

# ANNUAL REPORT | 2024

## HEAT PUMPING TECHNOLOGIES



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Technology Collaboration Programme  
on Heat Pumping Technologies

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## Disclaimer

The HPT TCP is part of a network of autonomous collaborative partnerships focused on a wide range of energy technologies known as Technology Collaboration Programmes or TCPs. The TCPs are organised under the auspices of the International Energy Agency (IEA), but the TCPs are functionally and legally autonomous. Views, findings and publications of the HPT TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

# Message from the Chairman

Heat pumps are highly efficient “temperature boosters”. With a relatively small input of exergy such as electricity used to drive compressors, otherwise unusable heat from the environment, from industry, or from other sources can be upgraded to a temperature level that can be used for many purposes. Compared to alternative technologies, heat pumps offer clear advantages in energy efficiency and air pollutant reduction, especially for demand-based heating up to approximately 200 °C. They are high on the IEA's list of priorities for a secure and net-zero emission energy system.



As part of the IEA's Technology Collaboration Programme, our mission is to enhance heat pumping technologies for heating, cooling, and refrigeration applications through international collaboration and knowledge exchange.

Some examples of this are our recent initiatives include *Project 66: Optimal Heat Pump Design and Operation*, launched in 2024, and the ongoing *Annex 63: Placement Impact on Heat Pump Acoustics*. Additionally, the completed *Annex 54: Heat Pump Systems with Low GWP Refrigerants* has significantly contributed to improving heat pump technology.

The development of economically viable, technically robust, and energy-efficient heat pump solutions for large domestic and non-domestic buildings, as well as industrial processes, remains critical. This is illustrated by ongoing projects *Annexes 60, 62, and 63* and the successfully completed *Annex 58* in 2024, a collaboration involving 14 of our 20 member countries. *Annex 61* further exemplifies how heat pumps can transform new and existing urban areas into positive energy districts.

An essential aspect of our work involves integrating heat pumps within broader energy systems. Solutions addressing this integration were explored in the recently completed *Annex 57: Flexibility by Implementation of Heat Pumps in Multi-Vector Energy Systems and Thermal Networks* and will continue in the planned project *Flexibility from Large-Scale and Aggregated Heat Pump Systems*. Additionally, we are expanding our scope to include digitalization and artificial intelligence, with a follow-up project, *Digital Services for Heat Pumps*, building on insights from the completed *Annex 56: Heat Pumps and IoT*.

Commitment to efficiency and sustainability also entails ensuring heat pumps are manufactured, installed, dismantled, and disposed off responsibly. Given the rapid growth in heat pump sales and the IEA's ambitious goal to increase global installations tenfold by 2050, these sustainability criteria become even more vital. I am therefore delighted that we launched *Project 65: Heat Pumps in a Circular Economy* in 2024 alongside our ongoing exploration of environmentally friendly refrigerants in *Annex 64: Safety Measures for Flammable Refrigerants*.

Our projects cover the most important challenges in the development and application of heat pumps, and we are making good progress on the path of our Strategic Work Plan 2023–2028. If you are interested in details of the projects mentioned, you will find further information on the following pages of this report or on our website accessible via the QR code at the front cover of this report.

The variety of topics we successfully deal with is only possible with a team of highly motivated and experienced people. Therefore, I thank the delegates of the executive committee, the experts in the Annexes/ Projects, the staff of the Heat Pump Center and of the IEA for their commitment. I would also like to express my gratitude to our member countries. Without their financial support, our activities would not be possible.

A handwritten signature in blue ink, appearing to read 'S. Renz', written in a cursive style.

Stephan Renz, Chairman of the Executive Committee

# Highlights 2024

## Heat Pumps Highlighted in IEA Flagship Reports

During 2024 heat pumps were highlighted in some of the most important IEA flagship reports, which provide critical insights into key technological aspects of the energy sector. Notably, the *Energy Technology Perspectives (ETP) 2024* report launched in October analyses the international trade of clean energy technologies and related materials, here heat pumps were one of the six technologies studied.

*The IEA World Energy Outlook 2024*, also released in October, highlighted the growing significance of heat pumps in the global transition to sustainable energy systems. The report forecasts a substantial increase in heat pump deployment in the analysed scenarios.

In March IEA published a report dedicated to *The Future of Heat Pumps in China*, which provided an overview of the status of heat pumping technologies in buildings, industry, and district heating in the country and explored the potential for further accelerating deployment.

For the first time, the IEA provided a bi-annual update on heat pump market trends with two editions of the *Clean Energy Market Monitor*, the March edition analysing heat pump trends in 2023 and the November edition analysing market trends in the first half of 2024. The transformative impact of heat pump technologies in leveraging geothermal energy was highlighted in the IEA report *The Future of Geothermal Energy* released in December.

## Launch of and Contribution to TCP Coordination Groups

During 2024 a new mechanism for collaboration between the different Technology Collaboration Programmes (TCPs) was initiated. Six TCP Coordination Groups (CG) were established on different topics. The aim of the CGs is to streamline ongoing research, to seek harmonisation of methodologies and taxonomy and to identify opportunities for collaboration. One CG on Heat Pumps was established. In addition to HPT TCP, four other TCPs joined this group to contribute actively and four others selected to follow the work as observers. In addition to this CG, HPT TCP has been actively involved in the CGs on Thermal Networks and on Energy System Flexibility and has the ambition to follow the work from CG on Critical Materials as observers.

For more information, please see the Activities and Achievements section on page 12 of this report.

## HPT National Experts Meeting

This year over 100 experts representing over 35 countries joined our annual National Experts Meeting which was hosted online on October 15, 2024. The participants spanned regions across North America, Europe, Asia, and other parts of the world, showcasing the international interest and collaboration in advancing heat pumping technologies. During the meeting a variety of projects and proposals and ideas under development were presented and discussed.



Front cover of IEA flagship reports.  
Source: IEA

## New Projects

Two new international collaboration projects (former annexes) were started during 2024. HPT TCP **Project 65 Heat Pumps in a Circular Economy** and **Project 66 Optimal heat pump design and operation**.



The first one was prepared during 2023 and started in January 2024, aiming at providing an overview of the status of heat pumps in relation to a circular economy, highlighting the technological possibilities for improving the circularity as well as develop best practice recommendations, see page 34–35.



Project 66 was launched in October at the Chillventa congress in Germany. The goal of this project is to bring an international team together to help collect and develop optimal heat pump designs, control strategies, and experimental data based on a common system understanding. For more information about this project see page 36–37.



Final reports and two-page summaries from finalized Annexes.

## Finalized Annexes

The work within three of the HPT Annexes were finalized during the year and the final reports have been published along with executive summary and fact sheet. The corresponding webinars to present the final results were received with very high participant attendance.

- » **Annex 54 Heat pump systems with low Global Warming Potential (GWP) refrigerants**
- » **Annex 57 Flexibility by implementation of heat pumps in multi-vector energy systems and thermal networks**
- » **Annex 58 High-Temperature Heat Pumps**

## Publication of Three Issues of the Heat Pumping Technologies Magazine in a New Digital Format

During 2024 the format of the Heat Pumping Technologies Magazine was renewed to increase the spread and improve the readability. The following three issues were published according to the new format:

- » **No.1/2024** "Heat Pumps Unleashing Flexibility and Sector Coupling Amidst Electric Grid Transformations and Strategic Investments"
- » **No.2/2024** "Heat Pumps for All: How to Extend the Working Envelope of Heat Pumps"
- » **No.3/2024** "Heat Pumps Revolutionizing Retrofits: Scaling Up Deployment with Innovative Solutions and Overcoming Barriers"



Layout/format and featuring images for the different issues of the HPT Magazine.

# International Energy Agency



The IEA works with governments and industry to shape a secure and sustainable energy future for all

## About the International Energy Agency (IEA)

The IEA is at the heart of global dialogue on energy, providing authoritative analysis, data, policy recommendations, and real-world solutions to help countries provide secure and sustainable energy for all. The IEA was created in 1974 to help co-ordinate a collective response to major disruptions in oil supply. Energy security remains central to the IEA's mission today, but the Agency's work has expanded significantly since its foundation.

Taking an all-fuels, all-technology approach, the IEA recommends policies that enhance the reliability, affordability, and sustainability of energy. It examines the full spectrum of issues, including renewables, oil, gas, and coal supply and demand, energy efficiency, clean energy technologies, electricity systems and markets, access to energy, demand-side management, and much more.

The IEA has also opened its doors to major emerging countries to expand its global impact and deepen cooperation in energy security, data and statistics, energy policy analysis, energy efficiency, and the growing use of clean energy technologies.

## About the IEA Technology Collaboration Programme

The Technology Collaboration Programme (TCP), a multilateral mechanism established by the International Energy Agency (IEA) 50 years ago, was created with a belief that the future of energy security and sustainability starts with global collaboration. Under this framework, thousands of experts from governments, academia, and industry representing 150 institutions from 55 countries are collaborating to enforce research, development, and commercialisation of energy technologies.

The scope and strategy of each collaboration is in keeping with the IEA Shared Goals of energy security, environmental protection, and economic growth, as well as engagement worldwide. Individual technology collaborations working across several technology or sector categories involve: energy efficiency end-use technologies (in buildings, transport, industry, and electricity), renewable energy and hydrogen, fossil energies, fusion power, and cross-cutting issues (energy system analyses and equality in energy transition).

These technology collaborations are a critical, member-driven part of the IEA family, but they are functionally and legally autonomous from the IEA Secretariat. The breadth of the analytical expertise in the Technology Collaboration Programme is a unique asset in the global transition to a cleaner energy future.

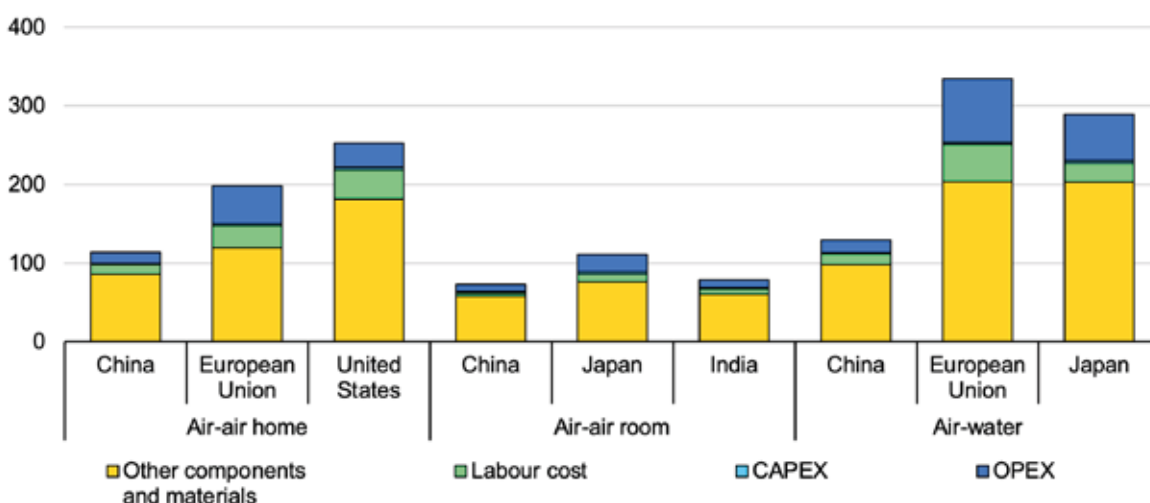
### About the IEA’s Work on Heat Pumps in 2024

#### » *Energy Technology Perspectives 2024*

The International Energy Agency (IEA) Energy Technology Perspectives (ETP) flagship series of reports has been providing critical insights into key technological aspects of the energy sector since 2006. ETP-2024, launched in October 2024, is the first report of its kind to analyse the future of manufacturing and international trade of clean energy technologies and related materials. The analysis covers six key clean energy technologies – electric vehicles, batteries, solar photovoltaics, wind turbines, heat pumps, and electrolysers, as well as the manufacturing and trade of the main components of these technologies, alongside three categories of materials – steel, aluminium, and ammonia (both for industrial and fuel-related applications) – with a focus on near-zero emissions manufacturing processes.

ETP-2024 looked in detail at the manufacture and trade of heat pumps. Unlike other clean technologies, such as solar panels or batteries, the share of trade in heat pumps is relatively low, and only a quarter of heat pump installations in 2023 were traded internationally. This is largely because local manufacturers are most familiar with local preferences, standards, or even traditional building designs, as heat pumps are part of an industry with differentiated markets and specialisation. ETP-24 explores how these trends might evolve in the future and provides detailed projections of manufacturing and trade trends for different scenarios, which vary mainly according to assumptions about government policies affecting energy use and supply and the overall pace of the clean energy transition.

Another aspect examined in detail in ETP-24 is the cost competitiveness of heat pump manufacturing in different regions. The cost of components such as compressors or heat exchangers represents the largest part of the manufacturing cost of heat pumps in all regions, but costs can vary significantly for different types of heat pumps and different efficiency levels, which may require different technical specifications. In addition, manufacturers that produce their own components and/or can benefit from economies of scale have a strong competitive advantage. These factors partly explain the significant cost differences between technologies and regions.



**Figure 1.** Levelised cost of production for heat pumps in selected countries/regions by type, 2023

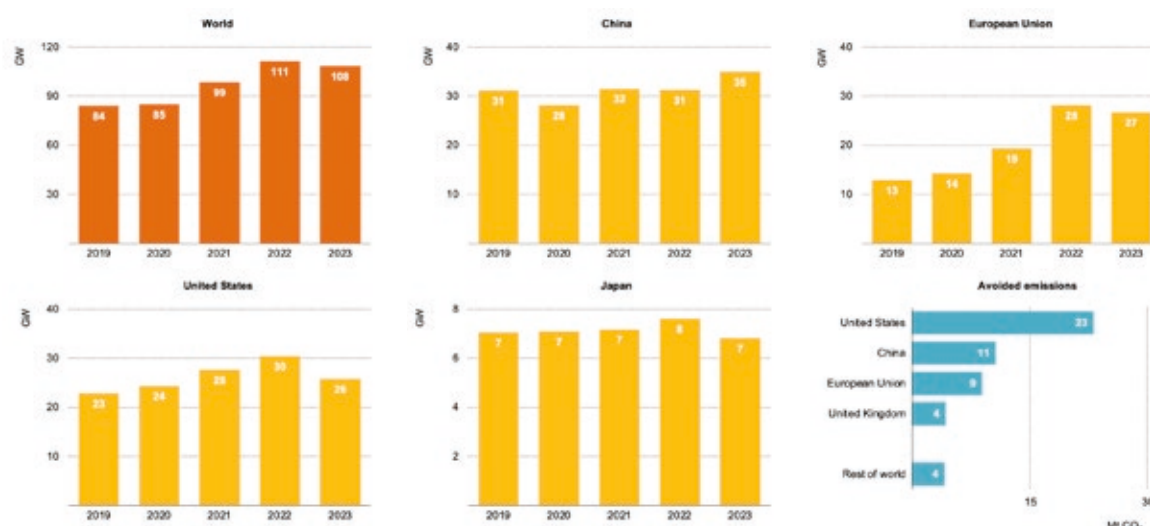
Notes: air-air home = air-to-air central heat pumps for the whole household; air-air room = air-to-air reversible air conditioners for a room; air-water = air-to-water units for the whole household. LCOP = levelised cost of production. For Japan, air-water units are intended as water heaters with tanks. USD = USD (2023, MER).

» **The Future of Heat Pumps in China**

The Future of Heat Pumps in China report provides an overview of the status of heat pumps in buildings, industry, and district heating in China and explores the potential for further accelerating deployment. This first-of-its-kind analysis was launched in Beijing in March 2024. In collaboration with Tsinghua University, the IEA examined China's policy framework, historical energy consumption for heating, market trends, and future opportunities for heat pump deployment. The modelling analysed the potential for heat pump deployment up to 2050, highlighting the impact on CO<sub>2</sub> emissions, air pollution, investment, job creation, and supply chains.

» Clean Energy Market Monitor, **March** and **November** editions

For the first time, the IEA provided a bi-annual update on heat pump market trends with two editions of the Clean Energy Market Monitor, the March edition analysing heat pump trends in 2023 and the November edition analysing market trends in the first half of 2024. The monitor shows that global heat pump sales peaked in 2022 and then declined sharply in 2023 and the first half of 2024. In the first six months of 2024, global heat pump sales fell by 10% compared to the same period last year. However, the global trend was significantly influenced by a sharp decline in heat pump sales in Europe, which was partially offset by rising sales in China and stable trends in the US and Japan.



**Figure 2.** Heat pump sales and avoided emissions

Notes: heat pumps that deliver heat directly to households and residential or commercial buildings for space heating and/or domestic hot water provision. It includes natural source heat pumps, including reversible air conditioners used as primary heating equipment. It excludes reversible air conditioners used only for cooling, or used as a complement to other heating equipment, such as a boiler. Source: IEA analysis based on data from ChinalOL; European Heat Pump Association; Air-Conditioning, Heating, and Refrigeration Institute; Canada National Statistical Agency; Japan Refrigeration and Air Conditioning Industry Association.

# Technology Collaboration Programme on Heat Pumping Technologies



Organised under the umbrella of the International Energy Agency since 1978, the Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP) is a non-profit organisation funded by its member countries. The scope of the Programme covers heat pumps, air conditioning and refrigeration, commonly denoted as heat pumping technologies. We continuously observe the development and requirements of our energy system and revise our strategy every five years according to the objectives of the IEA.

## Strategic Work Plan 2023–2028

### ***Vision***

Heat pumping technologies are the cornerstone for a secure, affordable, high-efficiency, clean and net-zero emission energy system for heating, cooling and refrigeration. We are the key worldwide independent actor to achieve this vision across multiple applications and contexts. We generate and communicate information, expertise and knowledge related to heat pumping technologies as well as enhance international collaboration.

### ***Mission***

To accelerate the transformation to an efficient, renewable, clean and secure energy sector in our member countries and beyond by performing collaborative research, demonstration and data collection as well as enabling innovations and deployment within the area of heat pumping technologies.




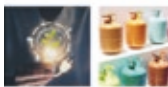
### ***Strategic Objectives***

- » ***Accelerated deployment***
  - A. The deployment rate is accelerated for efficient heat pumping technologies in different applications – buildings, industry, transport, electric and thermal energy systems – to keep pace with the milestones set out in the IEA Roadmap towards Net Zero Emissions by 2050.
  - B. Innovations related to heat pumping technologies are brought to the market, contributing to fulfilling the net zero emission targets.
- » ***Energy security***
  - C. Integrated, affordable solutions for heating and cooling, where heat pumping technology is a key element, are explored through collaboration with other TCPs, enabling energy savings, flexibility and responsiveness in the energy system and improving security of supply.
- » ***Economic growth of secure and sustainable solutions***
  - D. The HPT TCP contributes to removing gaps and overcoming barriers in the sustainable value chain of heat pumping technologies.
- » ***Environmental protection***
  - E. More decision-makers (policy, investors, utilities, real estate actors, industry, users, etc.) acknowledge the multiple benefits of heat pumping technologies as a sustainable, clean, enabling, connecting, and affordable heating and cooling solution to reach the climatic ambitions and strengthen energy security. Decisions which promote heat pumping technologies are implemented.
- » ***Engagement worldwide***
  - F. HPT TCP has more member countries representing the largest economies, different parts of the world facing different contexts, IEA key partner and association countries.
  - G. HPT TCP is an active player and / or partner to the IEA, other TCPs, various international initiatives and organisations related to secure and sustainable heating and cooling and flexible energy solutions for everyone.

## Strategic Initiatives

- 1. Advance the RDD&D** of heat pumping technologies through the creation of research opportunities, networking and meeting places for academia, industry, markets actors, investors and policy makers to collaborate under new Annexes (projects/tasks) and other activities (e.g. workshops) within the HPT TCP, see priority areas for RDD&D\* below.
- 2. Contribute to advanced and/or disruptive innovations** through cross-cutting networking and collaboration with other TCPs, IEA, Mission Innovation and other relevant organisations, attracting new actors representing other relevant areas of knowledge.
- 3. Communicate the results and impact from the RDD&D work**, tailor the messages and the dialogue using selected channels to reach relevant target groups, including policy makers, energy and environmental agencies, investors, utilities, manufacturers, city and building planners, system designers, architects, industry associations, installers, researchers and end-users. Arrange a high quality conference about heat pumping technologies at least every third year, and establish this conference as the most important networking place. For more information about the conference 2026, see page 16.
- 4. Providing and enlarging a dialogue platform to share and report back experiences** to those stakeholders and actors who could benefit from such knowledge.
- 5. Provide IEA, standardisation organisations and regional or national policy makers with reliable and independent guidance, data and knowledge** about heat pumping technologies, separately or in combination with other technologies.
- 6. Increase activities to attract new members**, including IEA key partners and association countries.

## RDD&D PRIORITY AREAS 2023–2028

System Integration	Robust, sustainable and affordable value chains	Extending operation range and applications	New technologies and refrigerants
			
Sector coupling, energy efficiency, flexibility, resilience, storage, digitalization, positive energy districts.	Improving affordability, securing value chains, circular economy, removing barriers from mass deployment.	To fulfill demands from all climate zones, new markets, new applications, and new demands. Refrigeration in emerging countries.	Non-traditional heat pumping technologies (for heating and cooling). Refrigerants (low GWP, safety etc.)
<ul style="list-style-type: none"> <li>The role of heat pumps in integrated energy systems on building, district and city levels</li> <li>Heat pumps as enabler for sector coupling</li> <li>Methods for evaluating smart, flexible heat pumps</li> </ul>	<ul style="list-style-type: none"> <li>Systems for circular economy for heat pumps</li> <li>New business models</li> <li>Easy to install products (plug and play and self commissioning)</li> <li>Standardization for scaling</li> <li>Using behaviour/ acceptance of HPT comfort and flexibility</li> </ul>	<ul style="list-style-type: none"> <li>Heat pumps for industrial application</li> <li>Heat pumps for district heating and cooling applications</li> <li>Heat pumps for retrofitting of existing buildings with special requirements</li> <li>Heat pumps/AC for cooling, dehumidification and drying</li> <li>Cold climate heat pumps</li> </ul>	<ul style="list-style-type: none"> <li>Non-vapour compression technologies</li> <li>Other areas that need low TRL level research</li> <li>Efficient operation, components and systems for Low GWP refrigerants</li> <li>Safety measures for operating with low GWP refrigerants</li> </ul>

## HPT TCP MEMBER COUNTRIES

- |                  |                     |
|------------------|---------------------|
| » Austria        | » Italy             |
| » Belgium        | » Japan             |
| » Canada         | » The Netherlands   |
| » China          | » Norway            |
| » Czech Republic | » South Korea       |
| » Denmark        | » Spain             |
| » Finland        | » Sweden            |
| » France         | » Switzerland       |
| » Germany        | » United Kingdom    |
| » Ireland        | » The United States |



\* Research, Development, Demonstration and Deployment

# Organisation of the HPT TCP

The work within the HPT TCP is organised in several interacting layers.

**The Executive Committee (ExCo)** is the board of the HPT TCP. Meetings are held twice a year. At the meetings, each member country has one vote. The meeting locations alternate between the member countries and regions.

**National Teams (NTs)** are important for promotion of the HPT TCP at the national level. The National Teams are experts on their countries' needs regarding industry, markets, deployment, research and development activities. It is a forum for discussion, networking and creation of new ideas. Thus, an interactive process where the National Team shares information with the ExCo delegates, the Heat Pump Centre, and other National Teams is highly important.

**Annexes /Projctcs** are the cooperative projects within the HPT, and are a central activity of the HPT TCP. Within these, new knowledge is elaborated through collaborative RDD&D work. They are conducted on a combination of cost-sharing and task-sharing basis by the participating countries. They are often conceived at the joint National Experts' meetings.

**The Heat Pump Centre (HPC)** is the central communication activity and programme office of HPT TCP. This involves information dissemination, for instance, regarding project reports, the HPT Magazine and Newsletter and the HPT Website; nowadays also social media such as LinkedIn, WeChat and X (@heatpumpingtech). It also involves programme support to ExCo, NTs and Annex/Project coordinators (called Operating Agents, OAs), as well as stimulating and supporting the generation of new activities, arranging National Experts' meetings, representing the TCP at IEA meetings, supporting IEA publications, and conducting outreach activities.

## This is the HPC Staff :



### **Monica Axell, Co-leader**

Monica has a long and extensive experience of heat pumping technologies. Through meetings and conferences for the HPC and others, she also has many contacts within not only this field but generally within the field of energy and beyond.

[monica.axell@ri.se](mailto:monica.axell@ri.se)



### **Caroline Haglund Stignor, Co-leader, Technical Expert**

Caroline also has a long and extensive experience of heat pumping technologies. Together with Monica, she is often the face of the HPC, presenting and representing HPT TCP in current and future member countries and conferences.

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### **Emilia Pisani Berglin, Programme Coordinator**

Emila is an international project coordinator with experience in strategic communication, dissemination and stakeholder engagement. She is the person to contact for general issues regarding the HPT TCP and HPC.

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### **Metkel Yebiyo, Technical Expert and Editor**

Metkel Yebiyo is a Researcher at RISE, working at the forefront of energy & sustainable built environment. At HPC, he is the editor of our prestigious Heat Pumping Technology Magazine and deals with annual reports, organising national expert meetings, and member country reports.

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### **Mia Westh, Communications Officer**

Communications specialist with long experience in editorial work, digital media production, web, content and media strategy with a focus on research, science, technology and digital media landscapes.

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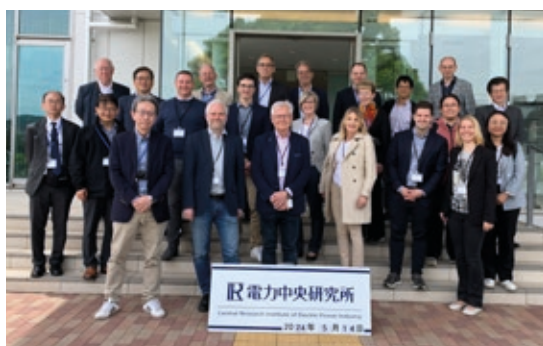
# Activities and Achievements

## Executive Meetings

The spring ExCo meeting took place in Yokohama in May and was hosted by the Japanese delegates. It had a great turnout with delegates and operating agents attending in person and online. Additionally, the IEA CERT\* delegate from Japan was invited and attended the first day of the meeting in order to enhance the interaction between CERT and the TCP community. Moreover, representatives from the EBC Annex 88, focusing on heat pumps, were invited to present and discuss intermediate results from their work with the HPT delegates and operating agents. The day prior to the meeting, the Japanese ExCo delegates organized a national workshop and a tour of the CRIEPI (Central Research Institute of Electric Power Industry) facility, which provided a comprehensive overview of the advancements and strategic directions in heat pump technologies and energy efficiency and decarbonization policies.

The fall ExCo meeting was hosted by one of the newest member countries of the TCP, Spain, and took place in Madrid in November. The meeting was well attended and a representative from the DG ENER at the European Commission attended the first day as an invited guest, since membership discussions are ongoing with this party. As an opening act to the ExCo meeting, the Spanish delegates organized a national workshop the day before the meetings, when researchers and experts from around twenty universities, companies, and technological centres from across Spain showcased the latest developments and achievements in national and international collaboration projects with the purpose of advancing heat pump technologies worldwide. In addition, the activities within the HPT TCP were presented to the national audience.

*CERT\* IEA's Committee for Energy Research and Technology*



Attendees at the CRIEPI facility in Japan.



First prototype of the Eco-Cute heat pump for domestic hot water heating, using CO<sub>2</sub> as refrigerant.

*[Strategic Objective E, Strategic Initiative 2, see page 9–10]*

## Workshops, Seminars and Webinars

During the year, the HPT TCP has organized several events. Three webinars were held during the spring, where the final results from three of the Annexes were presented. The webinars were recorded and are available on the Youtube channel of HPT TCP.

- » **June 11: Annex 54 Heat pump systems with low Global Warming Potential (GWP) refrigerants**
- » **May 6: Annex 57 Flexibility by implementation of heat pumps in multi-vector energy systems and thermal networks**
- » **April 23: Annex 58 High-Temperature Heat Pumps**

In addition an open definition workshop was organized by **HPT Annex 62 Heat Pumps for Multi-Family Residential Buildings in Cities** in June to discuss the Solution Matrix developed within the project.



Attendees of the HPT TCP Fall ExCo meeting.

Two digital Member Country Report Workshops took place, one in **March** and one in **September**, where delegates from China, Denmark, Germany, and South Korea shared information about policies, markets and ongoing research activities. The invitation was open to the public, so besides the delegates external attendees, from member countries and beyond, have the opportunity to listen, ask questions and take part in the discussion. The presentations from the workshops were published at the HPT website after the event. This offers website visitors a good source for information regarding market development and the present status and conditions for the deployment of heat pumps in different parts of the world.



In addition, several of the HPT annexes/project held presentations or were showcased during the Chillventa event in Germany in October – Annex 63, 64, 64. Moreover, the newest HPT TCP collaboration Project 66 organized their kick-off meeting there.

*[Strategic Objective E, Strategic Initiative 2, see page 9–10]*

### **HPT TCP National Experts Meeting**

The HPT TCP organizes every year meetings for national experts and stakeholders working in the field of heat pumping technologies. The invitation is open, and traditionally a physical meeting is held every second year and an online meeting the other years. On October 15 the annual National Experts meeting took place, this year as an online meeting. More than 100 experts representing over 35 countries globally joined the meeting. The participants spanned regions across North America, Europe, Asia, and other parts of the world, showcasing the international interest and collaboration in advancing heat pumping technologies. Notable contributors included countries like the United States, Germany, Italy, and China, which had the highest number of registrants, reflecting a strong global engagement in the discussion of future projects and ongoing initiatives.

During the meeting the new project and proposals and ideas under development were presented and discussed (see below). Following this, participants engaged in a brainstorming workshop to develop ideas for new international collaboration project topics across four prioritized areas for RDD&D within HPT TCP. Following this, participants engaged in a brainstorming workshop to develop ideas for new international collaboration project topics across the four prioritized areas for RDD&D within HPT TCP (see page 10). The outcomes from this meeting will be taken further to the physical National Experts meeting 2025.

*[Strategic Objective B, Strategic Initiative 1, see page 9–10]*

### **Ongoing, New and Completed Projects**

The international collaboration projects within the HPT TCP, the annexes, form the core of TCP activities.

During 2024, the following eleven annexes/projects were ongoing.

- » Heat Pump Systems with Low GWP Refrigerants (Annex 54)
- » Flexibility by Implementation of Heat Pumps in Multi-Vector Energy Systems and Thermal Grids (Annex 57)
- » High-Temperature Heat Pumps (Annex 58)
- » Heat Pumps for Drying (Annex 59)
- » Retrofit Heat Pump Systems in Large Non-domestic Buildings (Annex 60)
- » Heat Pumps in Positive Energy Districts (Annex 61)
- » Heat Pumps for Multi-Family Residential Buildings in Cities (Annex 62)
- » Placement Impact on Heat Pump Acoustics (Annex 63)
- » Safety Measures for Flammable Refrigerants (Annex 64)
- » Heat Pumps in a Circular Economy (Project 65)
- » Optimal Heat Pump Design and Operation: An International Collection of Common Techniques to Accelerate Broader Acceptance (Project 66)

However, Annex 54, Annex 57 and Annex 58 were in the reporting phase. More information can be found on page 19–21.

*[Strategic Objective B, Strategic Initiative 1, see page 9–10]*

## HPT Communications: Magazine, Newsletter, Website, Social Media and More

One of the Heat Pump Centre's (HPC) main activities is publishing the prestigious Heat Pumping Technologies Magazine. Each issue covers a specific topic and contains articles and a contribution from a guest columnist. Three issues of the HPT Magazine were published in 2024 on the topics:

- » **No.1/2024** "Heat Pumps Unleashing Flexibility and Sector Coupling Amidst Electric Grid Transformations and Strategic Investments"
- » **No.2/2024** "Heat Pumps for All: How to Extend the Working Envelope of Heat Pumps"
- » **No.3/2024** "Heat Pumps Revolutionizing Retrofits: Scaling Up Deployment with Innovative Solutions and Overcoming Barriers"

During 2024 the format of the Heat Pumping Technologies Magazine was renewed to a website-based format. It is disseminated to its subscribers, via social media and the website. The prestigious Heat Pumping Technology Magazine has played a significant role in expanding our research outreach, attracting new audiences, and sparking important discussions on the current energy challenges and the robust policy backing for heat-pump technologies. The new format has strengthened the outreach and the readability in different types of media, especially the mobile ones. However, a pdf for download is still offered to the readers.

In between the release of the magazine, the Heat Pumping Technologies Newsletter were sent out to the subscribers, summarizing the news of the latest month.



HPT TCP Magazine cover.

The HPT TCP website is continuously updated with news, information, new annex subsites and new publications. During 2024 the TCP started the work with revising the communication strategy and renewal of the website to better highlight and promote all the information available on the website and enhance the outreach to the prioritized target groups.

The Heat Pump Centre has been active on social media, publishing news on LinkedIn, and the Chinese social media platform WeChat. It continuously follows the web traffic and number of readers on our communication channels and has noted a considerable increase in both from year to year.

The Heat Pump Centre has continued to support the operating agents (project managers for the annexes/projects) in improving and updating annex pages on the website with new information, such as publications and links to webinars, reports etc. This is important for increasing the reach out of the results from the work within the HPT TCP. During the year the project managers have been encouraged to frequently publish news on their website, which are then spread via social media and the newsletter to attract interest for their work and their findings from different types of stakeholders.

Heat Pump Centre (HPC) continued to send out the "HPC 60 seconds" e-mail, a monthly overview in bulleted format of HPC activities for people actively involved in the TCP. As a complement, a more detailed information letter, the HPC letter, is distributed to the ExCo delegates between the ExCo meetings.

*[Strategic Objectives A and B, Strategic Initiative 3 and 4, see page 9–10]*

## Collaboration with IEA, other TCPs and TCP Coordination Groups

Representatives from the HPT TCP and Heat Pump Centre have had a continuous dialogue with the IEA secretariat and participated in meetings, most of them online but also on-site. The desk officer for HPT TCP from the IEA was invited to and participated in both the spring and fall ExCo meetings. Moreover, the CERT delegated from the host countries were invited to the ExCo meetings.

During the year, representatives from the HPT TCP contributed to the review and dissemination of several of the IEA reports publications with relation to heat pumping technologies (see page 6–8).

Moreover, the Heat Pump Centre took an active part in the IEA review of areas of improvement in CERT, its Working Parties and the TCPs together with ExCo Chair.

HPT TCP took an active role in the initiation of the new mechanism for collaboration between the different Technology Collaboration Programmes (TCPs) during 2024. Six TCP Coordination Groups (CG) were established on different topics. The aim of the CGs is to streamline ongoing research, to seek harmonisation of methodologies and taxonomy and to identify opportunities for collaboration. One CG on Heat Pumps was established, which is led by the vice Chair of the previous Working Party for End-Use of energy (EUWP) with support from the IEA secretariat. In addition to HPT TCP, four other TCPs joined this group to contribute actively and four others selected to follow the work as observers. HPT TCP contributed actively to the work, attended meetings and provided input to different outcomes from the CG. In addition to this CG, HPT TCP joined and contributed actively to the CG on Thermal Networks and the CG on Energy System Flexibility and has the ambition to follow the work from CG on Critical Materials as observers.

*[Strategic Objectives D, E, F, Strategic Initiative 5, see page 9-10]*

### Collaboration with Other International Organizations

During the year membership discussions have been going on with the European Commission and several meetings were held with representatives from DG ENER, were also invited to the ExCo meetings (and attended the fall meeting). A representative from the Heat Pump Centre was also approved to become a member of the European Commission's Heat Pump Accelerator Platform, starting in 2025.



The HPT TCP was presented by the Heat Pump Centre at the CHPF.

A recorded presentation about HPT TCP was given by one from the Heat Pump Centre team at the China Heat Pump Forum (CHPF), which took place in Shanghai in August 2024 and brought together more than 1000 attendees. In addition, HPT TCP disseminated a report from the event in their channels.

In September, a representative from the Heat Pump Centre participated in and reported from the Heat Pump Forum in Brussels, organized by the European Heat Pump Association (EHPA). The key question for that event was "Is Europe Ready to Eliminate Fossil Fuels for Heating?" In addition, there were four representatives from the HPT TCP in the Jury of their Heat Pump Award, which also presented the awardees during the event. The General Director was also invited to and attended part of the fall ExCo meeting.



Jury and winners during EHPA's Heat Pump Award Ceremony, including four representatives from the HPT TCP in the jury.

During the year the Heat Pump Centre attended meetings with the Energy Efficiency Hub and presented the TCP, reviewed a future guidebook for heat pumps from REHVA and an article about hybrid heat pumps published by RAP – the Regulatory Assistance Project. A representative from the IIR International Institute for Refrigeration attended and presented at the ExCo fall meeting.

*[Strategic Objective A, B, E, Strategic Initiative 4 and 6, see page 9-10]*

### Mission Innovation

During the year the Heat Pump Centre has attended meetings and followed the progress with Mission Innovation (MI) and investigated possibilities to collaboration. At the spring ExCo meeting a session was dedicated to MI calls, which can be a possible instrument for the future to find additional funding to HPT TCP projects.

# 15<sup>TH</sup> IEA HEAT PUMP CONFERENCE



## VIENNA 2026

The 15<sup>th</sup> IEA Heat Pump Conference is scheduled to take place from May 26 to 29, 2026, in the historic city of Vienna, Austria. This premier event serves as a global forum for academia, industry professionals, policymakers, and investors to discuss the latest advancements in heat pumping technologies. Under the theme "**Decarbonisation through Innovation**", the conference aims to explore innovative solutions for reducing greenhouse gas emissions and promoting sustainable heating and cooling systems.



The conference is organized by the Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP) under the auspices of the International Energy Agency (IEA). The AIT Austrian Institute of Technology, a leading research entity in heat pumps, is hosting the event. The venue for the conference is the prestigious Vienna Hofburg, a historic building in the heart of Vienna that offers a unique blend of imperial charm and modern conference facilities.

Participants are encouraged to submit abstracts showcasing their recent research and developments in heat pumping technologies. The call for abstracts opens on January 15, 2025, with a submission deadline of May 15, 2025. The con-

ference will cover a wide range of topics, including technological innovations, application case studies, policy frameworks, and market strategies related to heat pumps.

For more information on submissions, program details, and registration, visit the official conference website at <https://hpc2026.org/>. Stay updated by subscribing to the conference newsletter available on the website.

Join us in Vienna to contribute to and learn from the collective efforts driving the future of heat pump technology and its role in global decarbonization.

# HPT TCP Projects for Research, Development, Demonstration and Deployment

The projects within the HPT TCP have for a long time been known as annexes. However, with start in 2024 the TCP has started to name the new ones Project to be inline with the TCP framework of IEA. Participation in an annex/project is an efficient way of increasing national knowledge, both regarding the specific project objective, but also by international information exchange. Annexes/projects operate for a limited period of time, and objectives may vary from research to implementation of new technology. Market aspects are other examples of issues that can be highlighted in the projects.

# HPT TCP Annexes/Projects







The Technology Collaboration Programme on Heat Pumping Technologies participating countries are: Austria (AT), Belgium (BE), Canada (CA), Czech Republic (CZ), China (CN), Denmark (DK), Finland (FI), France (FR), Germany (DE), Ireland (IE), Italy (IT), Japan (JP), the Netherlands (NL), Norway (NO), South Korea (KR), Spain (ES), Sweden (SE), Switzerland (CH), the United Kingdom (UK), and the United States (US).

**Bold, red text** indicates Operating Agent (Project Leader).

 Finalized 2024

 NEW

Letters A-D in the right column, indicates which of the selected RDD&D areas in the Strategic Work Plan of HPT TCP the Annex is linked to, see below.

 54	HEAT PUMP SYSTEMS WITH LOW GWP REFRIGERANTS	AT, DE, FR, IT, JP, KR, SE, <b>US</b>	D
 57	FLEXIBILITY BY IMPLEMENTATION OF HEAT PUMPS IN MULTI-VECTOR ENERGY SYSTEMS AND THERMAL NETWORKS	AT, DE, <b>DK</b> , FR, NL, SE	A
 58	HIGH-TEMPERATURE HEAT PUMPS	AT, BE, CA, CH, CN, DE, <b>DK</b> , FI, FR, JP, KR, NL, NO, US	C
 59	HEAT PUMPS FOR DRYING	<b>AT</b> , CH, CN, DK, NO, SE, US	C
 60	RETROFIT HEAT PUMP SYSTEMS IN LARGE NON-DOMESTIC BUILDINGS	AT, CA, IT, IR, NL, SE, <b>UK</b>	C
 61	HEAT PUMPS IN POSITIVE ENERGY DISTRICTS	AT, <b>CH</b> , DE, IT, JP, US	A
 62	HEAT PUMPS FOR MULTI-FAMILY RESIDENTIAL BUILDINGS IN CITIES	BE, CH, CN, <b>DE</b> , ES, FR, IT, SE	C
 63	PLACEMENT IMPACT ON HEAT PUMP ACOUSTICS	<b>AT</b> , DE, FR, CH, NL, UK, IT, SE	B
 64	SAFETY MEASURES FOR FLAMMABLE REFRIGERANTS	AT, DE, FR, KR, <b>SE</b> , US	D
 65	HEAT PUMPS IN A CIRCULAR ECONOMY	DE, <b>DK</b> , IT	B
 66	OPTIMAL HEAT PUMP DESIGN AND OPERATION	DE, ES, <b>US</b>	B

Selected areas for RDD&D activities in HPT TCP (2023–2028). See page 38.

A)



System Integration

B)



Robust, sustainable and affordable value chains

C)



Extending operation range and applications

D)



New technologies and refrigerants

# ANNEX 54

## HEAT PUMP SYSTEMS WITH LOW GWP REFRIGERANTS

### INTRODUCTION

To reduce greenhouse gas emissions and achieve sustainable, low-carbon cooling and heating solutions, a transition to use of refrigerants with low global warming potential (low-GWP) in heat pump systems is essential. This process is accelerated by the development of guidelines for optimized components and systems to ensure safety, efficiency, and market readiness.

### KEY FINDINGS

The key findings from Annex 54, which was finalized during 2024 are structured according to the tasks of each participating country:

- » **Austria** identified low-GWP refrigerants and provided an overview of the Austrian heat pump market and examples of low-GWP refrigerants in applications.
- » **France** investigated the water-to-brine heat pump for a 5 kW residential space heating application that can be placed inside a house with a maximum admissible R-290 charge of 150 g.
- » **Germany** summarized the heat pump market survey, integrated fluid screening, and evaluated SCOP of HCs, HFOs, and mixtures.
- » **Italy** reported a solar-assisted heat pump water heater using CO<sub>2</sub> and compared R410A alternatives (R32, R454B, and R454C) for residential heat pumps.
- » **Japan** provided an in-depth analysis of the LCCP and risk evaluations for heat pump systems using low GWP refrigerants like R-410A, R-32, R-454C, R-290, and R-22.

- » **Korea** conducted a comparative study on the performance of R-32 versus R-410A refrigerants in residential air conditioners such as window-type and wall-mounted air conditioners.
- » **Sweden** provided the Swedish heat pump market for residential and commercial units, shared case studies and design guidelines for a geothermal R290 HP for multifamily buildings (EBOX), a CO<sub>2</sub> heat pump system for commercial buildings, and an R290 heat pump and chiller for the process cooling and heating.
- » **USA** reported the next-generation HX design framework and provided 5.3 kW condenser optimization for R32 and R454B.

The final reports are published on the annex website.

- » **Final Report**
- » **Executive Summary**
- » **2-page Summary**
- » **Country Report Austria**
- » **Country Report France**
- » **Country Report Germany**
- » **Country Report Italy**
- » **Country Report Japan**
- » **Country Report South Korea**
- » **Country Report Sweden**
- » **Country Report USA**



#### Contact person:

The operating Agent was Dr. Yunho Hwang from the University of Maryland, College Park, US.  
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#### Participating countries:

Austria, France, Germany, Italy, Japan, South Korea, Sweden, USA

#### Publications:

Final report, including country reports, and Executive Summary of Annex 54, available at [www.heatpumpingtechnologies.org/annex54](http://www.heatpumpingtechnologies.org/annex54)

#### Annex website:

[www.heatpumpingtechnologies.org/annex54](http://www.heatpumpingtechnologies.org/annex54)

# ANNEX 57

## FLEXIBILITY BY IMPLEMENTATION OF HEAT PUMPS IN MULTI-VECTOR ENERGY SYSTEMS AND THERMAL NETWORKS

### INTRODUCTION

As global electricity demand rises, driven by a shift from fossil fuels to electrification, heat pumps are becoming crucial in enhancing grid flexibility. These technologies effectively manage the variability of renewable energy sources, ensuring a resilient energy infrastructure that can adapt to fluctuating demands.

### KEY FINDINGS

Annex 57 was finalized during 2024 and the key findings were that heat pumps significantly enhance grid management and energy efficiency, playing a transformative role in the energy sector.

1. Potential Coverage in District Heating: Heat pumps are projected to provide about 25% of Europe's district heating by 2050, underscoring their importance in sustainable heating solutions.
2. Flexibility Services: Heat pumps are key in delivering ancillary services, such as frequency regulation, which contributes to the stability of the electrical grid.
3. Versatility Across Applications: Whether in individual installations, hybrid systems, or large-scale district heating setups, heat pumps show remarkable adaptability to various environments and needs.

4. Ancillary Service Market Participation: Heat pumps engage in diverse market segments, including day-ahead, intraday, and ancillary services, meeting the dynamic requirements of the energy market.
5. Barriers and Business Models: Despite facing technical, regulatory, and economic hurdles, innovative business models that involve aggregating distributed heat pumps for balancing services are proving effective.

The final reports are published on the annex website.

- » **Final Report**
- » **Executive Summary**
- » **2-page Summary**
- » Task 1 Report: **Country reports**
- » Task 2 Report: **Best practice examples – Description of existing projects** including **Task 2 – Appendices 1** and **Task 2 – Appendices 2**
- » Task 3 Report: **Concepts for heat pump flexibility and promising solutions**
- » Task 4 report: **Flexibility Assessment and Analyses of different options**
- » Task 5 Report: **Business models – development and evaluation of innovative concepts**

In addition, the project compiled and presented 28 **case studies** from 5 different countries.



#### Contact person:

Operating Agent was Svend Vinther Pedersen. For information contact Morten Herget Christensen from DTI, Denmark, [mohc@teknologisk.dk](mailto:mohc@teknologisk.dk)

#### Participating countries:

Austria, Denmark, France, Germany, the Netherlands and Sweden

#### Publications:

Final Report and Executive Summary of Annex 57 available at [www.heatpumpingtechnologies.org/publications](http://www.heatpumpingtechnologies.org/publications)

#### Annex website:

[www.heatpumpingtechnologies.org/annex57](http://www.heatpumpingtechnologies.org/annex57)

# ANNEX 58

## HIGH-TEMPERATURE HEAT PUMPS

### INTRODUCTION

High-temperature heat pumps (HTHP) have considerable potential for the decarbonization of industrial process heat for ever increasing temperature levels. They enable the utilization of excess heat to reduce primary energy consumption, lower CO<sub>2</sub> emissions and achieve economic benefits. However, collaboration among technology providers, end-users, policymakers, and R&D organizations is crucial to overcome barriers and maximize the potential.

### KEY FINDINGS

The key findings from Annex 58, which was finalized during 2024 were:

1. A technology review identified a wide range of HTHP technologies and noted that several suppliers are actively working on further developments. Additionally, 15 reviews of completed demonstrations confirm the benefits of heat pumps in real industrial applications. These demonstrations were implemented across various sectors, including food and beverage, pharmaceuticals, refineries, electronics, chemicals, plastics, paper, and minerals.
2. While some heat pump solutions are already established and implemented, others remain less mature, particularly at higher temperatures. The transition to a heat pump-based process heat supply is influenced by technological development, the ability of end-users to adapt their processes, and regulatory and economic constraints. Therefore, there should be a focus on addressing these factors.
3. HTHPs can be integrated into various processes, and the optimal integration practices vary depending on specific process require-

ments. However, heat pump concepts can be standardized for different applications to meet these requirements, with the majority falling into three basic applications: steam generation, hot water production, and heating with large temperature glides.

4. Developing a decarbonization strategy is a complex task, but it is essential to achieve efficient decarbonization of a site as quickly as possible. It includes developing an implementation roadmap that considers current and near-future technological developments.
5. Many aspects must be considered during a large-scale HTHP project. The detailed design must carefully address all safety, economic, and performance requirements without overly specifying the design of the heat pump. Moreover, a transparent testing phase is important to include.

The final reports are published on the annex website.

- » **Final Report**
- » **Executive Summary**
- » **2-page Summary**
- » Task 1 Report: **Technologies – State of the art and ongoing developments**
- » Task 2 report: **Concepts – Development of best practices for promising application areas**
- » Task 3 report: **Applications – Strategies for the conversion to HTHP-based process heat supply**
- » Task 4 report: **Definition and testing of HP specifications**



#### Contact person:

Operating Agent is Benjamin Zühlisdorf from Danish Technological Institute, Denmark. [bez@dti.dk](mailto:bez@dti.dk)

#### Participating countries:

Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Japan, Netherlands, Norway, South Korea, Switzerland, USA

#### Publications:

Final reports available on the Annex 58 website:

<https://heatpumpingtechnologies.org/annex58/>

#### Annex website:

<https://heatpumpingtechnologies.org/annex58/>

# ANNEX 59

## HEAT PUMPS FOR DRYING

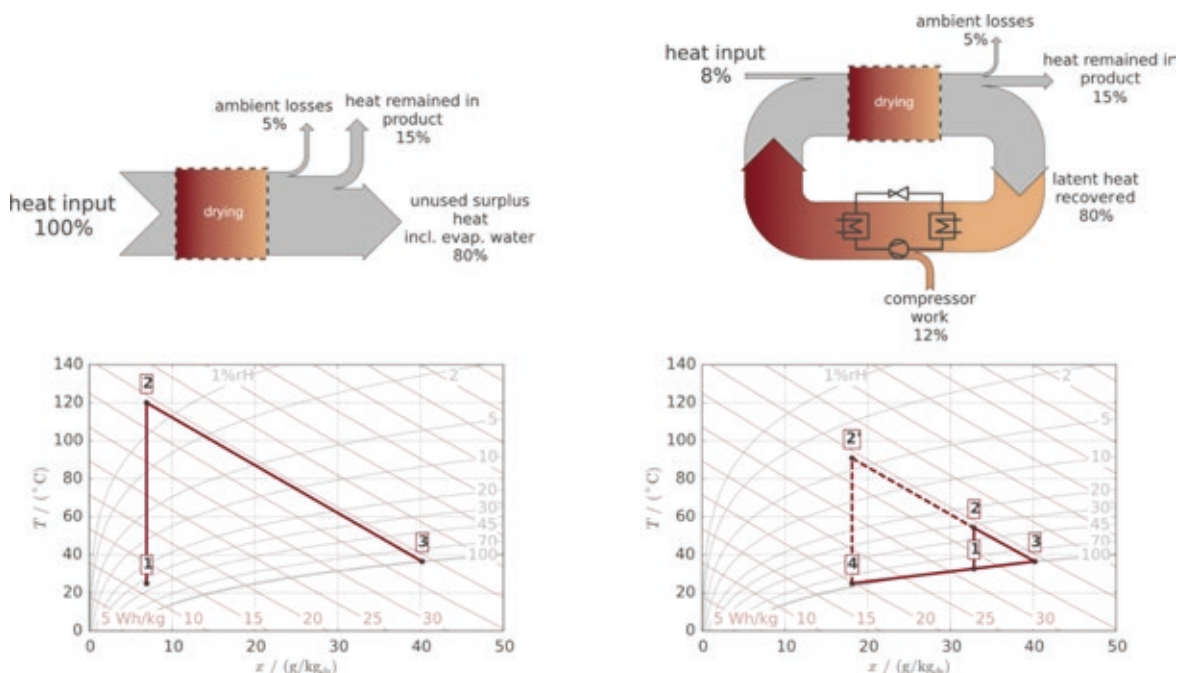
### INTRODUCTION

Drying processes are widely used in industry and commerce (food industry, paper industry, chemical industry, ceramics industry, laundries, etc.) as well as in household applications (white goods, tumble dryers, dishwashers) in various forms and contribute significantly to energy consumption. (10-25% of industrial energy consumption is used for drying processes).

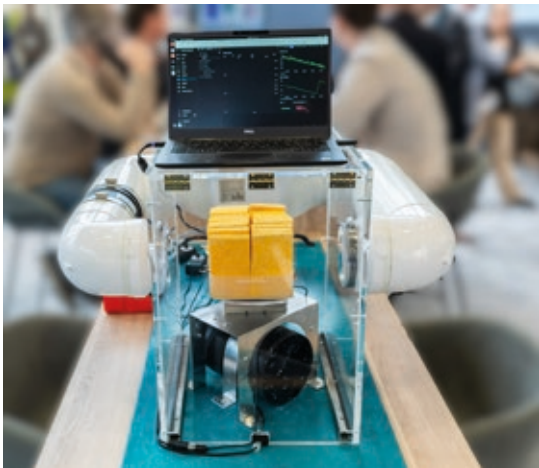
Depending on the type of heat input, a distinction is made between convective drying by a hot gas stream, contact drying by hot surfaces, and radiation drying, in which the energy is supplied by electromagnetic waves. However, the basic principle of drying is the same as it used to be thousands of years ago, and the most common dryer type is based on convective drying. Industrial convective drying plants are mainly operated by burning fossil energy sources and product waste. A comprehensive dryer comparison can be found here. The moisture (e.g. water) extracted from the material to be dried is in most cases released into the environment in pure gaseous form or with a drying medium (e.g. air, steam).

This exhaust air contains high amounts of energy, which is currently only partially used by heat recovery. Modern industrial drying processes are either an open loop system using heated ambient air or a closed loop system with recirculation of the drying air. Heat pumps are characterized by the possibility to utilize a heat source at low temperatures (at the evaporator) and supply a heat sink at a higher temperature (condenser). For the case of closed loop drying this combined heat and cool load is used for the recovery of drying energy (basically the latent heat of water evaporation) and delivers this energy back into the drying process in the form of de-humidified and re-heated drying air (as illustrated in Figure 1).

The Annex aims to structure and describe the numerous possibilities and advantages of heat pump integration in dryers. Both the state-of-the-art and innovative solutions in industrial, commercial, and domestic applications are examined and described.



**Figure 1:** Conventional open loop drying (left) vs. heat pump assisted drying for convective air drying in closed loop (right).



**Figure 2:** Small-scale dryer with heat pump.

Completely different challenges apply to the sectors. In the industrial sector, there is a certain variety of drying processes that do not allow for a universal solution. The situation is similar in the commercial sector. In the domestic sector, on the other hand, the challenges lie with heat pumps, as there are already products on the market that need to be converted to environmentally friendly refrigerants.

The Annex contributes to a significant transfer of knowledge and expertise to manufacturers, planners and operators in the sectors mentioned and is intended to raise awareness of the further use of heat pumps in the sectors under consideration and reduce barriers.

### OBJECTIVES

- » Collate relevant data of state of the art of drying processes equipped with heat pumps.
- » Analyse drying process on a theoretical level to find optima in process design (e.g., lowering temperatures), in process operation (drying time), as well as in heat pump design and integration.
- » Gather experience of demonstration projects by monitoring and simulation of the entire drying system.
- » Recommendations for design of heat pump drying systems regarding performance, cost, etc., and compare with conventional dryers.

- » Recommendations for concepts of dryers regarding heat pump integration and operations which are favourable for heat pump operation.
- » Dissemination of information and results on the Annex by a website, publications, workshops and reports.

### RESULTS

A small-scale demonstrator with a heat pump was built to showcase the functionality of a drying process. Figure 2 shows the demonstrator, which is used to dry sponges in a closed-loop cycle. A conventional air dehumidifier serves as a heat pump and condenses water in the exhaust air. In consequence, the exhaust air is reheated by the dehumidifier's waste heat and again fed into the drying chamber. Moreover, an additional fan is placed in the drying chamber to enhance heat transfer and the drying rate. The progress of the drying process is measured by a scale inside the drying chamber and displayed in real-time. Furthermore, the electric energy consumption is determined, and several KPIs are calculated. Using this illustrative demonstrator, energy-efficient drying with heat pumps can be explained to dryer manufacturers and potential users.

” ***Improved energy efficiency and electrification of drying processes can be achieved using air recirculation and heat pumps.*** ”

To quickly estimate the potential for energy savings, a web-tool called Drying Toolbox was developed. Based on the basic data of a given drying process, the tool calculates the energy demand for drying without heat recovery measures. By activating different heat recovery options like heat exchangers for direct heat recovery, a cooling zone for the product, air recirculation, and heat pumps, their impact on the energy demand is quantified. Finally, the results are visualized using a Sankey diagram.



**Project duration:**  
January 2022 – December 2025

**Contact person:**  
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**Participating countries:**  
Austria, China, Germany, Norway, Sweden, Switzerland, USA

**Annex website:**  
<https://heatpumpingtechnologies.org/annex59/>

# ANNEX 60

## RETROFIT HEAT PUMP SYSTEMS IN LARGE NON-DOMESTIC BUILDINGS

### INTRODUCTION

Non-domestic buildings are responsible for around 30% of building sector emissions. However, they are difficult to address because, unlike households, they vary in form, size, function, and, therefore, energy use, leading to a wide variety of possible heat pump system options. The purpose of Annex 60 is to help decision makers involved in the procurement process find their way through this complexity.

### OBJECTIVES

Our objective is to provide simple online guidance for decision makers to help them identify and compare heat pumps options suitable for their buildings. Our three main target audiences are:

- » Building owners and managers, who will need a general understanding of the heat pump system options available to them.
- » Key people in the heat pump procurement process, who will need more detailed information on system options and their performance.
- » Policy makers and their technical advisors, who will need information to assess the costs and likely outcomes of policy instruments.

The guidance we are developing consists of three elements:

- » Case studies act as example installations that illustrate the practical application of particular combinations of systems and buildings.
- » An interactive online tool that will generate a list of possible system configurations based on input from the tool user on their particular circumstances.
- » An indicative ranking of the system options based on capital cost and carbon saving metrics related to the barriers and drivers faced by the user.

### PROGRESS

In terms of the development of the guidance, we have largely completed our work on the logic model that will underpin the web development process. We are now in the process of procuring a web developer to build the website.

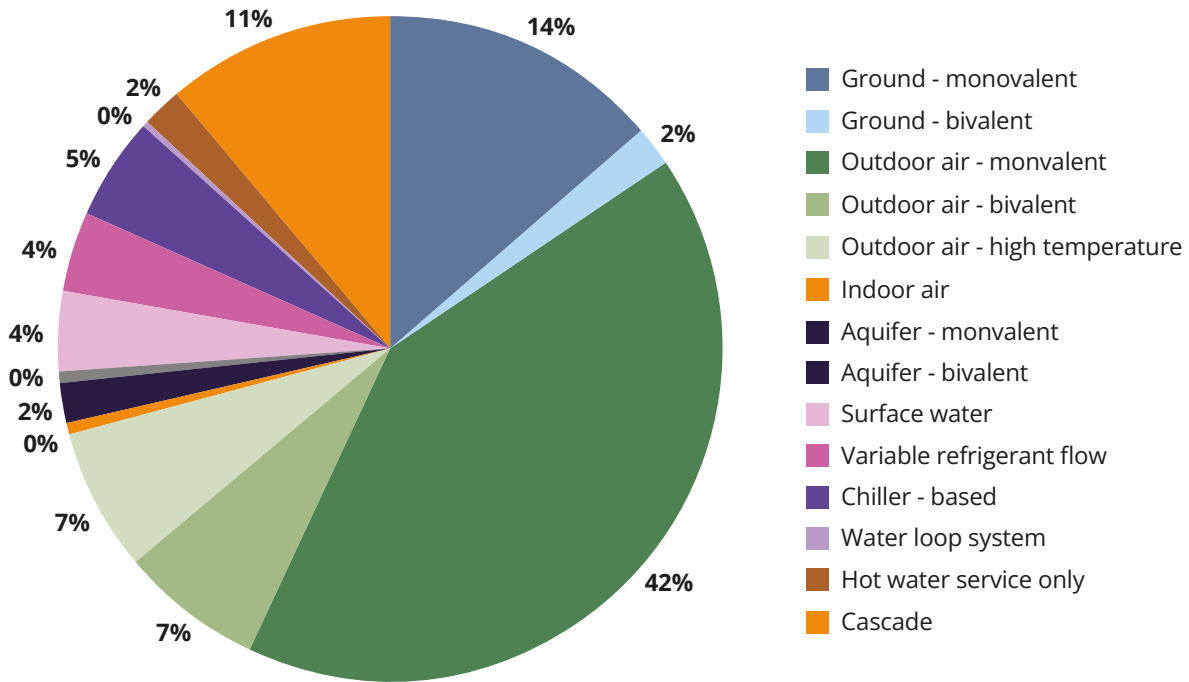
In terms of market intelligence, building on the evidence review carried out last year, we have collected and analysed over 120 case studies from participating countries and beyond. We have also engaged with a range of sector organisations and individual decision makers. Our outreach activities, although limited, have generated significant interest. In the UK we set up an Industry Liaison Group comprising leading market practitioners, to serve as an advisory resource and a sounding board.

”

***The non-domestic heat pump retrofit market is not as developed as we expected. The work of this Annex has made significant progress in our understanding of how the market works, and our guidance will fill a key information gap for users.***

”

The intention for the remainder of the project will be to build a framework that can be expanded in future TCP work as the market develops and a basis for other measures to encourage the widespread deployment of heat pumps in this sector.



**Figure 1:** Case Studies by System: February 2025.

Annex 60 has identified around 300 examples of non-domestic buildings with retrofitted heat pumps. Air to water systems (including bivalent, and higher-temperature heat pumps) are the most numerous, but are typically smaller than ground- and water- source systems (see Figure 1).

From this range of engagements, we now have a good understanding of the state of the market, certainly in the UK and, to an extent, in other participating countries. The headline is that it is considerably less well-developed and understood than we expected, with patchy levels of skills and experience across the sector. There also appears to be a significant number of smaller, hard-to-reach design and installation businesses. This

lack of capacity and understanding has significant implications for policy designed to accelerate heat pump deployment.

Our detailed analysis of the case studies we have collected support this conclusion. Our case studies are dominated by public sector organisations, which is not surprising as these are easier for governments to support. There is also a bias towards air source heat pumps and limited representation of some building types. We are confident that these gaps can probably be filled as experience is gained, which would improve the scope and effectiveness of the guidance as we gain experience. We are very pleased that Sweden has joined the Annex and agreed to lead this work.



**Project duration:**  
September 2022 – December 2025 (recently extended for 12 months from December 2024).

**Contact person:**  
Operating Agent is Dr. Peter Mallaburn, UK Department of Energy Security and Net Zero.

**Participating countries:**  
Austria, Canada, Italy, the Netherlands, Ireland, Sweden, United Kingdom.

# ANNEX 61

## HEAT PUMPS IN POSITIVE ENERGY DISTRICTS

### INTRODUCTION

Ambitious climate protection targets require a transition to a sustainable energy system. The built environment is a key sector for CO<sub>2</sub>-emissions in many countries. Heat pumps facilitate and accelerate the energy transition of the building sector since they are seen as the future heating system and are already well established in new buildings in many countries.

”

***The high performance of heat pumps facilitates the spread of positive energy districts, which are a key strategy for the urban energy transition.***

”

Thus, the integration of heat pumps on a large scale is a future challenge. Districts are seen as the right scale for the transformation since individual buildings miss synergies among buildings, but districts are not as complex as entire cities. Positive energy districts (PED) are an ambitious objective to pave the way for the urban energy transition. Heat pumps can effectively couple thermal and electric loads in districts at high performance. Using these synergies by system integration in districts can even increase the heat pump performance, while the coupling of electric and thermal loads also provides energy flexibility to the connected grids.

Annex 61 investigates heat pump application in building clusters and districts for both new and retrofit districts on a technical, economic, and ecological basis. Based on a state-of-the-art analysis of heat pumps in a cluster of buildings and PED, system concepts for the heat pump integration are derived and characterised regarding benefits and limitations. Based on decentralised heat pumps on the individual building level, different integration options up to a centralised heat pump heating/cooling systems are documented as generic concepts.

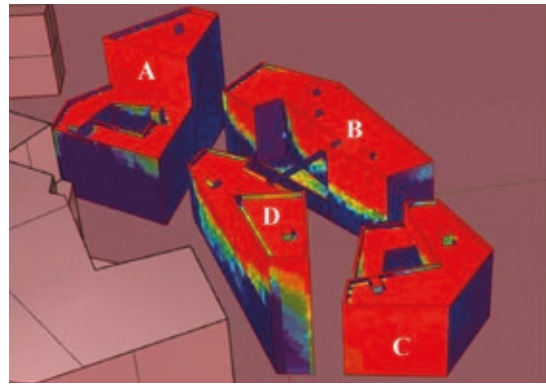
Favourable system concepts are analysed in more detail by techno-economic analyses using simulation. The focus is on integration of the heat pump with other technologies, e.g. on-site PV electricity generation and thermal/electric storage, as well as on design and control of the heat pump, also regarding energy flexibility potentials.

The simulations are accompanied by the real performance evaluation by monitoring heat pump operation in building clusters and districts. The monitoring results show optimisation potentials and are also used to verify the modelling and simulation results. In turn, the simulation can serve to specify the optimisation of the monitored systems. The monitoring systems are documented as best practice systems.

Results are used by building system technology designers, urban planners, and building companies to reach ambitious energy targets in districts as well as by utilities and ESCOs looking for new fossil-free business opportunities. Based on the results heat pump manufacturers can tailor and further develop their products for building cluster and district applications. Policy makers get evaluations to shape future ambitious energy targets.

### OBJECTIVES

- » Characterisation and cross-comparison of heat pump application in positive energy districts in the participating countries (completed).
- » Development of generic system concepts for the integration of heat pumps in districts (ongoing).
- » Techno-economic analyses of promising concepts by simulation (ongoing).
- » Evaluation of the real performance of heat pumps in districts by monitoring projects (ongoing).
- » Dissemination of interim and final results by workshops, articles, conference papers, and the final report (ongoing).



**Figure 1:** First four buildings of Campagne District, Innsbruck, AT, and evaluation of solar PV potential

## RESULTS

A state-of-the-art analysis of heat pumps in PED has been performed and compiled in an interim report (currently in final editing). The report contains the political framework, definitions, and Key Performance Indicators of PED, existing districts and applied technologies, in particular heat pump integration, favourable technologies for PED, planning-/simulation tools, labelling and certification, existing best practice district examples, and a cross-country comparison on the introduction of PED and used technologies. The evaluation confirms that heat pumps are the dominating building technology in these high performance districts, and the high performance of heat pumps facilitates the spread of positive energy districts, which are a key strategy for the urban energy transition.

An evaluation of Archetype PEDs has been performed. Based on the simplified modelling of key components, including five building types and different technology options, load profiles of the district energy demand and production can be generated. Based on the modelling, five Archetype PEDs have been derived, spanning from a newly built residential to a retrofitted and mixed residential and office/commercial district. Results confirm that only buildings with high performance envelope and efficient building technologies with heat pumps can reach the ambitious targets of PED on the buildings footprint. Also, the gap to reaching a positive balance and load mismatch between production and consumption can be evaluated.

Monitoring projects of heat pumps in high performance building clusters or districts are contributed to the Annex work, which also incorporates the transformation of existing districts to high energy performance. Different evaluations of monitoring have started, but some of the monitoring projects have also been delayed due to political and economic boundary conditions.

Modelling and simulation are performed for many of the field monitoring plants in order to perform an in-depth techno-economic evaluation of the heat pump system regarding design, control, energy flexibility, and system integration options. This serves to optimize the real system while, in turn, the monitoring data can validate and improve the simulation models. By simulations, also system comparisons are enabled. Figure 1 left shows the Campagne District in Innsbruck, AT, and Figure 1 right shows results of the BIPV potential in the façades regarding shading of adjacent buildings by simulations for the four buildings of the districts.

Generic system solutions of heat pump integration in districts cover the decentralized integration on the individual building level to an entirely centralized heat pump integration of district heating and cooling system. Top-level categorization is further specified and technically described as linked to the simulation and monitoring, contributing to the technical evaluation.



**Project duration:**  
September 2022 – December 2025

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**Annex website:**  
<https://www.heatpumpingtechnologies.org/annex61>

# ANNEX 62

## HEAT PUMPS FOR MULTI-FAMILY RESIDENTIAL BUILDINGS IN CITIES

### INTRODUCTION

Climate change demands urgent action to reduce greenhouse gas emissions, particularly from buildings' heating and cooling. Heat pumps present a promising solution, replacing fossil fuels and becoming the preferred choice in new single-family homes, especially in Europe. However, their use in multi-family buildings is not yet widespread, despite positive examples. The IEA's "Net Zero by 2050" report states that by 2045, at least 50% of global heating demand must be met by heat pumps.

In technical implementation, heat pump systems in multi-family buildings face greater challenges compared to single-family homes due to more complex administrative and technical hurdles. Different ownership structures and interests of the owners can lead to suboptimal decisions for climate protection. Additionally, the need for higher heating temperatures and space requirements for the systems must be taken into account.

The Annex 62 will therefore focus on demonstrating that it is possible to implement heat pumps in multi-family buildings (MFB). For that, a database will be created with Case studies analysing the Lessons Learned and showing best practices. In addition, the "General Classification" earlier compiled is validated with the help of the case studies and is regularly discussed and adapted.

### OBJECTIVES

One of the primary objectives is to develop an initial version of a "solution finder" designed to serve as an easy-to-use pre-planning tool. This tool will enable users to quickly identify potential heat pump solutions for specific buildings/environments. The results of the Annex should therefore help dealing with the complexity of heat pumps in MFB as well as communicate the standardized solutions.

The Annex 62 builds on the results of Annex 50 "Heat Pumps in Multi-Family Buildings" and consider the work from other Annexes, particularly Annex 49, Annex 46, and Annex 60.

The illustrations below show a unique case study from Geneva that clearly shows how important the communication and the work of the Annex is (*CH005 St Julien – Annex 62*)

### FULFILLED OBJECTIVES

- » Extension of the case studies database; the Annex work started with 20 Case studies from Annex 50 and we are now up to 45 Case studies (ongoing).
- » Extension of the "matrix tool", especially further description of each general concept with the aim of finding and establishing standard solutions.
- » Extending the range of participating countries. We are now up to eight countries, including a non-European member (China).

”

***The Annex 62 demonstrates that it is possible to successfully implement heat pumps in multi-family buildings in various solutions.***

”

### REMAINING OBJECTIVES

- » Implementation (for example in the form of an app) and extension of the tool "solution finder" with the aim of creating an easy-to-use pre-planning tool, allowing for quick recognition of possible heat pump solutions for specific cases
  - Status: discussed the first 13 parameters.
- » Statistical evaluation of the case studies with regard to the following parameters:
  - Heat sources
  - Central vs decentral solutions.
- » Cooling: Finding solutions including cooling (will probably be postponed to the successor Annex).

## RESULTS

The project is progressing well, marked by several significant developments. We have successfully reached an agreement on the KPIs (parameters) that will guide the construction of the "Solution Finder," with 14 parameters identified and definitions along with some parametrization already completed. The parameter for example, takes into account the size and insulation of the building, the complexity of the system, the flexibility to choose the heat source, the level of costs as well as the percentage of fossil energies in the system.

In the beginning of 2025, we will finalize the definitions of these parameters, and we will continue working on the development. Additionally, we created a preliminary visualization in the form of a spider map, serving as an initial step toward the "Solution Finder."



**Figure 1:** Picture of the MFB in St. Julien, Geneva, Switzerland.

A feedback workshop with external participants was conducted during 2024, leading to an initial reality check where we mapped the workshop outcomes to our case studies. The case study database continues to grow, with more contributions from Annex members, even outside of Europe. Furthermore, a task force named 'Resolution' has been established, currently consisting of four volunteers dedicated to addressing questions arising from the case studies, such as issues related to family membership. This task force enables the project team to continuously revise the general classification. Adjustments were already made and/ or need to be discussed.



**Figure 2:** Heat pump installation in the cellar of the building (in the place of the old oil-burner) St. Julien, Geneva, Switzerland.



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January 2023 – December 2025

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Sweden, Switzerland (USA, UK, Poland).

**Annex website:**  
<https://heatpumpingtechnologies.org/annex62/>

# ANNEX 63

## PLACEMENT IMPACT ON HEAT PUMP ACOUSTICS

### INTRODUCTION

IEA HPT Annex “Placement Impact on Heat Pump Acoustics” has been set up as a follow-up to the finalized IEA HPT Annex 51 “Acoustic Signatures of Heat Pumps” conducted by Austria, Denmark, Germany, France, Italy, and Sweden. There, the acoustic groundwork has been laid, the basics have been successfully covered, and its deliverables, executive summary and documents guide, as well as its umbrella report, are available for download at the IEA HPT [Annex 51 website](#).

The results have made their way into the development of standards. In the framework of IEA HPT Annex 51 psychoacoustics effects of heat pump acoustics have been studied. The acoustic effects of heat pump placement and the dependence on the operating conditions were reported and guidelines for installers have been developed and made available. In the course of finalizing IEA HPT Annex 51 and following recent industry requests and demands, special fields of interest emerged, which need international experience and collaboration to be treated effectively.

In the course of finalizing IEA HPT Annex 51 and following recent industry requests and demands, special fields of interest emerged, which need international experience and collaboration to be treated effectively. Thus, IEA HPT Annex 63 enriches independent information and expertise on the benefits of heat pumping technologies by focusing on the field of acoustics. Noise emissions are a potential threat to further spreading of heat pumps in the years to come. Thus, working on the acceptance of heat pumps by minimizing these adverse environmental impacts while keeping high energy efficiency is of great importance and in line with the Heat Pump Technologies (HPT) Technology Collaboration Programs (TCP) vision of the International Energy Agency (IEA).

### OBJECTIVES

IEA HPT Annex 63 is primarily focused on the “Placement Impact on Heat Pump Acoustics” but leaves room for special topics of heat pump acoustics covering selected applications and the refinement of methods.

The main objective from IEA HPT Annex 51 – removing acoustic market barriers to establish heat pumps as the number 1 choice as renewable energy and energy efficiency option for HVAC applications – remains. Intense discussions, however, emphasized that avoiding showstoppers in the rapidly growing deployment of heat pumps is gaining significance. Thus, the consortium comprised of 18 institutes from 8 different countries work on the following tasks:

- » Building Acoustics Impact of Heat Pumps
- » Urban Acoustics Impact of Heat Pumps
- » Psychoacoustics of Heat Pumps
- » Digitally Assisted Heat Pump Placement
- » Dissemination

Revision of cases of complaints showed, that each placement situation is unique, and several aspects contribute to a successful installation. Therefore, as a proper installation is key to low acoustic impact on the environment, the existing guides will be revised and linked to the developed placement tools.

”

***We work on delivering frequency and directivity resolved acoustic databases and sound visualization tools for assisting HP placement.***

”

### RESULTS

A direct data comparison between laboratory and field measurements for selected heat pumps including acoustic and vibration sensor data has been planned in 2024 and the measurement campaigns will be conducted in 2025 in task 1 „Building Acoustics Impact of Heat Pumps”.

In task 2 „Urban Acoustics Impact of Heat Pumps”, an air source heat pump (ASHP) measurement data base with focus on frequency content and directivity has been designed. It will be presented



**Figure 1:** A roof mounted ASHP installed in a house at Energy House 2.0, University of Salford, UK, was measured using Microflow's 2D Scan and Paint system. [Source: USAL]



**Figure 3:** Listening room: The psychoacoustics experiment set up in the University of Salford's listening room. [Source: USAL, HEAD]



**Figure 2:** A pair of ASHPs, located in the gardens of two new build houses in Nottingham, UK, were measured using a 180° microphone arc. 9 microphones were mounted on the arc, in order to observe interactive effects from the ASHPs caused by their close proximity. [Source: USAL, Heat Pump Association]



**Figure 4:** Perspective Final: Perspective showing the garden of the listener position and two neighbouring gardens. [Source: USAL]

including first analysis at Forum Acusticum EU-RONOISE 2025 in Malaga. During 2025 it will be enriched and further exploited for the IEA HPT conference in Vienna 2026. A roof mounted ASHP was measured at Energy House 2.0 (see Figure 1), a pair of ASHPs were measured at a new build house in Nottingham (see Figure 2).

Task 3 „Psychoacoustics of Heat Pumps“ reports the planning of a psychoacoustic jury test experiment with seven participating laboratories engaging between 25-30 participants per site aiming for a minimum of 200 in total (see Figure 3). All sites will use the same equipment for consistency provided by HEAD Acoustics utilizing ASHP recordings used for auralizations prepared by RWTH Aachen. Ambient background recordings are

provided by Peutz. A visual simulation matching the auralizations is used to provide visual context during the Training Section (see Figure 4).

In Task 4 „Digitally Assisted Heat Pump Placement“, the team worked on internationalization and further development of 1D, 2D and 3D tools for visualization and calculation of heat pump sound pressure levels.

The IEA HPT Annex 63 will focus on three international events: the Forum Acusticum Internoise in Malaga (June 2025), which provides a special session on heat pump acoustics, the Mostra Convegno in Milano (March 2026) and the IEA Heat Pump Conference in Vienna (May 2026) with both featuring a workshop on heat pump acoustics.



**Project duration:**  
June 2023 – May 2026

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**Annex website:**  
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# ANNEX 64

## SAFETY MEASURES FOR FLAMMABLE REFRIGERANTS

### INTRODUCTION

The hydrofluorocarbon (HFC) refrigerants have totally dominated the market since the phase-out of chlorofluorocarbons (CFCs and HCFCs). HFCs have no effect on the ozone layer but have a high global warming potential, GWP (Global Warming Potential). As global warming is accelerating it is necessary to turn to refrigerants with low GWP. Recently, the potential dangers of using substances belonging to, or in the atmosphere transferring to, the PFAS (per- and polyfluoroalkyl substances) group has been realized by the scientific community. Almost all synthetic refrigerants are PFAS (according to the OECD definition). As almost all refrigerant alternatives with low GWP are more or less flammable, the safety issues with using flammable fluids as refrigerants have to be addressed. The industry is already transferring to using natural fluids, such as CO<sub>2</sub> and hydrocarbons, primarily propane. Both theoretical comparisons and experimental work has shown that hydrocarbons can give as good, or better, performance than systems with synthetic refrigerants, but the safety issues related to flammability need to be taken seriously.

In this Annex, we focus on several aspects related to safety using flammable refrigerants. The work is divided into Tasks related to: T1: Technical solutions for limiting risks, T2: Investigation of leakage scenarios (see attached figures), T3: Leakage detection, T4: Charge reduction, T5: Risk assessment, and T6: Dissemination.

”

***Theory and experiments show that hydrocarbons give performance as good or better than synthetic refrigerants, but safety issues due to flammability must be taken seriously.*** ”

The Annex focuses on cooperation in high-quality research, resulting in scientific articles published in peer-reviewed journals or conference proceedings. The results should contribute to a broader, safe use of flammable refrigerants.

### OBJECTIVES

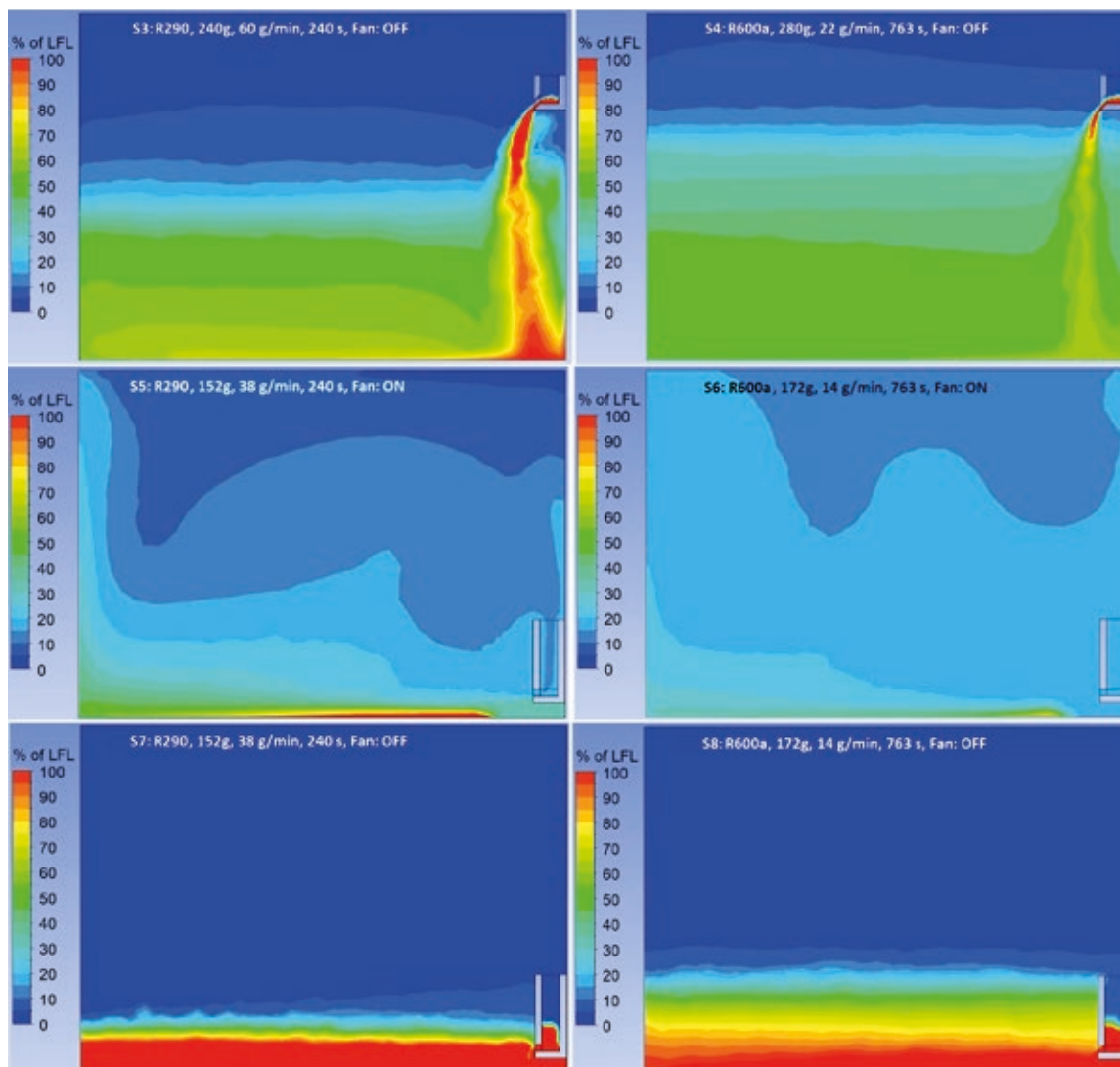
- » To contribute to a broader safe use of flammable refrigerants.
- » To increase the understanding of the risks related to the use of flammable refrigerants.
- » To develop methods and system designs to maintain the risks at acceptable levels.
- » To deliver findings that can be used as background for regulations and standards.
- » To present a set of recommendations for updates to the regulations/standards.

### PROGRESS AND RESULTS

During the year 2024, work in Sweden, Germany, and the USA has been done on numerical modelling (CFD) of leakage of refrigerants from heat pumps into a closed space. The aim has been to better understand under what conditions flammable concentrations can be expected. This work has resulted in two conference papers and will be the basis of an article in the Heat Pumping Technologies Magazine in the spring of 2025. One finding from these simulations is that having a fan in the room effectively enhances mixing and counteracts the stratification of gases due to differences in density. It has also been demonstrated that isobutane has a lower risk of resulting in flammable concentrations as compared to propane, when the leakages are assumed to come from the same size of hole, in spite of the two fluids having very similar Lower Flammability Limit. The reason is mainly that isobutane has a lower saturation pressure and therefore the leakage rate is lower and there is longer time for diffusion and other mixing processes to counteract the build-up of high refrigerant concentrations at the floor level. It is also found that there is a big difference if the leakage is at the floor level or if it is located high up on one wall. Some results of the CFD modelling are shown in Figure 1 below.

Work has also been done in South Korea and in France on methods of determining the charge in different parts of a system. Six internal meetings have been held, of which one was face to face. At each

meeting, a presentation was given by an invited speaker. A set of presentations were also given during the Chillventa Congress in Nuremberg, where the Annex and some of its results were presented.



**Figure 1:** Results from CFD models of leakages of isobutane (right) and propane (left) from a heat pump unit located high up on a wall (top) or at floor level (bottom). Results are shown for the central plane of a room (3x3,5x2,5 m) with the fan of the heat pump ON or OFF. The leakage rate is calculated based on an assumption that the maximum allowed charge according to IEC 60335-2-40 leaks out in four minutes. Concentrations are shown when the complete charge has leaked out and are expressed as % of the Lower Flammability Limit, LFL.



**Project duration:**  
April 2023 – December 2026

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**Annex website:**  
<https://heatpumpingtechnologies.org/annex64/home/>

# PROJECT 65

## HEAT PUMPS IN A CIRCULAR ECONOMY

### INTRODUCTION

The global transition to a circular economy is reshaping industries, and the heat pump sector is no exception. With rising concerns over resource depletion, climate change, and waste management, it is necessary to reevaluate how heat pumps are designed, produced, used, and disposed of. For the heat pump industry, and especially manufacturers, staying at the forefront of understanding the impacts of the circular economy is crucial.

The transition to a circular economy presents both challenges and opportunities for the heat pump industry. Domestic heat pumps rely on materials and processes that are increasingly subject to environmental and regulatory scrutiny. Manufacturers must find ways to balance performance, sustainability, and cost while reducing the environmental impact of their products. This requires integrating circular economy principles into every stage of the heat pump lifecycle, from material sourcing and design to end-of-life management.



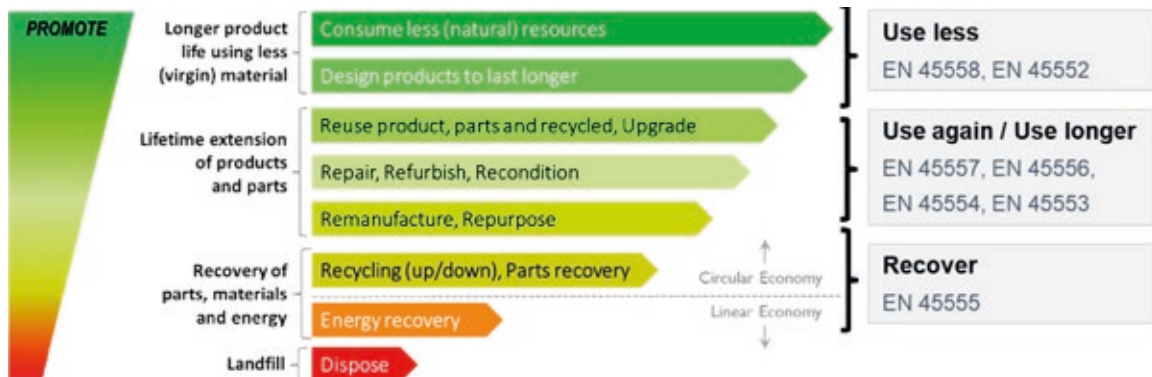
***Circularity in heat pumps means balancing performance, sustainability, and cost throughout the product lifecycle.***



This ambitious project is carried out through a series of collaborative tasks, each addressing a key aspect of circularity in heat pumps. Task 1 focuses on building a common understanding of circularity as it applies to heat pumps. Task 2 evaluates the current state-of-the-art, identifying existing practices, technologies, and innovations that align with circular economy goals. Task 3 examines the potential opportunities and barriers for implementing circular practices, including material efficiency, regulatory challenges, and market readiness. Task 4 develops actionable guidelines for future practices. Finally, Task 5 ensures the continuous dissemination of findings as they materialize.

### OBJECTIVES

- » **Task 1: *Understanding circularity in heat pumps***  
(Report available since March 2025)
- » **Task 2:** Evaluating the state-of-the-art (in progress)
- » **Task 3:** Identifying opportunities and barriers
- » **Task 4:** Developing guidelines for circularity
- » **Task 5:** Disseminating findings

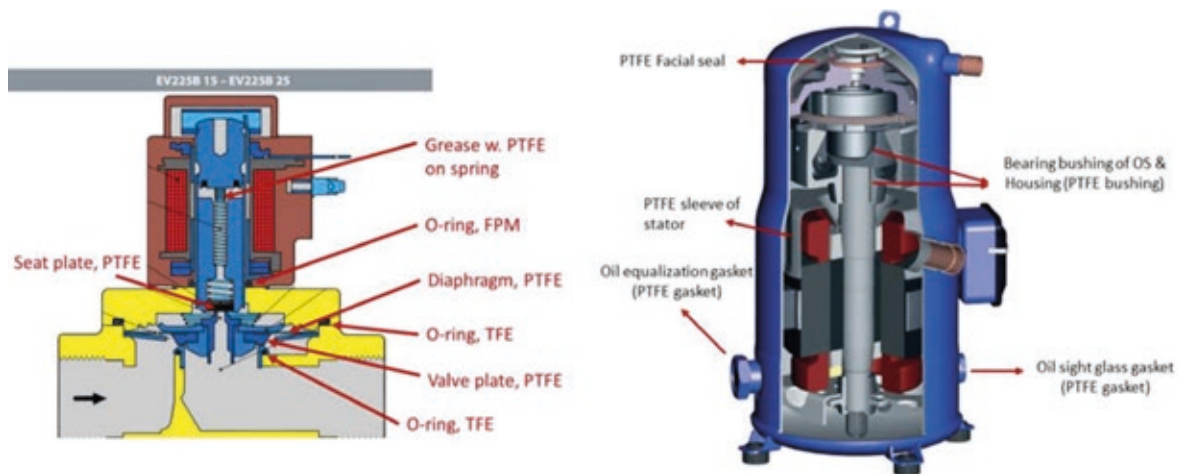


**Figure 1:** The use and waste hierarchy in material efficiency. Source: EN 45560.

## PROGRESS

In 2024, important steps were made toward advancing the understanding of circular economy principles in the heat pump industry. This involved exploring the foundational framework for circularity in heat pumps establishing definitions and concepts such as material efficiency, reparability, and recyclability. This framework provides a shared understanding for stakeholders and sets the stage for future work in aligning heat pump technologies with circular economy principles. The work also identified critical gaps in existing international standards, such as the ISO 59000 series and EN 4555X standards, and explored how these standards could be adapted to heat pump technologies. This has helped clarify the need for product-specific guidelines that directly address the unique challenges of the heat pump industry.

Another notable outcome was the review of relevant regulations, including Ecodesign, WEEE, and REACH, and their implications for heat pump design and production. The review highlighted the importance of lifecycle thinking in improving material efficiency and reducing environmental impacts. Additionally, the topic of PFAS substances, widely used in heat pump components for their durability and chemical resistance, was examined. While these materials are critical for product longevity, proposed restrictions under REACH introduce significant challenges for manufacturers, who must balance sustainability goals with maintaining product performance and reliability.



**Figure 2:** Fluoropolymers in solenoid valve and compressors. Source: Danfoss.



**Project duration:**  
January 2024 – December 2026

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# PROJECT 66

# OPTIMAL HEAT PUMP DESIGN AND OPERATION

## INTRODUCTION

Two main hindrances to the acceptance of heat pumps in residential applications have been initial equipment investment costs and the cost of equipment and retrofitting existing heating infrastructure. There is an urgent need for available optimized components, design processes and optimal system integration strategies to reduce the necessary capital investment and operating costs. The numerous types of different buildings, locations, state-dependent regulations, and residents for which heat pumps need to be designed make (1) the optimal design and selection of components and systems challenging and (2) the cost for both heat pump manufacturers and end users high with the current ratio of electricity to gas prices. A consolidation and summary of the state-of-the-art and best practices would bring all stakeholders further forward. Furthermore, a common heat pump design concept, platform, and basis protocol would help to reduce the barrier to entry as well as to increase the efficiency of resulting components and systems. A platform to share steady-state and transient data from laboratory and field measurements would significantly improve the ability of designers and modelers to validate and improve their simulations, improving both the rate and quality of heat pump development.

The primary aim of this Project is to increase the accessibility of experimental data design best practices and simulation tools for residential heat pumps to increase their implementation around the world. The Project concept and structure is shown in Figure 1. The target audience of this work is Original Equipment Manufacturers (OEMs) of

heat pumps, their suppliers, research groups, and legislators around the world working on heat pump development. The focus of this Project is the residential heat pump sector, for both single- and multi-family applications, with heating capacities up to 40 kW due to this heating capacity being a flexible upper limit to the application and components of interest in this design space. The goal of this Project is to bring an international team together to help collect and develop optimal heat pump designs, control strategies, and experimental data based on a common system understanding.

## OBJECTIVES

- » Collect and develop optimal heat pump design and control strategies along with experimental data from the respective member countries.
- » Develop design and control strategies on a common, holistic heat pump methodology with consideration of both the new build and retrofit applications.
- » Disseminate experimental data and simulation tools via open-source channels.

”  
**Colleagues from five countries attended the meeting. The team left the meeting energized and ready to get started with the project.**  
”

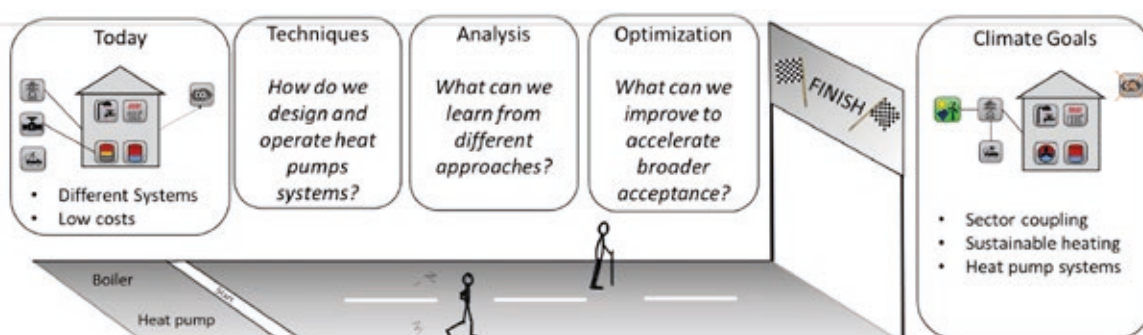


Figure 1: Project concept overview.

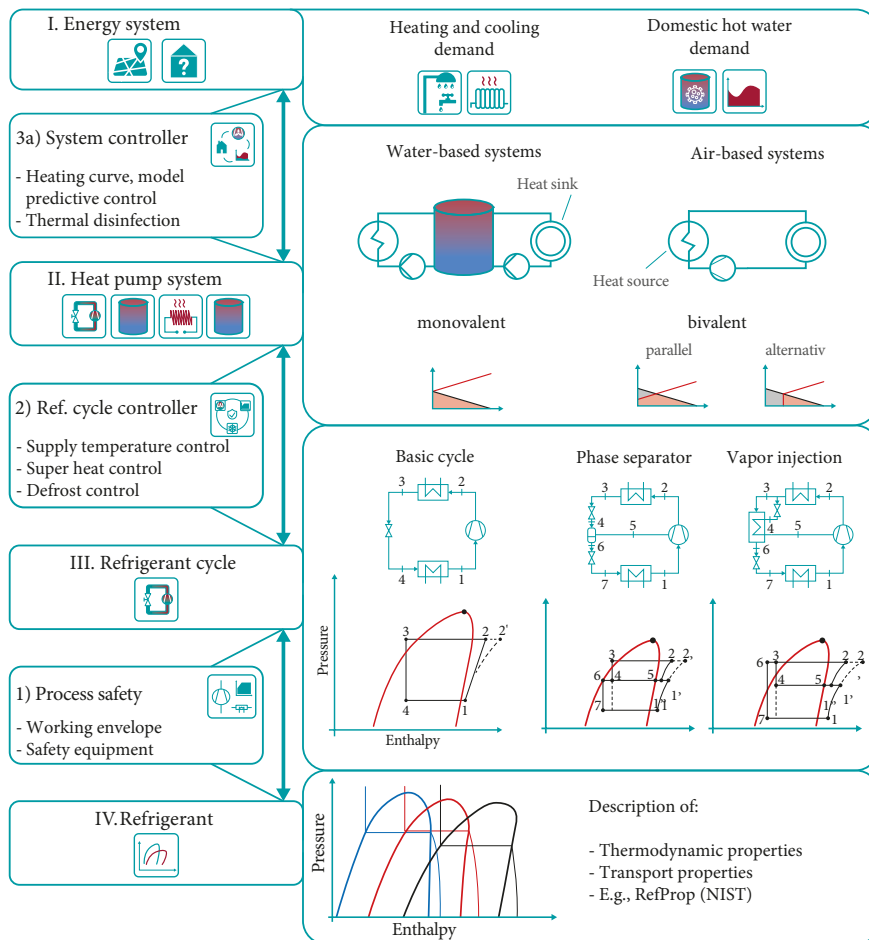
## PROGRESS

As the Project started in October 2024, our success story for 2024 was the kick-off meeting, held at the Chillventa Congress in Germany. Colleagues from 5 countries, spanning industry, academia, and national laboratories [Purdue University and Oak Ridge National Laboratories (USA), RWTH Aachen, TU Dresden, and Copeland (Germany), UPV (Spain) and LG Electronics (South Korea)] were in attendance. The scope of the entire Project was discussed, and suggestions for specific tasks, direction and methodologies were collected and iterated upon over the two-hour meeting. The team left the meeting energized and ready to get started with the Project, as shown by the photo from the meeting in Figure 2.



**Figure 2:** Project 66 kickoff meeting.

Additional progress was made in the structure and methodology through which state-of-the-art and best practices information will be collected from project partners, which is summarized in Figure 3.



**Figure 3:** State of the art scope summary.



**Project duration:**  
October 2024 – September 2027

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**Project website:**  
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# Outlook into the Future



In 2025, HPT TCP will continue the implementation of the strategic work plan for 2023–2028 (see page 9).

The TCP has selected some prioritized achievements to be reached during 2025. These are based on the HPT TCP Strategic Work Plan 2023-2028 in combination with the present status for heat pumping technologies within IEA, on different policy levels and the present market situation in different regions. Also, output from the different IEA reviews of TCP best practices on communications and on areas of improvement in CERT\*, its Working Parties and TCPs initiated by CERT.

The selected achievements for 2025 are:

- » Strengthened communication and improved outreach and impact for HPT TCP.
- » Initiatives to new HPT TCP Projects in the field of Comfort Cooling.
- » Improved collaboration with other Heat Pump related TCPs and business organizations/associations both through the TCP Coordination Groups and beyond.
- » Improved collaboration with governmental organizations in all regions.

## RDD&D\*\* Priority Areas 2023–2028 and Finalized, Ongoing and Planned Projects

System Integration	Robust, Sustainable and Affordable Value Chains	Extending Operation Range and Applications	Refrigerants and New Technologies
Sector coupling, energy efficiency, flexibility, resilience, storage, digitalization, positive energy districts	Improving affordability, securing value chains, circular economy, removing barriers for mass deployment	To fulfill demand from all climate zones, new markets, new applications and new demand. Refrigeration in emerging countries.	Non-traditional heat pumping technologies (for heating and cooling) Refrigerants (low GWP, safety etc.)
<ul style="list-style-type: none"> <li>• Annex 57: Heat pumps in multi- vector energy systems</li> <li>• Annex 61: Heat Pumps in Positive Energy Districts</li> <li>• Digital Services for Heat Pumps</li> <li>• Flexibility from Large-Scale and Aggregated Heat Pump Systems</li> <li>• Heat Pumps for Hydrogen and Carbon Capture</li> <li>• Comfort and Climate Box solutions for cooling and dehumidification</li> </ul>	<ul style="list-style-type: none"> <li>• Annex 63 Placement Impact on Heat Pump Acoustics</li> <li>• Project 65 Heat Pumps in a Circular Economy NEW</li> <li>• Project 66 Optimal Heat Pump Design and Operation for Broader Acceptance NEW</li> <li>• Enhanced Miniaturized Components</li> <li>• New or Alternative Business Models for Heat Pumps</li> </ul>	<ul style="list-style-type: none"> <li>• Annex 58: High Temperature Heat Pumps</li> <li>• Annex 60: Retrofit Heat Pump in Larger Non-domestic Buildings</li> <li>• Annex 59: Heat Pumps for Drying</li> <li>• Annex 62: Heat Pumps in Residential Multifamily Buildings in Cities</li> <li>• Industrial High Temperature Heat Pumps</li> <li>• Heat Pumps in Residential Multifamily Buildings in Cities – follow-up</li> </ul>	<ul style="list-style-type: none"> <li>• Annex 54: Heat Pump Systems with low GWP Refrigerants</li> <li>• Annex 64: Safety Measures on Flammable Refrigerants</li> <li>• Monitoring of Advanced Vapor-Compression and non-Vapour-Compression Technologies for Heating, Cooling and Refrigeration</li> </ul>
			Recently finalized, Ongoing, Proposals under discussion

\* CERT IEA's Committee for Energy Research and Technology

\*\* Research, Development, Demonstration and Deployment

The HPT TCP plans to continue to take an active role in the newly established TCP Coordination Groups within IEA, especially in the one on Heat Pumps, but also the one on Thermal Networks and the one on Energy System Flexibility are of high relevance for HPT TCP.

An international heat pump taxonomy is lacking and reporting of heat pump market data is heterogeneous, making it difficult to compile and compare data across markets (e.g. China, Europe and the United States). Data compilation challenges are even greater for industry and district heating applications where statistics are lacking. Tracking different data parameters on heat pump installations is essential in order to assess market development in different regions so as to provide reliable information to facilitate policy-making and research, and ultimately to support increased heat pump deployment around the world. Therefore, a working group for harmonization of heat pump data has been established within the Coordination Group on Heat Pumps. Other stakeholders than TCPs, such as business associations, policy makers, statistics organizations are invited to this working group and HPT TCP will take an active role in this working group.

In Europe a **Heat Pump Accelerator Platform** has been established, initiated by the European Commission. Its objective is to create of network, track policy impacts, align strategies on energy, industry, research, and education and tackle barriers for accelerated deployment. HPT TCP will be represented via the Heat Pump Centre in the platform as a selected stakeholder.

According to the work plan for 2023–2028, the prioritized areas for ongoing and future research, development, demonstration and deployment (RDD&D) projects within the HPT TCP should be (i) system integration, (ii) robust and sustainable and affordable value chains, (iii) extending operating range and applications and (iv) new technologies and refrigerants. The schematics below show the ongoing and recently started projects (annexes) in blue text and the proposals and ideas for new annexes under different stages of development in red.

As of 2024 all new collaborations will be renamed to Projects instead of Annexes in accordance with the newly updated TCP framework.

During 2025 several new projects are planned to be started. One project will deal with **Digital Services for Heat Pumps**. The project will focus on

the heat pump and its components and the aim is to answer the question how to make use of digital services for heat pumps in various fields of action during its life cycle, in particular for product design, system integration for higher efficiency and for digitalisation (models, controller) for the optimal operation of the heat pump system.

Another planned project has the title **Flexibility from Large-Scale and Aggregated Heat Pump Systems** and is a follow up to the recently finalized Annex 57. The overall objective is to establish an independent knowledge base with valuable, high-quality information about the flexibility of heat pumps. Ultimately this will contribute toward an accelerated capacity for heat pump solutions to provide flexibility towards both the greater energy systems that supply them and the thermal systems and loads that they supply heat for.

A follow-up project to the recently finalized Annex 58, having the title Industrial **High-Temperature Heat Pumps** will also be started during the year. The overall objective is to establish an independent knowledge hub with valuable, high-quality information about industrial high-temperature heat pumps, which will create a common understanding at a variety of stakeholders, ultimately leading to an accelerated uptake of industrial heat pumps in industrial applications.

A fourth project, prepared to be started will handle **Heat Pumps for Hydrogen and Carbon Capture**. The project will cover the most relevant technologies for hydrogen production, carbon capture and gas grid infrastructures, such as electrolysis, sorption processes, gas compression and gas cleaning. The project is not restricted to specific industrial sectors, nor to high temperature heat pumps only. It may also include emerging storage technologies for hydrogen and CO<sub>2</sub>, as well as liquification processes for gases, again focussing on heat integration. However, technology development for hydrogen production and carbon capture processes is out of the scope of the project.

In addition to this, project proposals on the topics Comfort and Climate Box solutions for Cooling and Dehumidification, Enhanced Miniaturized Components, New or Alternative Business Models for Heat Pumps, Heat Pumps in Residential Multifamily Buildings in Cities – follow-up on Annex 62 and Monitoring of Advanced Vapor-Compression and non-Vapour-Compression Technologies for Heating, Cooling and Refrigeration are under discussion and development within the HPT TCP.

# List of Publications for all Annexes 2024

## Annex 59

Lauermaann, M. *Energy efficiency in industrial drying*. Chillventa Congress, Nuremberg (DE), 2024.

Rezucha, M., Lauermaann M. *Drying Kinetics and Process Simulation: From Experiments to Modeling of a Belt Dryer and Heat Recovery Analysis*. 50<sup>th</sup> International Conference of the Slovak Society of Chemical Engineering (SSCHE), Tatranské Matliare (SK), 2024

## Annex 60

Hitchin, R., Mallaburn, P., *Developing the market for retrofitting heat pumps to non-domestic buildings*, 2024 CIBSE Technical Symposium, Cardiff University, May, 2024

Hitchin, R., Mallaburn, P., *The bigger picture: non-domestic heat pump retrofits*, CIBSE Journal, 2024

The annex was also presented at the Industrial and Commercial Heating Equipment Association (ICOM) winter conference in November 2024

## Annex 61

Ochs, F., Tosatto, A. Venturi, E., Breuss, S., Magni, M., Dermentzis, G., Wemhoener, C. *Characteristic Load Curves of Positive Energy Districts* Solar Energy Advances, Vol. 5, 2025

Wemhoener, C., Ochs, F., Betzold, C., Bockelmann, F., Zimmermann, J. IEA HPT Annex 61 – *Simulation of heat pumps in positive energy districts*, Bausim 2024, Vienna, Austria, 2024

Ochs, F., Breuss, S., Venturi E., Magni M., Dermentzis, G. *Towards Positive Energy Districts – Innsbruck, “Campagne Areal”* ISEC 2024 – 3rd International Sustainable Energy Conference, 2024

## Annex 63

Barton, L., Torija Martinez, A., Wong-McSweeney, D., *Higher-fidelity analysis of air source heat pump noise via scanning intensity measurement, internoise*, Nantes, France, 25.-29.08.2024

Stürenburg, L., Braren, H., Aspöck, L., & Fels, J., *Loudness and Preference Judgments for Noises of a Heat Pump*. Inter-Noise 2024, Nantes, France

Brandstätter, P., Krämer, M., *Investigation and comparison of heat pump noise in the lab and field*, INTER-NOISE and NOISE-CON Congress and Conference Proceedings, INTER-NOISE24, Nantes, France, Pages 1995-2992, pp. 2676-2684(9)

## Annex 64

Esmaeelian, J., Khodabandeh, R., Palm, B., Ignatowicz, M., *Critical Aspects in CFD-Modelling of R-290 Leakages* 16<sup>th</sup> IIR Gustav Lorentzen Conference on Natural Refrigerants, College Park, Maryland, USA, 2024 DOI: 10.18462/iir.gl2024.1287

Esmaeelian, J., Khodabandeh, R., Palm, B., Ignatowicz, M., *Impact of Hydrocarbon Refrigerants Type on Leakage Rate and Resulting Flammability Risk* IIR Compressors, Slovakia, 9–11 September 2024, DOI: 10.18462/iir.compr.2024.0694

Oltersdorf, T., Fugmann, H., Allenbacher, L., Schnabel, L., *Consequences and Prospects due to the Broad Use of R290 in Heat Pumps in Germany* IEA HPT Annex 64 Workshop on the Safe Use of Flammable Refrigerants, Nuremberg, Germany, October 8, 2024

# Image sources

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