21st EUROPEAN CONFERENCE RACHP

12TH – 13TH JUNE 2025 | POLITECNICO DI MILANO

Under the auspices of MINISTERO DELL'AMBIENTE E DELLA SICUREZZA ENERGETICA

1ST SESSION
NEW REFRIGERANTS AND FUTURE PERSPECTIVES IN REFERENCE TO EU 573/2024, F-GAS REGULATION, ENERGY SAVING

2ND SESSION
NEW COMPONENTS & EQUIPMENT WITH ALTERNATIVE REFRIGERANTS, CONSIDERING THEIR ENERGY EFFICIENCY AND ENVIRONMENTAL ISSUES, RESULTS AND UPDATES

SPECIAL SESSION
WOMEN IN REFRIGERATION AND AIR CONDITIONING

3RD SESSION
POLICY: GLOBAL F-GAS PHASE DOWN AND EU REGULATION, TRAINING AND CERTIFICATION, PFAS

4TH SESSION
GREEN COOLING, HEAT PUMPS AND ENERGY EFFICIENCY

5TH SESSION
THE COLD CHAIN, FOOD DISTRIBUTION AND CONSERVATION, COLD STORAGE AND TRANSPORT. EXPLAINABLE AI, DIGITAL TWINS AND/FOR PREDICTIVE MAINTENANCE

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HOW NATURAL REFRIGERANTS CONTRIBUTE TO DECREASING EMISSIONS FROM EQUIPMENT OPERATION

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About 35 years ago, arguments to avoid HFCs as ODS replacements led to two initiatives that paved the way for a different refrigerant-future. Lorentzen presented simple CO_2-refrigeration circuits and Greenpeace promoted the use of hydrocarbon-based refrigerators. The paper describes how this resulted in accelerated developments using "natural refrigerants" after 1995. The 2015 Paris Agreement (based on national NDCs) provides estimates for future emission reductions, while the 2016 Kigali Amendment declares high-GWP HFCs as controlled substances. Both together provide the right momentum for shifting to low/zero-GWP based applications in the RACHP sector with high energy efficiency. The definitions "green", "clean" or "sustainable" for these low/zero-GWP applications are analyzed. Within the total of sectors contributing to GHG emissions, RACHP is considered a relevant and growing sector. All types of zero-GWP refrigerants are briefly addressed including the current and expected future share of natural refrigerants in the total. For estimating the climate impact of replacing a large and rapidly growing amount of HFC equipment (particularly in the developing countries), analyses performed for this paper are reported. Particularly how much a worldwide replacement of HFCs by zero-GWP based equipment will contribute to low(er) or negligible emissions by 2040-2045. Assumptions are explained for the time-wise HFC-switchover in the various country groups, and for the additional time-related impact of the equipment-based refrigerant bank. Two scenarios are investigated: (a) applying Kigali control schedules, (b) ibid, and now with a phase-out of HFCs by mid-2040. The research conducted provides insights into refrigerant emission reductions, noting that energy efficiency and its relation to electricity-generation-related emissions is of great importance.

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DOES THE MARKET NEED FLUORINATED REFRIGERANTS?

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Alexander Cohr Pachai

The growing presence of trifluoroacetic acid (TFA) worldwide highlights the urgent need from our sector to act and replace fluorinated refrigerants with non-fluorinated alternatives in order to prevent harmful direct emissions caused by leaks, improper charging, or disposal.

It is also important to choose refrigerants with enable a high energy efficiency for these new and redesigned systems, as highlighted with examples.

This contribution is an update and explores the currently available non-fluorinated substitutes for fluorinated refrigerants and demonstrates that a transition to these non PFAS alternatives is not only feasible but has already been implemented in many applications across our sector.

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IEA HPT ANNEX 64: SAFETY MEASURES FOR FLAMMABLE REFRIGERANTS

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IEA HPT Annex 64 has as a goal to contribute to a broader safe use of flammable refrigerants. To reach this goal, the aim of the Annex is to increase the understanding of the risks related to the use of flammable refrigerants, and to develop methods and system designs to maintain the risks at acceptable levels also for systems with larger capacity than what is available on the market today. The objective is that the findings generated in the Annex will be used as background information when regulations regarding the use of flammable refrigerants are updated.

Tasks of the Annex include technical solutions for limiting risks, including charge reduction, investigation of leakage scenarios, leakage detection methods and risk assessment.

This short presentation will give an update on the status of the work within the Annex.

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REDUCING F-GAS EMISSIONS: ADVANCING REFRIGERANT AND CYLINDER MANAGEMENT SYSTEMS

Noboru Kagawa,
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Global warming caused by greenhouse gases is contributing to the increase in extreme weather events, and fluorocarbons, widely used in refrigeration and air conditioning systems, are a significant factor. Although fluorocarbon emissions account for only a small percentage of total greenhouse gases, their impact is increasing with the expansion of equipment usage. In particular reducing emissions of high-GWP HFCs requires regulatory measures under the Kigali Amendment.

To mitigate environmental impact, it is essential to improve refrigeration system efficiency, promote the use of low-GWP refrigerants including natural refrigerants, prevent refrigerant leaks, and establish a management system for refrigerant recovery, reclamation, and destruction. However, achieving complete refrigerant recovery and minimizing leakage remain technological and logistical challenges.

Since FY2023, JSRAE has been developing a refrigerant cylinder management system in collaboration with five academic experts and 13 companies, focusing on supply chain transparency and environmental impact reduction. This will report provides an overview of refrigerant supply, consumption, and recovery in key regions and presents K-plots (refrigerant recovery ratio vs. reclamation ratio) based on mass balance data. Using data from the refrigerant cylinder management system, we will also discuss strategies for reducing the environmental burden of refrigerants and their cylinders.

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EMPOWERING OUR WORKFORCE: BUILDING A SUSTAINABLE FUTURE

Andrés Sepúlveda
Fellow ASHRAE
2025-27 ASHRAE Elected Vice President

In this presentation, Andrés Sepúlveda, on behalf of ASHRAE President Dennis Knight will highlight how ASHRAE and its members are addressing one of the most critical issues of our HVAC&R industry the workforce development.

Creating indoor environments that are healthy, productive, and resilient — while also reducing greenhouse gas emissions — is essential to modern building design and sustainable operation. However, without new, diverse talent and a highly motivated, well-trained workforce, this mission will be impossible to achieve.

This paper outlines a visionary roadmap for transforming our workforce strategy, focusing on three key areas:

1. Attracting Talent
2. Engaging Talent
3. Retaining Talent

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THE IMPORTANCE OF RECOVERED AND REGENERATED HFCS IN HFC/HFO BLENDS

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With the introduction of the new F-Gas Regulation 573/2024 and the resulting cut in HFC quotas, the amount of usable refrigerant for the after-market sector is increasingly suffering. More than 50 percent of the installed bank is HFCs and another substantial portion is loaded with HFC-HFO blends, which have an average GWPs over 1200; thus heavily impacting the available CO_2 quota of individual importers/distributors.

The transition to low or very low GWP technologies, necessitates a major use of these medium-GWP blends that, on the one hand, ensure continuity for newly installed or maintained refrigeration units (less than the physiological payback time) and, on the other hand, ensure the lowest possible environmental impact in case of breakdowns and failures.

The only way, however, to use HFC-HFO blends and comply with the phase down imposed by the Regulations is to use gas recovered from end-of-life plants and regenerated. In fact, regenerated gas does not impact quotas, but has the same chemical and physical characteristics as virgin gas.

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R-474A: AN ULTRA-LOW GWP AND A2L ALTERNATIVE FOR STATIONARY APPLICATIONS

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In Europe the EU F-Gas Regulation is driving the need for more sustainable and safe refrigerant alternatives. R-474A, an ultra-low GWP refrigerant classified as A2L, offers a viable solution for residential and commercial applications, balancing environmental impact, energy efficiency, and safety.
While hydrocarbons (HCs) like R-290 are gaining interest due to their low GWP and being a natural refrigerant, their A3 classification poses safety concerns in either larger charge applications or where the building codes, as well as the installation conditions require refrigerants of lower flammability. R-474A provides a safer A2L alternative with much lower flammability risk while still achieving a substantial reduction in GWP compared to other state-of-the-art refrigerants like R-410A and R-454C used in the RACHP sector and thus R-474A can be widely installed in many applications in accordance with safety standards such as EN378 or ISO5149.
Regulatory developments around PFAS play an important role in shaping the future of synthetic refrigerants. As R-474A contains R-1234yf, ongoing discussions about a potential restriction could impact the future market deployment. Considering a balance of a scientific risk assessment, environmental benefits, and the regulatory framework, this paper will explore the potential of R-474A, its technical and regulatory challenges, and its role in shaping the future refrigerant landscape.

Keywords: Ultra-low GWP, A2L refrigerant, Alternative refrigerants, Energy efficiency, R-474A

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BENEFITS OF R-454C FOR HEAT PUMPS, COMMERCIAL AND INDUSTRIAL REFRIGERATION IN BOTH NEW AND RETROFIT APPLICATIONS

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Jean-Marc Christmann

The refrigerant R-454C is ramping up as a preferred solution in various market segments subject to the European F-Gas Regulation.

Heat pump manufacturers must follow strict guidelines to design safe, low GWP, and energy-efficient equipment. Retailers seek refrigeration systems that are easy to install and maintain, reduce electricity consumption with reasonable initial investment costs, and comply with environmental and safety regulations. The industrial segment looks for alternatives to high GWP refrigerants that allow seamless retrofitting to extend life time of existing systems in place, while minimizing costs and downtime.

R-454C has a combination of properties that make it an ideal candidate to address these needs. With a GWP below 150, low flammability profile, and ease of use it's an excellent option for both new system design and retrofit projects. In addition to reducing waste production by prolonging the life of equipment, R-454C also facilitates the circular economy because it can be recovered, recycled, and reclaimed.

In this paper, we present some of the most interesting case studies across several market segments to evaluate performance, energy efficiency, and value proposition.

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R455A HFO LOW GWP REFRIGERANT AS OPTIMAL SOLUTION FOR FOOD RETAIL REFRIGERATION SYSTEMS

Carmelo Di Pasquale

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The refrigeration segment is constantly evolving: on the one hand, the need to reduce costs and consumption; on the other hand, increasingly stringent regulations are pushing towards sustainable solutions. The question arises: what is the refrigerant of the future in commercial refrigeration? Various studies have compared three environmentally friendly alternatives - R-455A, R-448A and R-744 (CO_2) to see which of these is more efficient and sustainable than traditional systems operating with R-404A. The result? There is no single answer: the choice depends on key factors such as climate, plant technology and running costs. In this presentation, the strengths of the new low GWP HFO A2L refrigerant R-455A, as a long term solution with GWP < 150 and in line with the new F gas directives 2024/573 are analyzed. An analysis is also carried out highlighting the advantages of using R-455A over CO_2 transcritical systems in the food retail segment allowing for excellent TEWI (Total equivalent warming impact) values. Therefore, for the development of flammable refrigerants (A3 and A2L) as well as the refrigerants of the future in view of the strong restrictions of the F gas directive, the evaluation of the risk analysis according to the provisions of the Machinery and Ped Directive will be fundamental, with reference and in compliance with EN 378 standards dispositions to establish the charge limits of the various systems.

In contrast to what one might think, there is no change from the past for risk analysis, as it is a requirement that applies to A2L as well as A1 as CO_2 and applies regardless of the nature of the fluid.

With the large quota cut expected in the coming years, the development of HFO A2L refrigerants will be essential to sustain the demand of the HVAC-R market, while at the same time serving the market properly by not providing obsolete solutions and decreasing the average GWP of the market as soon as possible.

To pursue decarbonization goals, it will therefore be necessary to adopt a scientific and multi-technological approach reaching the technological neutrality and that can demonstrate to users in a timely manner which is the best solution with low GWP but at the same time offers high energy efficiency and low operating costs.

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HTHP BEYOND CONVENTIONAL LIMITS: UNDERSTANDING LUBRICANT-REFRIGERANT INTERACTIONS TO ADDRESS UNCONVENTIONAL CHALLENGES

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The range of working pressures and temperatures for HPs, make necessary a new assessment about the proper lubrication conditions in the compressors. We outline the parameters that influence in covering the proper lubrication needs in a compressor, a working viscosity enough to protect the mobile parts from wear and friction, combined with an effective sealing between high- and low-pressure side of the refrigeration circuit.

Refrigerant Chemistry, its influence on mutual solubility and miscibility, and how all these concepts determine the lubricant working viscosity will be described.

The role of hydrocarbons and its interaction lubricant-refrigerant will be described showing how different conditions influence oil capacity to provide the right viscosity at the right place, with real working conditions examples.

The unsaturated Hydro-Fluoro-Olefin (HFO) refrigerants solvent capability is much higher than the precedent HFCs. An example of different lubricants behavior will be shown, highlighting how a proper interaction lubricant-refrigerant assessment can provide a good working viscosity despite the circumstances.

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INNOVATIONS IN REFRIGERATION LUBRICANTS CRUCIAL ROLE OF ADDITIVES IN REFRIGERATION SYSTEM PERFORMANCE

Paolo Mattavelli,
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Technology in the world of refrigeration is evolving rapidly in search of increasingly optimized and sustainable performance. Regulations, on the other hand, are directing refrigerant gases in the sole direction of ecology, with little attention to performance, which nevertheless remains fundamental in the developments of those involved in the sector.

The Lubricant, which sees its primary function as reducing friction, is today increasingly important as a second system fluid. It must improve performance and increase the resistance and longevity of the system.

It is therefore strategic to direct the development of lubricants towards being a vector of components that can keep the level of humidity, acidity and oxidation under control. Intercept free radicals at the outset that can trigger unwanted and potentially harmful reactions, without neglecting the environmental impact and classifications. Like those that have recently affected several phosphonic products.

It is then necessary to optimize the synergy between the components of the additive package to achieve these objectives. The evolution of our studies has led to the identification of:

1) highly dehydrating molecules that give oil-soluble reaction by-products that do not alter the action of the lubricant.
2) Molecules with conjugated double bonds that can intercept free radicals
3) Anti-corrosive molecules
4) Anti-oxidant molecules.

The evolution of the additive field extends the life of the system and maintenance times with peaks of 40%. We are working to be able to increasingly monitor the condition of the fluids in real time through electronic systems.

Small Legislative part: The EUDR (European Union Deforestation Regulation) is a regulation introduced to prevent deforestation and forest degradation linked to the trade of certain products in the European Union. It requires companies to demonstrate that their products have not been associated with illegal deforestation and forest degradation, with the aim of reducing the negative environmental impact linked to commercial activities.

In the specific case of ester-based lubricants, the impact of the EUDR can be significant on the price and availability of the Lubricant. Especially the latest generation ones that boast biodegradability and renewable sources of raw materials.

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