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Heat Pumping Technologies MAGAZINE

A HEAT PUMP CENTRE PRODUCT

DECARBONISATION THROUGH INNOVATION

Highlights from the 15th IEA Heat Pump Conference in Vienna

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In this Issue

Welcome to the second issue of Heat Pumping Technologies Magazine for 2026, devoted in full to the 15th IEA Heat Pump Conference, held at the Hofburg in Vienna from 26 to 29 May 2026. With 812 participants, 367 scientific contributions, 78 chaired sessions, ten workshops and three policy forums, the Vienna conference was the largest in the history of the series. This issue is our attempt to distil four dense days into something you can read in one sitting. All papers from the 15th IEA Heat Pump Conference are available from the HPT TCP database: https://heatpumpingtechnologies.org/publications

The Foreword sets the scene, looking back at what the conference revealed about the state of heat pumping technologies and about the direction the field is taking. It draws out a shift that ran through the whole programme: the central questions are moving away from whether the technology can deliver and towards how it is integrated, operated, financed and regulated.

Under Heat Pumping Technologies News, we report on the five recipients of the Peter Ritter von Rittinger International Heat Pump Award 2026, presented during the conference dinner. Graeme G. Maidment, Thomas Nowak, Renato Lazzarin, Björn Palm and Choyu Watanabe, among them, represent several decades of work across research, industry, standardization and policy on four continents.

The report from the conference itself opens with the plenary opening session, where keynotes from the IEA, IIR, UNIDO, Wien Energie, the Heat Pump and Thermal Storage Technology Center of Japan and the Rocky Mountain Institute framed heat pumps as a matter of energy security and affordability as much as of climate policy. A summary report from the policy forums and workshops follows, covering circularity, multi-family buildings, positive energy districts, residential system design and the industrial deployment of high-temperature heat pumps.

The paper and pitch awards recognise three contributions selected through the conference review process, on frost formation measurement, borehole design uncertainty and hydrocarbon high-temperature heat pumps.

The Report from Selected Technical Sessions is the longest part of this issue. It is organised around the six key areas of research that shaped the Vienna programme: 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; and standards, certification and quality assurance. Each report draws on the papers presented in Vienna and attempts to identify not only what was shown but what it collectively means.

Finally, the Closing Ceremony section reports the conference in numbers and announces the destination for 2029.

Enjoy your reading!

Dr Metkel Yebiyo, Editor

Heat Pump Centre
The central communication activity of the Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)

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Foreword

The 15th IEA Heat Pump Conference in Vienna

By Thomas Fleckl, Chair of the National Organising Committee of the 15th IEA Heat Pump Conference and Head of Competence Unit "Sustainable Thermal Energy Systems" at AIT, Austrian Institute of Technology GmbH

The 15th IEA Heat Pump Conference brought 812 participants to the Hofburg in Vienna at the end of May, for four days of presentations, workshops, policy forums and the kind of corridor conversation that no programme can schedule. It was the largest conference in the forty-odd year history of the series, with 367 scientific contributions selected from a review process in which 317 reviewers completed 2,943 reviews. The scale itself says something about where the field now sits.
Three years ago in Chicago, the message was that heat pumps had finally arrived in the policy conversation. Vienna showed what happens next. The questions that dominated the sessions were not whether heat pumps can decarbonise heating, but how they are integrated into processes and networks that were designed around something else, how they are operated once installed, how their performance is verified, and how markets and regulation can be arranged so that the technology is deployed at the pace the climate targets require.

That shift was clearest in industry. High-temperature heat pumps have moved out of the laboratory. Papers and workshop discussions in Vienna described multi-megawatt installations in pulp and paper, steel, chemicals, ceramics and food processing, producing steam at temperatures and pressures that were until recently the exclusive territory of fossil boilers. The recurring lesson from those projects was not thermodynamic. It was that integration is harder, slower and more expensive than expected, that reliable process data is often missing, and that existing distribution systems are rarely ready to accept a heat pump without adaptation. The question has changed from whether the equipment exists to how it is successfully installed and run.
A similar maturing was visible in buildings and networks. Large heat pumps in district heating are now the subject of measured commissioning experience rather than feasibility studies. Work on positive energy districts showed that how a heat pump is integrated, centrally or decentrally, can matter as much for seasonal performance as the unit itself. The existing building stock, and multi-family housing in particular, remains the hardest problem in the field, and the workshop devoted to it made clear that the obstacles are as much about ownership, cost sensitivity, noise and space as about technology.

Digitalisation cut across everything. Machine learning, virtual sensors and physics-informed models appeared in sessions on fault detection, commissioning, control and fleet monitoring. What was

striking was the emphasis on the unglamorous foundations: data quality, standardised product information, labelled fault data, and test methods that reflect how equipment actually behaves rather than how it performs at a steady-state rating point.

The three policy forums, on global supply chains, on favourable energy policies and on innovation policy, added a dimension that a technical conference does not always capture. Their shared conclusion was that the barriers to deployment are mostly not technical. They lie in the price relationship between electricity and fossil fuels, in the stability of support schemes, in consumer trust, in access to finance and in the availability of skilled installers.

None of this diminishes the technology. It reflects a field that has won the argument about principle and is now doing the considerably harder work of delivery. That work is exactly what the international collaboration within the HPT TCP exists to support, and the number of project workshops in Vienna, several of them standing room only, suggests the appetite for it is strong.

My thanks go to the National and International Organising Committees, to the Scientific Committee and the Scientific Advisors, to the partners and sponsors, to the reviewers, to the session chairs, and to everyone who travelled to Vienna to share their work. The 16th IEA Heat Pump Conference will be held in Copenhagen in 2029. We look forward to seeing you there.

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Peter Ritter von Rittinger International Heat Pump Award

Five Awardees of the Peter Ritter von Rittinger International Heat Pump Award 2026

During the conference dinner at the 15th IEA Heat Pump Conference in Vienna, Austria, five distinguished professionals were presented with the Peter Ritter von Rittinger International Heat Pump Award 2026, the highest international honour in the heat pump, air conditioning and refrigeration sector.

The 2026 awardees are Prof. Graeme G. Maidment, London South Bank University; Thomas Nowak, Vice President Government Relations and Public Affairs, Qvantum International; Prof. Renato Lazzarin, Emeritus Professor at the University of Padua, Italy; Prof. Björn Palm, KTH Royal Institute of Technology, Sweden; and Dr. Choyu Watanabe, Executive Officer, Zeneral Heatpump Industry Co., Ltd. and Nagoya University.

The award recognises outstanding contributions to international collaboration in research, policy, market development and applications of energy-efficient heat

pumping technologies that strengthen energy resilience and deliver environmental benefits. Presented every three years in connection with the International IEA Heat Pump Conference, it was handed over by Stephan Renz, Chair of the Executive Committee of the Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP) under the International Energy Agency.

"It is my great pleasure to recognize these dignified nominees and honour them with the most prestigious prize in the field of heat pumping technologies," said Mr. Stephan Renz during the ceremony. "Our award winners are undoubtedly some of the most influential individuals in the history of HPT TCP by IEA."

Prof. Graeme G. Maidment, London South Bank University

Graeme Maidment has made internationally recognised contributions to heat pumping technologies over four decades. His career began as an apprentice at J&E Hall in 1983 and has since spanned academic, industrial and governmental leadership. He is Professor of Heating and Cooling at London South Bank University and holds an advisory role at the UK Department for Energy Security and Net Zero, helping shape national decarbonisation strategy. He co-leads the global Mission Innovation Affordable Heating and Cooling initiative and is a key figure in the UNEP-led Cool Coalition.

Maidment has led or co-led more than 40 major research and demonstration projects worth over GBP 15 million, advancing heat pump applications from supermarkets and data centres to rail infrastructure and district heating. His work on fifth-generation ambient-loop district heating and cooling, exemplified by the GreenSCIES project in London, has become a global reference for smart, low-temperature heat networks. His work on recovering waste heat from the London Underground earned the Rail Business Award and has been cited in UK Research Excellence Framework impact case studies. With more than 100 peer-reviewed publications, he has served as President of the Institute of Refrigeration, and his awards include the J&E Hall Gold Medal and the RAC Journal Gold Award. Prof. Graeme G. Maidment was awarded for great contributions in technology advancement and administration.

Thomas Nowak, Qvantum International

Thomas Nowak, Vice President Government Relations and Public Affairs at Qvantum International and former Secretary-General of the European Heat Pump Association, spent 17 years as the driving force behind EHPA, the voice of the European heat pump sector in Brussels. Under his leadership the association grew from a one-person organisation to a team of nearly 25 staff and more than 200 member organisations.

During this period European heat pump sales grew from 500,000 units annually to 3 million, with heat pumps now providing clean heating and cooling to nearly 16 percent of Europe's buildings. Nowak connected the sector to policymakers at European and international levels through advocacy, communications and certification work, establishing heat pumps as critical to decarbonising buildings and industry and to securing Europe's energy independence. Tomas Nowak was awarded for great contribution in market development.

Prof. Renato Lazzarin, University of Padua

Renato Lazzarin has built a career spanning some 40 years of pioneering research in heat pumping technologies. Holding degrees in Mechanical Engineering and in Statistical and Economic Sciences, he was Full Professor of Applied Physics and Thermodynamics at Padua from 1986 until attaining Emeritus status in 2022. His publication record exceeds 400 works in international and national journals and conference proceedings, alongside 18 books on heat pumps, energy conservation, renewable energy and air conditioning.

His early research in solar-assisted heat pumps and in open and closed cycle absorption systems produced papers now regarded as pioneering in the field. He subsequently developed multi-source heat pump systems, dual-source configurations and the integration of phase change materials in solar heating and cooling. He served as Chair of IIR Commission E1 on Air

Conditioning from 2011 to 2019 and has been President of IIR Section E since 2019. He organised major international conferences, including the IIR International Sorption Heat Pump Conference in Padua in 2011, and was President of the Italian Association of Air Conditioning, Heating and Refrigeration from 2008 to 2010. Prof. Renato Lazzarin was awarded for great contributions in technology advancement.

Prof. Björn Palm, KTH Royal Institute of Technology

Björn Palm brings more than 40 years of scientific research in applied thermodynamics, heat transfer, refrigeration and heat pumping technologies. He has published over 200 scientific papers, peer-reviewed conference papers and scientific reports, generating approximately 9,000 citations, and has supervised more than 30 PhD and Teknologie Licentiate graduates, most of whom now work as refrigeration and heat pumping experts in industry and academia worldwide.

Palm served as Head of the Division of Applied Thermodynamics and Refrigeration at KTH for 24 years, retiring from that role in 2023, and as Head of the Department of Energy Technology from 2011 to 2017. His research on heat pumping systems for heating and cooling, natural refrigerants, heat transfer in boiling and condensation, microchannel heat exchangers and nanofluids has been carried out in close collaboration with industry partners, primarily Swedish companies in the heating, cooling and telecom sectors. He received the ASME Outstanding Researcher Award in 2011 and the IIR Science and Technology Medal in 2023. Prof. Björn Palm was awarded for great contribution in **technology advancement.**

Dr. Choyu Watanabe, Zeneral Heatpump Industry Co., Ltd. and Nagoya University

Choyu Watanabe, Executive Officer at Zeneral Heatpump Industry and Visiting Professor at Nagoya University, has conducted research and development across the full spectrum of Japanese heat pump technology, from cryogenic refrigeration to high-temperature industrial heat pumps, and has played a significant role in introducing these technologies to the international community.

His technical contributions include CO2 supercritical high-temperature hot water production heat pumps reaching 90 degrees Celsius, 165 degree Celsius steam-generating heat pumps developed at the Central Research Institute of Electric Power Industry, and heat pumps for simultaneous cooling and heating in cutting and cleaning processes. He participated as a key member of IEA HPT TCP Annex 35 on Applications of Industrial Heat Pumps and Annex 48 on Industrial Heat Pumps, Second Phase, presenting Japan's advanced technologies to experts across Europe and North America. He served as Vice Chair of the Advisory Committee of the 24th IIR International Congress of Refrigeration in Yokohama in 2015. Watanabe holds US, European and Japanese patents and has received multiple awards from the Japan Society of Mechanical Engineers, the Japan Society of Refrigerating and Air-Conditioning Engineers, and the Japan Society of Heat Transfer. was awarded for great contributions in technology advancement and applications.

About the Peter Ritter von Rittinger International Heat Pump Award

The Rittinger Award is named after Peter Ritter von Rittinger, the Austrian engineer who designed and installed the first known heat pump in 1855. The award celebrates the technical skills and entrepreneurial spirit of Rittinger that is shared by the award winners.

Source: Based on the Heat Pump Centre press release, May 2026. For further information on the Peter Ritter von Rittinger International Heat Pump Award, contact the Heat Pump Centre at hpc@heatpumpcentre.org, or see https://heatpumpingtechnologies.org

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Opening of the 15th IEA Heat Pump Conference in Vienna

Caroline Haglund Stignor, Heat Pump Centre

The 15th IEA Heat Pump Conference opened on 26 May in the historic surroundings of the Vienna Hofburg, welcoming more than 800 attendees from around the world. The plenary opening session set the scene for a programme of 367 scientific contributions with a series of keynote presentations on policy, technology and industrial transformation.

Thomas Fleckl of AIT, the Austrian Institute of Technology and Chair of the National Organising Committee, welcomed the audience together with the Scientific Director of AIT, Andreas Kugi. Welcoming remarks followed from Peter Hanke, Federal Minister of Innovation, Mobility and Infrastructure of Austria, and from Jürgen Czernohorszky, Executive Councillor for Climate, Environment, Democracy and Human Resources for the City of Vienna.

Heat pumps, energy security and affordability

Mary Burce Warlick, Deputy Executive Director of the IEA, spoke on the role of heat pump technologies in reaching governments' policy priorities. She pointed to how important heat pumping technologies have become for energy security and affordability, and for shielding consumers and industries from price shocks, particularly during periods of uncertainty. The installed heat pump stock already reduces gas demand in Europe by an amount comparable to the output of the largest LNG terminal in the European Union.

The technology is mature and has been in use for more than a century, she noted, but innovation must continue. The Kigali Amendment is driving the transition to new refrigerants; smart features need further development for optimisation and flexibility, industrial heat pumps are needed at still higher temperatures, and in district heating, heat pumps are a key technology for the future, for example, large units recovering waste heat from data centres. She emphasised the role of the HPT TCP in ensuring competence and in generating and exchanging knowledge.

Stephan Renz, Chairman of the IEA Technology Collaboration Programme on Heat Pumping Technologies, gave his opening remarks on the theme Heat Pumping Technologies: Driving Transition Through Innovation, and described the activities under way within the collaboration programme. Sophie Hosatte-Ducassy, Chair of the International Organising

Committee, closed the first part of the opening session, expressing her gratitude to the organising committees.

Energy and climate policy keynotes

Yosr Allouche, Director General of the International Institute of Refrigeration, spoke on the global cooling and heating transition, its challenges and its innovations. Among the points she raised were the possibilities offered by the properties of low-GWP refrigerants. Flammability, she argued, should not be confused with safety: what matters is proper application, installation, standards and qualified workers. In many parts of the world, a reduced use of R410A can be observed, while the use of R32 and R290 is increasing.

Riccardo Savigliano, Chief of the Energy Systems and Industrial Decarbonization Unit at the United Nations Industrial Development Organization, addressed why heat pumps matter for energy security, resilience, decarbonisation and electrification in developing countries and emerging markets. He concluded that heat pumps are key to decarbonising many thermal energy applications, in industry as well as in stand-alone and district heating and cooling systems. The priority, he said, is to create the enabling conditions for proper adoption and scale-up, including localisation of the heat pump supply chain. He also recommended that the heat pump

community work alongside the solar thermal and wider renewable energy communities, since together they can reach markets that none can access as effectively alone.

Technology and industry transformation keynotes

Karl Gruber, Managing Director at Wien Energie, spoke on the role of heat pumps in the decarbonisation of Vienna. He described the vision of decarbonising the Vienna district heating grid by 2040 and the part heat pumps will play in it. Electrification of the heating sector is important, he argued, but so is changing how the electricity itself is produced. Vienna plans to expand wind generation and to phase out gas-fired combined heat and power. By 2040, the plan is for deep geothermal energy and heat pumps together to cover 55 percent of the heat supply, with the remainder from waste incineration and biomass, much of it already implemented.

Mitsunobu Nakajo, Director at the Heat Pump and Thermal Storage Technology Center of Japan, presented the potential of industrial heat pumps with case studies from Japan. He showed results mapping how much of the heating demand in different sectors, among them the food and automotive industries, could be covered by heat pumps, and described cases where separate boilers and liquid coolers had been replaced by combined heat pump and chiller systems, with significant energy savings as a result.

In the final presentation, Rushad Nanavatty, Managing Director at the Rocky Mountain Institute, described heat pumps as the quiet engine of the energy transition. His closing points were that no technology is more important, that between 55 and 65 percent of useful energy is addressable by heat pumps, that heat pumps are the biggest efficiency multiplier available, returning three to six times the energy put in, and that heat pumps are a flexibility resource, with heat pump networks amounting to distributed power plants in the making. He concluded by calling heat pumps the silver bullet of the energy transition, setting the tone for the three days of knowledge sharing that followed.

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Summary Report from the Workshops

Ten workshops were organised around the 15th IEA Heat Pump Conference, most of them by the project managers of the international collaboration projects within the HPT TCP. This section summarises the workshops for which reports were submitted, covering circularity, multi-family buildings, positive energy districts, residential system design, the industrial deployment of high-temperature heat pumps, comfort cooling, and how to break barriers to accelerate heat pump deployment.

Circularity in Heat Pumps: Challenges, Chances, Change

Organiser: IEA HPT Project 65, report contributed by Virginia Natonek, Danish Technological Institute

This workshop explored how circular economy principles can be applied to heat pumps and their components. Participants assessed the technical and economic viability of different circular strategies for compressors, heat exchangers, pipes, fans, casings and insulation, inverters and power electronics, and for heat pumps as complete units. The full set of circular R-strategies was used as a framework, from Refuse and Rethink through to Recycle and Recover. In practice, the discussion focused on Reduce through Recycle, as these were seen as most relevant for heat pumps.

Across most components, reducing material use and recycling were viewed as the most promising strategies. Recycling was considered particularly economically viable for pipes, while repair and refurbishment showed strong potential for fans, heat exchangers and complete systems. Repurposing was generally judged the least feasible strategy. Significant differences between components emerged. Compressors were considered difficult to reuse

and refurbish because of their hermetic design, precision manufacturing and testing requirements. Heat exchangers showed greater potential for repair, refurbishment and recycling, although the main barriers were identified as economic rather than technical. Power electronics presented a less clear-cut case, with opportunities for repair and remanufacturing but varied assessments because of technical uncertainty and concerns about economic viability. Casings and insulation were seen as particularly suitable for reduction, reuse and recycling, although wider reuse would require changes to product design and manufacturing. Fans stood out for repair and refurbishment potential.

The workshop highlighted heat pump refurbishment as a largely unexplored area. Open questions included the cost of refurbishing a unit, which components most often determine its end of life, the reliability of second-hand equipment, and whether manufacturers could develop viable refurbishment business models. Electronics may increasingly become the limiting factor for heat pump lifetime. Participants stressed the need for reverse logistics, transparent information on materials and substances, and design approaches that support dismantling and high-quality recycling. Digital product passports, producer responsibility, take-back systems and clearer allocation of collection and recycling costs were identified as possible enablers.

The main takeaway was that technology is often not the primary barrier to circularity in heat pumps. Progress will depend on viable business cases, economies of scale, supportive regulation and the integration of circular economy requirements from the earliest design stages.

More information about the slides shown at the workshop is available here.

From Theory to Practice: Heat Pump Solutions for Multi-Family Buildings

Organiser: IEA HPT Project 62, report contributed by Dr.-Ing. Marek Miara, Heat Pumps Watch

Nearly half of all Europeans live in multi-family buildings, yet heat pump adoption in new multi-family construction remains below 20 percent across most markets. This workshop set out to bridge that gap, drawing on the results of IEA HPT Project 62 and an interactive group exercise called The Solution Game.

Projects 50 and 62 established a classification framework of five solution families, running from fully centralised to room-based systems, and 13 system configurations. Project 62 tested this against nearly 80 real-world case studies from 14 countries. The statistics are telling: 76 percent of documented projects use centralised solutions, 50 percent are hybrid systems, 74 percent serve buildings with 21 or more apartments, and 73 percent are in well-insulated stock. The harder-to-retrofit existing building segment remains clearly underrepresented.

Nearly 60 participants were divided into five stakeholder groups: building owner or investor, tenant or resident, technical planner, installer or contractor, and policy or funding body. All groups worked on the same reference building, a 1968 urban apartment block with 32 units, end-of-life oil heating, condominium ownership, limited outdoor space, and a restricted noise zone. In the first step, each group selected three priority parameters from the seven defined in Project 62, covering building size suitability, insulation level, system complexity, fossil dependence, space requirements, heat source flexibility and investment cost, choosing from within their own stakeholder role. Investors focused on cost sensitivity, the policy group prioritised fossil energy dependence, and residents prioritised space requirements. In the second step, groups used their chosen parameters to recommend one of the five solution families. The centralised and combined central-decentral families came out on top, consistent with the actual distribution in the Project 62 database.

Three real case studies were revealed at the end. In Geneva, a 53-apartment building was retrofitted with a centralised water-to-water heat pump, made possible by access to Lake Leman as a heat source. In Innsbruck, a central rooftop heat pump feeding apartment-level 3 kW mini-units allowed installation to be phased across two separate ownership associations. In Flers, France, 112 individual exhaust-air heat pumps, one per flat, removed the need for outdoor units entirely.

The workshop made clear that choosing the right heat pump solution for a multi-family building is not a purely technical question. Stakeholder perspectives shape what is feasible, acceptable and prioritised, and they need to be considered in planning processes and in the broader development of technologies and deployment pathways.

Heat Pumps in Positive Energy Districts

Organiser: IEA HPT Project 61, report contributed by Carsten Wemhöner, OST – Eastern Switzerland University of Applied Sciences

The Project 61 workshop was divided into two parts. The first introduced the framework of Positive Energy Districts and presented two districts moving towards that status, meaning districts with high energy performance supplied by heat pumps but not entirely reaching a positive energy balance on the building footprint. In both the Austrian and Swiss districts, the optimisation potential identified was linked to heat pump integration. Both have centrally integrated heat pumps, which create greater system losses than more decentralised integration and also produce a higher temperature lift because of distribution losses. In the Austrian project, a performance increase of 1 to 1.5 points in seasonal performance factor was evaluated. In the Swiss project, the higher grid temperatures are driven by domestic hot water operation; temporary charging windows for decentralised hot water storage, with temperature reduction in the grid in between, led to an increase in seasonal performance factor of almost a factor of two. The first part concluded with a presentation on funding opportunities.

Discussion centred on the definition and implementation of positive energy districts in different countries and on heat pump integration. Participants debated whether the concept is too ambitious and whether a reduced ambition level would be more useful. The prevailing view was that even if a positive energy district is more a vision than a reality, it remains valuable as a planning guideline, since it forces designers towards maximum efficiency and on-site production even where the balance is not fully met. High, medium, and low temperature grids were all discussed as integration options.

The second part addressed heat pump integration options in districts and specific technology options. These included an asphalt collector as a heat source for a low-temperature grid, which also reduces the heat island effect in densely built areas, a mine water store used as integrated seasonal storage, and a dual-source heat pump using air and vertical ground probes. Measurements from the asphalt collector showed notably lower surface temperatures in the installation area. Mine water storage is restricted to sites with abandoned mines, though these exist in many places across Europe, and the results suggest that where waste heat and existing grids are available, it can be an economic option for seasonal storage. The dual-source solution can overcome the restrictions of single sources, increase overall performance, and allow the total ground probe length to be reduced disproportionately.

Subsequent discussion covered where asphalt collectors can be installed and which materials can support vehicle loads, as well as cost and installation time. For dual-source heat pumps, the discussion turned to control strategies and operating modes. On heat pump integration more generally, different opinions prevailed in the audience, and contrary recommendations for district supply were given.

Optimal Residential Heat Pump Design and Operation

Organiser: IEA HPT Project 66, report contributed by Riley Barta, Purdue University,

Colleagues from Purdue University and from RWTH Aachen, the university of the project deputy, hosted a workshop marking the mid-point of Project 66. Attendance was standing room only, with 60 chairs and well over 70 people present, most of them highly interactive. The session was facilitated by Professor Riley Barta, PhD student Ganesh Venkatesan, and RWTH Aachen researchers Sebastian Ostlender and Florian Will. Presentations came from Swiss project collaborators Leon Brendel and Silvan Bernal of OST on large-scale heat pump monitoring and quality assurance in Switzerland, and from Florian Will on building and heat pump modelling in Germany. Members from UPV in Spain and KTH in Sweden were also active and present.

The primary goals were to present initial findings and to collect feedback on project progress in three areas: a summary of best practices for design, selection and installation of residential heat pumps in both new build and retrofit; progress on control strategy collection and consolidation; and best practices for collecting and disseminating data and source code, in anticipation of the second half of the project, which will focus on experimental data and open-source heat pump models based on input from international stakeholders. Two breakout sessions led to active discussion and to concrete guidance from stakeholders for the remaining half of the project.

Decarbonising Industrial Process Heating with High-Temperature Heat Pumps: From Market to Application

Organiser: IEA HPT TCP Project 68, report contributed by Martin Stage Pihl Andersen, Danish Technological Institute

This workshop brought together more than 80 participants from manufacturers, end-users, research and technology organisations, consultants, universities and other parts of the value chain, to discuss how high-temperature heat pumps can move from emerging market availability to wider industrial deployment.

Three keynotes opened the session. Martin Pihl Andersen of the Danish Technological Institute presented on the developmental status of the technology, showing that the supplier landscape, the technology portfolio and the number of demonstration cases are all growing rapidly. Cordin Arpagaus of OST presented representative projects, highlighting realised and emerging industrial cases and the factors supporting successful implementation. Yannik Stark of GEA drew on experience from installing and operating the systems, particularly with mechanical vapour recompression. A key message was that MVR systems have built up extensive practical knowledge on integrating heat-upgrading technologies into industrial processes robustly and cost-effectively, and that the wider high-temperature heat pump community has a great deal to learn from that experience.

The interactive group session that followed was structured around four project phases: boundary conditions, conceptualisation, implementation and operation. Several recurring

lessons emerged. Early stakeholder alignment is essential, including end-users, process owners, suppliers, integrators, grid operators, permitting authorities and management. Reliable process data is critical, covering temperatures, pressures, operating profiles, contamination risks and production variability. Existing heat distribution systems and industrial processes are often not ready for direct heat pump integration without adaptation.

Implementation was repeatedly described as more complex than expected. Integration represents a major share of project cost and requires flexible schedules, clear responsibilities, backup concepts, electrical infrastructure, safety assessments and careful commissioning. For operation, participants highlighted training, monitoring, maintenance planning, performance validation and dynamic control. Overall, though, the majority of challenges were judged similar to those of integrating any other new process equipment.

The workshop confirmed that the main question is changing from whether high-temperature heat pumps are available to how they are integrated and operated successfully in real industrial processes. That marks an important step towards wider market uptake, which is what matters most for decarbonising industry.

More information and slides from the workshop are available here.

Comfort Cooling Concepts for Different Types of Climates and Regions
Organiser: Heat Pump Centre, in collaboration with ZHAW School of Engineering, Institute of Energy Systems and Fluid-Engineering (IEFE), report contributed by Emilia Pisani, Heat Pump Centre

Space cooling is one of the fastest-growing sources of energy demand in buildings. Rising temperatures, more frequent heatwaves, growing incomes and changing expectations for indoor comfort are all driving it. If efficient technologies and smart system solutions are not deployed at scale, cooling-driven electricity peaks can strain affordability, reliability and grid capacity.

Axel Nordin Furdos of the IEA opened by pointing to untapped potential in both technologies and business models, including cooling-as-a-service. A key message was that air conditioners and heat pumps should increasingly be seen as closely related technologies. Reversible air conditioners provide both cooling and heating, so their widespread use could help accelerate heat pump deployment. Johan Carlsson of the European Commission's Joint Research Centre presented rising cooling demand across Europe. He noted large differences between Member States and between income groups, since lower-income households are often more exposed to heat stress and less able to invest in efficient solutions.

A panel with Yunho Wang (University of Maryland), Johan Carlsson (JRC) and LV Han (China Heat Pump Alliance) compared regional perspectives:

- **China:** demand varies widely between regions. Challenges include installation quality, acoustics, knowledge gaps and the need for stronger policy support.
- **Europe:** demand is lower than in warmer regions but growing, as heatwaves expose buildings not designed for higher summer temperatures.
- **United States:** cooling adds to broader electricity demand growth, including growth from data centres. The shift from high-GWP to lower-GWP refrigerants remains a priority.

The second part explored a possible new HPT TCP collaboration project. Frank Tillenkamp of ZHAW presented the proposal CLImate-friendly COmfort units with focus on NATural refrigerants (CliCo-Nat). Working groups then discussed focus areas, tasks and barriers. Their priorities were:

- low-GWP refrigerants
- higher efficiency
- integration with photovoltaics and storage
- AI for forecasting and control
- business models that make efficient cooling affordable where high electricity prices are a barrier

The main takeaway was that comfort cooling is not a stand-alone issue. It is closely linked to building resilience, electricity system flexibility, refrigerant choices, affordability and the wider deployment of heat pumping technologies. More information and slides from the workshop are available here.

Breaking Barriers: Accelerating Heat Pump Deployment
Organiser: Heat Pump Centre, report contributed by Emilia Pisani, Heat Pump Centre

This workshop brought together a full room of participants from policy, research, industry and the market. They discussed how to overcome policy, market and user-related barriers so that heat pumps become the default choice for clean, efficient and secure heating.

Axel Nordin Furdos of the IEA gave a global overview of heat pump roll-out, showing positive growth but significant differences between markets. He identified the lack of common terminology as one barrier to communication and comparison across countries.

Silvia Rezessy of DG ENER presented the European policy context, including REPowerEU. She covered measures such as renewable energy integration, the phase-out of fossil fuel boilers, energy efficiency requirements, ecodesign and energy labelling.

Richard Lowes of the Regulatory Assistance Project described a "policy temple" resting on three pillars: economic and market instruments, financial support, and regulation. Participants highlighted price signals as important, since lower electricity prices relative to fossil fuels strengthen the case for heat pumps. They also stressed clear communication, because misinformation and uncertainty can slow adoption even where policies and technologies are in place.

A panel with Hengyi Zhao (China Heat Pump Alliance), Sophie Hosatte (Natural Resources Canada), Martin Forsén (NIBE) and Silvia Rezessy (DG ENER) agreed there is no single deployment pathway. Climate, grids, policy frameworks, market maturity, installer capacity and consumer expectations all shape what is possible:

- **China:** growth has partly been driven by replacing coal heating with air-to-water heat pumps in rural areas to improve air quality.
- **Europe:** the focus is on replacing gas boilers and providing predictable policy signals.

Across all regions, affordability and customer confidence were decisive. The shared long-term goal is for heat pumps to become so natural a choice that fossil boilers are no longer the default.

The second part turned to users and implementation:

- Anja Floetenmeyer-Woltmann addressed how customers make decisions about heating and what information they need to feel confident.
- Christian Vering of RWTH Aachen discussed the processes, skills and tools needed for high-quality planning and installation.
- Christoph Reichl of AIT and Michael Wernhart of TU Graz presented work on acoustic barriers and on visualising sound to address user acceptance concerns.

Group discussions identified five key themes: affordability, installer capacity, stable policy frameworks, local grid constraints, and communication with end-users. The main takeaway was that heat pump deployment is not only a technical challenge but also a question of markets, people, policies, and trust. It requires coordinated action across the value chain, supported by international knowledge exchange.

More information and slides from the workshop are available here.

Source: All papers from the 15th IEA Heat Pump Conference are available from the HPT TCP database: https://heatpumpingtechnologies.org/publications

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Paper and Pitch Awards at the 15th IEA Heat Pump Conference

Three papers were selected for awards in three different classes through a selection, nomination and evaluation process involving the Scientific Committee of the conference, consisting of a number of high-level researchers and experts in the field. The awards were presented during the closing session of the conference.

Best Scientific Paper Award

The Best Scientific Paper Award was given to the authors of Methodology to evaluate the uncertainty on the design length calculation of vertical ground heat exchangers, by Michel Bernier and Massimo Cimmino of Polytechnique Montréal.

The work compares several calculation methods for borehole length across five test cases, establishing an expected accuracy of around ten percent. Two calculation methods were used to evaluate local and global uncertainty, with seven system parameters examined across the test cases. Local and global uncertainty were found to be of a similar order, between plus and minus 11 and 14 percent, while uncertainty in the outlet fluid temperature at peak conditions was of the order of plus or minus 2 degrees Celsius. The result matters because borehole field sizing carries a large share of the capital cost of a ground-source installation, and quantifying the uncertainty in that calculation is a precondition for designing with appropriate rather than excessive margin.

Best Applied Research Paper Award

The Best Applied Research Paper Award was given to the authors of Development of a hydrocarbon high-temperature heat pump for industrial decarbonization, by Nils Ahlbrink, Fredrik Dupont Holdt, Jonas Lundsted Poulsen and Benjamin Zühlsdorf of the Danish Technological Institute.

The award recognises applied work directed at one of the central challenges discussed throughout the Vienna programme, namely raising the temperatures at which heat pumps can reliably supply industrial process heat while using working fluids that are compatible with long-term regulatory direction.

Best Pitch Presentation Award

The Best Pitch Presentation Award was given to the authors of Development and validation of micro-CT compatible experimental platform for frost formation studies, by Austin Labuschagne, Tingting Zhu and Wilko Rohlfs of the University of Twente and RWTH Aachen.

Frost formation on outdoor heat exchangers remains one of the more stubborn practical limits on air-source heat pump performance in cold climates, and the ability to observe frost growth directly and at high resolution provides a route to better defrost control and better fin geometry.

Source: Reported from the closing session of the 15th IEA Heat Pump Conference. Full report: https://heatpumpingtechnologies.org/as-we-close-this-conference-we-look-forward-to-2029/

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Decarbonisation of the Heating and Cooling Sector

Report from Selected Technical Sessions

Decarbonisation was the backdrop to the entire Vienna programme, but a distinct group of sessions addressed it directly: the transition to low-GWP working fluids, the displacement of fossil boilers in buildings and networks, and the increasingly quantitative assessment of what these changes actually deliver in emissions terms.

The refrigerant transition dominated. The direction of travel set by the Kigali Amendment and the European F-gas Regulation was treated throughout as settled, and the research question has moved to how systems are designed around the fluids that remain available. Work presented from Japan on the development of refrigeration and air-conditioning technologies for next-generation low-GWP refrigerants set out the practical difficulty plainly: many low-GWP candidates carry properties, from flammability to reduced volumetric capacity, that require the surrounding system to be reconsidered rather than simply refilled. Several papers examined heat transfer characteristics of low-GWP fluids in smooth horizontal tubes, including R454C, R455A and ternary blends, supplying the property data that heat exchanger design depends on.

Propane attracted particular attention. One contribution analysed releasable refrigerant charge in a residential R290 heat pump using one-dimensional dynamic distribution modelling, addressing the safety question that governs where a hydrocarbon unit may be installed, and doing so in the context of large multi-family buildings in European cities where gas boilers remain widespread. A companion study examined how far propane heat pumps

can be made more compact through sensitivity analysis via dynamic modelling. Together these illustrate a pattern visible across the conference: charge reduction is no longer a secondary optimisation but a primary design constraint that shapes compactness, component selection and installation options.

Carbon dioxide and ammonia both featured as routes to larger-scale decarbonisation. A field-performance evaluation was presented of a 1.5 MW reversible R744 air-source heat pump installed at the University of British Columbia Okanagan for an ambient district energy system, described as the largest known CO2 air-source heat pump deployed in a district energy context. Separately, heat pumps using a solution cycle with ammonia and water were presented for high-temperature applications and district heating, with the argument that these natural refrigerants have no greenhouse effect and contain no PFAS, giving long-term regulatory certainty that synthetic alternatives cannot match. The PFAS question surfaced repeatedly in discussion, and it is increasingly shaping fluid selection independently of global warming potential.

Assessing what decarbonisation delivers

A notable feature of the Vienna papers was the growing rigour of the assessments themselves. Several contributions moved beyond coefficient of performance to combined energy, economic and environmental evaluation. One such study assessed low-GWP combined air-source heat pump systems for residential heating and domestic hot water, evaluating energy performance, economic feasibility and environmental impact together. This matters because the three criteria do not always point the same way, and the sessions made clear that the fluid or configuration with the lowest direct emissions is not automatically the one that will be installed.

Hybrid systems were treated with more nuance than in previous conferences. A simulation and experimental sensitivity study on the impact of electric heat pump size within a hybrid heat pump examined how the sizing of the electric unit relative to the gas condensing boiler determines actual emissions reduction. The framing is pragmatic rather than ideological: in building stock where full electrification is not immediately feasible, the sizing decision determines whether a hybrid installation is a genuine step towards decarbonisation or a way of postponing it. Similar reasoning appeared in a study on large-scale gas absorption heat pumps for distributed heating, presented as a preferable alternative to gas boilers in contexts where electric heat pumps face constraints.

Networks, storage and the system view

At network scale, the decarbonisation of district heating and cooling was addressed through the combination of seasonal thermal energy storage and large heat pumps. The argument advanced was that scalable decarbonisation of district heating requires integrating renewable heat while reducing reliance on peak boilers, and that seasonal storage coupled with large heat pumps is among the few combinations that can do both. This connects

directly to the work reported in the thermal networks sessions and in the positive energy districts workshop, and it was one of the clearer points of convergence across the programme.

Flexibility appeared here as a decarbonisation instrument rather than purely an economic one. A fully reversible heat pump and organic Rankine cycle system using fixed-speed scroll machines was presented with start-up behaviour and first operational results, framed around the need for energy systems that can convert, store and dispatch across multiple vectors. The underlying claim, echoed in the opening keynotes, is that the emissions benefit of a heat pump depends on when it runs as much as on how efficiently it runs.

Materials, lifetime and the wider footprint

A smaller but growing strand looked past operational emissions. Work on heating and cooling terminal units designed to maximise recyclability of materials argued that as building standards converge on nearly zero and zero energy performance, the embodied and end-of-life impacts of the equipment become proportionally more significant. This connects to the circularity workshop held under HPT Project 65, where the conclusion was that the barriers to circular heat pumps are commercial and regulatory rather than technical. Related work on tribology, examining hybrid ceramic and surface-treated rolling bearings lubricated with oils heavily diluted by refrigerant, addresses a less visible aspect of the same problem: component lifetime under the operating conditions that low-GWP fluids and high-temperature duty impose.

Monitoring ran through the whole area as a precondition. Contributions on intermittent refrigerant mass flow rate sensing for performance monitoring made the point that the contribution of heat pumps to climate targets can only be claimed if real-world coefficient of performance and heat delivery are actually measured, rather than assumed from rating data. The same theme is taken up in the digitalisation and in the standards sections of this magazine.

Summary

Taken together, the decarbonisation sessions in Vienna showed a field that has largely finished arguing about direction and is now working through consequences. The refrigerant transition is under way and is reshaping system design rather than merely substituting fluids. The assessment methods are becoming more honest about cost and about lifecycle impact. And the emissions case for heat pumps is increasingly being made with measured data from operating installations rather than with modelled potential.

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Innovative Heat Pump Applications for Industry and Commerce

Report from Selected Technical Sessions

Industrial applications formed the largest single block of the Vienna programme. The most significant development was one of emphasis rather than of temperature record: high-temperature heat pumps are now being reported from operating industrial plants, and the research effort has shifted correspondingly from demonstrating capability to solving integration.

Each section is based on a report contributed by the organiser or session chair and has been edited by the HPT Magazine editor for length and consistency.

From pre-screening to installed plant

Report contributed by Benjamin Zühlsdorf, Danish Technological Institute

Session HTH1 laid out the logic of cost-optimal integration as a progression. Because temperature lift and equipment sizing dictate both capital and operating cost, the defining challenge is the balance between integration cost and thermodynamic efficiency. Kaida established an accessible baseline with a method to estimate standard heat pump coefficient of performance within plus or minus 10 percent using only external process temperatures and logarithmic mean temperature lift. Babaei and colleagues extended this with a Carnot-based pre-screening method combining pinch-based profiles with a genetic

algorithm, navigating the non-convex design space to identify the optimal trade-off between efficiency and total annual cost in seconds.

Thermodynamic targets must then become physical systems. Schlosser and colleagues introduced a technology-matching framework using generic energy demand models for common unit operations such as drying, sterilisation and separation, to match process temperature and load profiles with suitable configurations, refrigerants and cycle designs. Walden and colleagues addressed the limits of static matching by bringing time-resolved process data into the design stage, demonstrating that thermal storage buffers on both source and sink sides stabilise operation and absorb fluctuation. Sizing these buffers with a two-stage optimisation model achieved a 27.4 percent reduction in operating expenditure in an automotive paint shop case study. Jende and colleagues closed the loop with insights from active EU initiatives including SOLINDARITY and EEETHOS, scaling reversed Brayton and cascade steam-generating units to capacities up to 1 MW thermal in operating pulp and paper, food and ceramics plants.

Steam, and the industries that run on it

Steam generation was the centre of gravity. Papers addressed the conceptual design and integration of steam-generating units into high-temperature heat pumps, the combined pathway of high-temperature heat pumps and steam compressors for decarbonising chemical industry processes, and the optimal design of an industrial steam heat pump for paper drying. Several contributions reported on R718 systems, using water as the working fluid, including performance assessment and geometric design of a steam compressor within the GEOSYN project and dynamic performance evaluation of the resulting machine.

Pulp and paper recurred more than any other sector. Contributions covered technical, economic and environmental analysis of integrating a high-temperature heat pump coupled with mechanical vapour recompression into steam generation, the dynamic simulation of heat pump integration in paper drying to overcome system complexity, heat recovery with a steam compressor in superheated steam drying, the design of a heat upgrade system for a paper factory, and first operational experience of a steam-generating Type II absorption heat pump in a paper mill. The absorption heat transformer case is instructive: it upgrades roughly half of its driving heat to a higher temperature with almost negligible electricity consumption, an option that changes the economics wherever a large waste heat stream and a modest electricity price ratio coincide.

Drying more broadly was treated as a target in its own right. One overview analysed current drying processes and the energy reduction potential available through heat pumps, noting that industrial drying accounts for roughly 10 to 25 percent of total industrial energy consumption across sectors including food, chemicals, paper and textiles. A separate paper surveyed realised case studies of heat pumps in industrial drying, and another reported a mechanical vapour recompression system supplying 150 degree Celsius steam to an industrial drying process at a major production site.

Scale, replication and novel cycles

Session HTH13 showed the scale now being reached. Rizzi presented two large industrial cases, one in a steel plant where waste heat from an electric arc furnace cooling circuit is upgraded for district heating, and one in a paper mill where a large heat pump combined with mechanical vapour recompression produces process steam at around 170 degrees Celsius and 5 bar. That combination of temperature and pressure moves heat pumps into duty traditionally reserved for fossil steam systems. Parra Ruiz presented the 150 degree Celsius MVR drying case and underlined that performance depends strongly on vapour handling, control, buffering and matching the machine to the process.

Replication was treated seriously rather than assumed. An analysis of industrial decarbonisation with cascade heat pump systems assessed the replication potential across Austrian industry, building on pilot plants including the AHEAD project. Work on modularisation and upscaling of high-temperature heat pumps addressed the manufacturing question that follows: if every installation is bespoke, the sector cannot scale at the rate targets require. A high-temperature application study in the ceramic sector examined one of the hard-to-abate industries where economics depend on both private investment and public support.

Session HTH5 covered the novel cycles still expanding the technical boundary. Drews presented control strategies for constant supply temperature of a high-temperature Brayton heat pump, addressing the practical problem that Brayton cycles, though well suited to drying and preheating with their large temperature glides, are harder to hold at stable supply temperature than subcritical vapour compression systems. That the session gave space to control rather than cycle novelty is itself a sign of maturing. Chen presented a high-temperature tri-phase thermochemical heat pump for industrial process heating, reporting an efficiency improvement of nearly 20 percent for the test rig, and illustrating that alternative concepts may still offer substantial gains. Comparative assessments of mechanical vapour compression against Joule and Brayton configurations mapped where each belongs. Multi-stage rotary liquid-piston compression was presented as a further route to high temperature lift.

The overall picture from the industrial sessions is consistent with the conclusion of the HPT Project 68 workshop. The supplier landscape and the number of demonstration cases are growing rapidly, the equipment exists across a widening temperature range, and the decisive factor for performance and for decarbonisation impact is now the quality of process integration. The barriers most often reported are the availability of reliable process data, the readiness of existing distribution systems, the share of project cost taken by integration work, and the organisational task of aligning end-users, suppliers, integrators, grid operators and permitting authorities early enough to matter.

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Smart Grids, Digitalisation and System Integration

Report from Selected Technical Sessions

Digitalisation ran through the Vienna programme as a cross-cutting theme, but the dedicated sessions showed a field that has moved past demonstrating that machine learning can be applied to heat pumps and is now asking harder questions about data quality, deployability and what a digital method must do to earn a place in a commercial product.

Fault detection and diagnosis

Report contributed by Windholz Bernd, Austrian Institute of Technology

Fault detection attracted the largest concentration of papers. The problem is well defined: soft faults such as refrigerant leaks and heat exchanger fouling leave a system still able to meet the thermal load while quietly degrading its efficiency, so they are rarely noticed and rarely fixed. Mauro presented results from the EU-funded BEYOND project, which aims to detect and quantify refrigerant leaks and fouling before they significantly affect performance. An important early finding was that physics-based models provide more robust fault evaluation than purely data-driven methods, a result that recurred in several other contributions and that tempers the assumption that more data alone will solve the problem.

A two-stage artificial neural network tool for detection and diagnosis of soft faults in vapour compression systems was presented, separating the detection and diagnosis steps.

Machine learning based fault detection was also demonstrated on an R290 residential unit, reflecting the sector-wide move to hydrocarbon refrigerants. The most methodologically interesting contribution came from Leroy Roger, who proposed peer-benchmarking-based fault detection across a residential geothermal heat pump fleet. Applied to data from 199 units, the unsupervised approach identified five significant outliers, three of which were linked to confirmed faults such as short cycling or improper sizing. The appeal of the method is that it requires no labelled fault data, which is precisely the resource the field lacks.

Virtual sensors and the economics of instrumentation

Cost is the constraint that shapes domestic monitoring, and several papers attacked it from different directions. Nicholson presented physics-informed neural networks as virtual sensors for domestic heat pumps, combining machine learning with thermodynamic knowledge to estimate refrigerant mass flow without additional hardware, reporting around 93 percent accuracy. Tran and Speerforck examined the usability of a virtual sensor in a domestic application from a digital twin perspective. Fazaa and colleagues presented data-driven techniques for predicting refrigerant charge through machine learning soft sensors, drawing on more than 6,800 steady-state operating points from the LC150 project and achieving prediction accuracies up to an R-squared of 0.98, with applications in commissioning, leakage detection and diagnostics.

The alternative route is to make the hardware cheap rather than to eliminate it. Barandier presented a low-cost data acquisition system built around a microcontroller and ten digital temperature sensors, able to monitor key operating parameters continuously while keeping hardware cost low, and suitable both for standalone field diagnostics and for integration into connected monitoring platforms. Related work presented intermittent refrigerant mass flow measurement for enhanced performance monitoring. Between them these approaches sketch a plausible path to instrumenting the installed base rather than only new premium equipment.

Control, flexibility and the grid

Model predictive control appeared in several forms, and notably in field rather than simulation settings. A novel model predictive control framework was presented as a replacement for traditional on-board heat pump controls, and insights were reported from a field test of a predictively controlled air-source heat pump in single-family homes using non-linear optimisation, motivated by the observation that efficiency falls in winter precisely when heating demand peaks. Yang presented energy optimisation of a solar house using model predictive control for an integrated air-source heat pump water heater and radiant floor system, tested in two cells at Concordia University in Montréal, where predictive control notably reduced energy expenses compared with rule-based control while achieving slightly better comfort. Guo presented a multi-scale hybrid physical and data-driven HVAC model for optimal demand response control, explicitly addressing two barriers to

deployment: the degradation of data-driven accuracy under small-sample conditions, and computational cost.

Flexibility was framed around grid need. One contribution evaluated heat pump enabled building flexibility via deep reinforcement learning with an explicit trade-off analysis, noting that grid operators increasingly seek flexibility from underused resources such as the thermal inertia of residential buildings. Another experimentally evaluated the impact of circulation pump control on performance and energy flexibility in heat pumps with thermal storage, a reminder that flexibility claims depend on auxiliary components that are often ignored. Monitoring results were also presented from the SunStore project, where phase change material capsules in a buffer tank are being tested under real conditions. Dynamic controls for hybrid and efficient rooftop units extended the flexibility discussion into the commercial sector.

Data quality, tools and infrastructure

The most quietly consequential paper in this area may have been Uhl's evaluation of publicly available heat pump specifications for digital planning and design tools. The study assessed the quality and completeness of standardised product data and found substantial differences between manufacturers, along with gaps that currently limit automated design, three-dimensional planning and installation workflows. Digital services depend on product data that is consistent and machine-readable, and at present it is neither.

Velte-Schäfer and co-authors surveyed the application of AI tools along the heat pump value chain, from component design through performance-map generation to operational supervision, and Furtwengler presented neural network estimation of parameter values in installed systems where technical parameters such as pipe characteristics are often unknown or undocumented. Jensen presented the Digital Heat Pump Lab at DTU, a laboratory enabling real-time two-way communication between physical heat pumps and digital models, supporting research on advanced control, fault detection, hardware-in-the-loop testing and digital twins, and designed explicitly to bridge laboratory work and real-world digital services. Modelling contributions included dynamic simulation of an absorption heat pump integrated with mechanical vapour recompression and a temperature and pressure based polynomial regression model for predicting heat transfer rate and coefficient of performance across different system types.

Conclusions

The conclusion from these sessions is that the enabling technologies are largely in place and the constraints have moved elsewhere: to the availability of labelled data, to the consistency of manufacturer product information, to the cost of instrumentation in the domestic segment, and to the question of whether a method validated on one fleet transfers to another.

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Technologies for Urban Areas and Existing Buildings

Report from Selected Technical Sessions

The existing building stock remains the hardest problem in the field, and the urban sessions in Vienna reflected that. The papers divided between thermal networks at city scale, ground-source systems and their design methods (in the IGSHPA track), and the awkward particulars of retrofitting heat pumps into buildings that were never designed for them.

Heat pumps in thermal networks

Report contributed by Carsten Wemhöner, OST – Eastern Switzerland University of Applied Sciences

Session THN1 covered heat pump integration in district heating across a wide capacity range, from small machines to the multi-megawatt units recently introduced to the market. Peikani assessed natural refrigerants in heat pumps for micro-district heating with dual-source configurations, finding that natural refrigerants can outperform common HFCs and that a dual-source configuration can increase performance by up to 30 percent, particularly at lower outdoor temperatures, which supports their use despite the additional complexity. Meier examined covering peak loads in district heating networks using ground-source heat pumps, proposing that ground-coupled heat pumps and chillers installed locally at larger clients can provide free cooling and ground regeneration in summer while contributing to peak load coverage in winter, displacing fossil peak plant. The arrangement is potentially a

mutual benefit: the network carries more base load, and the decentralised peak capacity can be used to connect new customers.

Wittstadt reported measurement analyses from the research and development commissioning phase of multi-megawatt heat pumps at five German locations, monitored since 2021. The paper summarised the challenges of integrating both the thermal and the electrical side and presented performance data reflecting the particularities of each site. The conclusion, that the installations show a steep learning curve and confirm the potential of large heat pumps for district heating, is one of the more valuable findings in the conference precisely because it is based on commissioning experience rather than design studies. Related work was presented under the German living lab on large heat pumps in district heating networks.

Session THN4 turned to local networks and source configurations. The keynote by Gholamrezaie investigated the impact of local heat pump characteristics on the performance of a CO2-based thermal network combining centralised and decentralised zone-wise machines, a configuration resembling water-loop heat pumps within a building. The advantages identified were reduced grid losses and heat recovery between zones with simultaneous heating and cooling demand. Passarelli evaluated seasonal performance of large air-source heat pumps with multiple evaporators affected by frosting and defrosting, simulating configurations and time-based strategies under Harbin conditions; the difference between best and worst strategy reached 20 percent, with fin pitch the most influential geometric parameter, though the optimal approach combined field configuration and control rather than either alone.

Further contributions addressed the selection of natural refrigerants for district heating heat pumps, the identification of zeotropic mixtures of natural refrigerants for geothermal district heating, and an exergetic and energetic comparison of reverse Rankine, Brayton and Stirling cycles for district heating applications, reflecting the diversity of network temperature regimes. Adsorption cooling with biochar thermochemical storage was presented as an integration strategy for district heating, decoupling heat generation from cooling demand.

Ground-source systems and design methods (IGSHPA track)

Report contributed by Signhild Gehlin, The Swedish Geoenergy Center

The IGSHPA research track opened with a keynote from Spitler on designing the next generation of geothermal heat pump systems. He pointed to growing interest in larger systems serving large buildings and networks of buildings, where land area becomes a design constraint and the available area may be irregularly shaped and scattered between buildings, with varying demand profiles and multiple sources adding complexity. He introduced preliminary work on an open-source design tool that automatically places and

sizes an optimal number of boreholes within a land area to meet given heating and cooling loads.

Bernier presented the methodology for evaluating uncertainty in the design length calculation of vertical ground heat exchangers that went on to receive the Best Scientific Paper Award, comparing calculation methods across five test cases and finding local and global uncertainty of the order of plus or minus 11 to 14 percent. Angelotti addressed groundwater flow in borehole heat exchanger design, modifying the widely used ASHRAE sizing method to include medium and long-term advection effects, and concluding that above a Darcy velocity of 10^{-7} m/s these effects cannot be neglected, with the benefit most pronounced for shorter borehole spacing and unbalanced loads. Liu introduced GeoWISE, an online tool for preliminary design and techno-economic analysis now extended from individual buildings to district geothermal heating and cooling systems, drawing on a database of more than 125 million existing US buildings and using AutoBEM and EnergyPlus to predict thermal loads. He also presented a sensitivity analysis of design parameters in the RowWise borehole layout algorithm, which generates and optimises configurations within irregular polygonal land boundaries.

Supporting work included a high-order finite line source solution for simulating straight boreholes, a theoretical model for the thermal response of slender boreholes under short-term transient conditions, analysis of variable borehole thermal resistance and heat pump behaviour on sizing and energy consumption in a Swedish residential context, and the modelling of subsurface temperature fields around borehole heat exchangers from monitoring data. Mine water geothermal energy was presented both as a heat source and as seasonal storage, with attention to the conditions under which it becomes economic.

Retrofit, and the buildings that resist it

The retrofit papers were candid about difficulty. One contribution examined optimal retrofit levels for heat pump installation in residential buildings, noting that while heat pumps in new build are becoming routine, electrifying the existing stock remains a significant challenge because low-temperature heat distribution is often not feasible in existing dwellings without substantial intervention. Another presented low-temperature heating through façade-integrated thermal activation as a minimally invasive retrofit route, addressing the disruption that conventional emitter replacement entails. Work on air-to-air heat pumps in existing buildings examined the influence of building thermal mass on consumption, and a comparative analysis of heat pump applications in multi-family buildings set theoretical concepts against real-world installations, complementing the HPT Project 62 workshop.

Vienna itself provided a case study, with a paper on the flexible deployment of heat pumps for urban decarbonisation in the city, presenting a portfolio of heat pump based solutions complementing the rapidly expanding district heating system in pursuit of climate neutrality by 2040. Mine water heat storage was presented as a decarbonisation solution for urban areas, and a study of performance degradation of an air-source heat pump in a dormer room

enclosure offered experimental evidence on a space-saving roof-integrated approach for dense urban settings.

Acoustics, a recurring obstacle to urban deployment, was addressed through work under HPT Project 63 on the psychoacoustics of air-source heat pumps, studying human response to the cumulative impact of noise. Together with the space, ownership and cost constraints identified in the HPT Proejct 62workshop on heat pumps in multifamily buildings, it underlines the central message of these sessions: in the existing urban stock, the binding constraints are frequently not thermodynamic.

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Policy, Market Mechanisms and Regulatory Framework

Report from the Policy Forums and Selected Technical Sessions

Including material by Caroline Haglund Stignor, Heat Pump Centre,

Three policy forums were organised during the conference, on global supply chains, on favourable energy policies and on innovation policy. Alongside a smaller number of market-oriented papers, they made the case that the principal obstacles to heat pump deployment now lie outside the technology itself.

Policy Forum 1: Global supply chains in a fragmented world

Hosted by Rafael Martinez Gordon, Renewable Energy Analyst at the IEA, with panellists Barbara Priesching of the Vaillant Group, Justin Tamasauskas of Natural Resources Canada, Cooper Zhao of the China Heat Pump Alliance and Johan Carlsson of the EC Joint Research Centre, this forum considered how supply chains can scale in a world shaped by rising demand, shifting trade dynamics and industrial-policy tension.

A central message was that heat pumps are comparatively more geographically diversified than many other clean energy technologies, with production and assembly spread across several regions. Supply-chain resilience nonetheless remains a concern where markets rely heavily on imported components or on a limited number of supplying countries. Significant investment has been made in European manufacturing capacity, and panellists argued that industry can deliver if stable demand is created. Views differed on how far Made in Europe criteria should go, with several speakers cautioning that protective measures should be

avoided where they undermine affordability or international cooperation, while maintaining that fair competition is essential.

Contributions from China and Canada broadened the picture. China was presented not only as a manufacturing base but as a large domestic market whose demand drives innovation and scale. Canada illustrated a different challenge: heat pumps are a key strategy but the market remains relatively small, imports are significant, and products must be adapted to colder climates and local energy-system needs. Resilience, the forum concluded, is not only about where products are made but whether they suit local markets, grids, installation practices and service models. The suggested agenda was to stimulate stable end-user demand, support local value creation, maintain international trade on fair terms, and build resilience through diversification, scale, product adaptation and business models that ensure long-term service.

Policy Forum 2: Favourable energy policies for heat pumps

Hosted by Paul Kenny, Director General of EHPA, with Silvia Rezessy of DG Energy, Duncan Gibb of the Regulatory Assistance Project, Andreas Piontek of the European Investment Bank and Kari Ochsner of Ochsner Wärmepumpen, this forum focused on moving markets from stagnation to growth.

The central message was that subsidies alone are not enough. Deployment depends on a coherent policy environment, predictable long-term signals, and energy market design that makes electrified heating economically attractive. Several examples underlined the importance of correcting the price balance between electricity and fossil fuels, whether by reducing electricity levies, exempting electricity used for heating from certain taxes, or shifting levies from electricity to gas. Sweden was cited as a strong example where low electricity prices, carbon taxation, and clear communication have supported uptake.

Support schemes must also match market maturity and social conditions. In less mature markets, broad subsidy programmes may be needed to trigger demand, while advanced markets may require targeted support for households facing barriers. France was highlighted for placing equity at the centre of subsidy design, while the European Investment Bank emphasized one-stop-shop solutions, affordable finance and loan guarantees to reduce upfront barriers. Participants stressed that policy volatility raises costs and uncertainty for consumers and industry alike, and that a stable framework is essential for building supply chains and maintaining manufacturing capacity.

Beyond economics, the forum pointed to trust and communication. Consumers are not primarily interested in technical indicators such as coefficient of performance but in comfort, reliability and affordability. Installers, clear market information and trusted advisory structures were described as crucial to prevent poor-quality offers from damaging market confidence. European policy already contains many of the necessary elements, including electrification plans, renewable heating and cooling targets and restrictions on

fossil boiler support; the remaining challenge is translating these into coordinated national action and credible consumer narratives.

Policy Forum 3: Innovation policy for a rapid and resilient transition

Hosted by Sabine Mitter of the Austrian Federal Ministry of Innovation, Mobility and Infrastructure, with Susanne Buscher of the German Federal Ministry for Economic Affairs and Energy, Ricardo Leon Baquero of UNIDO, Susumu Uenotsuchi of the Heat Pump and Thermal Storage Technology Center of Japan, Enrique Vilamitjana of Panasonic Heating and Cooling Solutions Europe and Wim Boydens of Ghent University, this forum addressed research and innovation policy.

The panel held that deployment remains too slow to meet political targets, and moved the discussion beyond conventional building applications to large-scale heat pumps for district heating, high-temperature machines for industry, and systems combined with storage and digitalisation to provide flexibility. A key message was that innovation policy cannot rely on linear models with simple objectives and indicators. Heat pump innovation is complex, circular and system-dependent, requiring approaches that address technology development, system integration, market formation, user acceptance and social impact simultaneously. Different applications need different support: industrial machines still need technology development, district heating requires stronger system integration, and building applications face new requirements linked to refrigerants, circularity and digital services.

The panel called for more flexible and differentiated instruments, including programmes adapted to different technology readiness levels, living labs close to the market, and small low-administration projects accessible to SMEs. Cross-sector and value-chain collaboration, including installers and digital solution providers, was seen as essential. Participants also suggested that policy learning should include what does not work and how barriers are overcome, shared faster than traditional multi-year research projects allow.

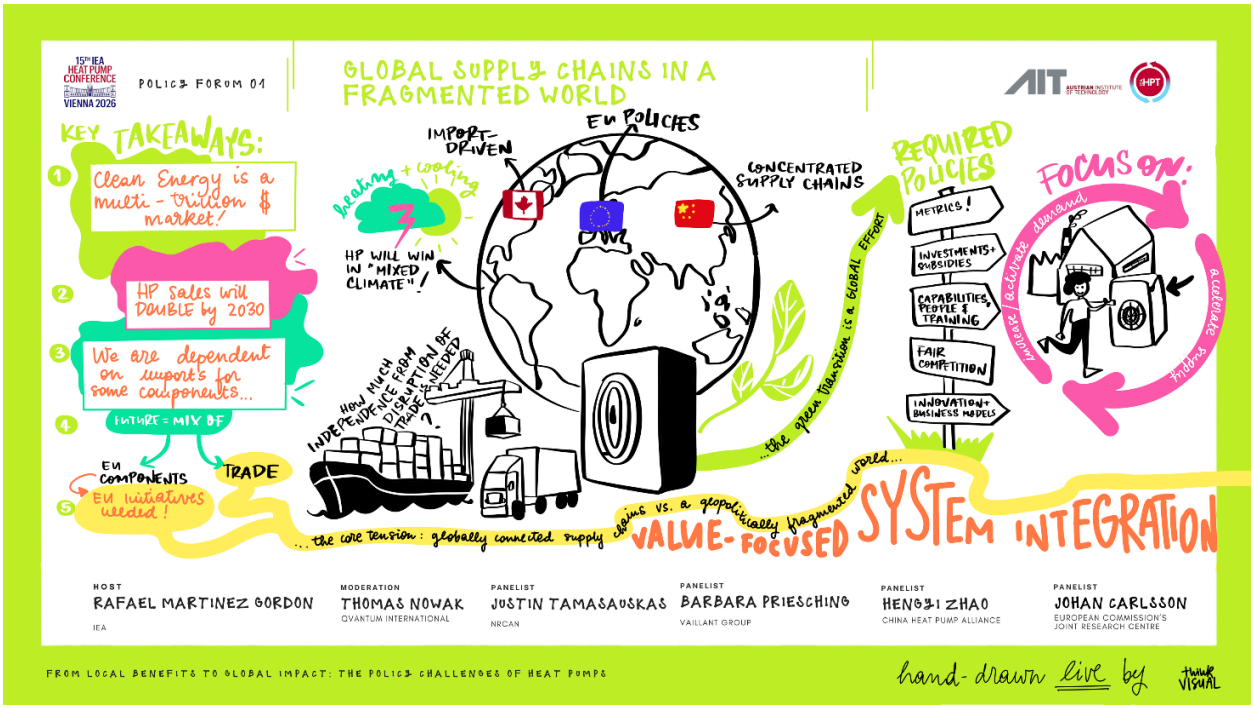
Market and regulations in the technical programme

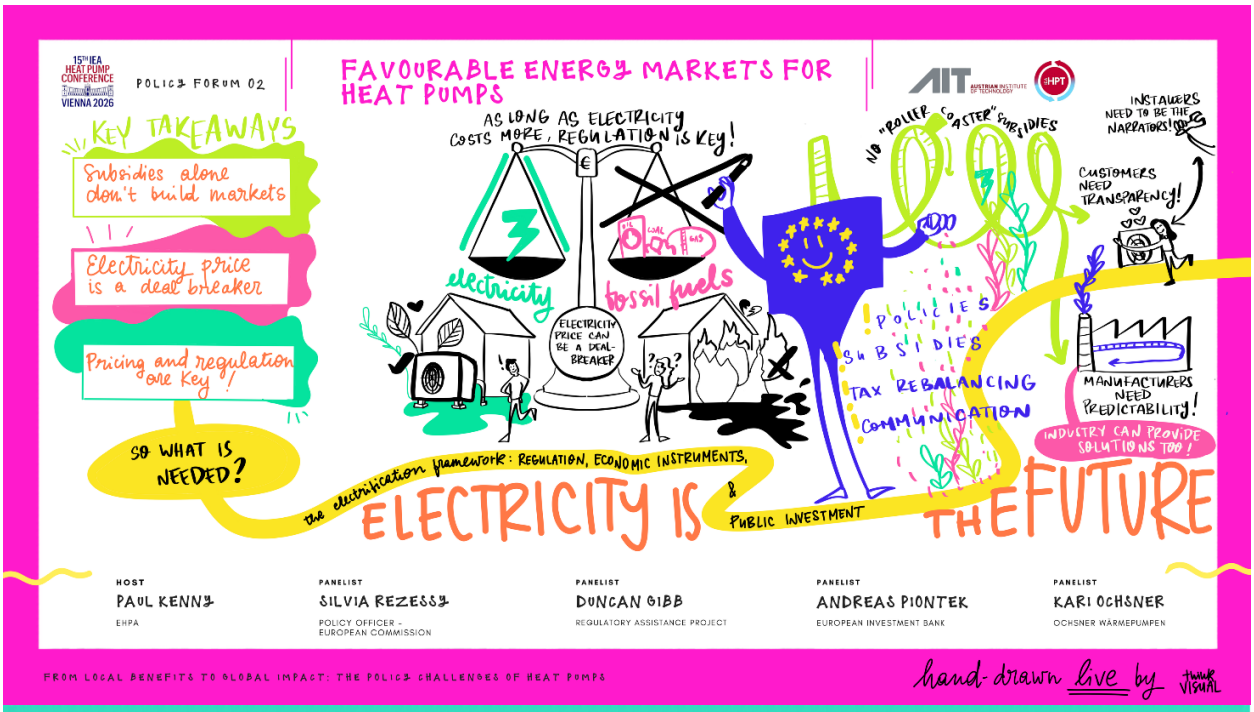
A smaller group of papers addressed these questions directly. The European Heat Pump Association presented its strategy for accelerating deployment while safeguarding industrial competitiveness, building on its competitiveness analysis and recent market evidence. A second contribution reported insights from testing three innovative business models for the heat pump rollout, addressing the high upfront costs, limited consumer awareness and fragmented supply chains that hinder adoption. A third examined community-based events using behavioural design as a scalable strategy for adoption in Germany, explicitly targeting the gap between intention and action.

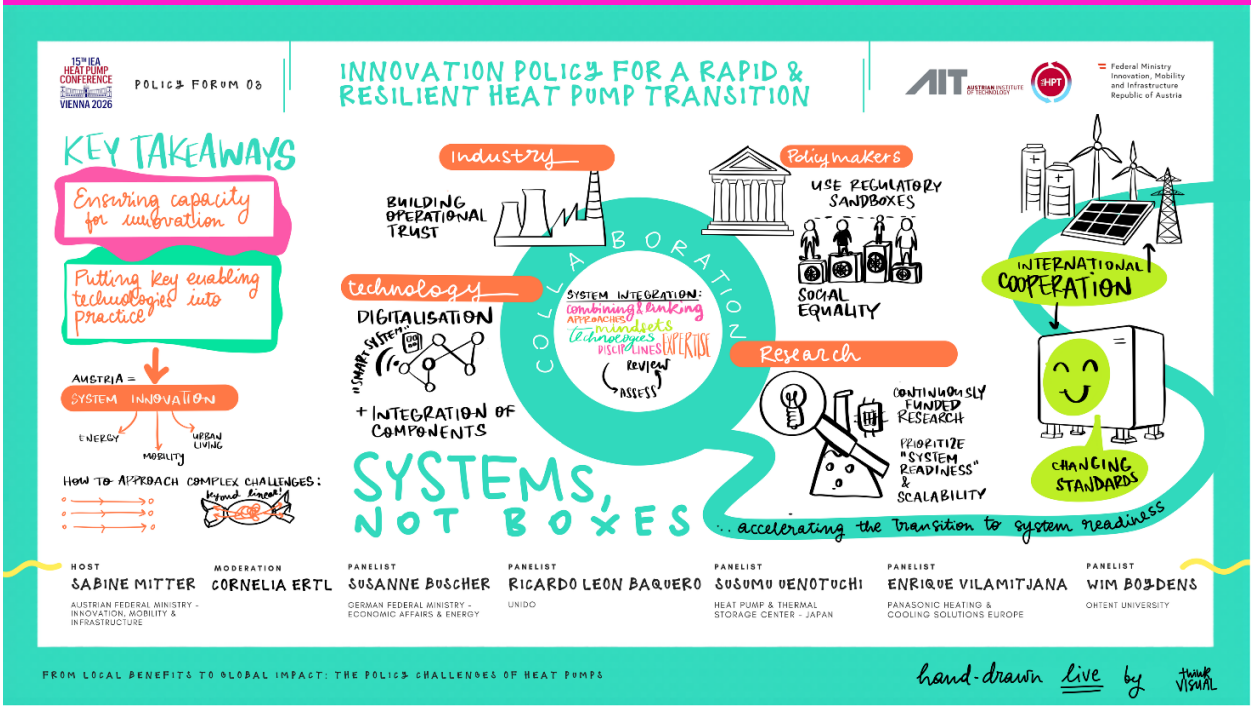
Regulation appeared in less obvious places. An Austrian survey on the frequency, location and detection of leaks in heat pump and cooling systems up to 50 kW addressed the safety and monitoring requirements arising from the F-gas Regulation and the proposed REACH

restrictions, and a study on the common failure analysis of domestic heat pumps and air conditioners approached product lifetime from the perspective of circular economy requirements. A comparison of operating costs between heat pumps and condensing gas boilers for residential heating in Italy spoke directly to the price-ratio question that dominated the second policy forum.

The consistent thread across forums and papers is that the technology case has largely been accepted and the delivery case has not yet been resolved. Price signals, policy stability, finance, installer capacity and consumer trust were named repeatedly, and were treated by participants as the variables that will determine deployment rates over the next decade.







The panel discussions were live captured in graphic recordings

All conference papers are available from the searchable HPT TCP database: https://heatpumpingtechnologies.org/publications

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Standards, Certification and Quality Assurance

Report from Selected Technical Sessions

A recurring argument ran through these sessions: the test methods on which certification, energy labelling and consumer information depend were designed around steady-state operation, while the equipment they assess increasingly operates dynamically, under variable-speed control and in interaction with storage and with the grid.

The limits of steady-state rating

Several papers addressed this directly. An experimental comparison of heat pump seasonal efficiency using EN 14825 alongside a dynamic load emulation approach set out the problem plainly: current standards including EN 14511-3 and EN 14825 assess performance under steady-state conditions that do not reflect real-world dynamics. A related study examined the impact of the heat pump controller on measured performance, comparing results from the EN 14825 and EN 14511 procedures against a two-mass compensation method, and found that the controller itself can materially change the outcome. That finding has uncomfortable implications: if the control logic influences the rating, then two units with identical components may be labelled differently, and a rating obtained under one method may not predict performance under another.

Work on fostering innovation in heat pump controllers through real-life testing addressed the same question from the policy side, noting that revision of the test method within the EU Energy Labelling regulation for central space heating appliances is under discussion, with

the proposed change replacing stationary measurement with procedures that capture dynamic behaviour. The evaluation of reproducibility of a load-based and climate-specific test procedure using a centrally ducted cold-climate air-source heat pump, conducted as part of representativeness, repeatability and reproducibility testing, tackled the practical obstacle to any such transition: a more realistic method is only usable if different laboratories obtain comparable results from it.

Frost complicates matters further. One contribution investigated the influence of frosting on the selection of typical days for heat pump evaluation, where annual performance is extrapolated from measurements on representative days in order to reduce test time. Another examined defrost control logic for air-source heat pumps using image and cycle data, and a third assessed the impact of nozzle material and integration practices on defrost efficiency and system compliance in heat pump fans. These are unglamorous topics, but they determine whether a seasonal performance figure quoted to a consumer bears any relation to what the machine will deliver through a real winter.

Reducing the cost of certification

Certification cost is a genuine barrier to product variety, particularly for variable-speed machines and for hybrid configurations where the number of combinations to be tested multiplies quickly. Chaignon and colleagues presented model-based performance prediction of variable-speed heat pumps as a possible route to reducing certification costs, with attention to hybrid heat pumps combining a heat pump and a boiler for unrefurbished existing buildings, where the combinatorial problem is most acute. The approach raises an obvious question of confidence, and the discussion turned on how much physical testing is needed to validate a model before the model can substitute for further tests.

Analysis of the energy performance of residential inverter-driven heat pumps made the complementary point that manufacturer declarations are made under particular conditions while actual consumption depends on real operating conditions and on choices made at the design stage. Research on testing methods for refrigerant direct condensation radiation air-source heat pumps addressed a product category that existing procedures do not cover well, a reminder that standardisation lags product innovation by design.

Safety, fluids and the standards that govern them

The refrigerant transition has created a substantial standards agenda of its own. Work on the revision of ISO 817 presented an evaluation method for the self-decomposition reactivity of next-generation refrigerants, prompted by the observation that certain ethylene-based hydrofluoroolefins exhibit self-decomposition behaviour. Since ISO 817 governs refrigerant designation and safety classification, the method feeds directly into how these fluids may be applied. The Austrian survey of leak frequency, location and detection in systems up to 50 kW addressed the monitoring and safety requirements that follow from the use of flammable fluids under the F-gas Regulation and the proposed REACH restrictions.

This connects to the point made by Yosr Allouche in the opening plenary, that flammability should not be confused with safety, and that what matters is proper application, installation, standards and qualified workers. The standards sessions gave that argument technical substance: the safe deployment of hydrocarbons and other low-GWP fluids at scale rests on classification methods, charge limits, leak detection requirements and installer competence, each of which is a standardisation question rather than a research question.

Quality assurance in the field

Quality assurance extended well beyond the test laboratory. A comprehensive overview was presented of a hardware-in-the-loop testbed and testing procedure for developing district heating substations that integrate heat pumps, allowing component and control behaviour to be assessed against a simulated network before installation. The Digital Heat Pump Lab at DTU, reported in the digitalisation sessions, serves a related purpose for digital services. HPT Project 66 reported on large-scale heat pump monitoring and quality assurance in Switzerland, presented at its workshop by collaborators from OST, and a methodology for optimal high-temperature heat pump design integrating working fluid and cycle configuration selection addressed quality at the design stage for industrial machines.

The evaluation and demonstration of actual energy efficiency of heat pump systems in buildings, reported from IEA collaboration work, speaks to the underlying issue across all of this material. The credibility of heat pumps with policymakers and with consumers rests on the gap between rated and delivered performance being small and well understood. Where that gap is large, the consequences are not only technical: they feed directly into the consumer trust problem identified in the second policy forum, where participants noted that poor-quality offers damage confidence across an entire market.

The direction of travel from these sessions is reasonably clear. Test procedures are moving, slowly and with justified caution about reproducibility, from steady-state points towards load-based and dynamic methods. Modelling is being proposed as a partial substitute for physical testing, with the burden of proof still being negotiated. The refrigerant transition is generating a parallel standards workload around classification, safety and installation. And field monitoring is increasingly treated not as research but as the routine quality assurance mechanism that a mass-deployed technology requires.

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Report from the 15th IEA Heat Pump Conference in Vienna 2026

Place and Dates for the 16th IEA Heat Pump Conference Presented during the Closing Ceremony

After four days of presentations, discussions and exchange among more than 800 attendees, the 15th IEA Heat Pump Conference came to an end. The closing session summarised the conference in numbers, acknowledged the people involved, presented the paper and pitch awards and the main takeaways from the policy forums, and announced where the 16th IEA Heat Pump Conference will take place in three years.

The conference in numbers

Thomas Fleckl, Chair of the National Organising Committee, opened the closing session by summarising the conference in numbers.

- 812 participants
- 6 plenary lectures
- 367 scientific contributions, comprising 261 scientific papers and 106 applied research papers
- 317 reviewers, who completed 2,943 reviews
- 367 presentations across 78 chaired sessions

- 10 workshops
- 3 policy forums
- 15 exhibitions
- 6 technical site visits
- 4 awards: the Peter Ritter von Rittinger Award, the Best Scientific Paper Award, the Best Applied Research Paper Award and the Best Pitch Presentation Award

Acknowledgements

During the session the members of the Scientific Committee and of the International and National Organising Committees were acknowledged for their work in developing a programme spanning a wide range of applications, from buildings to industry and transport, from component to system level, and from novel technologies through to applications in the real world. The proceedings will be openly available three months after the conference.

The 16th IEA Heat Pump Conference in 2029

Photo credit: Alexandru Enache

Place and Dates for the 16th IEA Heat Pump Conference Presented during the Closing Ceremony

The closing session ended with the announcement of the location and host of the next IEA Heat Pump Conference. Benjamin Zühlsdorf of the Danish Technological Institute revealed that, by coincidence, the 2029 conference will be organised in the country of the winners of the Best Applied Research Paper Award, Denmark, much as in the Eurovision Song Contest that had taken place in Vienna earlier in May.

The 16th IEA Heat Pump Conference will take place in Copenhagen, in May or June 2029. The exact dates and place will be defined and communicated in due course.

We hope to see you in Copenhagen in 2029!

Source: Reported from the closing session of the 15th IEA Heat Pump Conference. Full report: https://heatpumpingtechnologies.org/as-we-close-this-conference-we-look-forward-to-2029/

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Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP) International collaboration for energy efficient heating, refrigeration, and air-conditioning.

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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.

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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.

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