Heat Pumping Technologies
MAGAZINE
Natural Refrigerants in Heat Pumps: Pushing the Boundaries of Sustainability
Vol.43 No.1/2025
A HEAT PUMP CENTER PRODUCT

Foreword

Natural Refrigerants in Heat Pumps: Pushing the Boundaries of Sustainability

By senior professor Björn Palm, Department of Energy Technology, KTH Royal Institute of Technology, and Operating Agent for HPT Annex 64

In Europe, the F-gas regulation from last year has increased the rate of the phase-down of synthetic refrigerants. By 2050, HFCs will no longer be allowed to be put on the market. The HFOs are excluded from this phase-out, but will be hit by the prohibition to market products with a nominal capacity of less than 12 kW, using any type of F-gases (unless required for safety reasons). In the rest of the world, the Kigali amendment to the Montreal Protocol prescribes a (slower) phase-down of the use of F-gases. In parallel, there is a growing concern about the release of PFAS, also known as "forever chemicals". Almost all synthetic refrigerants belong to the PFAS group (according to the OECD definition). In the EU, there is a proposal to ban the use of all PFAS substances. Restrictions of these substances is also discussed or implemented in other parts of the world, e.g., in some states in the US. As the refrigerants constitute about 60% of all released PFAS, it can be expected that these restrictions will include most of the synthetic refrigerants we use today.

As a result of the implemented and expected restrictions on synthetic refrigerants, most manufacturers in Europe are already introducing products using natural refrigerants. As Europe is an important market also for companies outside of the EU, producers from other countries are developing products with natural refrigerants as well. At Chillventa last year, there were about 15 Chinese companies displaying heat pumps with hydrocarbons! As shown in a recent Technical Brief by the IIR [1], the sales of hydrocarbon heat pumps, as well as the number of models on the European market, have increased considerably over the last few years.

For domestic heat pumps, the most common natural refrigerant is propane, R290. As this is a highly flammable substance, it is important to ensure that the products and installations are safe. The standard IEC/EN/UL 60335-2-40 describes how safe products with flammable refrigerants can be designed, also for installation indoors. In the EU, an updated version of the EN378 on safety and environmental requirements for refrigeration systems and heat pumps is expected to be launched soon. In general, safety can be increased, e.g., by reduced charge, increased tightness, tight enclosures ventilated to the ambient, sensors to switch off the systems in case of a leak, etc.

Research related to these topics is ongoing at many universities in Europe as well as in the US, Japan, and China. Part of this work is done within the IEA HPT Annex 64. The work on charge reduction has demonstrated, by Fraunhofer ISE [3] and independently by KTH [4] [5], that it is possible to build a heat pump with a capacity of 12 kW using only 120 g of hydrocarbon. To reach a low specific charge, it is necessary to consider all the components in the system. We can therefore expect in the near future to see enhanced designs of heat exchangers, as well as new types of compressors, with low charge of oil (or oil-free), and small internal volume.

For larger systems like heat pumps for district heating, we already see a growing market for CO_2 heat pumps. But hydrocarbons are also being introduced in very large systems, both for district heating (50 MW) [5] and for industrial applications [6] [7]. And, we should not forget that ammonia has been the standard solution in industrial applications of heat pumping technologies for more than 100 years.

Every year, there are several fires caused by gas heaters and the gas networks in the built environment. Exchanging these heaters for heat pumps with natural refrigerants, even if they are flammable, would probably be a much safer alternative. And much better for the environment!

References:

[1] Domestic heat pumps using hydrocarbons : current status and market overview... - IIF-IIR - 2024/11
[2] Fraunhofer ISE. (n.d.). The LC150 Project. Retrieved june 15, 2024, from LC150: https://lc150.eu/project/lc150/
[3] Granryd, E., Palm, B., Ölén, V., Andersson, K., & Nowacki, J.-E. (2022). Ecopac – isobutane heat pump acting as economizer. Gustav Lorentzen Conference. Trondheim: IIR. doi:10.18462/iir.gl2022.0093
[4] Ölén, V., Granryd, E., Palm, B., Andersson, K., & Nowacki, J.-E. (2022). EcoPac – High temperature low charge Isobutane heat pump. Gustav Lorentzen Conference. Trondheim: IIR. doi:10.18462/iir.gl2022.0092
[5] STRABAG Umwelttechnik GmbH - STRABAG building 50 MW industrial heat pump in Gothenburg, Sweden
[6] Mayekawa Ammonia-Pentane Cascade Heat Pump System
[7] Prawn processing in Norway – Spirit-Heat.

Name Björn Palm
Title Senior professor
Affiliation Department of Energy Technology, KTH Royal Institute of Technology
E-mail address Bjorn.Palm@energy.kth.se