on new equipment developments, as well as interaction with universities and training schools to inspire the next generation through initiatives such as the annual Students' Day.

eurammon will also continue to strengthen and expand its international network. At the same time, eurammon will highlight the many advantages of natural refrigerants. Alongside their strong environmental and energy-efficiency benefits, they are increasingly important as PFAS-free alternatives to synthetic refrigerants. eurammon will work to raise awareness of these benefits and support their broader uptake in sustainable cooling and heating appliances worldwide.

An equally important area of work will be advocacy. eurammon will continue contributing its expertise to policy and standard-setting processes so that future regulations support, rather than hinder, the wider use of natural refrigerants.

In this way, eurammon will continue to help shape a future in which natural refrigerants are acknowledged as the reliable and sustainable future solution for climate-friendly, energy-efficient cooling and heating, reinforcing the sector's contribution to net zero emissions.



THIRTY YEARS OF EURAMMON: A CONVERSATION WITH ROB VANDENBOER AND MICHAEL FREIHERR

On eurammon's 30th anniversary, Chair Rob Vandenboer and Deputy Chair Michael Freiherr look ahead at the challenges facing refrigeration, air conditioning and heat pumps, and where the association can make the biggest difference.



Cool topics, 36 °C outside: the eurammon members meeting 2026 in Belgium

What challenge is the sector not discussing enough as it looks to the next decade?

Rob Vandenboer: Sustainable cooling and reliable cold chains are becoming strategically important as we experience the impact of global warming. The challenge is to meet these needs while balancing energy and natural resources. Keeping natural refrigerants at the heart of sustainable cooling solutions is a major task for our industry and an opportunity for eurammon.

Michael Freiherr: For me, the biggest challenge is not the refrigerant itself. It is how we provide dramatically more cooling with dramatically fewer resources. We cannot meet that demand simply by installing three times as much of what we install

today. Energy matters, but so do water, materials and grid capacity. We need to look at how systems actually perform in the real world, not just at nominal efficiencies. Natural refrigerants are an important part of that answer, but the challenge is much bigger than replacing one refrigerant with another.

When does the shift to natural refrigerants become driven by the market rather than regulation?

Michael Freiherr: Regulation has certainly accelerated the transition. But real market pull starts when customers choose natural refrigerants because they are simply the better technical and economic choice. Investment security, efficiency and avoiding another refrigerant phase-down are strong arguments.

Add heat recovery, integrated heating and cooling or industrial heat pumps, and the business case becomes even stronger. For me, that is the real transition: from “we have to change refrigerant” to “this is the better system.”

Rob Vandenboer: It is important to identify natural refrigeration as a differentiator when formulating the environmental pledge of companies and organizations. We already see natural refrigeration appearing in the ESG statements of larger companies and once this pledge is implemented in the company culture, natural refrigeration will be transferred and applied in subsequent structures.

How urgent is the shortage of skilled refrigeration technicians, and what can eurammon do?

Rob Vandenboer: The cooling industry is promptly implementing the European F-gas regulation - it is absolutely urgent. The rapid growth in the use of natural refrigerants is not being matched by a parallel growth in the number of technicians skilled in designing, building and handling these installations.

Michael Freiherr: What we can do is multiply knowledge. We can connect industry, education and institutions, provide practical technical guidance and support the people who train the next generation. There are decades of experience within our membership. Our job should be to make as much of that knowledge accessible as possible.

Which application area would you recommend to a young engineer who wants to make a difference?

Michael Freiherr: Industrial heat pumps, and more broadly, integrated heating and cooling. We still reject enormous amounts of useful energy as waste heat. Turning that into useful heat is a huge opportunity. This connects heat recovery, electrification and industrial decarbonisation. Natural refrigerants, particularly ammonia and CO₂, are very well positioned for many of these applications.

How can eurammon help bring European experience with natural refrigerants to other regions?

Rob Vandenboer: eurammon takes part in international events and seeks cooperation with similar organisations to share positive experiences with natural refrigerants. Our extensive database of case

studies and success stories is a good example of practical knowledge that attracts interest from organisations around the world.

Michael Freiherr: Europe has become a proving ground for natural refrigerants at scale. I don't think our job is to export European regulation. We should export what we have learned: what works, what is safe, what is efficient and what makes economic sense. Natural refrigerants are not a European solution to a European problem. The physics is global, and so are the challenges we are trying to solve.

Where should eurammon make its voice heard more strongly to advance natural refrigerants?

Rob Vandenboer: We should reach out to end users, particularly those operating larger refrigeration, air-conditioning and heat-pump systems. We need to explain the economic and environmental advantages while putting the challenges into perspective. Europe is leading the global implementation of natural refrigerants, and we should communicate its successes and progress more confidently.

In five years, what would you like to say eurammon helped make happen?

Michael Freiherr: I would like natural refrigerants to have lost the label "alternative". They should simply be one of the first options considered when a new system is designed, because of performance, efficiency and lifecycle economics.

Rob Vandenboer: Let's start by encouraging the younger generation

to pursue careers in our industry and continue informing users about the positive environmental impact of cooling, heating and refrigeration with natural refrigerants. We are on the right path.

What would you like to say to members on the occasion of the anniversary?

Rob Vandenboer: Thank you for your years of courage and dedication to advancing natural refrigerants. eurammon members helped create a can-do mindset and contributed to the legislative framework. An important part of the mission has been accomplished, but the most important part, implementation, is happening now and must be carried through responsibly. Stay on board: the work is not done! Those of us who carry natural refrigerants in their hearts should carry their expertise to the world.

Michael Freiherr: Thank you! What eurammon has achieved over the past 30 years is the result of people willing to share knowledge, experience and conviction.

GLOBAL CHALLENGES REQUIRE GLOBAL NETWORKS – INTERVIEW WITH IIAR

IIAR and eurammon: Two Continents, One Mission for Natural Refrigeration

By The International Institute of All-Natural Refrigeration, IIAR
Yesenia Rector, Vice President - Education, Outreach and Events, IIAR



The story of natural refrigeration in the Americas is one of proven solutions gaining renewed momentum, built on more than a century of experience and decades of significant progress.

Ammonia has long been the foundation of industrial refrigeration across North America and Latin America. It remains the primary refrigerant for food processing, cold storage, and other large industrial applications. In the United States alone, an estimated 25,000 ammonia systems are in operation, representing approximately 80 to 90 percent of the industrial refrigeration market. Across Latin America, ammonia also supports food production, agricultural exports, and the continued expansion of the cold chain.

Low charge ammonia systems, packaged equipment, advanced controls, enhanced leak detection, and predictive monitoring are expanding where and how ammonia can be used. These advances are reducing refrigerant charges, improving safety, and opening the door to applications once served

almost exclusively by synthetic refrigerants.

At the same time, the use of carbon dioxide has accelerated rapidly, particularly in food retail. A 2026 survey conducted by the North American Sustainable Refrigeration Council, or NASRC, included 18 major United States food retailers representing more than 29,000 stores. The survey projects that the number of CO₂ systems in the United States will exceed 10,000 by 2029. CO₂ is becoming the dominant technology in new store construction, while installations of CO₂ systems replacing existing refrigeration equipment are significantly outpacing installations in newly constructed stores. CO₂ has become part of the long-term planning of major companies across the Americas.

IIAR has played a central role in this progress. Through ammonia and CO₂ standards creation and updates, education programs development, collaboration with allied associations, advocacy to government agencies, and the application of research results, IIAR has helped establish the technical foundation for the safe and effective use of natural refrigerants. IIAR standards for natural refrigeration systems are approved by the American National Standards Institute, or ANSI, as U.S. National Standards. They have also been incorporated into model codes adopted by jurisdictions throughout the United States and are increasingly used across Latin America. IIAR's Latin American

chapters and seminars bring practical education and professional development directly to local markets.

This work is strengthened by IIAR's partnership with eurammon. For 30 years, eurammon has advanced the use of natural refrigerants across Europe. IIAR and eurammon operate in different regulatory environments and take different approaches to standards, but our goal is the same: to advance safe, sustainable, and reliable refrigeration using natural refrigerants.

Our cooperation reflects the global nature of that mission. Natural refrigerants are proven. They are sustainable. And they are essential to the future of refrigeration.

Together, IIAR and eurammon connect technical expertise with practical application, helping industry leaders, regulators, engineers, and technicians learn from the progress made on both continents. This partnership also helps ensure that regional differences strengthen, rather than divide, the global natural refrigeration community.

Two organizations, two continents, one focus: creating a better world through the safe and sustainable use of natural refrigerants.



SAFETY STANDARDS: FROM INHIBITOR TO ENABLER OF NATURAL REFRIGERANTS

Dr Daniel Colbourne, Re-phridge Ltd

For three decades, the rules that define a “safe” refrigeration system have decided how far natural refrigerants could go. Daniel Colbourne, who is active on several IEC, ISO and CEN standardisation committees explains how the core safety standards are changing, what still holds hydrocarbons back and why the revision of EN 378 matters now.

Every refrigeration, air-conditioning and heat pump (RACHP) system is built to a safety standard. As expectations of safety have risen, RACHP safety standards have become increasingly important. They prescribe requirements for achieving a “safe” system: for instance, how much refrigerant may be charged, where a system may be installed, what detection and ventilation must be in place. They are written by technical committees comprising manufacturers, users, test laboratories and other stakeholders and can exert a lot of influence on refrigerant selection decisions. Since the advent of the Montreal Protocol, national and international standards have received more and more attention, as in principle, they should facilitate the implementation of alternative refrigerants with tolerable impact on risk.

Natural refrigerants have been treated differently. As the use of R717 (ammonia) has been consistent for over a century in industrial and process applications, safety standards have been consistent and practical. Due to the relatively benign nature of R744 (carbon dioxide) with lower toxicity and non-flammability, it has never been seriously constrained by the standards. For Hydrocarbons (HCs), though, such as R600a (isobutane) and R290 (propane), inclusion of reasonable requirements into the standards has been a struggle over the past few decades. This has been partly due to lack of constructive data, concerns of stakeholders and practitioners and partly resistance

from those businesses that would be affected by wide introduction of such fluids.

The “core” RACHP safety standards include:

- EN IEC 60335-2-40 covering a wide range of AC and HP appliances
- EN IEC 60335-2-89 for commercial refrigeration appliances
- EN 378 is a European standard which deals with all RACHP systems
- ISO 5149 is an international standard, similarly for all types of systems

What has changed: Over the past 10 – 15 years, requirements in safety standards have been greatly improved and various standards development committees are evolving to bring better and more practical requirements into these standards, rather than blanket restrictions that effectively blocked the introduction of certain refrigerants across a range of different systems and applications. With the exponential increase of interest in natural refrigerants, largely driven by European activities, but also being strongly encouraged by international events such as the Kigali Amendment to the Montreal Protocol, more stakeholders are paying attention to the rules laid out in these safety standards.

Two milestones stand out enabling much wider application of natural refrigerants. In June 2019 IEC 60335-2-89 raised the permitted charge of A3 (higher-flammability) refrigerants in self-contained commercial refrigeration appliances

from 150 g to 500 g. For the first time, a full-size R290 display cabinet in a supermarket became possible under this international standard. In April 2022, after a six-and-a-half-year revision, publication of Edition 7 of IEC 60335-2-40 included requirements that drastically reduced the minimum room sizes for systems using up to 1 kg of HCs, thus removing a significant barrier to their use.

EN 378, being a standard that most designers, planners and operators work with day to day, is currently going through a similar process. The draft standard currently includes increased charge limits, a range of options for enabling greater refrigerant quantities for a room of a given size, introduction of the releasable charge approach and more refined ventilation methodologies. The draft revision, prEN 378:2025, was in public enquiry from July to September 2025 and the final vote is expected in 2027, with publication following, if the vote is positive. A new edition of ISO 5149, its international counterpart, is being published but unfortunately retains the majority of its established obstructive requirements, such as restrictive charge limits and refrigerant quantity calculations, sustaining significant barriers to the adoption of HCs across a wider range of systems and applications.

Specifically, certain areas will decide how quickly the next editions keep pace with what is technically possible:

- **Leak detection and response:** technologies for leak detection

and initiation of mitigation measures are progressing rapidly, with new developments being frequently reported. These are not well handled in the safety standards so future editions are expected to handle requirements for these in a more practicable manner.

- **Upper charge /cap quantity limits:** standards currently impose limits on the refrigerant charge of a system, often reflecting historical concerns rather than from risk data. As confidence and understanding of the risk-related mechanisms improve throughout the industry, and demand grows for larger systems using natural refrigerants, these restrictions are being dissolved.
- **Releasable charge:** a large system charge does not have to mean a large release. As with charge limits, there is increasing recognition of technologies which shut-off sections of a system so as to minimise the size of releases, despite a large system charge. Formalised approaches are gradually finding their way into the standards.

Standards work is slow, technical and rarely visible from the outside, yet they have a strong influence on the transition to natural refrigerants. But the importance of safety standards is increasingly recognised and similarly the need for constructive improvements. Moreover, once a standard is well written and refined, it can be an effective enabler for deployment of safe, cost-effective RACHP systems with natural refrigerants, giving confidence to those who are new to the sector. Thirty years on, some eurammon members already contribute to RACHP safety standards committees and growing interest is expected to encourage wider participation. The more the sector takes part, with design expertise, operating data, field experience and test data, the faster the standards will reflect what practitioners already know: that natural refrigerants can be applied safely across the full range of RACHP applications.



DECARBONISING THE INDUSTRIAL PROCESS HEAT SUPPLY: THE POTENTIAL OF HIGH-TEMPERATURE HEAT PUMPS

Dr. Benjamin Zühlsdorf, Innovation Director Energy and Climate, Danish Technological Institute

Benjamin Zühlsdorf coordinates the IEA HPT Annexes 58 and 68 on high-temperature heat pumps, a programme spanning 14 countries, and is a co-initiator and the main organiser of the HTHP Symposium. A view from DTI's Innovation Director on where the technology stands, what the past decade delivered, and what still needs to move.



Industrial heat pumps are able to provide heat at highest efficiencies based on electric power, which makes them a key technology for the decarbonization of industrial process heating. While they were well proven for long time for supply temperatures below 100 °C with moderate temperature lifts, it was clear that they will become a key technology for decarbonizing process heating at even higher temperatures. It was just a matter of time until the boundary conditions would become favourable enough to make them competitive at even higher temperatures, enabling them to cover most of the process heating for the food & beverage, pulp and paper, chemicals, pharmaceuticals, minerals, textiles and more.

In 2020, DTI and a number of other European research and technology organizations have written the white paper “Strengthening Industrial Heat Pump Innovation – Decarbonizing Industrial Heat” to create awareness for the massive potential of high-temperature heat pumps (HTHP). The white paper has

also outlined a way for advancing the technology and unfolding its potential, suggesting both regulatory measures and support for research, development and demonstration activities.

During the subsequent years, a massive increase in R&D activities could be observed, driven by national and international projects, as well as a substantial scaling of the industry, resulting in more than 50 HTHP technologies currently being close-to-market or commercially available. The technologies emerged from both upgraded refrigeration technologies, process gas compression technologies, and novel concepts, and are predominantly based on natural refrigerants.

From DTI, we have been involved in the development, test and demonstration of a variety of technologies, such as: The SuPrHeat project, with a CO₂ system, a hydrocarbon cascade system and a steam compression system; The InterHeat project, with two cascade HTHPs with hydrocarbons and steam compression; The SPIRIT project with a 4 MW hydrocarbon heat pump; The Might-HP project with a hydrocarbon-steam cascade system; The EEETHOS project with hydrocarbon and steam compression systems – All of them tested and demonstrated at 500 kW to 4 MW and temperatures well above 100 °C. Today, these technologies are being commercialized, driving the uptake of HTHPs in industries. At

the same time, we organize the HTHP Symposium, which became the meeting place of the HTHP community, and coordinate the IEA HPT Projects 58 and 68, which are the key resource of independent information about the HTHP sector.

Looking at these developments, it can be concluded that technologies are now available for a large range of applications. This shifts the focus towards bringing them into application and scaling deployment.

For the process industry, the electrification of process heating is a major step, requiring nothing less than a complete shift of mindset – in how we design process heating systems, and in how we approach decision-making and long-term planning.

This transition is a major effort for industry and is often seen as a challenge. Yet I encourage decision makers to also see its potential – not only to become sustainable, but also more independent, resilient, and ultimately more competitive.

There are three critical trends, which are giving a whole new dynamic for electrifying industries:

- The Electrotech revolution, transforming how we generate, transport, store, and use electric power – enabling increasingly low-cost electricity for industrial end-users
- The Clean Industrial Deal of the European Commission, strengthening EU leadership in industrial electrification, making decarbonization more

competitive, and reducing fossil fuel imports through substantial support

- Sustainability requirements, driven by big companies' 2030 targets, forcing suppliers to electrify. This removes fossil fuels as an option, shifting the question from "Does it make sense to electrify?" to "What is the cheapest way to electrify?" – a direct, global lever regardless of local conditions

We are at a decisive moment for bringing high-temperature heat pump technologies into application, with the chance to establish HTHPs in the key role they should play in unlocking the potential of electrifying industries. Beyond a strong focus on application, reference installations, operating experience, and scaling the supply chain, I expect further progress in system integration, combination with electric heating and thermal storage, and direct integration into process equipment.

Our most important learning has been that collaboration is key to success. The biggest achievements came whenever we brought together players along the value chain – component manufacturers, system builders, integrators, process equipment manufacturers, end-users, and R&D organizations – to develop, test, and demonstrate technologies.

This is why I believe collaboration is also the key to bringing these technologies into application at the pace needed.



FROM NICHE TO CORE: TEACHING NATURAL REFRIGERANTS A PERSPECTIVE FROM UCLL UNIVERSITY OF APPLIED SCIENCES, BELGIUM

Interview with Walter Reulens, Research & Expertise UCLL

What role do natural refrigerants play in your curriculum today, and where do you see room to strengthen them?

At UCLL University of Applied Sciences, natural refrigerants are becoming an increasingly important part of our RACHP education and professional training. Within our Sustainable Resources expertise centre, we combine education, applied research and services to industry. Our facilities in Houthalen allow students and professionals to work with real CO₂ and propane systems, covering refrigeration, heat pumps and air-conditioning applications. The recent evolution of the European F-gas certification framework reinforces this need. The new certification requirements explicitly include alternatives such as hydrocarbons, CO₂ and ammonia, meaning that future technicians need competencies that go beyond traditional F-gas handling.

We therefore believe natural refrigerants should no longer be treated as a specialised topic, but as an integral part of modern RACHP education. In particular, practical skills, safety, risk assessment and understanding the specific characteristics of each refrigerant need to become core competencies.

The RACHP sector is growing and offers real career potential, yet stays invisible to young people. What would change that?

We need to show young people what modern RACHP technology really looks like. At UCLL, we try to do this by giving students hands-on experience with real installations and by connecting education directly with

companies and the professional field. RACHP combines thermodynamics, electrical engineering, digitalisation, energy efficiency and sustainability. It is therefore a high-tech sector with an important role in the energy transition. More practical projects, company visits and closer cooperation between schools and industry could make these career opportunities much more visible.

Looking ten years ahead, what do you see as the biggest challenges and opportunities?

Technically, we will have to deal with increasingly efficient and complex systems, higher pressures, flammability and new applications.

At the same time, the new European certification framework means that technicians are increasingly expected to work safely with a broader range of refrigerants and technologies. The certification requirements explicitly address safe handling of equipment containing flammable or toxic gases and equipment operating at high pressures.

The biggest challenge may therefore be finding enough skilled people who understand both the technology and the associated safety requirements. This is also a major opportunity for education. We need to move beyond teaching people simply how to install and maintain equipment, towards understanding systems, assessing risks, troubleshooting and working safely with different refrigerants.

What is needed from industry, and from a network like eurammon, to prepare the next generation?

We need a strong and continuous connection with industry. Access to

modern equipment, real-life cases, technical expertise and practical experience is invaluable. Industry can help education understand which skills will actually be needed in the workplace. Networks such as eurammon can help connect universities, training providers, manufacturers, contractors and end users, while sharing knowledge and best practices across Europe. A good example is the eurammon Students Day organised together with UCLL, which brought students into direct contact with experts and companies from the natural refrigerant sector. Initiatives like this are valuable because they give students a broader view of the industry, its technologies and the career opportunities it offers.

For UCLL, this fits very well with our role as a university of applied sciences: bringing together education, applied research and the professional field, and translating technological developments and new regulatory requirements into practical knowledge for students and industry.

eurammon

CASE STUDIES

The strongest argument for natural refrigerants is not made in a magazine - it is made in operating plants. Our case studies from eurammon members show what that looks like today.
The full collection is available at eurammon.com | [Case studies](#) | [eurammon](#)

2025

Penta Infra HAM01 – Propane-Based Cooling for a Hamburg Colocation Data Center

Efficient and environmentally friendly cooling for a medium-sized colocation data center

Hydrocarbons

Data Centres

2025

Smart Cooling Modernization with R290 at Hermann Hauff GmbH & Co. KG

Reduced CO2 emissions, electricity and water consumption in injection molding

Hydrocarbons

Other Manufacturing

2024

Office Heating and Cooling with Ammonia, Vienna

Decarbonizing heating and cooling in the renovated European Patent office with ammonia heat pumps

Ammonia

HVAC (Heating & Air Conditioning)

2024

Refosteel Efficient Cryogenic Hardening for Precision Tool Manufacturing

Reliable -120°C steel hardening with 70% less energy consumption and only air as refrigerant

Air

Other Manufacturing

2021

Solvent condensation for recycling in pharmaceutical processes

Sustainability through high-efficiency solvent recovery with air refrigeration

Air

Pharmaceutical

2021

Recipharm Germany

Future-proof pharmaceutical cryogenic storage using air as refrigerant.

Air

Pharmaceutical

2021

Fernhurst Australia

Redefining cold storage efficiency with ammonia refrigeration technology.

Ammonia

Logistics

2019

London District Heating with Ammonia Heat Pumps

A blueprint for the use of waste heat from public facilities

Ammonia

District Heating / Cooling

2019

L.A. FARM Greek dairy

A cooler dairy with natural refrigerants

Ammonia

Food & Beverage Manufacturing

CASE STUDY

OFFICE HEATING AND COOLING WITH AMMONIA, VIENNA

Decarbonizing heating and cooling in the renovated European Patent Office with ammonia heat pumps.

Key information

Client: European Patent Office, Vienna

Supplier: Equans (heat pump system); Alfa Laval (heat exchangers)

Type of facility: Office building

System start-up: 2024

The European Patent Office (EPO) in Vienna transformed its 1972 headquarters into one of Austria's most sustainable office buildings through a renovation completed in 2024. At the heart of the energy concept are two tailor-made ground-source heat pumps using ammonia (R717) as refrigerant, delivering highly efficient heating and cooling with zero global warming potential.

The installation - supplied by Equans with Alfa Laval compact plate heat exchangers - played a vital part when the building earned a BREEAM Outstanding certification, the highest rating in the German-speaking region of Europe, with 100% scores in Energy, Health, Waste, and Environmental assessment categories.

Requirements

The EPO's Vienna office building, dating from 1972, had reached the end of its operational life. Demolition and full reconstruction would have been the conventional route, but the EPO decided to renovate in line with European Green Deal ambitions.

The project required a state-of-the-art heating and cooling solution that could meet the following objectives:

- Transform the building into a climate-neutral, highly sustainable "Green Hub" by 2024 and achieve full carbon neutrality by 2030
- Achieve BREEAM "Outstanding" certification — the highest level of the Building Research Establishment Environmental Assessment Method
- Use a natural refrigerant with zero global warming potential (GWP), zero ozone depletion potential (ODP), and zero trifluoroacetic acid (TFA) content
- Minimise energy consumption while ensuring reliable year-round heating, cooling, and domestic hot water supply
- Avoid demolition where possible: retaining the

original concrete structure was estimated to save approximately 50% of the CO₂ emissions of a full rebuild

Solution

The integrated energy heating and cooling concept for the EPO Vienna headquarters centres on a geothermal ground-source system with 20 probes drilled 200 metres deep into the ground below the building's second basement level. An ethylene glycol brine circulates through these probes, acting as a heat source in winter and a heat sink in summer. Two tailor-made Equans smartPACK-L7 compact heat pump units drive the system.

Ammonia (R717) was selected as the refrigerant due to its outstanding thermodynamic properties and its environmental profile: GWP = 0, ODP = 0, and zero TFA content. While ammonia requires careful system design due to its toxicity, the smartPACK-L7 integrates Alfa Laval semi-welded plate heat exchangers (type T10-EW) as evaporators and condensers, minimising the refrigerant charge to an absolute minimum while maximising heat transfer efficiency.

In heating mode, the evaporator cools the glycol brine from 16°C to 7°C at an evaporation temperature of 4°C, extracting approximately 252 kW of geothermal energy. The condenser delivers 292 kW of space heating at a condensing temperature of 50°C. A dedicated Alfa Laval fusion-bonded plate heat exchanger uses compressed ammonia gas at 116°C to heat domestic hot water to 60°C, providing a further 38 kW. In summer, the system reverses into chiller mode, with the ground probes absorbing excess building heat.

The system achieves a coefficient of performance (COP) of approximately 5, meaning 80% of all heating and cooling energy originates from the ground and only 20% is consumed as electricity. A photovoltaic installation covering both the roof and the building facades generates more electricity than the building needs for heating, cooling, ventilation, lighting, and hot water combined - making the building effectively energy-positive. A wooden facade, rainwater retention tanks, and extensive green planting complete the sustainability package.

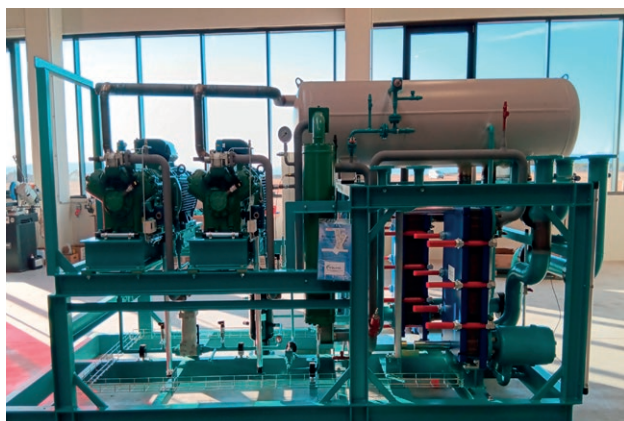


Photo credit: Alfa Laval, Equans smartPACK-L7

Key Benefits and Features:

- **Ammonia as refrigerant:** GWP = 0, ODP = 0, and zero TFA content
- **High energy efficiency:** COP of approx. 5 — 80% of building energy supplied by geothermal ground energy
- **Carbon-neutral design:** Combination of ground-source heat pump, on-site PV generation, and passive building measures delivers carbon neutrality by 2030
- **Circular economy approach:** Retaining the original concrete structure reduced embodied CO2 by approximately 50% compared to full demolition and reconstruction
- **Compact, safe system design:** Alfa Laval T10-EW semi-welded plate heat exchangers minimise ammonia charge, reducing toxicity risk while maximising heat transfer performance

Technical data

Cooling capacity: ~252 kW

Heating capacity: 292 kW

Evaporating temperature: 4 °C

Condensing temperature: 50 °C

Main components:

- 2x Equans smartPACK-L7 heat pump units, including
 - » 4x Alfa Laval T10-EW (semi-welded) plate heat exchangers
 - » 1x Alfa Laval fusion-bonded PHE DHW heat exchanger

Contact

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CASE STUDY

SMART COOLING MODERNIZATION WITH R290 AT HERMANN HAUFF GMBH & CO. KG

Reduced CO2 emissions, electricity and water consumption in injection molding

By modernizing its cooling system, Hermann Hauff GmbH & Co. KG has achieved annual savings of around 300,000 kWh of electricity, 110 tons of CO2 emissions, and 1,000 m3 of drinking water.

The company, a producer of precision plastic injection-molded parts for industries ranging from household appliances and consumer goods to automotive, medical, and precision engineering, upgraded its Pforzheim plant with six water-cooled compact chillers using the natural refrigerant R290.

The system is regulated via an MSR control system for demand-based cooling and energy optimization, while waste heat from production machines is reused for building heating. Installed during ongoing production, the solution ensures high operational reliability and full transparency through real-time monitoring.

Key information

Client: Hermann Hauff GmbH & Co. KG, Germany

Supplier: Frank Schlittenhardt GmbH, SECON GmbH

Type of facility: Precision plastic injection molding and mold making

Refrigerant: R290 (Propane)

System start-up: 2025

Requirements

The modernization project aimed to replace aging cooling technology with a future-proof, climate-friendly solution. The new system needed to be highly energy-efficient while ensuring reliable 24/7 operation across three shifts, even during hot summer months. Integration into building management and MSR systems was required for central control, automated fault reporting, and transparent real-time monitoring of energy flows.

Beyond cooling, the solution was expected to reduce electricity and water consumption, safeguard production through redundant system components, and make full use of available waste heat for building heating. Long-term operation and serviceability were equally important, calling for a modular, expandable, and maintenance-friendly design.

Solution

The modernization of the cooling technology was completed in 2024/2025 during ongoing production, with commissioning in March 2025. At its core, the new system consists of two groups of three FXP compact chillers manufactured by Secon GmbH, each operating with the natural refrigerant R290 (propane). The chillers are supported by air-cooled dry coolers that provide free cooling above +9°C for tool cooling and +24.5°C for hydraulic cooling, completely eliminating the need for compression cooling in these conditions and reducing water consumption by around 1,000 m3 annually. Frank Schlittenhardt GmbH was responsible for the system concept, planning, and integration into the building automation, including ventilation, fire protection flaps, and the heat pump. The MSR system dynamically regulates power demand, switches automatically between heat sources, and provides seamless monitoring with real-time data, status reports, and fault messages — ensuring maximum operational safety even in unmanned shifts. To further improve efficiency, the existing heat pump was optimized for higher source temperatures and is now primarily used on production-free days. During regular operation, waste heat from compressed air compressors is utilized for building heating, automatically managed by the MSR system. The entire installation is redundantly configured with frost-proof cooling media to secure continuous production under extreme conditions. With a seasonal efficiency (SEPR) of 32.57, the plant achieves an outstanding performance level, generating on average 32.57 kW of cooling per 1 kW of electricity annually.

Key benefits and features

- **Energy savings:** approx. 300,000 kWh/year, lowering operation costs by roughly 11%
- **CO2 savings:** approx. 110 t/year
- **Water savings:** approx. 1,000 m3/year thanks to the switch from spray-water-based to air-cooled recooling.
- **Operational safety:** MSR-controlled monitoring
- **Flexibility:** Modular design, transferable to other industrial applications



Photo credit: Hermann Hauff GmbH & Co. KG

Technical data

Cooling capacity: Tool cooling 3 × 85 kW, hydraulic cooling 3 × 80 kW

Refrigerant charge: 2,5 kg R290 per refrigeration unit

Evaporation temperature: Approx. +9,5°C tool, +24°C hydraulics

Condensing temperature: Depending on outside temperature / operating conditions

Main components:

- Water-cooled compact chillers with R290, operated with reciprocating compressors, regulated by inverters: Tool cooling 3 x compact chillers, type FXP160-995.S-I-ST (manufacturer: Secon GmbH)
- Hydraulic cooling 3 x compact chillers, type FXP80-565.S-I-ST (manufacturer: Secon GmbH)
- 4 screw compressors with two refrigeration dryers generate around 1.238 million m3 of compressed air: 3 ALMIG Variable 24 and 1 ALMIG V75

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CASE STUDY

PENTA INFRA HAM01 – PROPANE-BASED COOLING FOR A HAMBURG COLOCATION DATA CENTER

Efficient and Environmentally Friendly Cooling for a Medium-Sized Colocation Data Center

Key information

Client: Penta Infra

Supplier: Secon GmbH

Type of facility: Colocation Data Center

System start-up: 2025

Penta Infra broke ground in September 2023 on a new 4.4 MW colocation data center in Hamburg, Germany, near the airport.

The facility, named HAM01, opened in the first half of 2025 and provides 2,500 m² of IT space. Six Secon R290 air-cooled liquid chillers were installed on the roof, delivering reliable cooling performance with high energy efficiency (EER 4.15 @ +40 °C).

Next to 4 of the 6 chillers, 4 Secon dry-coolers are located. The 4 chillers with separate dry coolers are equipped with additional integrated hydraulic equipment to seamlessly integrate the dry coolers into the operation. In full free cooling mode, the heat is transferred directly to the ambient air without activating compressors. In addition the dry coolers can be integrated as pre-cooling before entering the evaporators of the chillers. Up to 80 % of annual operating hours can be covered without activating the chillers, significantly reducing energy consumption and supporting a low Power Usage Effectiveness (PUE). The system is designed to meet the German Energy Efficiency Act (EnEfG) requirements and provides operational redundancy, safety features, and flexibility for future integration with district heating networks.

Requirements

The data center required a high cooling capacity to support 2,500 m² of IT space while maintaining a very low PUE of 1.2. It was essential to use an environmentally friendly refrigerant with a low global warming potential. The cooling solution also needed to maximize the use of free cooling, taking advantage of Hamburg's mild climate, and provide redundant and reliable control to ensure continuous operation. Additionally, the system had to be flexible enough to allow integration with future district heating networks for potential waste heat reuse.

Solution

To meet these requirements, six air-cooled liquid chillers were installed on the roof. Each chiller has a refrigerant charge of 64 kg R290 distributed across four individual circuits and is controlled via a master-slave network with two fully redundant and self-monitoring master controllers. Automatic Transfer Switch (ATS) and Uninterruptible Power Supply (UPS) systems ensure operational redundancy.

The system integrates free cooling to reduce active chiller operation. Four additional dry coolers expand the free-cooling capacity. These dry coolers, while separate units, are fully integrated hydraulically and via the control system with the chillers, ensuring seamless operation. Water for the IT space is supplied at 20 °C and returns at 32 °C, and the chillers operate with inverter-controlled capacity regulation for energy efficiency.

Key Benefits and Features:

The cooling solution provides high energy efficiency (EER 4.15 @ +40 °C) and reliable performance for medium-capacity applications. By leveraging free cooling for the majority of the year, energy consumption is significantly reduced, contributing to a low PUE. The system uses a natural refrigerant (R290), reducing environmental impact. Operational safety and redundancy are ensured through the master-slave control network, ATS, and UPS, while additional features such as Fast-Restart, Efficient-Flow, and ultrasonic flowmeters enhance reliability. The design also allows for future integration with district heating networks and reversible heat pumps.

Hamburg experiences mild summers (10–36 °C) and winters (-3–4 °C), which allows extensive use of free cooling. The facility complies with the EnEfG, which mandates PUE ≤1.5 by 2026 and ≤1.3 by 2030 for data centers with loads above 300 kW. HAM01 is designed for a PUE of 1.2 and includes two heat exchangers in the basement to facilitate future connection to a district heating network. Client demand for natural refrigerants is growing, and hydrocarbons are preferred over synthetic alternatives where feasible.



Photo credit: Penta Infra

Technical data

Cooling capacity: 6 x 960 kW

Refrigerant charge: 4 x 16 kg (each chiller)

Evaporating temperature: Supply 20 °C, return 32 °C

Condensing temperature: +40 °C

Main components:

- 6 x Secon Stratos VP16-4-2400.S-I4-EFMV-PEC1-FCE-LN air-cooled liquid chillers
- Master-slave controllers (2 redundant masters)
- ATS and UPS
- Integrated three-way-valve for free-cooling
- Dry coolers hydraulically and control-integrated with the chillers
- Ultrasonic flowmeter
- Fast-Restart and Efficient-Flow features

Special features:

- **Capacity regulation:** 4 x Inverter
- **Energy Efficiency Ratio (EER):** 4.15 @ +40 °C
- **Sound pressure level:** 57 dB(A)/10 m

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CASE STUDY

REFOBLAST VIENNA: PROPANE-BASED RAPID PLASMA FREEZING

Compact, future-proof plasma freezing and cold storage with R290

Key information

Client: Plasma center, Austria

Supplier: Refolution Industriekälte GmbH, Teledoor Melle Isoliertechnik GmbH

Type of facility: Rapid plasma freezing and integrated cold storage

System start-up: 2025

The RefoBlast Vienna installation demonstrates that pharmaceutical-grade rapid plasma freezing can be achieved with natural refrigerants - without the complexity of conventional large-scale refrigeration systems. Bridging the gap between underperforming compact freezers and complex CO2 plants, the project provides plasma centres with a practical alternative that combines high freezing performance, natural refrigerant technology, modular scalability and an integrated cold-chain concept. The installed solution combines two RefoBlast rapid freezers with a dedicated cold storage cell, creating a seamless process from loading plasma bags or bottles through rapid freezing to controlled low-temperature storage. Following successful testing, qualification and validation for industrial plasma used in pharmaceutical production, the facility entered regular operation in 2025. The project demonstrates that R290 (propane) refrigeration can meet the demanding performance, reliability and regulatory requirements of pharmaceutical plasma processing while providing a compact, operator-friendly and future-proof solution.

Requirements

A plasma center in Austria required a high-performance, compact and service-friendly solution for the rapid freezing and subsequent storage of blood plasma. The system had to be suitable for a pharmaceutical environment, support validated operation and avoid dependence on synthetic refrigerants with long-term regulatory uncertainty.

The following objectives had to be met:

- Rapidly and reproducibly freeze blood plasma to a core temperature of $\leq -25^{\circ}\text{C}$ before storage.
- Provide sufficient freezing capacity for a high-throughput plasma center while maintaining a compact system footprint.

- Support validated pharmaceutical processes using a refrigerant concept that is future-proof with respect to the F-Gas phase-down and potential PFAS restrictions.
- Avoid cooling water requirements in the standard configuration and allow integration into an existing building.
- Provide a robust and service-friendly system that can be maintained without dependence on complex large-plant service infrastructure.
- Plan rapid freezing, transfer, storage, interfaces and service as one integrated cold-chain concept rather than as separate standalone systems.

Solution

Refolution, in collaboration with Teledoor, developed the RefoBlast concept as a modular rapid-freezing platform for blood plasma bags and bottles. Each RefoBlast unit contains two independent freezing chambers, each equipped with its own R290 refrigeration unit, high-efficiency fan and product loading system. The freezing process is based on low room temperature and forced air circulation to remove heat from the product quickly and evenly.

For the project, two RefoBlast units were installed together with a dedicated cold storage cell. This configuration creates a compact, scalable and integrated cold chain: plasma is rapidly frozen under controlled conditions before being transferred over short distances to the adjacent cold storage cell. The refrigeration concept uses propane (R290) in small, hermetically sealed circuits with a maximum charge of 150 g per refrigerant circuit. The air-cooled standard design requires no cooling water; the installation room only needs suitable ventilation or temperature control to dissipate the heat rejected by the refrigeration units.

Key Benefits and Features:

- Future-proof refrigerant strategy: R290 eliminates synthetic F-gases and provides long-term regulatory compliance for pharmaceutical operators.
- Validated process performance: Rapid freezing to a core temperature of $\leq -25^{\circ}\text{C}$ supports plasma quality and pharmaceutical process requirements.
- Modular scalability: Capacity can be expanded simply by adding RefoBlast units, without major



Photo credit: Refolution Industriekälte GmbH

- infrastructure changes.
- Integrated cold chain: Rapid freezing and cold storage are designed as one coordinated process, minimizing product handling and transfer distances.
- Easy maintenance: Plug-and-play refrigeration modules simplify servicing, reduce downtime and allow off-site repair.
- Simple installation: The air-cooled design avoids cooling water infrastructure and facilitates integration into existing buildings.

Technical data

Refrigerant charge: R290 (propane), max. 150 g per hermetic refrigerant circuit

Main components:

- 2 x RefoBlast rapid freezers plus a cold storage cell using the same natural refrigeration approach

Special features:

- **Freezing principle:** Forced air circulation / blast-freezing
- **Freezing modules:** Two independent freezing chambers per RefoBlast unit, each with its own refrigeration unit
- **Temperature range:** 0 °C to -35 °C in the freezing modules
- **Product target:** Core temperature ≤ -25 °C for plasma bags and bottles
- **Standard batch:** 30 plasma bags of 850 ml per freezing module within ≤ 4 hours; scalable by operating multiple modules and units
- **Airflow:** 2,500 m³/h per freezing chamber
- **Refrigerant charge:** R290 (propane), max. 150 g per refrigerant circuit
- **Electrical supply:** 400 V / 50 Hz
- **Service concept:** Plug-and-play main components; refrigeration unit, fan and display can be replaced as modules

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CASE STUDY

REFOSTEEL – EFFICIENT CRYOGENIC HARDENING FOR PRECISION TOOL MANUFACTURING

Reliable -120°C steel hardening with 70% less energy consumption and only air as refrigerant

Key information

Client: Rudolf Rieker GmbH, Germany

Supplier: Refolution Industriekälte GmbH, Germany

Type of facility: Cryogenic hardening chamber for steel tool components

Refrigerant: Air

System start-up: 2024

Requirements

Rieker is a specialist in induction hardening, a process that creates a very hard surface layer on low- or high-strength workpieces. Usually, the workpiece is hardened selectively in a specific area, using an induction coil to heat the surface to the hardening temperature. A special quenching medium is then sprayed onto the workpiece, producing a martensitic structure in the hardened layer. In its pursuit of more sustainable production methods, the company sought alternative solutions to the commonly used liquid nitrogen systems and chose air as a refrigerant in the cooling process.

The new system was required to meet several key criteria:

- Achieve precise and repeatable martensite transformation at -120°C
- Eliminate the need for furnace re-tempering between cycles to minimize downtime
- Avoid the risks and logistical challenges associated with liquid nitrogen (LN2)
- Ensure environmentally sustainable operations with a lower CO2 footprint
- Ensure flexibility and compliance with future refrigerant regulations

Solution

The innovative Refosteel system features dual insulated chambers enabling thermal energy recirculation between loads. When one batch cools down, its cold air is reused to pre-cool the following batch—a design that delivers up to 70% energy savings and significantly improves thermal efficiency.

Temperature control spans from -40°C to -140°C , with continuous operation thanks to Mirai Intex's turbo-

compressed air-cycle refrigeration, avoiding the need for periodic furnace re-tempering.

The system includes oil-free compressors, mobile chassis, robust insulation panels, and Siemens PLC with LED status indicators to ensure easy operation and low maintenance.

Open air cycle machine: The open air cycle machine uses the air inside of the chamber as a refrigerant. No additional refrigerant is needed. The air is sucked by the machine and compressed in a turbo compressor. At a maximum pressure of 1.2 bar, the air is cooled in an air cooler. The turbine reduces the pressure of the cooled air, resulting in lower temperatures at the outlet of the turbine. The cold air then enters the room again.

Key benefits and features

The Refosteel system delivers:

- **Efficient Energy Recovery:** Dual-chamber thermal recirculation eliminates furnace re-tempering cycles, cutting energy use by up to 70%.
- **Continuous Hardening Process:** No downtime for temperature stabilization or chamber reconditioning between loads.
- **Sustainable and Safe Refrigeration Technology:** Uses only ambient air, eliminating synthetic refrigerants, LN2 logistics, and related regulatory burdens.
- **Low CO2 Footprint:** Natural refrigerant ensures future-proof compliance and reduced environmental impact.
- **Robust, Low-Maintenance Design:** Mirai Intex's oil-free turbo compressors run smoothly, while thick insulation and sturdy panels ensure long-term reliability.

Technical data

Cooling capacity: 10 kW at -80°C & 5 kW at -120°C

Refrigerant charge: only ambient air

Heat source temperature: -120°C

Condensing temperature: $+6^{\circ}\text{C}$

Main components:

- Mirai Intex air-cycle chiller MC22 O/W
- Dual-chamber insulated hardening cell



Photo credit: Refolution Industriekälte GmbH

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CASE STUDY

HIGH-TEMPERATURE HEAT PUMP FOR SUGAR PRODUCTION

Pentane heat pump at Tiense Suikerraffinaderij, Tienen, Belgium

At the Tiense Suikerraffinaderij in Belgium, a 4 MW heat pump from GEA Refrigeration Germany GmbH uses the natural refrigerant pentane to recover waste heat from the sugar production process and generate steam at temperatures of up to around 139 °C. The system reduces the consumption of fossil fuels and is expected to cut CO₂ emissions by around 3,000 to 3,500 tonnes per year. Inaugurated in February 2025, the installation is a full-scale demonstration plant in the EU-funded SPIRIT project.

Key information

Client: Tiense Suikerraffinaderij / Raffinerie Tirlémontoise, part of Südzucker Group, Tienen, Belgium

Supplier: GEA Refrigeration Germany GmbH

Type of facility: Industrial heat recovery and process steam generation in beet sugar production

Refrigerant: n-Pentane (R601)

System start-up: 2025

Requirements

Sugar production is highly energy-intensive. After washing, slicing, diffusion and juice purification, large quantities of water must be evaporated before crystallisation. These process steps require significant amounts of steam and have traditionally relied on fossil-fuel boiler systems. For the Tienen site, the challenge was to make available waste heat useful at a temperature level high enough for industrial steam generation with a high coefficient of performance (COP). While many industrial heat pumps in the 500 kW to 10 MW range have historically been limited to lower supply temperatures, the sugar process requires substantially higher temperature levels.

Solution

As part of the EU-funded SPIRIT project which demonstrates sustainable heat upgrade technologies for the food and beverage and the pulp and paper industries aimed at decarbonising industrial processes in the food and paper industries, GEA Refrigeration Germany GmbH and Tiense Suikerraffinaderij N.V. jointly realised a full-scale heat pump system. The heat

pump system is integrated into the heart of the sugar production process and uses vacuum steam from the evaporation plants as its heat source. The system uses pentane R601 as a refrigerant – a natural hydrocarbon that is particularly suitable for heat pumps operating in the high-temperature range.

The refrigerant absorbs heat from the vacuum steam. A GEA screw compressor then compresses the pentane to a higher temperature level, and a shell-and-tube condenser / steam generator converts condensate into usable process steam – thereby replacing some of the steam that would otherwise be generated from fossil fuels.

Technical concept

Figure 1 shows the layout of the heat pump installation. The numbers 1 to 8 mark the main components of the refrigerant circuit and correspond to the same numbers in the flow diagram in Figure 2:

- 1 – Screw compressor & electric motor
- 2 – Oil separator
- 3 – Steam generator (heat sink): shell-and-tube condenser raising process steam
- 4 – Internal heat exchanger (IHX)
- 5 – Level-controlled expansion valve
- 6 – Heat pump evaporator (heat source)
- 7 – Oil cooling circuit
- 8 – Steam condensate tank with feed pump

Figure 2 shows the design of the heat pump system. In addition to the standard components of a refrigerant circuit – expansion valve, evaporator, compressor



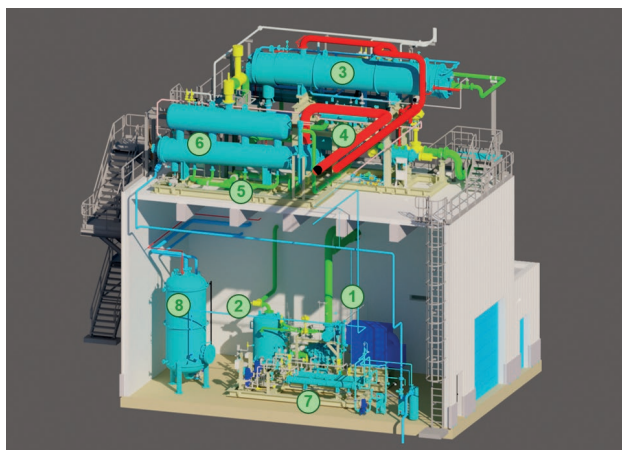


Figure 1: Layout of the heat pump installation at Tienese Suikerraffinaderij, Credit: Tienese Suikerraffinaderij

and condenser – an internal heat exchanger (IHx) is installed. It superheats the suction gas and at the same time sub-cools the pentane condensate.

The heat pump is designed for a heating capacity of approximately 3.5–4 MW. Energy from vacuum steam, which is process waste heat at a temperature of approximately 75–92 °C, is used to upgrade process steam from condensate. During the main sugar beet campaign, the process steam temperature is around 138–139 °C; during the secondary campaign for thick juice production, the required steam temperature is around 114 °C. The project also covers long-term operation as well as data logging for process optimisation and performance validation. A digital process simulation supports the optimisation of the systems.

Key benefits and features:

- **CO₂ reduction:** around 3,000 to 3,500 tonnes of CO₂ avoided per year at full seasonal capacity.
- **Fossil fuel replacement:** the heat pump covers around 5 % of the factory's process heat demand and displaces fossil gas in the evaporation stages.
- **High-temperature capability:** process steam at up to around 139 °C, generated from waste heat at 75–92 °C.
- **Natural refrigerant:** n-pentane (R601) is a natural hydrocarbon with zero ozone depletion potential and negligible global warming potential.
- **Proven at scale:** a full-scale 4 MW installation integrated into a running production process.
- **Validated performance:** continuous data logging and digital process simulation for performance validation and optimisation.

Pentane enables high-temperature heat pumps to operate without the use of synthetic refrigerants. For industries with available waste heat and a demand for high-temperature steam, heat pumps using natural refrigerants offer a pathway to electrification, reduced dependence on fossil fuels and a smaller environmental impact. This makes the Tienen installation an important signal for the food and beverage industry as well as for other process industries.

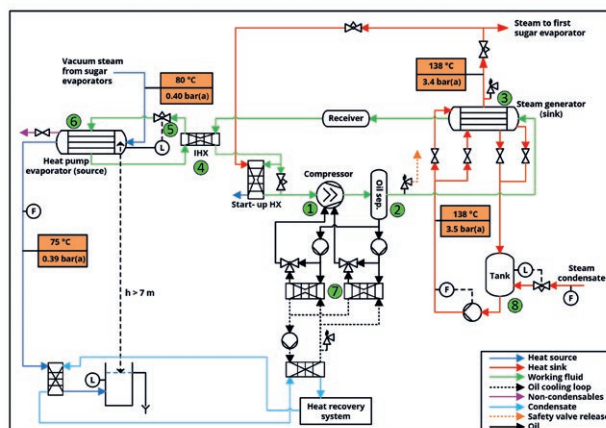


Figure 2: Flow diagram of the heat pump system at Tienese Suikerraffinaderij N.V. Credit: Danish Technological Institute

Outlook

The heat pump at Tienese Suikerraffinaderij is part of a wider industrial transition: replacing fossil-fuel-based process heat with electrically driven heat pump technology wherever suitable waste heat sources are available. SPIRIT – Implementation of sustainable heat upgrade technologies for industry – runs until 2027 under the Horizon Europe programme and demonstrates heat upgrade technologies for the food and beverage and the pulp and paper sectors. The long-term goal is to support the potential future full electrification and decarbonisation of production processes. The operational data from Tienen can help to scale up similar high-temperature heat pump applications in the food, paper, chemical and other energy-intensive industries.

Technical data

Heat source: Vacuum steam from the evaporation plant, approx. 70–92 °C; around 72 °C as representative operating point

Heat sink: Process steam up to approx. 138–141 °C during the beet campaign; approx. 114 °C during the secondary thick-juice campaign

Main components:

- Screw compressor & electric motor
- Oil separator
- Steam generator (heat sink): shell-and-tube condenser raising process steam
- Internal heat exchanger (IHx)
- Level-controlled expansion valve
- Heat pump evaporator (heat source)
- Oil cooling circuit
- Steam condensate tank with feed pump

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