Technology Collaboration Programme
by iea

ANNUAL REPORT 2025

HEAT PUMPING TECHNOLOGIES

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Technology Collaborating Programme on Heat Pumping Technologies – HPT TCP

IEA HPT

Content

Message from the Chairman

Heat pumping technologies meet multiple requirements at once. They are highly efficient, emit no pollutants, and they can reversibly meet both heating and cooling needs. It is a proven technology that has been used in industry since the late 19th century, and with time has evolved to be able to provide heating and cooling to district energy networks and satisfy heating and cooling demands in buildings. In fact, today's cooling needs—ranging from room air conditioning to the refrigeration of food and medicines and specialized deep-freeze applications—could not be met without heat pumping technologies. This also applies to data centers, whose growth is currently driving up demand for cooling systems.

Heat pumps are a key technology that enable and ensure our well-being. To ensure a secure and environmentally sound energy supply by 2050, the number of installed systems in the building sector alone must increase tenfold worldwide.[1] The use of heat pumps (for heating and cooling) in emerging and developing countries is therefore an essential prerequisite for their progress and development. In addition, there is a significant demand from industry.

Heat pumps are also a key component of the future energy systems, which will increasingly rely on electricity. Electricity can be generated from a variety of renewable energy sources such as hydropower, biomass, solar, and wind, which are locally available in many places. When combined with thermal or electrical storage systems, the use of heat pumps can be flexibly adapted to the specific conditions of the local power network. Moreover, heat pumps are one of the most important technologies for ensuring a reliable supply of thermal energy. This is clearly illustrated during periods of supply uncertainty as they are often accompanied by a significant increase in heat pump sales.

However, there is still much work to be done to continue improving these marvelous technologies. We can still increase their efficiency, using environmentally friendly refrigerants or offering adjustable temperature ranges. In addition, there is a need to improve integration into building heating systems or industrial processes, as well as for improvements in how the heat source is utilized and regenerated. The need to incorporate power availability into both technical and economic operational optimization requires smarter system control. In the design, manufacturing, and installation of heat pumps, measures are needed to reduce costs, account for the availability of materials, and recycle them after use.

The IEA Technology Collaboration Programme on Heat Pumping Technologies plays a key role in ensuring that heat pumps serve as the cornerstone of a secure, affordable, highly efficient, clean, and zero-emission energy system for heating, cooling, and refrigeration. To achieve this, specialists from twenty countries are collaborating on ten ongoing projects and disseminating their findings and results through our website, reports, webinars, IEA publications, and at our triennial International IEA Heat Pump Conference. The next conference will take place in Vienna from May 26 to 29, 2026. In addition to presentations of projects, workshops and roundtable discussions will explore new challenges facing research, industry, the economy, and politics. I look forward to seeing you there!

To ensure that our international cooperation is successful and that we achieve our goals, we need competent and highly motivated individuals from our member countries. I would therefore like to thank the members of the Executive Committee, the experts involved in the projects, and the staff of the Heat Pump Center and the IEA for their dedication. My thanks also go to our member countries—without their financial support, our activities would not be possible.

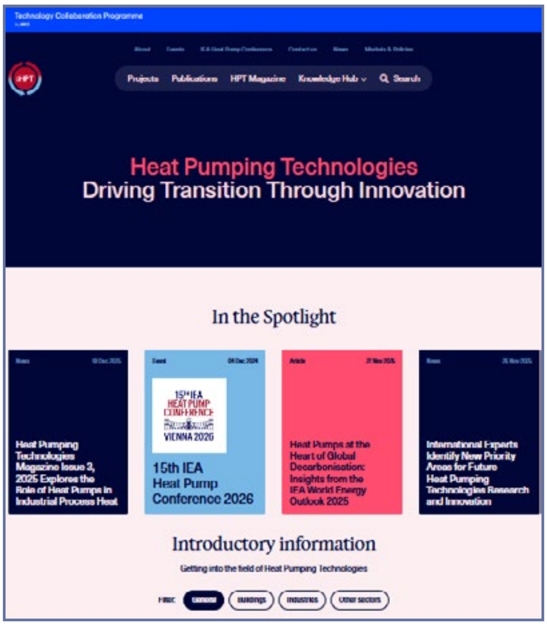
Stephan Renz, Chairman of the Executive Committee

[1] *IEA Net Zero by 2050: A Roadmap for the Global Energy Sector*

Highlights 2025

LAUNCH OF THE RENEWED HPT TCP WEBSITE

The HPT TCP ***website*** includes introductory and deep-dive information about the technology and is continuously updated with news and results from international collaboration projects. It also includes a search function for the HPT TCP publication database. The website was renewed during 2025 to make it more user friendly and to better promote and display all the results achieved within the TCP over the years. The project websites are included as subsites to the main sites to ease the website visitors' access to them.



Renewed HPT TCP website.

HEAT PUMPS HIGHLIGHTED IN IEA FLAGSHIP REPORTS

The IEA pointed out in the ***Global Energy Review 2025*** that heat pumps, alongside solar PV, wind, EVs, and nuclear, are already avoiding 2.6 billion tonnes of CO_2 annually. The report also reveals that despite their critical role in decarbonisation, global heat pump markets are fluctuating and vary between regions. The recent sales dips in some regions serve as a reminder that supportive policy frameworks, affordability, and market certainty are essential to maintaining momentum.

The State of Energy Innovation report showcases significant strides in global energy innovation, outlining key findings across critical technology areas and policy action recommendations. Notably, the report emphasized considerable advancements in heat pumping technologies, including solid-state cooling, demonstration of low-charge propane heat pumps, and heat pumps for industrial and district heating applications.

The ***Energy and AI report*** made it clear: heat pumps, when integrated into smart heat recovery systems, are a key technology enabling AI-driven infrastructure to contribute to decarbonization efforts.

The ***IEA Renewables 2025 report*** underscores the accelerating role of heat pumping technologies in advancing global energy transitions. Heat pumps, ranging from residential air-source systems to industrial-scale high-temperature installations, are emerging as a cornerstone of decarbonized heating.

The ***World Energy Outlook 2025*** confirmed: heat pumps are driving the global clean energy transition. Heat pumps not only cut emissions but also improve energy efficiency and reduce reliance on fossil fuels.

HPT TCP reported on all these reports on their website and reviewed some of them.

Front cover of IEA flagship reports. Source: IEA

CONTRIBUTION TO IEA'S TCP COORDINATION GROUPS

HPT TCP actively contributed to the work of several TCP Coordination Groups (CGs). In the **CG on Heat Pumps**, they attended workshops and performed reviews related to the work on heat pump data for policy making and innovation.

In the **CG on Thermal Networks**, the HPT TCP was part of the team elaborating the report ***Thermal networks: Empowering the smart transition to net-zero*** and a collection of impact fact sheets and success stories, which show the mutual benefits of thermal networks to the technologies covered by the other TCPs, for example, heat pumps.
The HPT TCP also provided input to the **CG on Energy System Flexibility**, related to the flexibility potential of heat pumping technologies. Read more ***on page 14–15***.

HPT TCP NATIONAL EXPERTS MEETING

HPT TCP hosted its 2025 National Experts Meeting on 30 October in Nuremberg, bringing together thirty experts from twelve countries across academia, industry, and research institutions. Participants gathered to generate, elaborate, and discuss ideas for new international collaboration projects that align with the HPT TCP Strategic Work Plan 2023 to 2028 in a very productive meeting. Read more about the meeting and the projects in the pipeline ***on page 13***.

NEW PROJECTS

Two new international collaboration projects (former annexes) were started during 2025.

HPT Project 67 Digital Services for Heat Pumps

The project focuses on the heat pump and its components and should answer the question of how to make use of digital services for heat pumps in various fields of action during its life cycle, in particular product design, testing, operation, integration, and maintenance.

HPT Project 68 Industrial High-Temperature Heat Pumps

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.

CALL FOR ABSTRACTS AND PAPERS FOR THE 15TH IEA HEAT PUMP CONFERENCE

The promotion of the 15th IEA Heat Pump Conference began during the year, and the call for abstracts closed in spring. More than 600 abstracts were received, resulting in 385 submitted full papers. Planning for the plenary opening session, workshops, and the policy forum also began during the year.

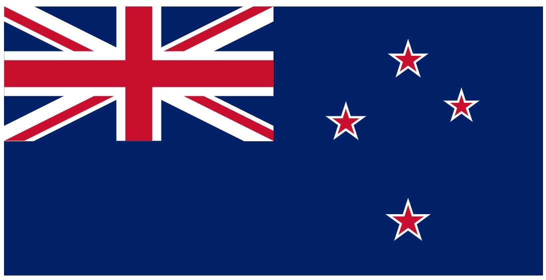
PUBLICATION OF THREE ISSUES OF THE HEAT PUMPING TECHNOLOGIES MAGAZINE

- ***No 1/2025*** Natural Refrigerants in Heat Pumps: Pushing the Boundaries of Sustainability
- ***No 2/2025*** Smart Controls and AI for Next-Generation Heat Pump Efficiency
- ***No 3/2025*** Heat Pumps in Industrial Applications: Pioneering High-Temperature Solutions

Featuring images of the three issues of the Heat Pumping Technologies Magazine published on the renewed HPT TCP website.

NEW ZEALAND JOINED AS LIMITED SPONSOR TO THE HPT TCP

New Zealand has joined IEA HPT TCP Project 68 as a limited sponsor, reinforcing its commitment to advancing high-temperature heat pump technologies and accelerating the decarbonisation of industrial process heat.



Attendees at the HPT TCP national experts meeting.

International Energy Agency

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 coordinate 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) over 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 advance 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 include: energy efficiency end-use technologies (in buildings, transport, industry, and electricity), renewable energy and hydrogen, fossil energy, fusion power, and cross-cutting issues (energy system analyses and equality in the 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 2025

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-2026 ***Energy Technology Perspectives 2026*** follows up on the analysis of the future of manufacturing and international trade of clean energy technologies that was featured in the previous edition of the ETP report. For heat pumps, ETP-2026 dives deeper into the manufacturing and supply chains of compressors, a key component for all modern heat pumps that greatly influences their production costs. ETP-2026 identifies that while final assembly of heat pumps is globally dispersed and adapted to local market conditions, manufacturing of rotary compressors (an essential upstream component for many types of heat pumps) is concentrated mainly in China. While heat pump manufacturing is still geographically diverse today, ETP-2026 identifies that China has the potential to play a larger role in global supply in the future due to its strong position in upstream supply chains and lower manufacturing costs than other regions.

ETP-2026 also introduces 10 key questions for the future of energy technology and a collection of dashboards on clean energy technologies (including dashboards on heat pumps in buildings and in industry).

ETP-2026 is scheduled to launch in Q1 2026.

HEAT PUMP TAXONOMY

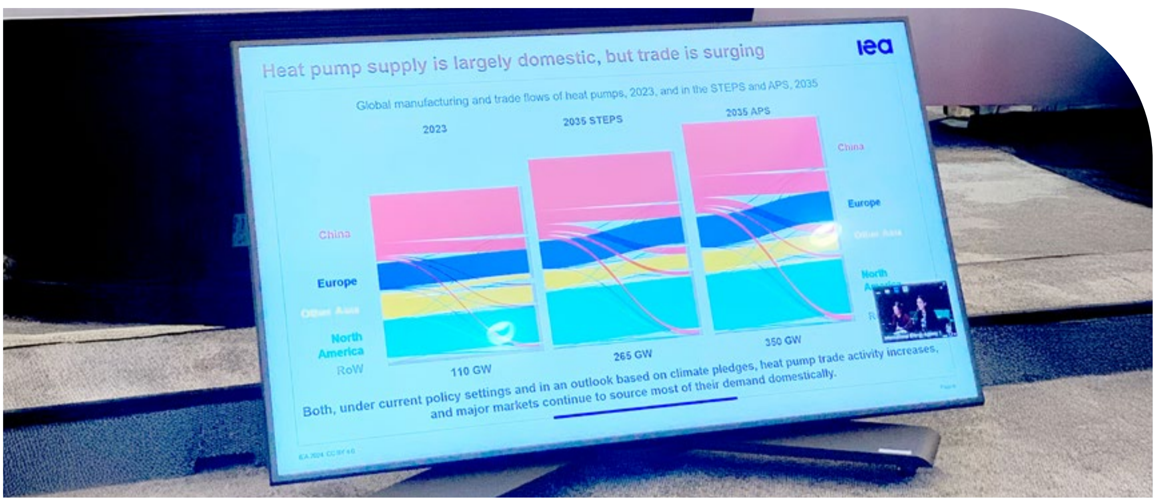
Across the globe, different types of heat pumps are used in a variety of contexts, greatly influenced by local conditions and standards. This makes international comparisons of heat pump deployment difficult, as the precise definitions and reporting practices change from one market to another. The heat pump taxonomy project brings together (through the networks of the IEA and the Heat Pumping Technologies TCP) international stakeholders across the heat pump technology sector to create a common framework (i.e. a taxonomy) for heat pumping technology.

The project examines the different preferences, reporting practices, and terminologies used for heat pump deployment in the world's major heat pump markets (China, Europe, Japan, and the United States). From this, a common global heat pump taxonomy is created that would allow all major markets to implement consistent, comparable reporting practices for heat pump statistics.

The four main outcomes of the project are:

- A common framework (i.e. taxonomy) for reporting of heat pump statistics
- A reporting matrix, showing how current reporting practices for heat pump statistics compare across the world and how it aligns with the proposed taxonomy
- An online tool, the taxonomy explorer, targeted at a broader non-technical audience that provides educational information and examples of different types of heat pumps
- A technical note (short report) explaining further the background and details of the project

The project is scheduled to finish in early 2026.



Presentation shown during the workshop on the Heat Pump Taxonomy Project at the IEA office in Paris.

WORLD ENERGY OUTLOOK 2025

For the ***2025 edition of the World Energy Outlook***, the annual IEA flagship report and most authoritative source of global energy analysis and projections, heat pumps are prominently featured. The report shows that under stated policies, by 2035, heat pumps could meet nearly 40% of space heating demand in Japan and the United States, while the share of space heating provided by heat pumps doubles in the European Union and China, assuming that consistent policy measures are sustained (see Figure below).

GLOBAL ENERGY REVIEW 2026

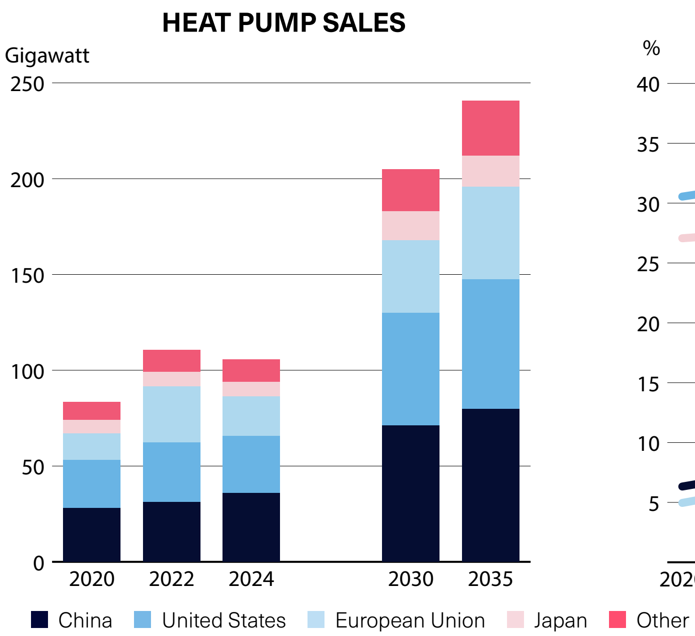
The Global Energy Review is a comprehensive depiction of the 2025 trends across the entire energy sector, covering data for all fuels and technologies, including heat pumps. The 2026 edition includes an update on heat pump sales across all major markets and an estimate of the emissions saved by heat pumps. The report is scheduled to launch in Q1 2026.

HEAT PUMP MONITOR

The heat pump monitor is a collection of 20 online dashboards that present concise, digestible information about heat pumps across different contexts. Each dashboard (of either one or two pages) explores one theme, each essential to heat pumps. The dashboards are arranged into four “pillars”, with one, “Deep dive into buildings”, further divided into four “sub-pillars”.

The monitor, together with a short executive summary, is scheduled to launch in Q1 2026.

> ***Heat pump sales double by 2030 with strong growth in four major markets, and meet an increasing share of space heating demand.***
>
> Source: IEA World Energy Outlook 2025



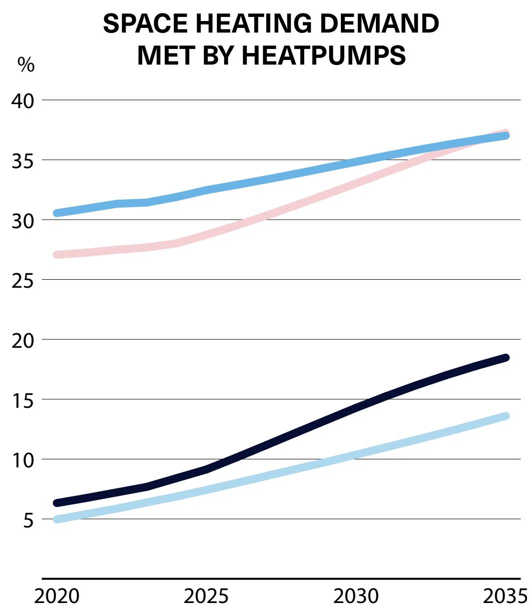


Figure 1: Global heat pump sales and contributions to space heating demand in selected regions in the STEPS 2020 – 2035. Source: IEA World Energy Outlook 2025, Fig 4.11

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 monitor the development and requirements of our energy system and revise our strategy every 5 years in line with the IEA's objectives.

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, and 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 pump technologies as a sustainable, clean, enabling, connecting, and affordable heating and cooling solution to achieve climate ambitions and strengthen energy security. Decisions that promote heat pumping technologies are implemented.

» *Engagement worldwide*

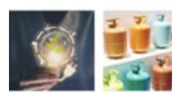
F. HPT TCP has more member countries representing the largest economies, different parts of the world facing different contexts, IEA key partner, and association countries.

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

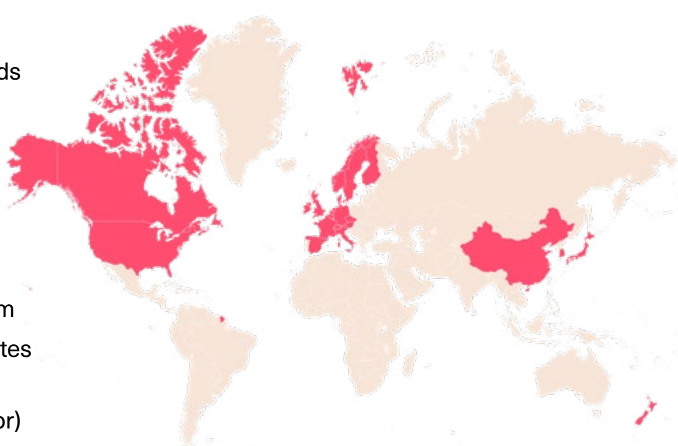
1. Advance the RDD&D* of heat pumping technologies through the creation of research opportunities, networking, and meeting places for academia, industry, market actors, investors, and policy makers to collaborate under new Annexes (projects/tasks) and other activities (e.g., workshops) within the HPT 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. Organise a high-quality conference on heat pumping technologies at least every third year, and establish it as the most important networking event. For more information about the 15th IEA Heat Pump Conference, *see page 16–17*.
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 FOR 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 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.)
• The role of heat pumps in integrated energy systems on building, district and city levels. • Heat pumps as an enabler for sector coupling • Methods for evaluating smart, flexible heat pumps	• Systems for circular economy for heat pumps • New business models • Easy to install products (plug and play and self commissioning) • Standardization for scaling • User behaviour/ acceptance of HPT, comfort and flexibility	• Heat pumps for industrial applications • Heat pumps for district heating and cooling applications • Heat pumps for retrofitting of existing buildings with special requirements • Heat pumps/AC for cooling, dehumidification and drying • Cold climate heat pumps	• Non-vapour compression technologies • Other areas that need low TRL level research • Efficient operation, components and systems for Low GWP refrigerants • Safety measures for operating with low GWP refrigerants

HPT TCP MEMBER COUNTRIES

» Austria
» Belgium
» Canada
» China
» Czech Republic
» Denmark
» Finland
» France
» Germany
» Ireland
» Italy
» Japan
» The Netherlands
» Norway
» South Korea
» Spain
» Sweden
» Switzerland
» United Kingdom
» The United States
» New Zeland (limited sponsor)



* Research, Development, Demonstration, and Deployment

Organisation of the HPT TCP

The work within the HPT TCP is organized 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 the 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.

Projects 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 also generally within the field of energy and beyond.
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, conferences, and meetings.
caroline.haglundstignor@ri.se

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 senior Researcher at RISE, working at the forefront of energy and the sustainable built environment. At HPC, he is the editor of our prestigious Heat Pumping Technologies Magazine and deals with annual reports, organising national expert meetings, and member country reports, etc.
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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 2025

EXECUTIVE COMMITTEE MEETINGS

The spring ExCo meeting took place in Montreal, Canada, in May and was hosted by the Canadian delegate and a colleague at Natural Resources Canada (NRCan). Most of the delegates and also HPT project managers attended the meeting in person. Additionally some attended online. As usual the IEA CERT* delegate from the host country was invited. The delegate from Canada, Jason Gadoury, could only attend online and gave an intervention to enhance interaction between CERT and the TCP community. Moreover, Canadian delegates from six other Technology Collaboration Programmes working with other themes and technologies such as buildings (EBC TCP), electric grids (ISGAN TCP), solar panels (PVPS TCP), district heating and cooling (DHC TCP), users' perspectives (USERs TCP), and cities and communities (Cities TCP) attended the meeting and gave presentations. This was followed by discussions between these TCPs and the HPT TCP concerning areas of synergy and collaboration. The agenda also included a presentation by the TCPs' IEA desk officer and discussions on the potential to link the TCP efforts with Mission Innovation (MI), including the MI Calls and the MI Funders Dialogue.

ExCo Vice Chair Sophie Hosatte (meeting host) and colleagues.

Canadian ISGAN TCP delegate, Josef Ayoub, meeting co-host.

Participants at ExCo meeting events in Montreal.

The day before the meeting, the Canadian representative in HPT TCP and NRCan, together with Concordia University, organized a very interesting workshop titled "Canadian perspectives on Heat Pumping Technologies". HPT TCP delegates and project managers from all over the world got together with representatives from the heat pump sector in Canada during the workshop to be informed about the heat pump related initiatives in Canada. The audience was informed about the many policy drivers for increased heat pump adoption in Canada, including affordability, energy security, emission reductions, and access to cooling. However, deployment is also facing some challenges, including very cold climates in some regions, insufficient capacity of the electricity grid in some locations, a high electricity-to-gas price ratio in some regions, a shortage of skilled workers, etc. To stimulate energy efficiency and the deployment of heat pumps in Canada, targeted incentive programs are available. The Canadian HPT delegate gave an overview of the Buildings Program at CanmetENERGY and was accompanied by many interesting presenters in the program (read more).

During the HPT TCP ExCo fall meeting in Freiburg in November, participants exchanged a lot of information and discussed research needs, as well as barriers and opportunities related to energy security, energy efficiency, and the decarbonization of the energy system through the innovation and deployment of heat pumping technologies. During the meetings, delegates from the member countries met with HPT project managers, invited guests, the alternate German CERT* delegate, representatives from the IEA bureau, and German researchers and industry representatives active within the sector to receive updates on the ongoing HPT Projects, discuss topics for new projects, and collaborate with other organizations.

The German ExCo delegates hosted the meeting together with Fraunhofer ISE, and in addition, they organized a national workshop on heat pumping technologies, which brought together leading researchers, industry representatives, and policymakers to discuss the current state and future direction of heat pump technology in Germany. A significant focus was placed on Germany's ener-

* IEA's Committee for Energy Research and Technology

gy transition, detailing funding schemes and research initiatives supporting the deployment of heat pumps. The market status was presented, which highlighted a structural shift: while the overall heating market has contracted, heat pumps are gaining market share, driven by policy changes and increased government support. Several German research institutions showcased innovations in component design, digital twins, high-temperature heat pumps, and safety for flammable refrigerants, and industry leaders from the sector presented results from innovation projects, new products, and case studies, emphasising efficiency, sustainability, and integration into district heating and industrial processes. During the day, the participants had the opportunity to visit two leading research facilities at Fraunhofer ISE. One of them focuses on performance testing and the development of heat pumps, and the other, the outdoor refrigerant safety lab, is dedicated to the safety of hydrocarbons as refrigerants (***read more***).

Attendees at ExCo meeting in Freiburg.

ExCo Chair Stephan Renz.

HPT TCP NATIONAL EXPERTS MEETING

The HPT TCP hosted its ***2025 National Experts Meeting*** on 30 October in Nuremberg, bringing together thirty experts from twelve countries across academia, industry, and research institutes. Participants gathered to generate new ideas for international collaboration projects that align with the HPT TCP Strategic Work Plan 2023 to 2028. The meeting featured presentation sessions and an extensive ideation workshop structured around five thematic areas reflecting key challenges and opportunities for heat pump technologies. The purpose of the meeting was to generate and further develop concepts that could evolve into new HPT TCP international collaboration projects. Participants received updates on project proposals and ideas already in the pipeline.

- Heat pumps for hydrogen and carbon capture
- Flexibility from Large-Scale and Aggregated Heat Pump Systems
- Enhanced miniaturized components

Thereafter followed the ideation workshop structured to cover different themes. The workshop produced a rich set of project concepts that are now under consideration for future HPT TCP international collaboration projects.

- Comfort cooling in different types of climates
- Heat pumps and refrigeration systems along the food chain
- Heat pumps and the EU network code for flexibility
- Integration of energy storage and flexible heat pumps
- Heat pumps in combined district heating and cooling systems

Read more about ideas and proposals ***on page 40***.

Attendees at the HPT TCP National Experts Meeting in Nuremberg.

ONGOING, NEW AND COMPLETED HPT PROJECTS

The international collaboration ***projects*** within the HPT TCP (formerly called annexes) form the core of TCP activities.

DURING 2025, THE FOLLOWING PROJECTS WERE ONGOING:

- Heat Pumps for Drying (***Project 59***)
- Retrofit Heat Pump Systems in Large Non-domestic Buildings (***Project 60***)
- Heat Pumps in Positive Energy Districts (***Project 61***)
- Heat Pumps for Multi-Family Residential Buildings in Cities (***Project 62***)
- Placement Impact on Heat Pump Acoustics (***Project 63***)
- Safety Measures for Flammable Refrigerants (***Project 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***)
- Digital Services for Heat Pumps (***Project 67***)
- Industrial High Temperature Heat Pumps (***Project 68***)

More information can be found ***on page 19***.

HPT TCP COMMUNICATIONS: WEBSITE, MAGAZINE, NEWSLETTER, SOCIAL MEDIA AND MORE

The HPT TCP ***website*** is managed by the Heat Pump Centre (HPC, the programme office and communication centre of the HPT TCP) together with the project managers (also called operating agents) of the HPT projects. During 2025, the website was renewed and modernized to make it more user-friendly and to better promote and display all the results achieved within the TCP over the years. This full makeover required a lot of resources and attention from the Heat Pump Centre, the project managers, and the communication task force of the HPT TCP. The new website includes introductory and deep-dive information about the technology to reach different target groups. It is continuously updated with news and results from the international collaboration projects. The HPT project websites are included as subsites to the main sites to ease the website visitors' access to them. The website also includes a search function for the HPT TCP publication database and different filter functions that apply to all the content on the website.

During the year, the Heat Pump Centre has continued to encourage project managers to publish updates, news, and results from their projects on their project websites. This type of information is now better displayed on the new website, thanks to the improved filter and search functions.

One of Heat Pump Centre's main activities is publishing the prestigious web-based Heat Pumping Technologies Magazine. Each issue covers a specific topic and contains articles and a contribution from a guest columnist. Three issues of the Magazine were published in 2025 on the topics:

» ***No 1/2025*** Natural Refrigerants in Heat Pumps: Pushing the Boundaries of Sustainability
» ***No 2/2025*** Smart Controls and AI for Next-Generation Heat Pump Efficiency
» ***No 3/2025*** Heat Pumps in Industrial Applications: Pioneering High-Temperature Solutions

During 2025, the visual appearance and format was adapted to the renewed website.

HPT Magazine published on the renewed website.

In between the release of the Magazine, the Heat Pumping Technologies Newsletter was sent out to the subscribers, summarizing the news of the latest month and promoting upcoming events. During 2025, ten newsletters were sent out, and the format was adapted to align with the new website.

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 the TCP's communication channels and has noted a considerable increase in both from year to year.

Heat Pump Centre continued to send out the "HPC 60 seconds" e-mail, a monthly overview in bulleted format of HPC activities for the people actively involved in the TCP.

COLLABORATION WITH IEA AND OTHER TCPS, TCP COORDINATION GROUPS

HPT TCP contributed actively to the work of several TCP Coordination Groups (CGs), especially the CG on Heat Pumps. During the year, representatives from ExCo and the Heat Pump Centre attended workshops on the theme "The importance of heat pump data for policy-making and innovation". ***The first workshop*** was held at the IEA headquarters in Paris and online. The workshop was organized by the IEA secretariat in collaboration with the CG on Heat Pumps. It assembled a broad array of stakeholders - from policy makers, statistics organizations, industry, business associations, and consumer organizations to TCP representatives and research institutes, among others. The HPT TCP contributed to the arrangements with contacts, interventions, and the moderation of an interactive discussion session. Later during the year, two more hybrid follow-up sessions were held, and a draft Heat Pump Taxonomy was developed by the CG (to be published early 2026).

Thermal networks Empowering the smart transition to net-zero report.

In the **TCP CG on Thermal Networks**, the HPT TCP was part of the team elaborating the report ***Thermal networks: Empowering the smart transition to net-zero*** and a collection of impact fact sheets and success stories, which show the mutual benefits of thermal networks to the technologies covered by the other TCPs, for example, heat pumps. HPT TCP was able to contribute with several cases and fact-based information thanks to the results from previous HPT Projects.

The HPT TCP also provided input to the **TCP CG on Energy System Flexibility**, related to the flexibility potential of heat pumping technologies, and attended an on-site workshop at the IEA office in April. The main outcome from this CG presented to CERT[1] at the end of the year was a joint definition of flexibility, which all participating TCPs agreed on, four dimensions and metrics to describe flexibility, and 21 use cases from the participating TCPs, which could be described by these dimensions and metrics.

Neither behavioural changes nor low-carbon technologies alone are sufficient for the vital energy and climate transition. Low-carbon technologies with the active involvement of consumers will be key to mitigating climate change and reaching a sustainable and affordable energy sector. With this background, IEA's Technology Collaboration Programmes on User-Centred Energy Systems (USERs TCP) and Heat Pumping Technologies (HPT TCP), and the Swedish Energy Agency (SEA) organized a ***joint workshop*** in conjunction with the USERs TCP ExCo meeting in Stockholm. The workshop brought together participants from the different fields – social scientists, technology experts, and policy makers – to agree on priorities for future international collaborative research to support the transition to heat pumps across our member countries.

In October, the Vice ExCo Chair of HPT TCP attended IEA's Energy Innovation Forum in Canada. During the year, representatives from the HPT TCP (primarily the ExCo Chair and Heat Pump Centre staff) have reviewed some of IEA's flagship reports, of highest relevance for heat pumping technologies, published during 2025 or early 2026 (***see page 4***).

Participants at the joint USERs and HPT TCP workshop in Stockholm. Photo: Jörgen Lööf, Electricity.

COLLABORATION WITH OTHER INTERNATIONAL ORGANIZATIONS

Representative from the Heat Pump Centre has attended stakeholder meetings and contributed to the work of the ***Heat Pump Accelerator Platform***, a platform financed by the European Commission with the objective to identify barriers to the deployment of heat pumps across the EU, and suggest targeted policy measures to address them, which was initiated in the beginning of 2025.

In May the HPT TCP was represented at the conference ***DeCarbCities*** in Poland and promoted the HPT TCP and especially the call for abstract for the upcoming IEA Heat Pump Conference 2026. The Heat Pump Centre informed about the latest news from HPT TCP and promoted the conference at the European Heat Pump Summit which took place in the end of October, in a booth and during a presentation. In addition, several of the HPT Projects were presented during the summit (***read more***).

HPT TCP booth at European Heat Pump Summit (Dr Metkel Yebiyo and Dr Caroline Haglund Stignor).

Audience at and organizer (Dr Rainer Jacobs) of European Heat Pump Summit.

[1] IEA's Committee for Energy Research and Technology

Decarbonisation through Innovation

From **26 to 29 May 2026**, Vienna will open its doors for the 15th IEA Heat Pump Conference – the leading scientific conference and meeting place for academia, industry, market, policy makers, and investors interested in the field of heat pumping technologies. Under the motto 'Decarbonisation through Innovation', experts from all over the world will meet to present and discuss the latest advances and developments.

The conference is organized by the **Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)** by IEA. The **AIT Austrian Institute of Technology** is hosting the event. AIT began researching and developing high-temperature heat pumps around ten years ago and established itself as a top research partner in Europe. The conference takes place every three years – the location alter between USA, Europe, and Asia – and serves as a lively forum for the exchange of information on research, applications, market, policy, and standards in the field of heat pump technologies.

To receive the latest information about our conference, subscribe to our **newsletter** ***here***.

PROGRAM OVERVIEW

The four-day international conference offers a unique platform for intensive exchange of information and dialogues. With around 400 scientific submissions from international experts, the **scientific and applied technical presentations** offer comprehensive insight into the current state of research and innovation.

The conference program runs on **Tuesday from 10:00 to 17:00**, and on **Wednesday to Friday from 09:00 to 18:00**.

KEY TOPICS:

- Decarbonisation of the heating and cooling sector
- Innovative heat pump applications for industry and commerce
- Smart grids, digitalisation and system integration
- Technologies for urban areas and existing buildings
- Policy, market mechanisms, and regulatory framework
- Standards, certification, and quality assurance

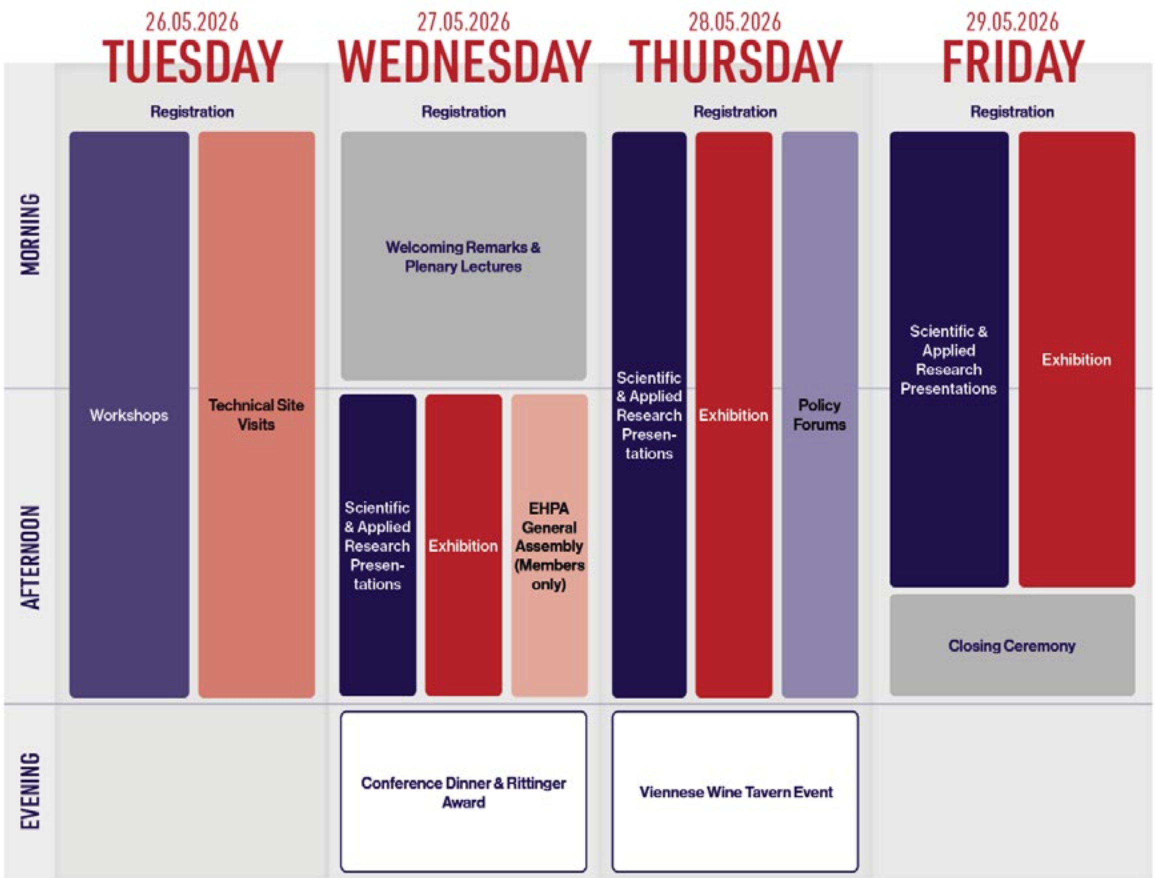
TUESDAY, 26TH MAY 2026
The first day, Tuesday after the Pentecost weekend, starts with parallel ***workshops*** and ***technical site visits***, which provide practical insights into current technologies and applications in the Vienna area.

WEDNESDAY, 27TH MAY 2026
The official opening will take place on Wednesday, with opening remarks from the IEA and the Austrian Federal Ministry of Innovation, Mobility and Infrastructure, followed by international plenary lectures on Energy & Climate Policy and Technology & Industry Transformation.

In the afternoon, the program starts with **scientific and applied technical presentations**, accompanied by the ***exhibition***. **The EHPA general assembly** will take place at the same time. The day will conclude in the evening with the ***conference dinner*** and **the Rittinger award ceremony**.

THURSDAY, 28TH MAY 2026
On Thursday, in addition to further **scientific & applied research presentations** and the **exhibition**, the ***policy forums*** will provide a space for discussions on current strategic, policy, and regulatory issues. In the evening, a ***Viennese Heurigen evening*** will invite informal networking in a special atmosphere.

FRIDAY, 29TH MAY 2026
On Friday, further **scientific & applied research presentations** and the **exhibition** will conclude the conference, before the **closing ceremony** brings the official proceedings to a close.



HPT TCP Projects for Research, Development, Demonstration and Deployment

Participation in a HPT TCP project is an efficient way of increasing national knowledge, both regarding the specific project objective, but also by international information exchange. The 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. The projects within the HPT TCP have for a long time been known as Annexes. However, they are now named Project to be inline with the TCP framework of IEA.

HPT TCP 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), New Zealand (NZ), South Korea (KR), Spain (ES), Sweden (SE), Switzerland (CH), the United Kingdom (UK), and the United States (US).

Bold, pink text indicates the lead country.

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 Project is linked to, see below.

59	Heat pumps for drying	**AT**, CH, CN, DE, NO, SE, US	C
60	Retrofit heat pump systems in large non-domestic buildings	AT, CA, IT, IE, NL, SE, **UK**	C
61	Heat pumps in positive energy districts	AT, **CH**, DE, IT, JP, US	A
62	Heat pumps for multi-family residential buildings in cities	BE, CH, CN, DE, ES, FR, IT, SE	C
63	Placement impact on heat pump acoustics	AT, **DE**, FR, CH, NL, UK, IT, SE	B
64	Safety measures for flammable refrigerants	**AT**, DE, FR, KR, **SE**, US	D
65	Heat pumps in a circular economy	DE, **DK**, IT, FR, BE, CH	B
66	Optimal heat pump design and operation	DE, ES, **US**, SE, CH	B
67	Digital services for heat pumps	**AT**, BE, DK, SE	A
68	Industrial high-temperature heat pumps	AT, BE, **DK**, FI, FR, DE, JP, NL, NO, NZ, KR, ES, SE, CH	C

Selected areas for RDD&D activities in HPT TCP (2023–2028). *See page 10*.

A)

System Integration

B)

Robust, sustainable and affordable value chains

C)

Extending operation range and applications

D)

New technologies and refrigerants

Project 59

Heat Pumps for Drying

INTRODUCTION

Drying processes are widely used in industry and commerce (food, paper, chemical, ceramics industries, 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)[1].

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 was 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 fuels and using product waste. A comprehensive dryer comparison can be found here[2]. The moisture (e.g., water) extracted from the material to be dried is, in most cases, released into the environment as a pure gas or with a drying medium (e.g., air or steam).

This exhaust air contains a high amount of energy, which is currently only partially recovered through heat recovery. Modern industrial drying processes are either open-loop systems that use heated ambient air or closed-loop systems that recirculate drying air. Heat pumps are characterized by the ability to utilize a heat source at low temperatures (at the evaporator) and to supply a heat sink at a higher temperature (at the 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 Project aims to structure and describe the numerous possibilities and advantages of integrating heat pumps into dryers. Both the state-of-the-art and innovative solutions in industrial, commercial, and domestic applications are examined and described. 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 project 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 these sectors and to reduce barriers.

> *"Using the online tool Drying Toolbox, everyone is invited to determine the energy-saving potential of their drying process."*

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 project by a website, publications, workshops, and reports.

[1] Eurostat. Consumption of Energy. Available online: *https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Consumption_of_energy* (accessed on 12 April 2021)

[2] [online]: Portal für industrielle Trocknungsanlagen (*http://www.drying.de/*)

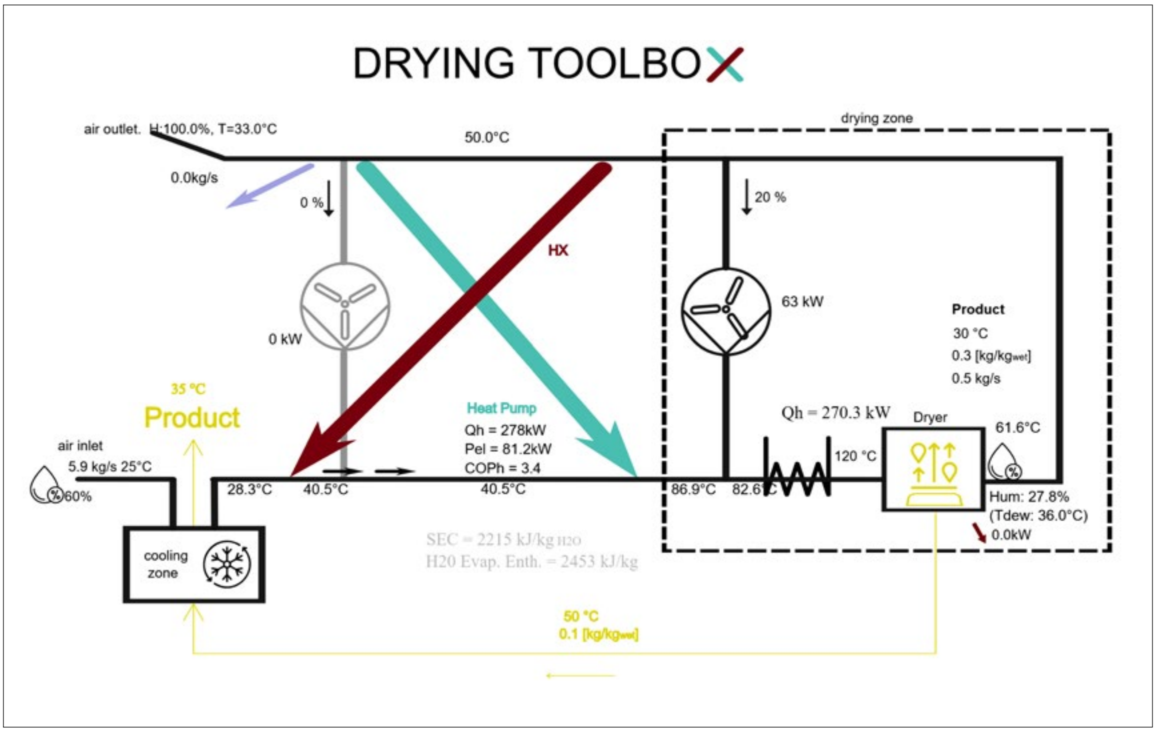
RESULTS

A web tool called Drying Toolbox was launched and is freely available. After inputting 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. The key parameters of the drying process and heat recovery measures, as well as the resulting energy demand, are shown in the visualisation (see Figure 2). Additionally, the results are visualized using a Sankey diagram. ***The Drying Toolbox*** empowers researchers, engineers, and industry professionals to evaluate and compare different alternatives to improve energy efficiency. More information on how to use the tool is available in an online ***YouTube tutorial.***

An overview of industrial drying technologies was elaborated, and KPIs for the drying process and its energy efficiency were defined. A comparison of different drying technologies and processes shows that, in general, energy efficiency and the potential for energy savings from heat pump integration are higher at lower drying temperatures. To demonstrate the technical and economic feasibility, several successful heat pump use cases in drying processes are presented. Furthermore, a procedure guide to help dryer operators concretise the idea of energy-efficient drying and realise that it is in progress.

LIST OF PUBLICATIONS 2025

Lauermann, M. (2024). **AIT industrial cooperation in cutting energy consumption in drying processes**. In: 50th International Conference of the Slovak Society of Chemical Engineering (SSCHE), Tatranské Matliare, Slovakia.



Schematic visualization of the Drying Toolbox.

Project duration:
January 2022 – December 2025

Contact person:
Project Manager is Verena Sulzgruber AIT Institute of Technology GmbH,
verena.sulzgruber@ait.ac.at

Participating countries:
Austria, China, Germany, Norway, Sweden, Switzerland, USA

Website:
https://heatpumpingtechnologies.org/project59/

Project 60 Retrofitting Heat Pump Systems in Large Non-domestic Buildings

INTRODUCTION

The greatest potential for carbon reductions in buildings is in existing buildings, and about one-third of the heated floor area is typically in non-domestic buildings. The non-domestic sector is inherently complex with wide variations of building size, construction, use, HVAC systems, and owner or occupant motivations. There are also many possible types of heat pump systems that could be installed. Since replacing existing heating distribution systems is costly and likely to disrupt the building's operations, a retrofitted heat pump system should be compatible with the existing system. Unlike dwellings, most of the market is business-to-business – but, like dwellings, it is divided between rented and owner-occupied buildings. Additionally, there are several supply chains, ranging from small installer/designers to specialist designers with formal tenders for installation. This is a complex landscape for policymakers and building owners to navigate. Most policy instruments focus on dwellings and, at the start of this project, technical guidance for the sector was sparse - it has developed somewhat since.

> *"An interactive web-based guidance tool for owners of non-domestic buildings has been developed: market statistics are sorely lacking."*

Building owners and managers, and their suppliers, will usually be familiar with like-for-like boiler replacements and other heat generators. Retrofitting heat pumps is less straightforward and is a new and challenging experience for many building owners, especially those who do not have established relationships with designers or installers familiar with heat pump systems. In particular, they are likely to be unaware of all the factors to be considered and concerned about the uncertainties of a relatively new technology. Project 60 addresses these concerns by helping building owners, via a web-based tool, prepare for more detailed discussions with experienced suppliers who have inspected the building in question and, preferably, reviewed energy consumption records.

OBJECTIVES

The principal formal objectives of Project 60 were to deliver

- Evidence of the practical feasibility and satisfactory operation of a range of installed retrofit systems in large non-domestic buildings in a number of countries, together with insights into the thinking that led to the choice of system.
- Simple to use, accessible advice to support the initial selection of system options for specific circumstances, signposted to evidence and summaries of the relative strengths of each option.

It was also hoped that the project would be able to provide some broader insights:

- Deeper understanding of the non-domestic heat pump market, how it works, and its stage of development,
- Better understanding of who makes the key procurement decisions as part of the retrofit procurement process, and what their needs and aspirations are
- Insight to help policymakers to assess which policies and measures will be most effective in accelerating non-domestic heat pump deployment

RESULTS

The project has delivered its principal objective by developing the interactive web-based "Smart Guide" for first-time purchasers of retrofit heat pump systems in non-domestic buildings. It provides the user with a list of feasible systems that are consistent with their responses to questions about the building and its existing HVAC systems. The list is accompanied by links to information sheets illustrating relevant completed retrofit projects. This will be accessible from the TCP website.
The web-based guidance tool:

- Presents the questions that an installer will ask building owners, allowing them to reflect on their responses and, where necessary, to seek missing information
- From the answers, it selects a short list of options for systems that are likely to be feasible for the building and provides a qualitative relative comparison of capital costs and carbon savings.

Figure 1: Renovation of non-domestic building.

» Provides summaries of existing retrofits in buildings that resemble the one described, to provide reassurance that they are not stepping into the unknown.

This tool should also have value for non-technical people in the decision chain, for policy makers and their advisors, and perhaps for suppliers during initial customer contact. It cannot directly address the risk that, at current levels of market penetration, installers are bound to have variable levels of familiarity and experience. However, even a basic awareness of the likely constraints and established practice can help the prospective buyer to assess this. Complementary training and competency certification would be complementary measures to address this, but are outside the scope of the project.

It was only partially successful in its secondary objectives. In particular, it discovered that relevant market statistics and performance data are sorely lacking in most countries - the semi-quantitative aspects of the results rely on interpolating from limited, mostly UK data sources, generally on anticipated performance and costs.
It proved impossible to obtain the expected performance and cost information for existing retrofits, as this was either unknown or inaccessible. It had also been intended to supplement the illustrative project summaries with more detailed measured information from selective "deep dive" studies. While suitable projects were identified, the results were not available within the project's timescale.

Project 60 revealed that information about the non-domestic building sector (which typically accounts for about 1/3 of heating consumption) is sparse and lacking in detail in most countries: In the UK it was possible to develop some understanding of the non-domestic retrofit heat pump market and its supply chains, decision making, drivers and barriers, from a mixture of existing studies and informal interactions with the heat pump industry.

LIST OF PUBLICATIONS 2025

Hitchin, R. (2024). **Heat Pumps Revolutionizing Retrofits: Scaling Up Deployment with Innovative Solutions and Overcoming Barriers. Early-stage Guidance on Heat Pump Retrofit for Non-Domestic Buildings: Interim Results from HPT Project 60.** Heat Pumping Technologies Magazine, 42(3). DOI: 10.23697/xjt0-9197.

Project duration:
January 2022 – December 2025

Contact person:
Peter Mallaburn, UK Department of Energy Security and Net Zero. (For information, contact Oliver Sutton ***oliver.sutton@energysecurity.gov.uk***

Participating countries:
Austria, Canada, Italy, the Netherlands, the Republic of Ireland, Sweden, the United Kingdom

Website
https://heatpumpingtechnologies.org/project60/

Project

61

Heat Pumps in Positive Energy Districts

INTRODUCTION

The objectives of the Paris Agreement on climate protection, including the 1.5 °C target, may already be reached in the next few years. Thus, drastic greenhouse gas (GHG) emission reductions have to extend remaining GHG budgets. Globally, cities are responsible for ca. 60% of the GHG emissions and play a key role in climate protection in many countries. However, cities exhibit high complexity, while individual building considerations miss opportunities to leverage synergies among buildings. Thus, districts seem to be the right scale for an integral energy planning, which led to the concept of Positive Energy Districts (PED). PEDs are typically defined as energy-efficient and energy-flexible urban areas or groups of interconnected buildings that have no net GHG emissions and actively manage an annual local or regional surplus of renewable energy. The main functions of PEDs are energy efficiency, energy flexibility, and on-site energy generation to provide services to surrounding parts of the city.

> ***Heat pumps are already well established in existing PED, accelerating the urban energy transition towards sustainable and emission-free energy systems.***

Due to their unique features, heat pumps are seen as the future heating system and are well-suited for PED supply, since they exhibit the required high energy performance and can provide different building services of space heating, domestic hot water, and space cooling, even at the same time. Furthermore, they enable balancing thermal and electric loads in the district to enhance self-consumption and the use of waste heat. Heat pumps are already well established in existing "towards" PEDs, accelerating the urban energy transition towards sustainable, emission-free energy systems in cities.

Project 61 investigates heat pump applications in building clusters and districts for both new and retrofit districts on a technical, economic, and ecological basis. Thereby, the future necessary large-scale integration of heat pumps from the individual building to the district level is promoted. As a basis for the investigation, a state-of-the-art analysis of heat pumps in clusters of buildings and PEDs led to system concepts for heat pump integration, characterized with regard to their benefits and limitations. Starting with decentralized heat pumps at the individual building level, different integration options, up to a centralized heat pump heating/cooling system, are documented as generic concepts.

The concepts are also evaluated by monitoring in clusters and districts to characterize the actual performance of heat pump operation (see Figure 1). Many of the monitored systems are also investigated through techno-economic analysis using modelling and simulation in parallel. In this way, optimization potentials identified in monitoring and simulation can be implemented in the real system, while measurement data can be used to verify the modelling and simulation results. The monitoring systems are documented as best practice systems.

Results are used by building system technology designers, urban planners, and building companies to achieve ambitious energy targets in districts, as well as by utilities and ESCOs seeking 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 use evaluations to shape ambitious future energy targets.

OBJECTIVES

The objectives of Project 61 were

- 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)

Figure 1. Impressions of the monitored Papieri District in Cham, CH, with centralised heat pump system.
Source: Cham Immobilien AG

- Dissemination of interim and final results by workshops, articles, conference papers, and the final report (ongoing)

RESULTS

Results derived in 2025 are based on simulation and monitoring of existing building clusters and "towards" PED with heat pumps. As project 61 will be concluded by June 2026, results are currently documented and updated for the final reporting.

A state-of-the-art analysis of heat pumps in PED compiles the political framework, definitions, and Key Performance Indicators of PED, as elaborated across different projects, as well as labelling and certification schemes. A technology analysis of existing "towards" PEDs confirms that heat pumps are a dominant technology for achieving the required high performance and facilitating the propagation of PED.

Monitoring heat pump projects in high-performance building clusters or districts has been a focus of work in 2025. Monitoring results showed that performance does not always meet expectations, often due to system integration issues. Despite good heat pump performance, losses and expenses limit the system's performance.

Modelling and simulation are performed for many field-monitoring plants to conduct in-depth techno-economic evaluations of the heat pump system regarding design, control, and integration. By the simulations, a substantial performance increase could be verified, mainly due to the unfavourable system integration of the heat pump in the real district application, which causes unnecessary losses and a temperature increase, limiting the heat pump performance. Simulation results can be implemented to improve the real district performance.

A workflow for heat pump design and integration in PED has been derived from a generic system comparison of integration options from individual buildings to centralized district systems. Comparison of heat pump integration reveals that the best integration depends on local boundary conditions, but more decentralized heat pump integration tends to improve performance due to reduced system losses, lower auxiliary expenses, and lower temperature levels. Thus, more centralized integration must be thoroughly analysed to keep temperatures and losses at a minimum, which has a major impact on heat pump performance. Generally, the complexity of heat pump planning in districts increases due to various building services and temperature levels, which calls for simulation-based planning tools.

LIST OF PUBLICATIONS 2025

Wemhoener, C., Ochs, F., Breuss, S., Betzold, C., Bockelmann, F., & Zimmermann, J. (2025). **Heat pump integration in Positive Energy Districts: Simulation and monitoring results of IEA HPT Annex 61.** J. Phys.: Conf. Ser., 3140, 022011.

Ochs, F., Tosatto, A., Venturi, E., Breuss, S., Magni, M., Dermentzis, G., & Wemhoener, C. (2025). **Characteristic load curves of Positive Energy Districts.** Solar Energy Advances, 5, 100081.

Project duration:
September 2022 – June 2026

Contact person:
Project Manager is Carsten Wemhoener, OST – Eastern Switzerland University of Applied Sciences, Campus Rapperswil,
carsten.wemhoener@ost.ch

Participating countries:
Austria, Germany, Italy, Japan, Switzerland, USA

Website:
https://www.heatpumpingtechnologies.org/project61

Project 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 terms of technical implementation, heat pump systems in multi-family buildings face greater challenges than in single-family homes due to more complex administrative and technical hurdles. Different ownership structures and owners' interests 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.

Project 62 focuses on demonstrating that heat pumps can be implemented in multi-family buildings (MFB). For that purpose, a database is being created that includes case studies analysing lessons learned and demonstrating best practices. In addition, a "General Classification" is validated through case studies and is regularly discussed and adapted.

> *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 enables users to quickly identify potential heat pump solutions for specific buildings and environments. The results of Project 62 help address the complexity of heat pumps in MFB and communicate standardized solutions.

The picture on next page presents a unique ***case study*** from Geneva that clearly demonstrates the importance of communication and the work of the Project.

OBJECTIVES

Most of the objectives of the project have been fulfilled:

- The case study database has been significantly extended; the Project work started with roughly 40 case studies from Annex 50 and now includes more than 80 case studies in total.
- The case studies have been statistically evaluated with regard to the following parameters: heat sources, central vs. decentral solutions, and family members.
- The „matrix tool" has been extended, in particular by adding further descriptions of each general concept, with the aim of identifying and establishing standard solutions.
- The range of participating countries has been extended; Project 62 now includes 8 countries, including a non-European member (China).
- The "solution finder" tool has been further developed and specified (for example, regarding a potential app implementation) with the aim of creating an easy-to-use pre-planning tool that allows quick recognition of possible heat pump solutions for specific cases. The visualization and first results have been discussed, and it has been decided that the actual implementation will take place in the follow-up Project.

RESULTS

During Project 62, particular emphasis was placed on linking the theoretical classification of heat pump solutions with practical experience gained from real-world case studies while closely reflecting ongoing market developments. The steadily growing and increasingly diverse case study database revealed that some emerging solution types were not fully captured by the existing categories. As a result, the general classification was systematically reviewed and adjusted to better represent these new practical developments and ensure its ongoing relevance.

For instance, similar central–decentralized concepts within Family B were streamlined by merging overlapping solution types into broader, more comprehensive categories. Additionally, entirely new family types were introduced to accommodate documented projects that didn't fit prior structures – including innovative systems combining central low-temperature heat sources with decentralized temperature boosters, as well as approaches using shared central heat infrastructure with apartment-specific heat pumps.

Concrete examples from the database illustrate these adaptations: the Innsbruck hybrid retrofit project (AT002 Fennerstrasse) demonstrates a central rooftop heat pump paired with a 20°C distribution circuit and compact 3 kW mini heat pumps in each of 48 apartments, achieving an impressive SCOP of 4.0 at very low noise levels (38 dB). Similarly, the UK's GB003 Chadwell St Mary project (Kensa & Thurrock Council) features a shared ground loop feeding individual 3–6 kW apartment heat pumps for both heating (up to 65°C) and domestic hot water, with a COP of 3.8 per unit. The fully updated classification is shown in Figure 2.

The website now reflects these classification updates, demonstrating Project 62's flexible and proactive adaptation to rapidly evolving market trends and technological innovations. Given the continuing importance of the topic and dynamic market developments, participants recommended extending the Project to build further on these achievements, deepen international cooperation, and amplify its practical impact.

LIST OF PUBLICATIONS 2025

Miara, M. (2025). **Existing Building: Installation Solutions and User Experiences.** Presentation at Hamburg/Online.

Miara, M. (2025). **Implementation of heat pumps in multi-unit residential buildings: information for the housing sector.** Housing Industry Climate Summit 2025, Konstanz, February 20, 2025.

Miara, M. (2025). **Are the ambitious heat pump targets achievable?** 31st Conference of the BFE Research Programme Heat Pumps and Refrigeration, Bern, June 2025.

Figure 1: Picture of the MFB in St. Julien, Geneva, Switzerland heated by heat pumps.

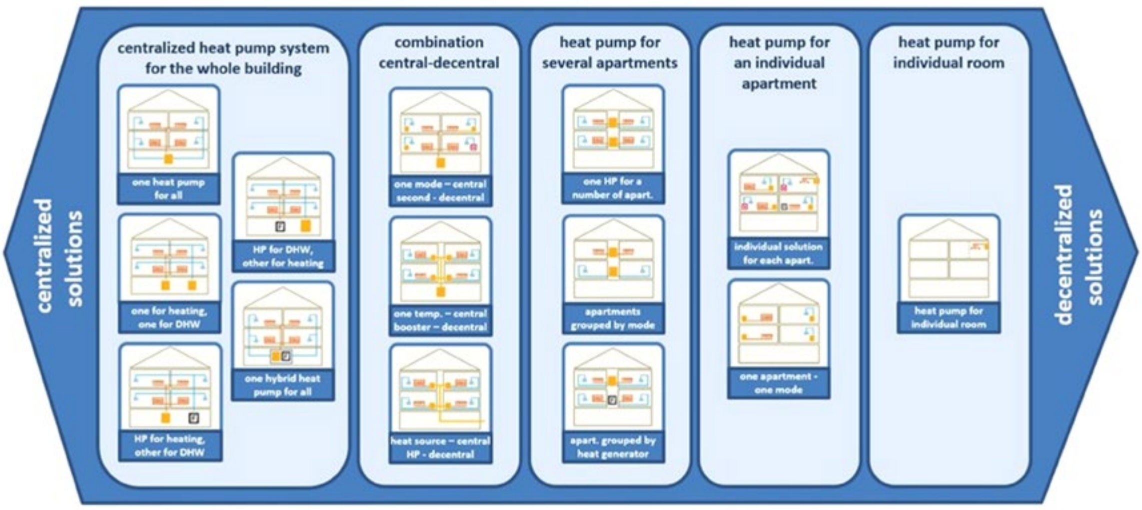


Figure 2: Updated General Classification

Project duration:
January 2023 – December 2025

Contact person:
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Participating countries:
Belgium, China, Germany, France, Italy, Spain, Sweden, Switzerland (USA, UK, Poland)

Project website:
https://heatpumpingtechnologies.org/project62/

Project 63

Placement Impact on Heat Pump Acoustics

INTRODUCTION

Project 63 “Placement Impact on Heat Pump Acoustics” has been set up as a follow-up to the finalized Project 51 (aka 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 final umbrella report, are available for download at the ***Project 51 website***.

The results have made their way into the development of standards. Within the framework of the Project 51, the psychoacoustic 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 Project 51 and in response to recent industry requests and demands, special fields of interest emerged that required international experience and collaboration to be addressed effectively.

Thus, the Project 63 enriches independent information and expertise on the benefits of heat pump technologies by focusing on acoustics. Noise emissions are a potential threat to the further spread of heat pumps in the years to come. Thus, advancing the acceptance of heat pumps by minimizing these adverse environmental impacts while maintaining high energy efficiency is of great importance and aligns with the vision of the Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP).

Project 63 has transitioned into its dissemination phase with papers on all 4 tasks submitted and accepted to the 15th IEA Heat Pump Conference scheduled in May 2026 in Vienna. A paper on the structure-borne noise of heat pumps and its impact on the resident will be presented by task 1, task 2 presents an open database on frequency-resolved acoustic directivity data to improve knowledge to assist in heat pump placement. The psychoacoustic study performed in the framework of task 3 will show a study on human response to the cumulative impact of air source heat pump noise, and finally, a web-based tool for visualizing sound propagation from air-to-water heat pumps using a map interface is presented by participants of task 4.

OBJECTIVES

Project 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 Project 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.The consortium comprised of 18 institutes from 8 different countries work on the following tasks:

- **Task 1:** Building Acoustics Impact of Heat Pumps
- **Task 2:** Urban Acoustics Impact of Heat Pumps
- **Task 3:** Psychoacoustics of Heat Pumps
- **Task 4:** Digitally Assisted Heat Pump Placement
- **Task 5:** 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, which will be internationalized during the course of the project.

RESULTS

In partnership with the Heat Pump Association, the University of Salford Acoustics Team studied the cumulative noise impact of multiple air source heat pumps installed close together in Nottinghamshire. Measurements showed wooden fences offer little low-frequency attenuation, with compressor tones more prominent at neighbouring properties and high-frequency tones stronger at the source property (see Figure 1). The team also presented machine-learning research on

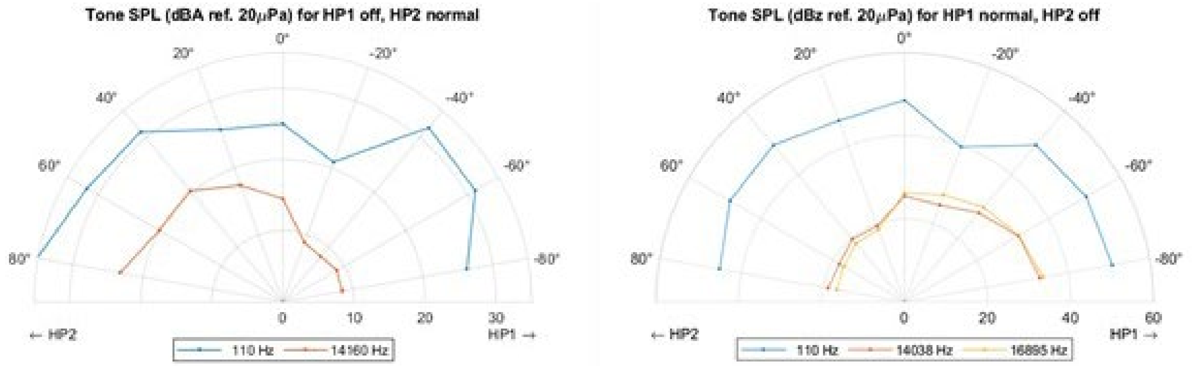

Figure 1: Directivity plots showing the A-weighted Sound Pressure Level (SPL) of tonal components at the frequencies of prominent tones across the microphone arc. Source: USAL

air-source heat pump noise annoyance at the Euronoise Forum Acusticum 2025 and was invited to publish in Acta Acustica.

In Germany, RWTH Aachen has finalized the national project "LowNoise - Integral consideration, optimization, and methodical evaluation of air-water heat pumps for the reduction of acoustic emissions."

As part of Task 3, "Psychoacoustics of Heat Pumps", a collaborative listening experiment is being conducted across ten sites in six countries. This study investigates the cumulative impact of multiple air source heat pumps. The preliminary findings are set to be presented at the 15th IEA Heat Pump Conference.

To reduce residents' uncertainty and concern regarding noise and to enable sound propagation assessments for residential heat pump planning, a web-based tool (see Figure 2) has been developed in task 4, "Digitally Assisted Heat Pump Placement". This tool builds upon a 2D version previously developed by the Danish partner DTI during Project 51, originally created for the Danish Energy Agency. The enhanced platform allows users to select different heat pump models, position them in real-world locations using geospatial data, and assess the resulting sound pressure levels and noise propagation in the surrounding environment (e.g., surface conditions, noise diffraction effects) through an interactive map interface. The tool will be presented during the 15th IEA Heat Pump Conference in Vienna.

Source: TU Graz, Austria

Figure 2: Result from enhanced web-based tool to enable sound propagation assessments for residential heat pump planning.

LIST OF PUBLICATIONS 2025

Acun, V., Graetzer, S., & Torija Martinez, A. J. (2025). **Machine learning-based prediction of air source heat pump noise annoyance.** Proceedings of Forum Acusticum Euronoise 2025, Malaga, Spain.

Barton, L., Hargreaves, J., Acun, V., Torija Martinez, A., Graetzer, S., Salter, K., & Waddington, D. (2025). **Noise Measurement of Two Air Source Heat Pumps in Close Proximity.** Proceedings of Forum Acusticum Euronoise 2025, Malaga, Spain.

Stürenburg, L., Lukas, A., & Fels, J. (2025). **Investigating the perception of a heat pump in different audio-visual settings.** Proceedings of DAS|DAGA 2025, Deutsche Gesellschaft für Akustik e.V. (DEGA), Berlin. Available at: ***https://pub.dega-akustik.de/DAS-DAGA_2025.***

Project duration:
Project duration: June 2023 – September 2026

Contact person:
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Website:
https://heatpumpingtechnologies.org/project63/

Project 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). As global warming accelerates, it is necessary to switch 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 have 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 CO2 and hydrocarbons, primarily propane. Both theoretical comparisons and experimental work have shown that hydrocarbons can deliver performance as good as, or better than, that of systems with synthetic refrigerants, but the safety issues related to flammability need to be taken seriously.

In this Project, we focus on several safety aspects when using flammable refrigerants. The work is divided into the following tasks:

- **Task 1:** Technical solutions for limiting risks;
- **Task 2:** Investigation of leakage scenarios;
- **Task 3:** Leakage detection;
- **Task 4:** Charge reduction;
- **Task 5:** Risk assessment; and
- **Task 6:** Dissemination.

The Project focuses on collaboration in high-quality research, resulting in scientific articles published in peer-reviewed journals or conference proceedings. The results should contribute to broader, safer use of flammable refrigerants. The year 2025 was the second active year of the Project. Since the first year, more flammable refrigerant products have been introduced on the market. Discussions on eliminating PFAS fluids have intensified, as authorities in Europe and elsewhere are about to introduce stricter legislation on PFAS.

> *The CFD simulations clearly show the importance of air circulation in the event of a propane leak, preventing stratification and high concentrations at the floor.*

OBJECTIVES

The objectives of the Project have not changed since the start, and can be expressed as follows

- 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

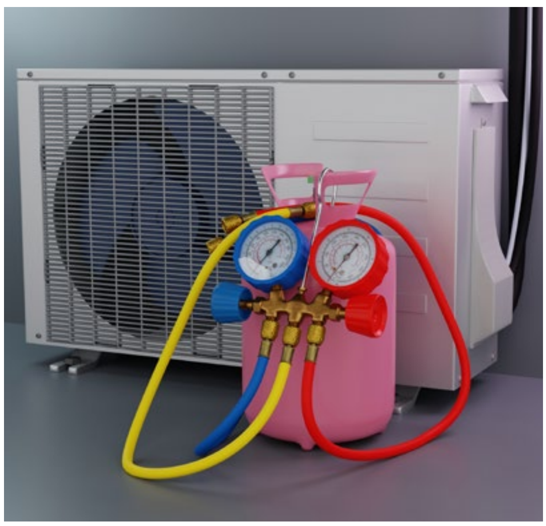

Figure 1: Refrigerant gas cylinder, pressure gauges and air conditioner outdoor unit.

RESULTS

In France, a Ph.D. thesis was defended by Maëlle Jounay on a new method of quantifying refrigerant charge in domestic heat pumps. Odile Cauret (supervisor) also worked on safety with flammable refrigerants in lab environments.

In Sweden, CFD modelling of leakage scenarios continued. The CFD simulations clearly show the importance of air circulation in the event of a propane leak, preventing stratification and high concentrations at the floor. This work was done in collaboration with the German partners, who used lab measurements to determine the spread of the refrigerant. The Swedish team also conducted tests on the leakage rates of propane from a simulated system, both in the liquid and vapor phases.

The German team also investigated leaking plate heat exchangers and how they were broken. The most common reason was freezing. They also looked at new methods for leak detection.

The Austrian team worked on several activities, and one finalized report focused on the legislation governing the design of systems containing flammable refrigerants in the EU and Austria.
The Korean team has been investigating the refrigerant charge in plate heat exchangers using IR photography.

Figure 2: Safety group classifications of common flammable refrigerants, ranging from A2L to A3, highlighting their respective flammability designations.

In the US, activities were focused on risk analysis and on charge reduction in small systems.
Most of the activities are work in progress and have not yet been reported in journal articles or conference proceedings. Several contributions are prepared for the 15th IEA Heat Pump Conference in Vienna, May 2026.

The Project has had six internal meetings in 2025. Each meeting has ended with a presentation by an invited speaker. The Project was presented at the XXI RACHP conference in Milan. We also had four presentations at the IEA Heat Pump Summit in Nuremberg.

One webinar was arranged to present the results from the Project. Most presentations are available on the Project website.

LIST OF PUBLICATIONS 2025

Jounay, M., Cauret, O., Teuillières, C., & Tran, C. T. (2025). **A novel on-board method for quantifying refrigerant charge in residential heat pumps.** International Journal of Refrigeration, 177, 263–272. DOI: 10.1016/j.ijrefrig.2025.06.008.

Palm, B., Esmaeelian, J., Nawaz, K., & Colbourne, D. (2025). **Modelling leaks of flammable refrigerants.** Heat Pumping Technologies Magazine, 1.

Project duration:
April 2023 – December 2026

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Website:
https://heatpumpingtechnologies.org/project64/legal-text/

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 (in progress)**
  Define and establish a framework for circularity in heat pumps. Develop definitions and explore frameworks for circular economy and material efficiency in heat pumps, providing the foundation for the project.
- **Task 2: Evaluating the state-of-the-art (in progress)**
  Review and collect information on national and international initiatives and practices related to material efficiency and circular economy in heat pumps.
- **Task 3: Identifying opportunities and barriers**
  Assess potential opportunities and obstacles for implementing circular practices, including dismantling, reusing, and improving material efficiency in heat pump design and lifecycle management.
- **Task 4: Developing guidelines for circularity**
  Create best-practice guidelines for design and dismantling processes to improve material efficiency and circularity in heat pumps.
- **Task 5: Disseminating findings**
  Ensure continuous dissemination of results and insights through tailored communication, workshops, and reports, ensuring stakeholders are informed as findings materialize.

RESULTS

Throughout 2025, Project 65 made significant strides in applying circular economy principles to the heat pump sector. The project's international collaboration expanded, with France and Belgium officially joining in September and October, respectively.

The year's primary achievement was the publication of two major reports. Published in March 2025, the ***Task 1 report*** established a foundational framework for circularity in the heat pump industry. It reviewed key standards (e.g., ISO

Picture from the physical workshop held on the 25th of November 2025, focusing on task 3 of Project 65.

59000, EN 4555X) and regulations (e.g., Ecodesign, REACH), concluding they require adaptation for heat pumps. The report also analysed lifecycle studies and industry case studies, identifying the key challenges and opportunities for designing more sustainable, circular products.

The Task 2 report, *Heat pumps in a circular economy,* was released in October. It analysed the industry's state of the art, shifting the focus from theory to practice. Key findings highlighted the viability of take-back and remanufacturing models, showcased digitalisation (e.g., Digital Product Passports) as a critical enabler for transparency, and detailed the rise of circular business models like "Heat-as-a-Service." An open deep-dive session on the 26th of June supported the report's findings with practical industry insights from Grundfos and Nibe.

Building on this, the project continues working on Task 3, which systematically identifies key potentials and barriers. This work is informed by a detailed "Component Overview" that maps materials to pinpoint circular opportunities, an analysis of end-of-life handling practices, and a stakeholder survey (still ongoing) that gathers firsthand data on industry challenges and drivers.
With this analytical foundation in place, initial work on **Task 4** began late in the year of 2025. This task will focus on creating actionable guidelines for circular design and dismantling, leveraging the insights gathered in 2025 to provide practical recommendations for the industry. The successful delivery of the Task 1 and 2 reports has established a robust evidence base, setting a clear trajectory for the project's final phase in 2026.

Project duration:
January 2024 – December 2026

Contact person:
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Participating countries:
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Website:
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Project 66

Optimal Heat Pump Design and Operation: An International Collection of Common Techniques to Accelerate Broader Acceptance

INTRODUCTION

Two main hindrances to the acceptance of heat pumps in residential applications have been initial equipment costs and retrofitting existing heating infrastructure. There is an urgent need for optimized components, design processes, and optimal system integration strategies to reduce 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 move all stakeholders forward. Furthermore, a common heat pump design concept, platform, and basis protocol would help reduce barriers to entry and increase the efficiency of resulting components and systems. A platform to share steady-state and transient data from laboratory and field measurements would significantly enhance designers' and modelers' ability to validate and refine their simulations, thereby accelerating and improving the quality of heat pump development.

The primary aim of this Project 66 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 are working to develop heat pumps. 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, as this heating capacity serves as a flexible upper limit for 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.

> ***Gathered perspectives were interpreted by researchers in the field and discussed with stakeholders from around the world.***

OBJECTIVES

The objectives of Project 66 are to:

- 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.

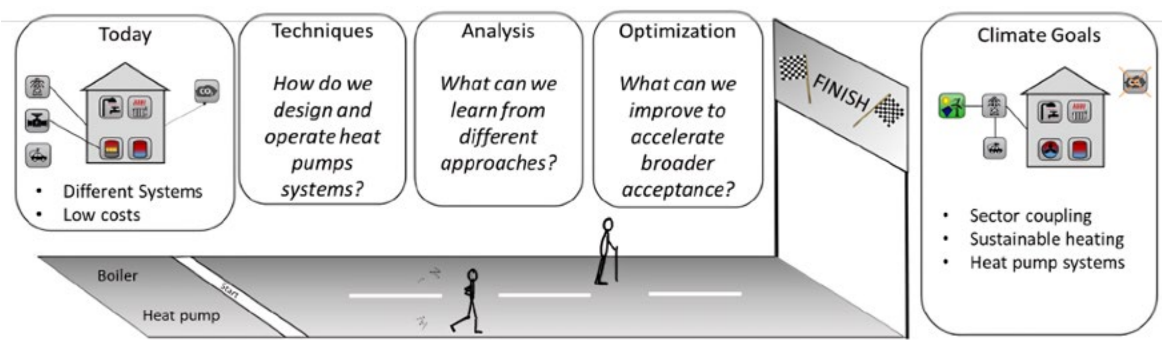

Figure 1: Project 66 Concept Overview.

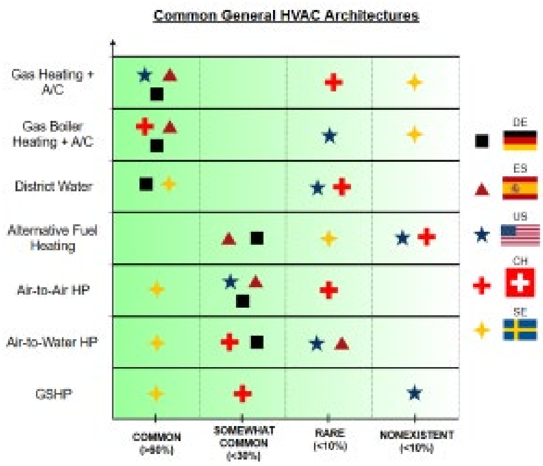

Figure 2: Heating and Cooling Architecture Prevalence by Region.

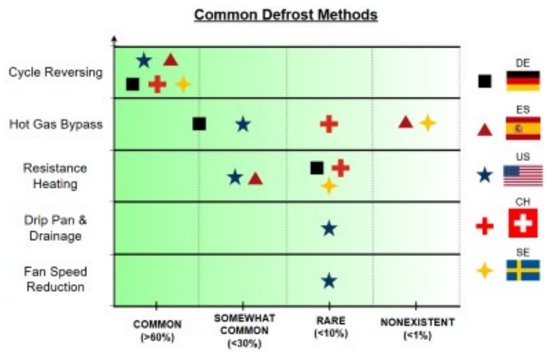

Figure 3: Defrost Strategy Prevalence by Region.

RESULTS

The progress in 2025 centered around tasks 1 and 2 – collecting state-of-the-art in heat pump design and control. These results were collected through surveys, semi-annual project meetings to clarify content, and a literature review, allowing various perspectives on heat pump design and control from a range of stakeholders to be collected and summarized. Ranging from sink temperatures and capacities to the prevalence of variable-speed scroll compressors in applications around the world, gathered perspectives were interpreted by researchers in the field and discussed with stakeholders worldwide to confirm understanding and identify nuances, thereby maximizing insights. Two examples of collected and interpreted results are common heating and cooling system architectures and various defrost methods, shown in Figures 2 and 3, respectively.

Furthermore, an online repository was developed to collect and distribute data and code from project stakeholders, thus laying the groundwork for tasks 3 and 4, in which data and open-source modelling tools will be collected and assessed, then distributed to all project stakeholders. A journal publication summarizing perspectives on heat pump design and control collected in tasks 1 and 2 is in preparation, as is an HPT Magazine article on laboratory infrastructure and testing methods for A3 refrigerants.

Project duration:
October 2024 – September 2027

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Project website:
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Project 67

Digital Services for Heat Pumps

INTRODUCTION

Heating and cooling account for a major share of global energy demand, and transforming this sector is essential for reaching climate and energy goals. As more countries commit to reducing carbon emissions, the need for efficient, flexible heating solutions grows. Heat pumps are key to the transition, but a rapid rollout poses challenges: systems must be well-designed, easy to install, reliably operated, and able to interact with an increasingly digital and dynamic energy system.

Digitalisation offers a strong solution. By integrating data-driven services, advanced modelling, smart controls, and automated diagnostics, heat pumps can operate more efficiently, adjust their consumption to the electricity supply, and reduce costs for users and grid operators. Digital services help manufacturers improve product quality, support installers with better planning and commissioning tools, and enable building owners to benefit from lower operating costs and fewer disruptions.

In the short run, the project will equip the heat pump value chain manufacturers, planners, installers, and operators with practical knowledge on digital methods already available or emerging. In the long run, wider adoption of digital services will improve reliability, reduce emissions, and support the large-scale integration of heat pumps required to meet climate targets. Policymakers, research institutions, and associations will also benefit, gaining insights into trends, research gaps, and best-practice applications.

> *“Heat pumps are key to the transition, but a rapid roll-out poses challenges. Digitalisation offers a strong solution.”*

The project builds on international collaboration and shared expertise. It collects knowledge, evaluates methods, synthesizes results, and communicates them to a broad audience. Rather than focusing on grid-level orchestration, the project concentrates on the heat pump itself, its components, life-cycle processes, and digital optimisation opportunities.

From a more technical perspective, the project evaluates digital tools such as semantic modelling for faster system representation, digital twins across the product life cycle, hardware-in-the-loop testing for realistic control validation, AR-assisted placement and maintenance, model-based control strategies, fault-tolerant control, and predictive maintenance strategies. Together, these approaches aim to unlock the full potential of digitally enhanced heat pump systems.

OBJECTIVES

The planned objectives for this project are to:

» Build a shared knowledge base on digital methods for heat pumps.

» Identify relevant digital services from research, national projects, and industry.

» Complete a public knowledge base with examples and implementation guidance.

» Analyse findings to derive development needs and research gaps.

» Provide recommendations for integrating digital services in design, installation, operation, and maintenance.

» Disseminate results via a website, reports, webinars, and collaboration across IEA TCPs, to strengthen understanding across the value chain to support large-scale heat pump deployment.

RESULTS

The design and structure of the knowledge base on the use of digital methods for heat pumps was further developed and refined during the reporting period. In this context, various approaches for presenting case studies on the project website were analyzed, drawing on best-practice examples from other HPT projects (e.g., Project 58) and leveraging the extended functionalities available on the newly updated HPT TCP homepage. Based on this review, the most suitable concepts and structural elements for Project 67 were identified and selected. These will serve as the foundation for the continued development of the knowledge base and the layout of the case study section.

A key aspect of the future homepage will be its comprehensive filtering options, enabling users to quickly navigate through a growing number of case studies. Stakeholders such as heat pump manufacturers, planners, installers, operators, heat pump associations and their members, as well as the research community, will be able to efficiently find information tailored to their specific interests. The filters are intended to ensure that the knowledge base not only collects information but also presents it in a meaningful, user-oriented, and easily accessible way.

In addition to the conceptual work on the knowledge base design, the relevant categories and data fields for digital services were defined. These elements will form the basis of a structured questionnaire to be completed by stakeholders. The questionnaire - covering aspects such as type and purpose of the digital service, target groups, rationale and added value, supported life cycle phases, and technology readiness level - will be tested with heat pump manufacturers in early 2026 to validate its usability and completeness.

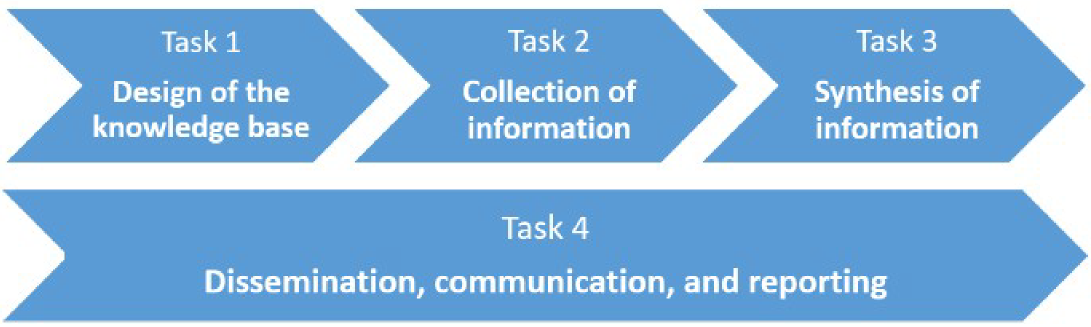

Figure 1: Overview of Project 67.

Project duration:
May 2025 – April 2028

Contact person:
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Participating countries:
Austria, Belgium, Denmark, Sweden

Website:
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Project 68

Industrial High-Temperature Heat Pumps

INTRODUCTION

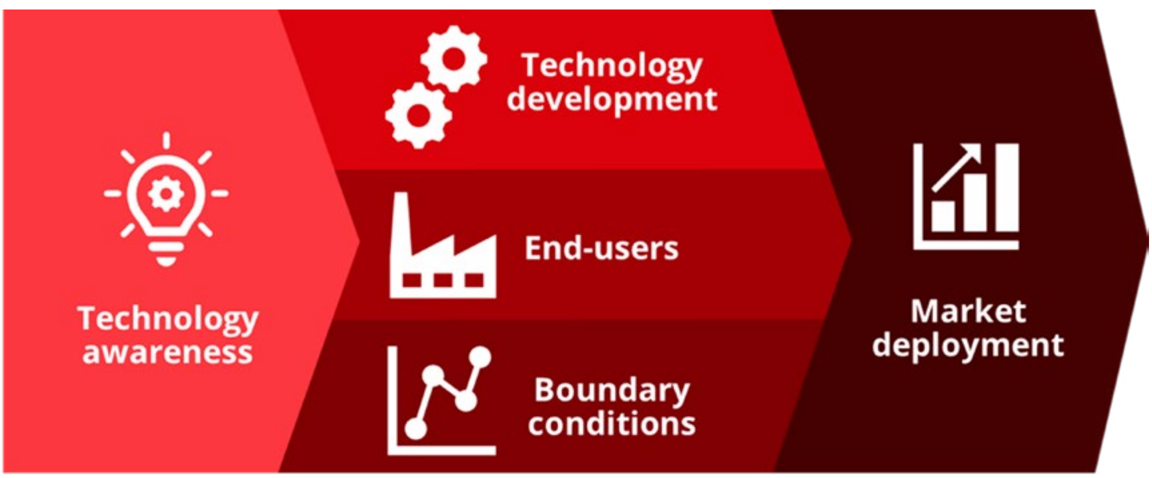
The decarbonization of industrial process heating is a top priority for industries as process heating accounts for a large share of their greenhouse gas emissions. High-temperature heat pumps (HTHP) are considered a key technology for decarbonizing the industrial process heat supply, but their deployment is still limited. The transition to a heat pump-based process heat supply requires a common understanding of the technology and a strategy for various stakeholders.

Three main developments are expected to be decisive for the development and to which extent the growth curve achieves the required numbers for exploiting the full potential: i) Technology developments, ii) End-user adoption and iii) Boundary conditions. These developments are mutually interdependent and may develop a self-reinforcing dynamic, and communication is key to unfold the full potentials.

Therefore, Project 68 aims to support the development of HTHPs by giving an overview of available and close-to-market technologies and demonstrations as generated within Task 1 of Annex 58 and build on the same structure. This database was found to be valuable information for a variety of stakeholders, and it is expected that it becomes even more important considering the rapidly growing market. Another goal is to establish sector collaborations to facilitate a dialogue between technology suppliers, end-users, sector organizations, R&D organizations, consultants and other stakeholders, ultimately leading to sector specific solutions, that are enabling a sector-wide rollout of HTHP technologies and developing education materials specifically for each group to facilitate the implementation of these concepts. The findings are disseminated to increase the awareness and understanding of various stakeholders, such as manufacturers, consultants, end-users, R&D institutes and policy makers.

OBJECTIVES

- Provide a regularly updated overview of available and close-to-market technologies for high-temperature heat pumps and realized demonstration cases of high-temperature heat pumps.
- Facilitate the knowledge exchange between solution providers and end-users to develop sector-specific solution concepts and increase the awareness for these solutions in the selected sectors.
- Develop and provide education materials to support the education in academia and industries.
- Disseminate the gathered information to create a common understanding at a variety of stakeholders



RESULTS

The year 2025 was pivotal for HTHPs, marked by technological advancements and increased deployment. However, collaboration among technology providers, end-users, policymakers, and R&D organizations is still essential to overcome challenges and fully realize their potential. Project 68 played a key role by gathering and sharing the latest insights, culminating in a large expansion of the HTHP database with 55 technologies and above 40 demonstration cases described together with a report analysis the biggest trends. The analysis showed on increase in HTHP technologies using natural refrigerants while systems able to run of HFO's or naturals also became more common. See figure 2

> ***The HTHP technology is slowly, but surely translating into commercial roll outs – especially below supply temperatures of 130 °C.***

Looking at the demonstration cases of HTHPs, the food and beverages sector, the pulp and paper sector, and building material drying dominate the picture, with almost half of the cases falling into these categories. District heating networks operating at high temperatures and chemical processes still constitute a good portion of the collected cases, while new sectors for HTHP applications are turning up, such as steel manufacturing and wastewater treatment.

The collected data show that new demonstration cases use primarily synthetic working fluids and water as working fluids, with only few hydrocarbon systems commissioned or planned. This is in contrast with the collected data on technology suppliers, where few synthetic working fluid-based technologies are reported and a significant growth in hydrocarbon systems is observed.

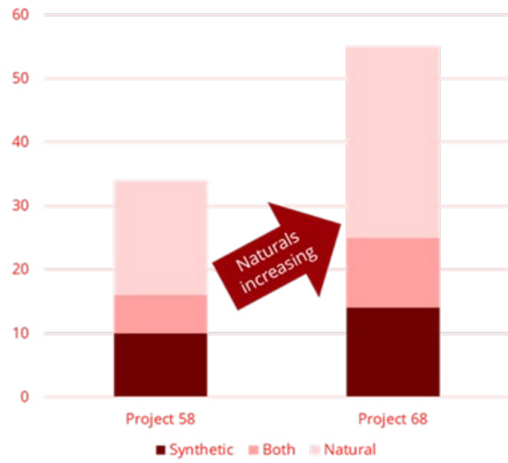


Figure 1: Number of HTHP suppliers with systems designed for natural refrigerants, synthetic refrigerants, or both, in Project 58 and 68.

In terms of the compressor type, piston and centrifugal compressors are found to be the most used for the newly collected demonstration projects. Looking ahead, the HTHP technology is slowly, but surely translating into commercial roll outs – especially below supply temperatures of 130 °C. Below 160 °C, technologies are increasingly available commercially and are being deployed at scale – multiple suppliers are delivering installations that validate performance, uptime, and O&M at hundred kilowatt to multi megawatt sizes. This consolidation at 100 °C to 160 °C is what Project 58 anticipated as a major facilitator for mainstream adoption of HTHPs. At the same time, the frontier is moving upward in both temperature and scale.

LIST OF PUBLICATIONS 2025

Zühlsdorf, B., Andersen, M. P., Tammone, C. et.al. **Industrial High-Temperature Heat Pumps. Task 1 – Technologies. Yearly Report 2025.** IEA Heat Pump Centre. https://doi.org/10.23697/9b7b-sz34, 2025

Andersen, M.P, **Accelerating Industrial Decarbonisation with High- Temperature Heat Pumps,** European heat pump summit, Nürnberg, 2025

Project duration:
June 2025 – May 2028

Contact person:

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Participating countries:
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website:
https://heatpumpingtechnologies.org/project68/

Outlook into the Future

In 2026 HPT TCP will continue the implementation of the strategic work plan for 2023–2028 (*see page 9*). However, since this plan was developed and adopted, the surrounding world has changes to some extent. There has been many changes on a global level, regarding the geopolitical situation, policies, economy, technological development and impact of global warming, which might have on impact on the relevance of different aspects of the strategic work plan. Therefore, a mid-term evaluation of the plan will be performed in order to investigate and discuss among the delegates priorities during the last years of the strategy period.

Since the 15th IEA Heat Pump Conference will be held during the year, much of the work within the Heat Pump Centre as well as the whole TCP will be related to the conference – promotion, planning, organizing and reporting from the conference.

The HPT TCP plans to continue to take an active role in the established TCP Coordination Groups (CG) within IEA, especially in the one on Heat Pumps, which will continue its work during 2026, with focus on the work related to developing and implementing an internationally harmonized taxonomy for heat pump data. The work in the CG on Thermal Networks and Energy System Flexibility was finalized during 2025, however, discussions on continuations are ongoing and HPT TCP will take part of this since the areas are of high relevance for the TCP.

Representatives from the Heat Pump Centre will also continue to follow and contribute to the work of the ***Heat Pump Accelerator Platform***, a platform financed by the European Commission with the objective to identify barriers to the deployment of heat pumps across the EU, and suggest targeted policy measures to address them which was initiated in the beginning of 2025.

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 projects under different stages of development in red.

RDD&D* Priority Areas 2023 – 2028

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.)
• Project 61: Heat Pumps in Positive Energy Districts • Project 67: Digital Services for Heat Pumps NEW • Project 70: Flexibility from Large-Scale and Aggregated Heat Pump Systems NEW • Heat Pumps for Hydrogen and Carbon Capture • Comfort Cooling Concepts for Different Types of Climates	• Project 63: Placement Impact on Heat Pump Acoustics • Project 65: Heat Pumps in a Circular Economy • Project 66: Optimal Heat Pump Design and Operation for Broader Acceptance • Project 69: Enhanced Miniaturized Components NEW • New or Alternative Business Models for Heat Pumps	• Project 59: Heat Pumps for Drying • Project 60: Retrofit Heat Pump in Larger Non-domestic Buildings • Project 62: Heat Pumps in residential multifamily buildings in cities • Project 68: Industrial High Temperature Heat Pumps NEW • Heat Pumps in Action! Operating Heat Pumps in Multi-Family Residential Buildings	• Project 64: Safety Measures on Flammable Refrigerants • Monitoring of Advanced Vapor-Compression and non-Vapour-Compression Technologies for Heating, Cooling and Refrigeration

* Research, Development, Demonstration and Deployment

Recently finalized, Ongoing, Proposals under discussion

It is well known that IEA foresee that the demand for comfort cooling will increase extensively during the coming decades, primarily in emerging countries, but also colder regions see an increased demand for cooling during parts of the year. Without further action to address equipment and buildings' performance, energy consumption for space cooling is foreseen to almost triple by 2050. Heat pumping technologies will be needed to provide much of the requested comfort cooling, and HPT TCP should, therefore, increase their activities in the field. Since the tradition of the TCP to work in this field is weaker (compared to the field of heating), dedicated efforts will be needed to initiate more projects within the field. More projects in the field of comfort cooling would make the HPT TCP attractive for new member countries with warm/hot climates.

During 2026, extra efforts will be made to initiate a new international collaboration project around cooling and refrigeration within HPT TCP. One of the activities is to organize a workshop about comfort cooling concepts for different types of climates at the 15th IEA Heat Pump Conference.

In the beginning of 2026 two new projects were started. One is Project 69 *Enhanced Miniaturized Components*. The background of this project is that today a large share of private homes in temperate zones are heated by fossil fuels. For warmer climates a large increase of the use of air conditioning units is expected. In order to phase out fossil fuel and be able to meet the growing demand for comfort cooling, a large number of heat pumps and air conditioning units are foreseen to be deployed. The aim of the project is to gain new knowledge that supports the development of new enhanced miniaturized components and systems for heat pumping technologies. This knowledge will allow components for heat pumps, air conditioning units and refrigeration equipment to be produced with reduced cost, lower environmental impact and will also reduce the risks related to flammability, since smaller components enable use of less refrigerant with maintained or improved functionality and efficiency.

The other one is Project 70 *Flexibility from Large-Scale and Aggregated Heat Pump Systems*. Heat pumps play a pivotal role in integrating renewable energy sources into the heating and cooling sector, as the main economically viable and clean alternative to fossil fuels (next to thermal networks fed by residual heat). Heat pumps also have the potential to address the critical need for flexibility in power systems, district energy systems and large industrial facilities. From the electrical perspective, the inherent intermittency of renewable energy sources, such as wind and solar power, necessitates adaptable energy-using systems capable of balancing supply and demand. Heat pumps, with advanced control methods, can dynamically adjust their operation based on the availability of renewable energy and/or boundary conditions that influence their performance, effectively acting as a demand response resource. This adaptability not only helps in stabilizing the grid but also in optimizing the efficient use of green energy for heating and cooling purposes. 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 towards 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. Flexibility from large heat pumps in thermal grids and industry as well as from the aggregation of large pools of decentralized heat pumps, when these are operated in a coordinated manner are within the scope of this project.

Another 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_2, 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 titled *Heat Pumps in Action! Operating Heat Pumps in Multi-Family Residential Buildings* – a follow-up on Project 62 is under development. Moreover, the TCP is investing the possibilities to start a new project on *Monitoring of Advanced Vapor-Compression and non-Vapour-Compression Technologies for Heating, Cooling and Refrigeration* and on *New or Alternative Business Models for Heat Pumps.*

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