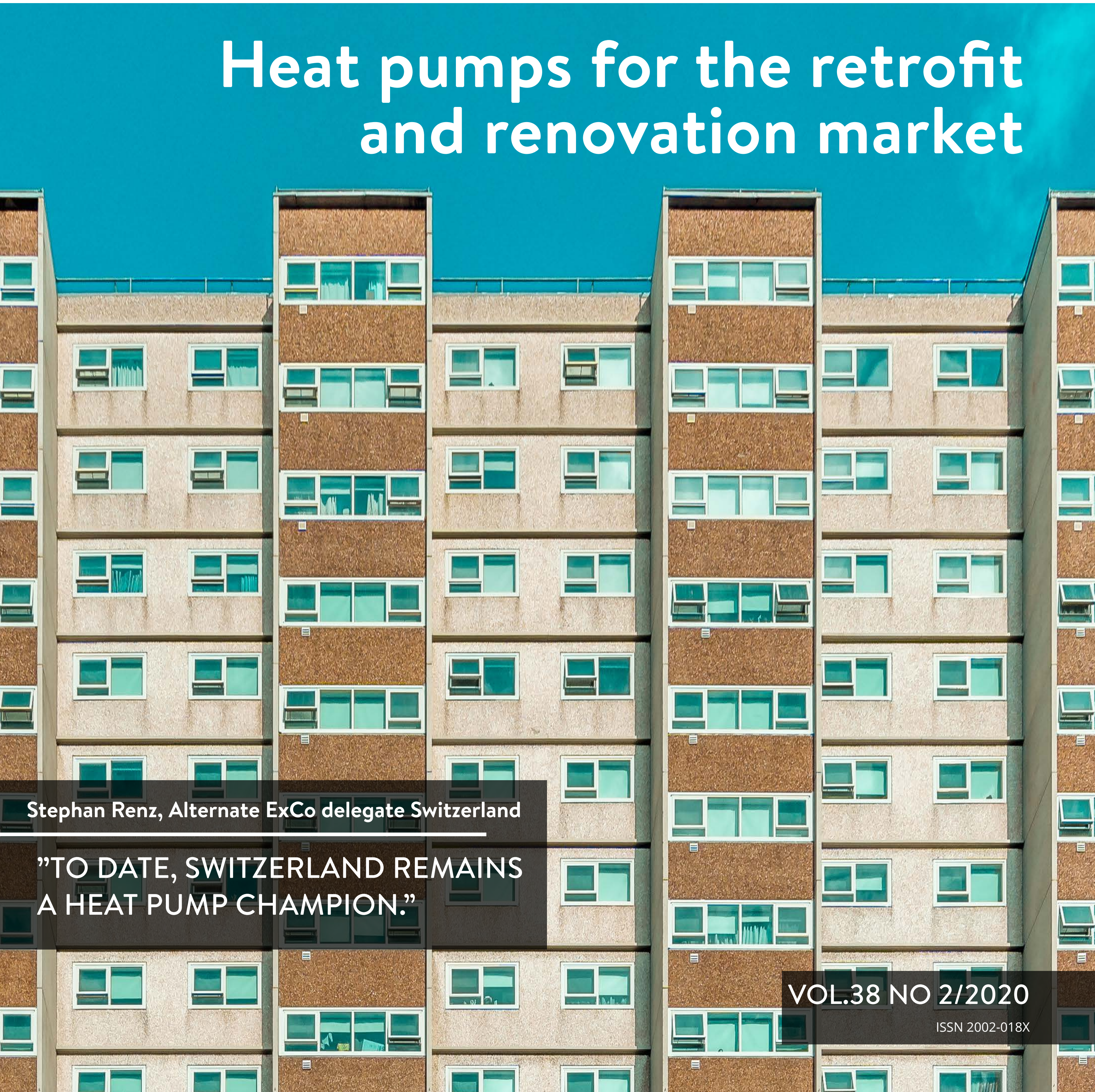
Technology Collaboration Programme
by iea

Heat Pumping Technologies MAGAZINE

A HEAT PUMP CENTRE PRODUCT

Heat pumps for the retrofit and renovation market



Stephan Renz, Alternate ExCo delegate Switzerland

”TO DATE, SWITZERLAND REMAINS A HEAT PUMP CHAMPION.”

VOL.38 NO 2/2020
ISSN 2002-018X

Heat Pumping Technologies
MAGAZINE

VOL.38 NO.2/2020

In this issue

The fight against the Corona virus and its effects continues globally. We should now expect restrictions to continue throughout the entire 2020, with variations between nations and over time. As an effect, the 13th IEA Heat Pump Conference in Jeju, South Korea, is once more postponed and will be held in April 2021.

The fight against global warming and energy-related pollution also continues. The HPT contribution to this fight is, of course, to support wider market deployment of heat pumps. In this issue of the HPT Magazine, the focus lies on "Heat pumps for the retrofit and renovation market". This is a market of great potential, considering the amount of already existing buildings world-wide with need for an improved heating or cooling system. The two topical articles give examples on this from the Netherlands and Finland.

In the Market Report the situation in Switzerland is described. Heat pumps have a long history in the country, and they have become even more popular since the mid-90s. They are common in both residential buildings and for industrial applications. One of the main drivers for continued installation is decarbonisation of the heating system.

The Column presents an overview over the situation in Canada. Heat pumps are identified as key in the decarbonization transition, and especially those specifically developed for a colder climate. Further action for increased market adoption is still needed.

Enjoy your reading!

Johan Berg, Editor

Heat Pump Centre

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

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Front page: Shutterstock

ISSN 2002-018X
https://doi.org/10.23697/bf4a-4919

FOREWORD

The renovation challenge

During our work for HPT Annex 46 on heat pump water heaters, we realized that renovation of residential buildings offers the largest challenge when progressing to a more sustainable built environment. Experience shows that it is hard to boost deep renovation, including the conversion to low carbon heating and domestic hot water supply. The ownership of existing dwellings seems to be a hindering factor. In Europe, over half of the dwellings are privately owned, which means that different (read: limited) renovation levels are chosen.

The key decision patterns look quite different when smaller overhaul and retrofit measures are taken into account, such as maintenance of the façade, or the overhaul of an existing heating system. In those cases, phases of strategic definition and preparation are often being curtailed or loosely applied. In many cases no architect, engineer or planner is involved, which results in heuristic decisions (like installing the same system again, or just choosing the same installation as the neighbours did). In many cases, low-carbon approaches are not part of the decision framework.

Deep renovation of terraced houses or multifamily buildings almost solely occurs when these are owned by a housing corporation, commercial landlord or local municipality. In such cases, overall energy management should be considered with a major renovation of the heating system. Due to higher levels of insulation after renovation, domestic hot water will be a more decisive factor in energy systems. Given the total sum of energy losses of collective systems, the best solution for both single-family and multi-family buildings is to install individual systems generating hot water where and when needed. However, that is not always possible.

Simple market mechanisms show that for private ownership with a free customer choice, the up-front investment costs of alternative energy technologies prevail. Since heat pump installations are more expensive and complex than traditional heating systems, many installers are not keen to advise heat pump technology for individual houses, unless their client is convinced it is in his or her best interest. New energy concepts, like plug and play solutions, might help to persuade sceptical installers. A successful example is the emergence of hybrid heat pumps combining heat pump technology with gas boilers. In many cases this can be a first step towards full electrification.

One of the conclusions of HPT Annex 46 is that mandatory legal measurements can be an important policy tool to enlarge the market share of heat pump water heaters. Overall, governments should support the interest of commercial market players selling or installing heat pump technology. Obviously, this can be adverse to the economic interests of companies selling competing, fossil fuelled technologies. Despite the strong need for straightforward policy support for heat pumps, it is still rare and not very consistent across Europe, North America and Asia.

In this Magazine issue, a number of examples are described, showing some of the possibilities. And it is clear that there is strong willingness of a number of housing corporations to step forward.

Onno Kleefkens
Operating Agent of HPT Annex 46
Phetradico Communication & Publishing, Netherlands

Increasing Heat Pump Market Adoption in Canada

Under the Pan-Canadian Framework on Clean Growth and Climate Change [1], Canada has committed to reducing its greenhouse gas (GHG) emissions by 30% over 2005 levels by 2030. In support, a Market Transformation Roadmap [2] has been developed, presenting a framework for an increased adoption of the high efficiency systems needed to drive decarbonisation of the built environment. Heat pumps are a key element of this plan, responding to aspirational goals regarding future high efficiency space heating systems (seasonal efficiency > 100%; SPF > 1) and the integration of renewable energy.

Cold climate air-to-air heat pumps (CC AAHPs) are one promising solution gaining increasing market interest, driven by lower costs and relative ease of installation. Using variable speed compressors, these systems can offer higher seasonal efficiencies by combining improved low temperature heating capacity with an ability to efficiently modulate at milder conditions. However, strong regional variations in climate, and utility rates, along with the electric grid implications of greater heat pump adoption, mean that no single integration is optimal across Canada. A systematic framework, driven by testing, simulation, and new performance ratings, is needed to support market adoption and ensure that systems are optimally integrated.

Sizing is a critical and often misunderstood factor in system performance. A common belief is that CC AAHPs can be sized for the full heating load without sacrificing efficiency at milder conditions. However, performance testing reveals that many units have a smaller window (e.g. 30-100% of max. capacity) to modulate before cycling begins. Sizing for a design condition that only occurs a few hours per year can lead to oversizing, degrading energy performance at milder conditions due to increased cycling. Simulation results show that a heat pump sized for the full design load of a Montreal home (at -23 °C) offers 50% less energy savings vs. a unit sized for milder conditions (-8 °C).

Consumers must also be able to easily and accurately understand how a system performs. Current Canadian performance ratings are based on two design points, making it difficult to differentiate between systems. A new variable capacity heat pump draft standard (CSA EXP07) better reflects actual seasonal efficiencies, highlighting better performing systems while building confidence that units will perform as advertised. CC AAHPs can play a key role in meeting Canada's GHG emission reduction targets and supporting a transition to a low carbon economy. However, new approaches, leveraging increased performance testing and simulation, are needed to capitalize on this potential. Through new tools, updated training programs, more suitable performance ratings and the acquisition of detailed performance data, Canada is committed to maximizing the potential of CC AAHPs and supporting the decarbonisation of the Canadian built environment.

References

[1] Pan-Canadian Framework on Clean Growth and Climate Change. Environment and Climate Change Canada, 2016. http://publications.gc.ca/collections/collection_2017/eccc/En4-294-2016-eng.pdf

[2] Paving the Road to 2030 and Beyond: Market transformation road map for energy efficient equipment in the building sector. Iqaluit, Nunavut. Natural Resources Canada, 2018. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/emmc/pdf/2018/en/18-00072-nrcan-road-map-eng.pdf




MARTIN KEGEL STEPHANIE BRETON SOLANGE PRUD'HOMME JUSTIN TAMASAUSKAS

Natural Resources Canada, Canada

Welcome to the 13th IEA Heat Pump Conference, 2021

Additional Postponement of the 13th IEA Heat Pump Conference to April 26-29, 2021

Location: Ramada Plaza Hotel Jeju, Korea

Due to the coronavirus (COVID-19) outbreak, the 13th IEA Heat Pump Conference (HPC2020) is rescheduled again, to April 26-29, 2021. The conference venue remains the same, Ramada Plaza Hotel Jeju, Korea.

After the first postponement to September 21-24, 2020, the pandemic situation has not yet recovered, and seems to last for at least several more months globally. Thus, the organizing committees no longer believe it to be feasible to hold the conference in September, and thus they have decided on additional postponement. The decision was made based on the comments and agreement of the International and National Organizing Committees as the safety of all participants is our priority.

Due to the additional postponement of the HPC2020 Conference, the Organizing Committee will start the entire process from the beginning including paper handling and registration.

Status of the submitted papers

Out of the 297 abstracts, the 225 full papers have passed the review process and are accepted for the conference program. The accepted full papers will be kept valid until the new conference dates, and the authors do not have to take any action at this time. Authors who would like to edit or modify their paper can send the revised version directly to the secretariat (secretariat@hpc2020.org) by email, no later than November 15, 2020. If a major modification has been made, the Scientific Committee will decide whether they will start an additional review process or not. If the author considers the paper to be outdated or inadequate, the author may withdraw the paper. In this case, please inform the secretariat as soon as possible.

New call for papers opened

To follow the technical advancement and keep the quality of the presentations for HPC2020, a new call for papers is opened. At this time, there is no abstract screening stage, but full paper submission is required by November 30, 2020. Then the newly submitted papers will be reviewed by the Scientific Committee. Due to the postponement of the conference, the important dates have been changed as follows:

- **November 30, 2020, Full Paper Submission Due**
- **December 20, 2020, Full Paper Review (for the new submitted papers)**
- **January 15, 2021, Final Full Paper Submission Due (for the new submitted papers)**
- **February 28, 2021, Pre-registration Due**

The Organizing Committee encourages heat pump experts to contribute more recent and state-of-the-art articles to the conference.

Updates and promotions

Regarding the additional postponement of HPC2020, the Conference Organizing Committee sincerely hopes for your understanding. In the meantime, additional promotion of the conference will be provided to enhance the conference quality and participants' satisfaction.

Additional updates and details will be provided on the website of the conference http://www.hpc2020.org/ and via www.heatpumpingtechnologies.org

Although the conference is delayed, we greatly appreciate your patience, understanding and strong support of HPC 2020. We hope you stay safe and healthy and we are looking forward to seeing you next year.

13th IEA HEAT PUMP CONFERENCE
2020 | JEJU KOREA

Images of Jeju island.

Efforts for heat pump deployment are bearing fruit, but more will be needed.

Energy-related CO_2 emissions from buildings have risen in recent years after flattening between 2013 and 2016. Direct and indirect emissions from electricity and commercial heat used in buildings rose to 10 gigatonne (Gt) CO_2 in 2019, the highest level ever recorded. Several factors have contributed to this increase, including growing energy demand for heating and cooling with rising air-conditioner ownership and extreme weather events. Enormous emissions reduction potential remains untapped due to the continued use of fossil fuel-based assets, a lack of effective energy-efficiency policies and insufficient investment in sustainable buildings.

An updated version of the Tracking Clean Energy Progress Report from IEA, June 2020, is presented at the IEA website. Worth noticing in this tracking report is that the progress for Heat Pumps is going in the right direction. The status has changed from "not on track" to "more efforts needed", which is a very positive sign.

Thibaut Abergel, Clean Energy Technology Analyst at IEA, described this progress more in detail during the HPT TCP ExCo spring meeting in May 2020. He showed some of the trends regarding the heat pump market development and deployment.

Efforts are bearing fruit, but more will be needed

The heat pump market is particularly dynamic since 2015. In the United States, for example, annual shipments grew from 2.3 million units in 2015 to 3.1 million units in 2019. The European Union market is expanding quickly, with around 1.3 million households purchasing a heat pump in 2018 (a 12% annual average growth rate since 2015).

The heat pump market growth is uneven, mostly driven by newly built houses. The share of heat pump sales across newly built buildings can reach 50% or more (IEA, 2018), while the deployment in existing buildings is much slower.

Heat pumping technologies subtypes are all on the rise and the sales of heat pump water heaters have more than tripled since 2010, largely driven by China. Ground-source heat pumps are less common globally but growing effectively in many countries including the United States, China, Sweden and Germany.

Performance is increasing steadily

Typical seasonal energy performance factors fall in the range from 3 to 5. An SPF of 4 would be the average in 2019 in the United States (MEPS = 3.8) and most European countries (An SPF of 4 would result in A++, and all heat pumps are labelled from A+ to A+++ on the mandatory Energy Label). The SPF is highly dependent on temperature, hence the range from 3 to 5. The average SPF of heat pumps sold has risen steadily since 2000.

The revision of standards spurred efficiency improvements, and heat pump energy performance in the US rose by 13% 2006 and 8% in 2015 following updates in minimum energy performance standards.

In order to reduce the lifecycle environmental impact of heat pumps, they should move towards low-to-zero GWP refrigerants.

Heat pumps – an effective decarbonisation solution

The heat pumps of today could supply around 90% of heating needs in the world with a lower CO_2 footprint than gas boilers, particularly in major heating markets such as Canada, China, Europe and the United States. This map (Figure 1) shows the heat pump competitiveness index relative to regional heating demand, in 2017. The index compares the carbon footprint of a heat pump relative to a gas condensing boiler, accounting for electricity-related CO_2 emissions. A low index indicates that the carbon footprint of the heat pump is lower than that of the boiler.

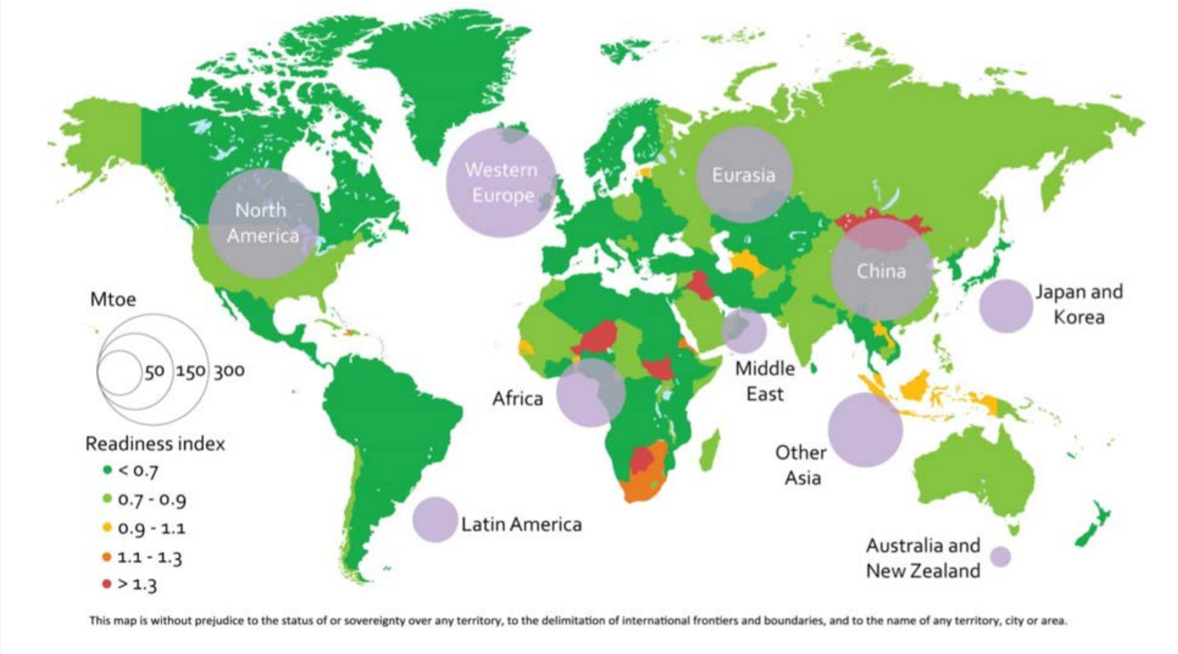

Fig. 1: Perspectives for the Clean Energy Transition, Source: IEA (2018)

Policy plays a strong role in the increase of sales
Energy efficiency programmes specific to heat pumps play a strong role in the increase of heat pump sales. A good example is that subsidies for air source heat pumps, 3400-4100 USD/household in Beijing, Tianjin, and Shanxi, have led to an increased deployment in those regions. Further, subsidies for ground-source heat pumps, covering 30% of the investment cost, in the United States and Beijing, have spurred the market there.

Regulations and labelling on heat pump energy performance, like mandatory standards in the United States and EU, for instance, has also contributed. The fact that heat pumps are considered as renewable heat in China and EU also stimulates the market. In addition, technology-neutral performance requirements push the development in the right direction. For example, Canada is considering mandating an energy performance greater than 1.0 for all heating technologies by 2030.

Policies need to play a stronger role in heat pump development
To conclude, even if the efforts made so far to speed up heat pump deployment are successful, more efforts will be needed to reach the Sustainable Development Scenario. Policies must play a major role in different ways from now on.

One way is to reduce upfront purchase costs, by continued subsidy efforts, particularly in hard-to-reach market segments (e.g., the renovation market). Subsequently, a progressive decrease of the amount of subsidies in markets in which heat pumps have proven cost-effective should be done. Another way is to reduce operational costs by rethinking energy pricing to narrow the gap between electricity and natural gas prices. Moreover, increased R&D investment to foster innovation on next generation components and exploit the multiple services heat pumps can deliver (e.g. heat, cooling, hot water, flexibility, district energy, storage...) should be applied.

Heat pumps should be made a solution to building renovation, by deploying renovation packages which involve both building shell elements and equipment upgrades to reduce installation costs.

Finally, upcoming power system transformation needs can be handled in different ways. Possible synergy with on-site solar PV and storage should be exploited, and heat pumps should be able to respond to price signals so that they can participate in demand-side response markets.

Read the updated Tracking Clean Energy Progress Report (June 2020) at:
https://www.iea.org/reports/tracking-buildings-2020

THIBAUT ABERGEL
Clean Energy Technology Analyst, IEA

Ongoing Annexes in HPT TCP

The projects within the HPT TCP are known as Annexes. Participation in an Annex is an efficient way of increasing national knowledge, both regarding the specific project objective, but also by international information exchange. Annexes operate for a limited period of time, and the objectives may vary from research to implementation of new technology.

INDUSTRIAL HEAT PUMPS, SECOND PHASE	48	AT, CH, **DE***, DK, FR, JP, UK
DESIGN AND INTEGRATION OF HEAT PUMPS FOR nZEB	49	AT, BE, **CH**, DE, NO, SE, UK, US
HEAT PUMPS IN MULTI-FAMILY BUILDINGS FOR SPACE HEATING AND DHW	50	AT, CH, **DE**, FR, IT, NL
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LONG-TERM MEASUREMENTS OF GSHP SYSTEMS PERFORMANCE IN COMMERCIAL, INSTITUTIONAL AND MULTI-FAMILY BUILDINGS	52	DE , FI, IT, NL, NO, **SE**, UK, US
ADVANCED COOLING/ REFRIGERATION TECHNOLOGIES DEVELOPMENT	53	CN, DE, IT, KR, SE, **US**
HEAT PUMP SYSTEMS WITH LOW GWP REFRIGERANTS	54	AT, DE, FR, IT, JP, KR, SE, **US**
COMFORT AND CLIMATE BOX	55	AT, CA, DE, FR, IT, **NL,** SE, UK, US
INTERNET OF THINGS FOR HEAT PUMPS	56	**AT**, FR, DE, NO, CH

NEW

*) Operating Agent from Germany, but no other parties from the country participate.

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

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

ANNEX **48**

INDUSTRIAL HEAT PUMPS, SECOND PHASE

Introduction

What does "industrial heat pump" (IHP) actually mean? What expectations does it create for the actual business? What are the drivers and what are the barriers? Researchers, technicians, product developers, decision makers and consulting engineers, component manufacturers and suppliers, designers and architects, refrigerant plant and heat pumps operators need to be able to understand the possibilities and challenges of IHPs in the industrial processes.

Securing a reliable, economic and sustainable energy supply as well as environmental and climate protection are important global challenges of the 21st century. Increasing the production and use of renewable energy, as well as improving energy efficiency are the most important steps in order to achieve these goals of energy policy.

While the residential heat pump market may be satisfied with standardised products and installations, most IHP applications need to be adapted to unique conditions. In addition, a high level of expertise is crucial. The main goal is to overcome still existing difficulties and barriers for the larger scale market in industrial applications. IHPs are active heat-recovery devices that increase the temperature of waste heat in an industrial process to a higher temperature, to be used in the same process or another adjacent process or heat demand. See Figure 1.

IHPs offer various opportunities to all types of manufacturing processes and operations. They use waste process heat as the heat source, delivering heat at higher temperatures for use in industrial processes, heating or preheating, and industrial space heating and cooling. IHPs can significantly reduce fossil fuel consumption and GHG emissions in a variety of applications.

Objectives

- develop a framework which structures information on IHP applications, using acquired case studies from Europe and Japan;
- select best available technologies and best practices;
- distribution of condensed and clear information materials for policy makers, associations, and industries;
- demonstrate the IHP potential for more efficient use of energy and reduction of greenhouse gas emissions
- create training / information material regarding IHPs.

Results

Research and practical applications show increasingly clear that IHPs can provide heating/cooling to industrial applications and district grids. The latest outcomes of the Annex show more than three hundred good practices of IHPs in a variety of applications, such as drying, washing, evaporation, and distillation processes. A wide range of industries can benefit from this technology. Information material based on experience across the regions (Europe-Japan) has been assembled and published in connection with meetings during 2019.

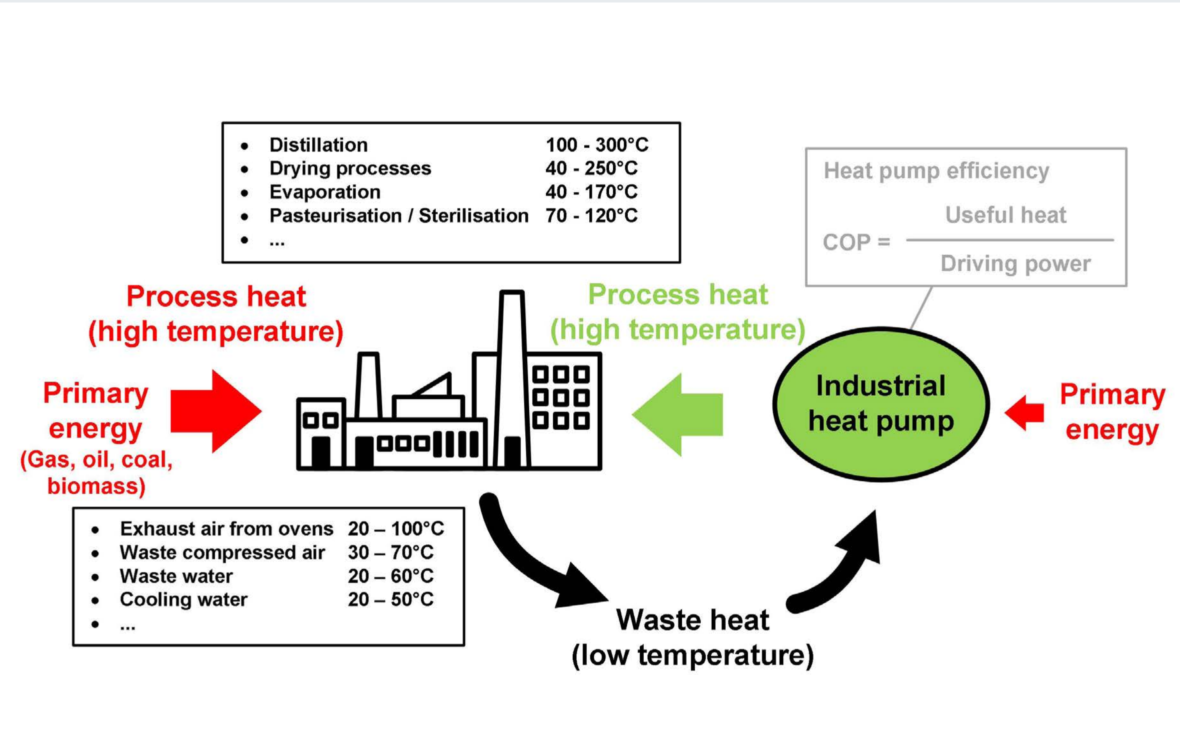

Fig. 1: Principle of industrial heat pumps.

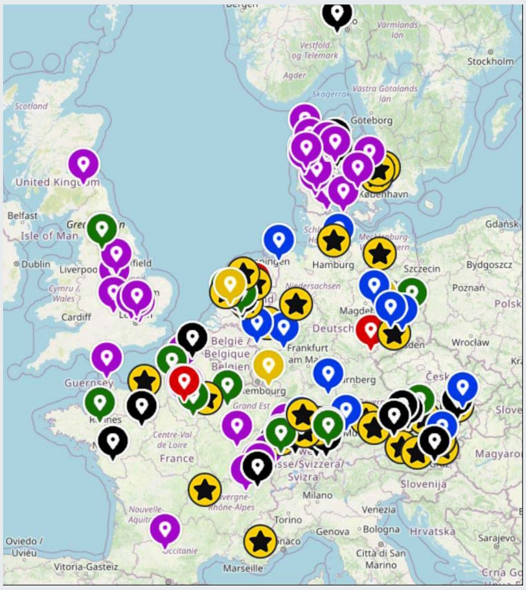

Fig. 2: Map with IHP cases in different industry segments in Europe. (IZW e.V.)

High temperature heat pumps are HPs with heat sink temperatures in the range of 100 to 160 °C. They may become increasingly commercialized during the coming years, particularly in the food, paper, metal and chemical industries.

On the website of Annex 48, https://heatpumpingtechnologies.org/annex48/, the direct results of the Annex are demonstrated by more than 60 presentations and more than 60 publications. Practical guidelines and insights for the application of existing models and tools to aid systematic heat pump integration with industrial processes are shown in a special report. The country reports contain selected case studies with good and best practices; see Figure 2 for cases in Europe.
Lessons learned: The industrial process of drying is a very promising application for heat pumps, and is suggested by all Annex members for future work in R&D. The quality of the process could be improved, and energy cost and CO_2 emissions could be reduced. AIT in Austria leads a European project, "Dry-Ficiency". EDF in France sees a great demand for this purpose in the paper industry. Japan is also starting a project in this direction according to CRIEPI.

Meetings
The general activities of the Annex were closed in spring 2019. The last meeting was in Tokyo, Japan, in May. Homepage, guidelines and information tools for the final reports were discussed; the further dissemination of the results were agreed for the rest of 2019 (HPT Magazine No 2+3; IIR-Montreal-workshop, presentations on the EHPS, and the Annual DKV-meeting), independent of the Annex closing, thanks to the active members.

Annex website
https://heatpumpingtechnologies.org/annex48/

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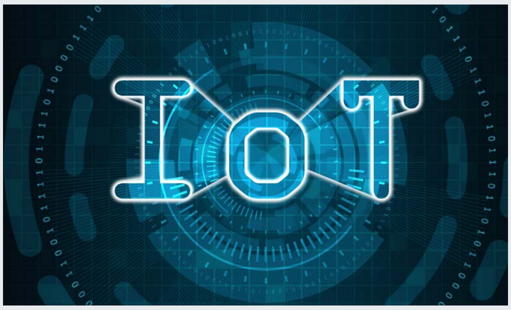
INFORMATION



New HPT TCP Annex: Internet of Things for Heat Pumps

The IoT Annex focuses on the opportunities and challenges of IoT enabled heat pumps. Connected devices will play a major role in the future addressing multiple aims, such as increased comfort for the user, reduction in energy consumption and decarbonization of heat supply. The Annex will include both, heat pumps for household and commercial applications and heat pumps for industrial applications. It aims to increase knowledge at different levels (OEMs, heat pump manufacturers, consultants, installers, legislators, etc.) and to provide guidance and contributions to the development of future standards.

Visit the Annex website for more information:

https://heatpumpingtechnologies.org/annex56/

ANNEX 49

DESIGN AND INTEGRATION OF HEAT PUMPS FOR nZEB

Introduction

About half a year to go until all new buildings in Europe have to fulfil the requirements of nearly Zero Energy Buildings (nZEB), by January 1, 2021. Thereby, the EU Directive of the Energy Performance of Buildings EPBD (recast) is implemented, see the time schedule in Figure 1. Also in the USA and Canada, as well as in Asian countries such as Japan and China, nZEB targets are to be introduced in the time frame between 2020 and 2030.

Due to different nZEB definitions across European member states, which may lead to different requirements of energy performance of the system technology, common and standardised system solutions for nZEB application are limited. However, heat pumps are already well-established for the application in nZEB and are seen frequently in this market segment.

On this background, system concepts which comply with nZEB requirements in various applications such as residential or office use, are highly interesting for the market stakeholders and heating industry.

Annex 49 has thus investigated heat pump concepts for nZEB, both by simulation and in field monitoring, to verify the real performance reached by the buildings. A focus is thereby on system integration, since multifunctional heat pumps can yield better performance and facilitate to fulfil the nZEB balance.

Since in nZEB, the buildings will also generate electricity for the grid, a good integration to work in line with connected energy grids is equally important for nZEB concepts. The heat pump can thereby unlock flexibility options, which is addressed in Annex 49 by control concepts.

Objectives

- » Continuous update on nZEB requirements in the participating countries;
- » Investigation of integration options for heat pumps and storage technologies for multi-functional operation and energy flexibility;
- » Real-world performance characterisation by monitoring of nZE-buildings in the participating countries, partly accompanied by simulation to optimise building and heat pump performance;
- » Design and control of heat pump systems for various applications in residential and office buildings in terms of achievable performance;
- » Recommendations for integrated heat pump systems, as well as heat pump design and control in nZEB.

Results

Two nZE multi-family buildings in Tyrol, certified as passive houses, have been simulated and monitored over a period of three years. The results show that they achieved continuous improvement of the energy balance. Optimisations showed that the nZEB target is ambitious to be achieved in multi-family houses, where there is limited space in the building envelope. However, is possible with optimised PV on the roof and heat pump operation, see monthly balance in Figure 2.

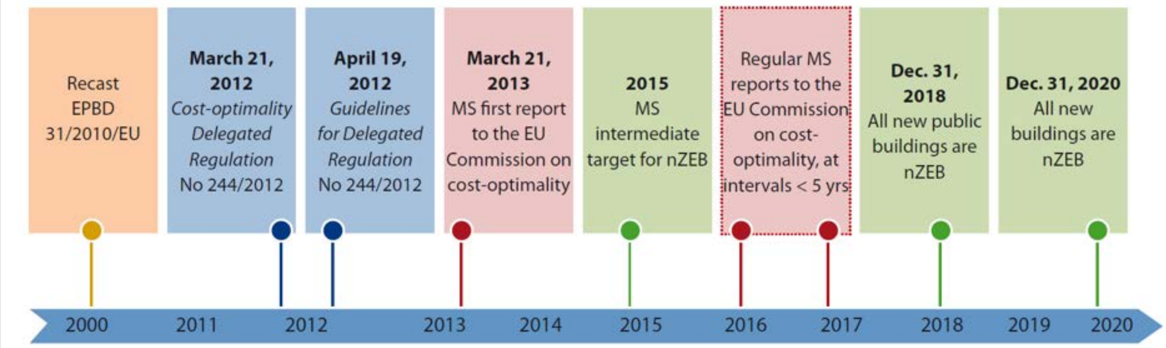


Fig. 1: Time schedule for the implementation of the EPBD recast of 2010.

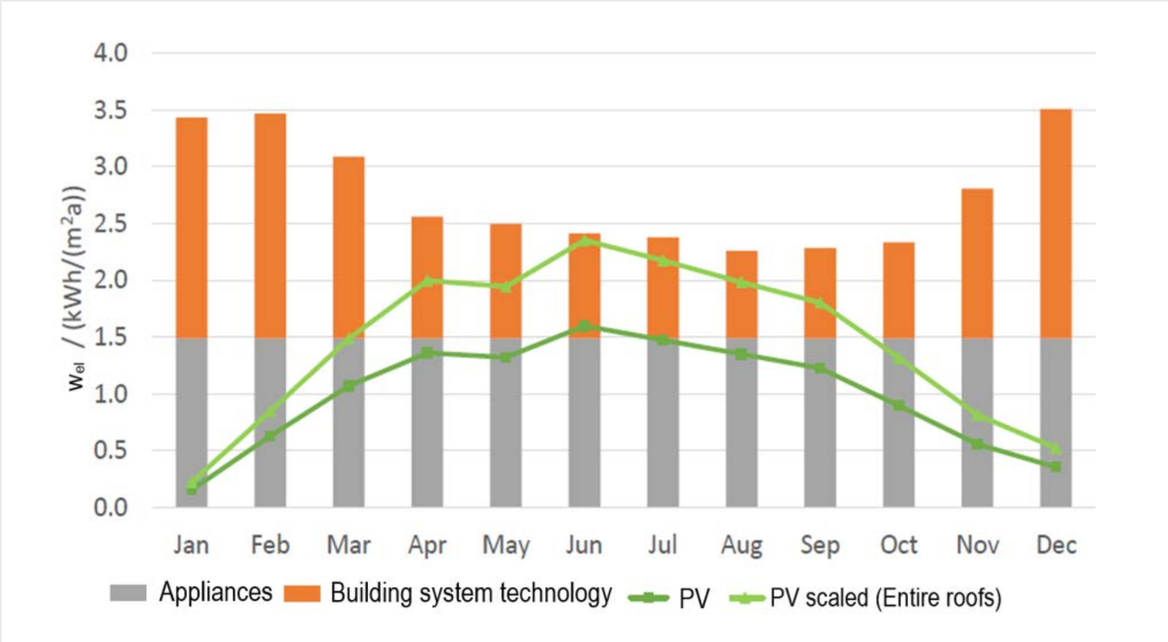


Fig. 2: Monthly balance of the two multi-family passive houses in Tyrol.

A feasibility study was performed for a group of buildings with laboratory, open plan office and a hotel in Rapperswil-Jona. This yielded the results that a heat pump system is more economic than a fossil gas boiler, due to higher space cooling demand for the office use. Moreover, the nZE balance can be reached with PV on the roofs and at suited facades of the buildings. Furthermore, the nZE balance is also economically feasible at favourable boundary conditions regarding feed-in tariffs and self-consumption of on-site PV production.

Meetings

The last Annex 49 meeting took place at the Free University in Brussels ULB on February 27-28, 2020. Final results of the national contributions and final reports were discussed.

Annex website

http://heatpumpingtechnologies.org/annex49/

Contact

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INFORMATION

53 ADVANCED COOLING/ REFRIGERATION TECHNOLOGIES DEVELOPMENT

Introduction

Air conditioning (AC) and refrigeration systems are responsible for a large share of worldwide energy consumption today, with demand is expected to increase sharply in the next 50 years, absent corrective action. IEA projects that AC energy use by 2050 will increase 4.5 times over 2013 levels for non-OECD countries and 1.3 times for OECD countries. Worldwide action, both near-term (e.g., increase deployment of current "best" technologies) and longer-term (RD&D to develop advanced solutions), is urgently needed to address this challenge. HPT Annex 53 focuses on the longer-term RD&D need. Technologies of interest include vapor compression (VC) and non-traditional cooling approaches.

VC technology has had decades of RD&D to date, and this is continuing. It may continue to be the system of choice. However, it is also vulnerable to further refrigerant restrictions. Non-traditional technologies (e.g., magnetocaloric (MC), elastocaloric (EC), electrochemical compression (ECC)) are generally not subject to this challenge, since they do not rely on fluorocarbon-based refrigerants. The technical scope of Annex 53 is very broad by design. It is not likely that there will be only one or even a few "right" solutions to the challenge.

Objectives

Annex 53's main objective is longer term R&D and information sharing to push development of higher efficiency and reduced greenhouse gas (GHG) emission AC/refrigeration focused HP technologies. Specific areas of investigation include but are not limited to the following:

- Advance the technology readiness level (TRL) of non-traditional and alternative VC technologies to bring them closer to the market;
- Independent control of latent and sensible cooling and tailoring systems for different climates (e.g. hot dry or hot humid);
- Advances to VC-based technologies, both conventional and non-traditional.

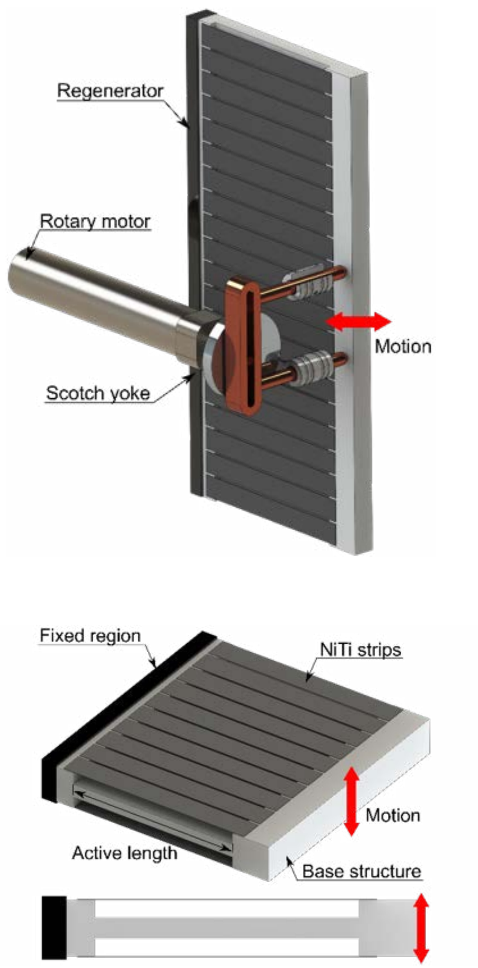

Fig. 2: Motor driven EC regenerator concepts: (top) one-side regenerator system; (bottom) two-side regenerator with strain bias and energy recovery. (courtesy of Ames Laboratory, J. Slaughter)

Results

Annex participants have made progress on EC systems R&D. At Xi'an Jiao Tong University a low-grade heat-driven EC system concept is developed based on a heat-activated high-temperature shape memory alloy (SMA) actuator driving a low-temperature super elastic (SE) alloy refrigerant. This approach could reduce actuator size and weight by more than 10 times compared to a mechanical actuator (Figure 1).

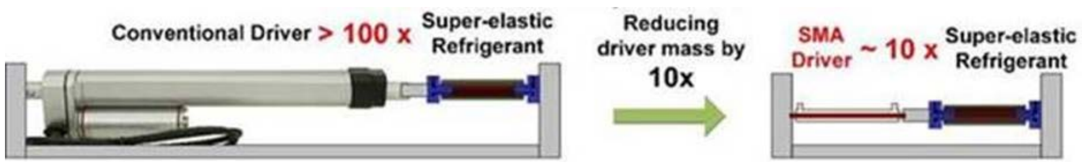

Fig. 1: Heat-driven EC system. (courtesy of Xi'an Jiao Tong University, S. Qian)

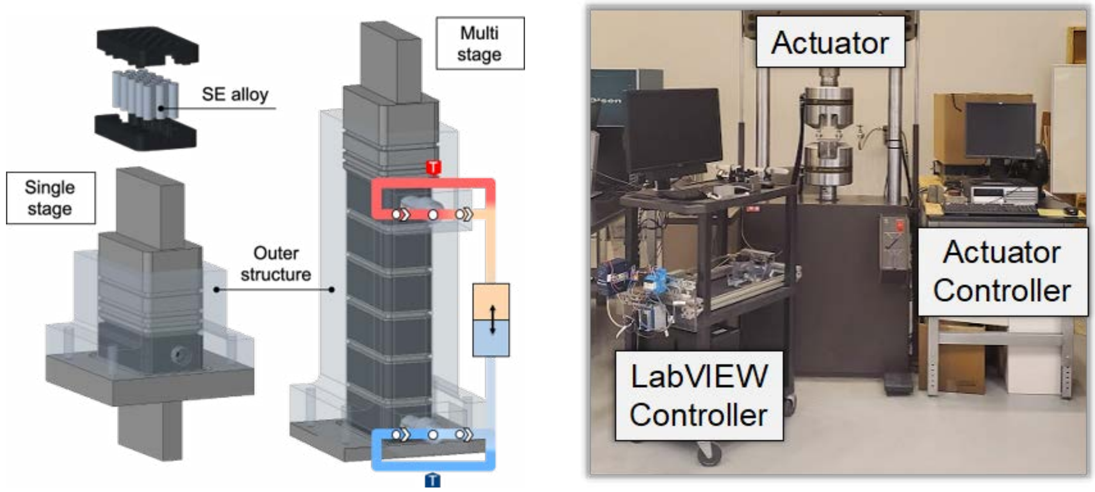

Fig. 3: Top left, single stage SE compression cell; bottom left, single-stage system under test; middle, multi-stage concept with heat transfer fluid loop; right, operational facility. (courtesy of Univ. Maryland, D. Catalini, N. Emaikwu)

Ames Laboratory has studied cost-effective actuator selection for EC systems. Magnetic SMAs are a good match for energy density, but have limited availability. Electric motors are widely available and can provide the necessary power density with gearboxes. A rotary-to-linear converter with a bending-type regenerator (Figure 2) provides a compact EC heat pump concept.

University of Maryland is investigating the potential of stacked SE layers for an EC system. A single stage EC system test station is operational, Figure 3. Promising tests are being performed on SE Nitinol®. Results indicate that direct strain measurement is required to provide accurate data. The station could become a rapid test facility for EC materials.

Meetings

First working meeting held Oct. 22-23 at Fraunhofer Institute in Freiburg, Germany. Reviewed draft Task 1 report; final version in preparation.

Annex website

https://heatpumpingtechnologies.org/annex53/

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INFORMATION

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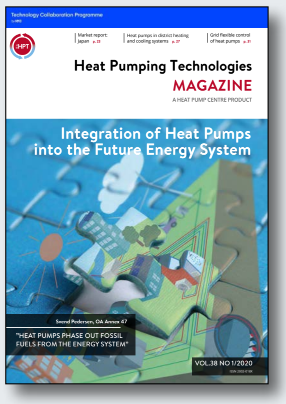

ANNEX 54 HEAT PUMP SYSTEMS WITH LOW GWP REFRIGERANTS

Introduction
A threefold growth of global air conditioning system demand is expected during the next three decades, particularly soaring in world's warmest countries (The Future of Cooling, IEA 2018). This demand growth would cause much higher consumption of electricity and high-GWP (Global Warming Potential) refrigerants than is the case today. Thus, we urgently need to shift from current air conditioning systems with high-GWP refrigerants to more efficient air conditioning systems with low-GWP refrigerants.

Objectives
Annex 54 promotes the application of low-GWP refrigerant to air-conditioning (AC) and heat pump systems in order to accelerate the phase-down of high-GWP HFCs. For this purpose, the annex plans to develop design guidelines for optimized components and systems for low-GWP refrigerants. Current annex participants are Austria, France, Germany, Italy, Japan, South Korea, Sweden and the US.

Progress in 2019
Annex 54 held its kick-off meeting and a workshop in Atlanta, US in January. The annex also organized two workshops for "Heat Pumps for Low-GWP Refrigerants" at the 25th IIR Conference - International Congress of Refrigeration 2019 in Montréal, Canada in August, see Fig 1. Seven presentations were provided by experts from the participating countries in the annex.

Fig. 1: Annex 54 organized two workshops for "Heat Pumps for Low-GWP Refrigerants" at the 25th IIR Conference - International Congress of Refrigeration 2019 in Montréal, Canada.

Further, we collected draft country reports for Task 1, Review of state-of-the-art technologies, and compiled them into a single report. This report provides a comprehensive, up-to-date review of current research, product development and regulation status of low-GWP refrigerants for heat pump application. It summarizes the collective efforts by researchers, engineers and regulation committees across the industry, and contains the following key elements:

- » a high-level review on efforts ensuring safe use of flammable refrigerants;
- » a comprehensive update on recent regulations and research advancements in bringing low-GWP refrigerants to residential AC systems;

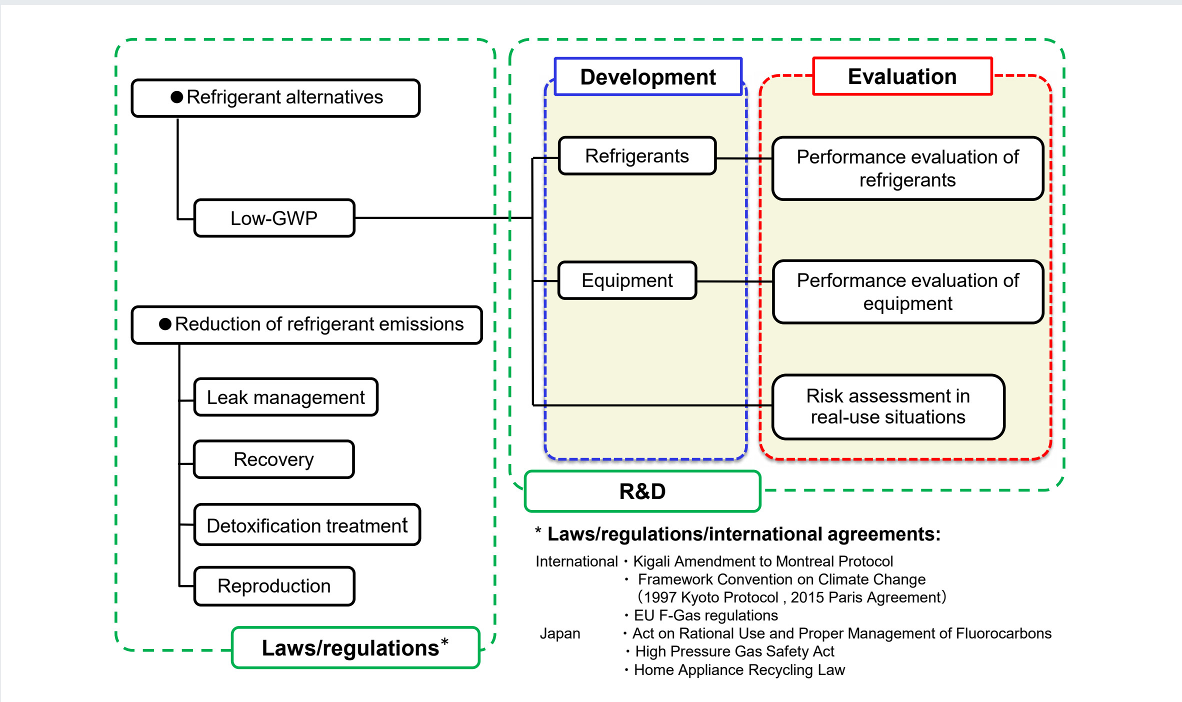

Fig. 2: Review of refrigerant regulations, initiatives and market progress in Japan.

- current standards and policies for residential and commercial heat pump (HP) systems with low-GWP refrigerants. The report also explains the policy drivers for refrigerant transition with a special focus on low-GWP HP applications and the GWP thresholds for the next step of HP component and system optimization;
- an update on bringing R32 to window-type ACs and split ACs;
- the on-going activities carried out in Italy regarding the use of low-GWP refrigerants in HPs. Consequently, research institutes, universities and companies have started research programs aimed at studying low-GWP refrigerants in the most comprehensive way;
- a literature review conducted for application of low-GWP refrigerants in high temperature HPs, including some showcases;
- a comprehensive review of refrigerant regulations, initiatives and market progress in Japan, see Figure 2. The report also provides an update on how Japan moves forward with regulations, research activities and market for low-GWP refrigerants, and its future plans.

The annex is planning to participate in the 13th IEA Heat Pump Conference, Jeju, Korea, organizing a workshop with seven speakers. We have also planned for a third project meeting during the Conference, to discuss tasks and progress status among members .

Annex website
All presentation materials, meeting agenda, minutes and attendee lists are available at the annex website, https://heatpumpingtechnologies.org/annex54/

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INFORMATION

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ANNEX 55 COMFORT AND CLIMATE BOX

Introduction
Integrated systems consisting of heat pumps and storage are an important technological option to accelerate the use of renewable energy for heating and cooling, see Figure 1. By combining heat pumps and storage, several issues may be tackled, such as

- Balancing & controlling electricity grid loads;
- Capturing a large(r) share of renewable (local/regional) input (i.e., solar thermal, solar PV);
- Optimizing economics, CO_2 emissions, fuel use over time;
- Providing optimal supply security to buildings.

Commercial development of this type of solution is progressing very slowly. This Combined Annex will accelerate market development of combined heat pump/storage packages. This will be the first Annex to integrate the work from the HPT and ECES Technology Collaboration Programmes (TCPs), building upon earlier work in the fields of Heat Pumps and Storage systems.

The underlying drive is to accelerate the market development for Comfort and Climate Boxes (CCBs) to enable rapid growth of the application of these promising heating systems in differing climate zones. The importance of this Annex is that we want to offer two technologies (energy storage and heat pumps) combined with boosting development in speed, and thus shorten the time to market for new concepts and developments.

Objectives

- Main goal: to develop improved CCBs in existing buildings to speed op market development.
  We will strongly focus on systems that will be close to commercial realization (i.e., Technology Readiness Level of 7 and above) and have a high quality, adopted to their local market. The work will be oriented around the nine quality criteria (see Figure 2) to define the concept of improved quality.

- The underlying drive is to accelerate the market development for CCBs to enable rapid growth of the application of these promising heating systems in differing climate zones.

By exchanging the lessons learned from the separate developments in each participating country, we will enable the participants to help each other to speed up their local market development.

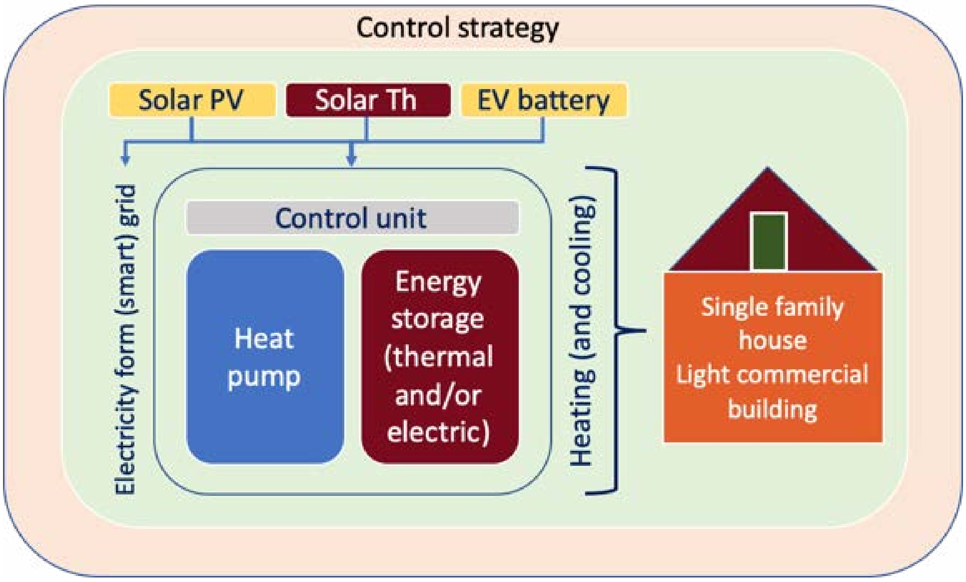

Fig. 1: Comfort & Climate Box.

Progress

Normally, the Annex progress in the participant countries is shared at meetings in these countries. Understandably, Covid-19 has changed this into online meetings. We may be forced to maintain this during the remainder of the Annex, until the foreseen completion in September 2021. Regarding progress in the project, the first results have been discussed in the Annex group.

Meetings

Freiburg, October 17 and 18, 2019: WP1: Investigate the present market status. WP2: Develop or assemble market prototypes.
Rome, February 5-7, 2020: WP3: Testing and standards for prototypes. WP4: Roadmap for CCBs.

Annex website

https://heatpumpingtechnologies.org/annex55

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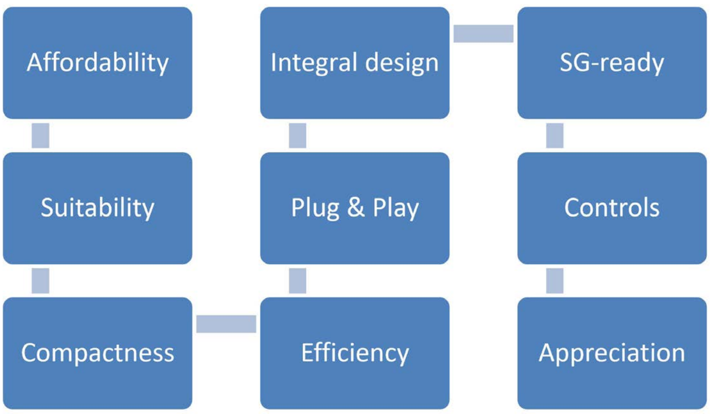

Fig. 2: Quality criteria

Heat Pump Market Development in Switzerland

Stephan Renz, Switzerland

Switzerland has been a pioneer in the development and commercialization of heat pumps. Until the 1980s, mainly large heat pumps were sold. Since the 1990s, the availability of reliable and efficient small devices as well as environmental aspects have been driving forces. In a ten-year period from 2007 onwards, almost 20,000 units were sold year after year. Since 2018, sales have risen again, reaching 23,980 units in 2019. Of these, 85% are small systems up to 20 kW heating capacity for single-family homes. Future challenges lie in the retrofitting of heat pumps in existing multi-family buildings and in office buildings in urban environments.

Introduction

Renewable energy sources and energy efficiency are pillars of the Energy Strategy 2050, which guides the way towards a sustainable transformation of the Swiss energy supply. Heat pumps play an important role in this process. The sales figures for heat pumps in Switzerland were constant for a long time, but have now been rising for two years in a row. This article provides background to this development.

History

Swiss technology pioneers were the first to construct vapour recompression plants [1]. Probably stimulated by the experiments of Peter von Rittinger at Ebensee, the first truly functioning vapor recompression salt plant was developed in Switzerland and put in operation in 1878 at the salt works at Bex. It was the first heat pump in Switzerland (Figure 1).

Until the 1930s, industrial chillers in sizes up to several megawatts were the primary applications of heat pumping technology in Switzerland. Before and during the Second World War, Switzerland experienced a severe coal supply shortage. This stimulated the construction of more hydroelectric power plants and a rational use of hydroelectricity, the so called “Swiss White Coal”.

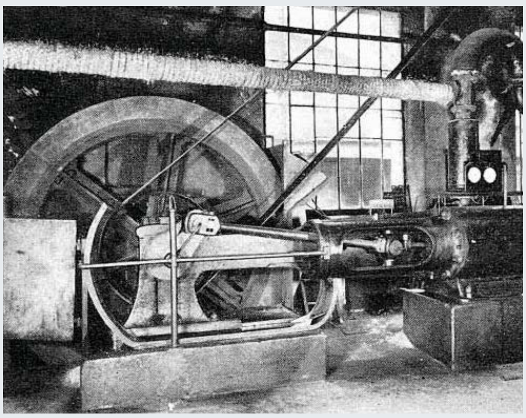

Fig. 1: Compressor installed at the Saline Bex in 1878 [1]

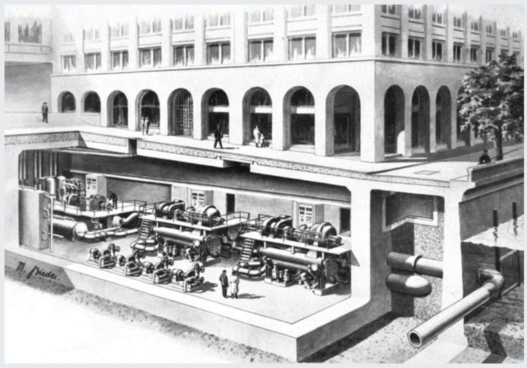

Fig. 2: 5.86 MW heat pump plant at Walche, 1942 [1]

Advanced mechanical and thermal engineering skills allowed Switzerland to become a heat pump pioneering country. Between 1938 and 1945, 35 large heat pumps were manufactured and installed in Switzerland, by companies such as Sulzer in Winterthur, Escher Wyss in Zurich and Brown Boveri in Baden. These heat pumps were used for space heating, but also for other low temperature heating purposes (e.g. domestic hot water, water in a public swimming pools). The main heat sources were lake water, river water, ground water and waste heat. Exploiting waste heat from cooling at skating rinks and breweries was practiced already in the 1930s. After the Second World War heat pumps remained important. In 1955, there were about 60 large heat pumps in Switzerland, the biggest of them reaching 5.86 MW (Figure 2).

To date, Switzerland remains a heat pump champion. The country’s pioneering work in the development of borehole heat exchangers, sewage heat recovery, oil free piston compressors and turbo compressors is well known. Some of the biggest heat pumps ever built comes from Switzerland. Although there is a rather large natural gas distribution grid, 90% of new single-family homes in Switzerland in 2019 were equipped with heat pumps. Recent developments in the Swiss heat pump market are discussed in the Market Overview further below.

Policy and drivers

Federal policy and laws
Swiss energy policy is characterized by two fundamental drivers: phasing out of nuclear energy and reducing greenhouse gas emissions. The challenge is to achieve these objectives while maintaining security of supply at affordable costs. The core measures of the revised Energy Act [2], in force since 2017, are therefore to withdraw step by step from the use of nuclear energy, to reduce electricity consumption, and an expansion of hydropower and new renewable energy sources.

Climate change discussions worldwide and local youth movements such as "Fridays for Future" had tangible impacts on the Swiss parliamentary elections in autumn 2019 when Green party candidates won numerous seats. Several cities and cantons declared state of climate emergency. Furthermore, the Federal Council decided in August 2019 to reduce Switzerland's net carbon emissions to zero by 2050. The new parliament is expected to pass a revised CO_2 Act soon, in which the CO_2 tax could be massively increased from today's CHF 96/tonne CO_2 to CHF 210/tonne CO_2 (1 CHF = 0.97 USD). And after 2030, the installation of new boilers with fossil fuels could be largely banned if CO_2-emissions of the building sector will not have been cut in half compared to 1990.

One way to achieve these objectives is to replace outdated heating systems within the scope of building renovations. As forecast in 2019, around 900,000 fossil-fuelled heating systems will need to be overhauled or replaced by 2050, which presents a huge opportunity for heat pump technologies [3].

Energy-legislation at cantonal level
Legislation for buildings is the responsibility of the cantons. In order to standardize energy legislation in the 26 cantons in Switzerland, their energy ministers have drawn up a model template [4]. In this act, heat pumps are a preferred solution for heat generation. As cantonal parliaments are in charge of updates to the existing building regulations, they decide whether to deviate from the model template and, for example, demand lower or higher energy efficiency. After the parliamentary decision, citizens are free to demand a popular vote on the new bill. Figure 3 shows where a revised energy law was rejected (red) and where it is in force (dark green). Clearly, the status of implementation varies greatly between the cantons.

Incentives
Each canton also decides on their own subsidies for energy efficiency measures. The amount of subsidies varies widely. Some cantons make a minimum amount of CHF 2000 available for heat pumps, whereas the canton of Basel-Stadt offers maximum contributions per installed heating capacity of 10 kW: CHF 10,500 towards expenses for air-to-water heat pumps or CHF 30,000 for brine-to-water heat pumps.

Market overview

After two decades of stagnation, the heat pump market was reinvigorated during the oil crises in 1973 and 1979. The development of smaller heat pumps for central water heating systems in single-family homes and larger residential buildings began. Between the 1980s and the mid-1990s, around 2000 - 3000 heat pumps were sold in Switzerland each year. Establishing the Swiss Association for the Promotion of Heat Pumps (FWS) in 1993 contributed to the success. Its tasks include the provision of information and advice, education and training, advocacy and quality assurance [3]. Sales rose rapidly in the mid-1990s and reached a first peak in 2007 with 20,670 units. In 2018 sales numbers rose again and in 2019 a new record of 23,980 units sold was reached (Figure 4). Please note that these and the following statistics do not include hot water heat pumps (6071 units sold in 2018), large heat pumps, e.g. in district heating applications or custom-made products for the industry.

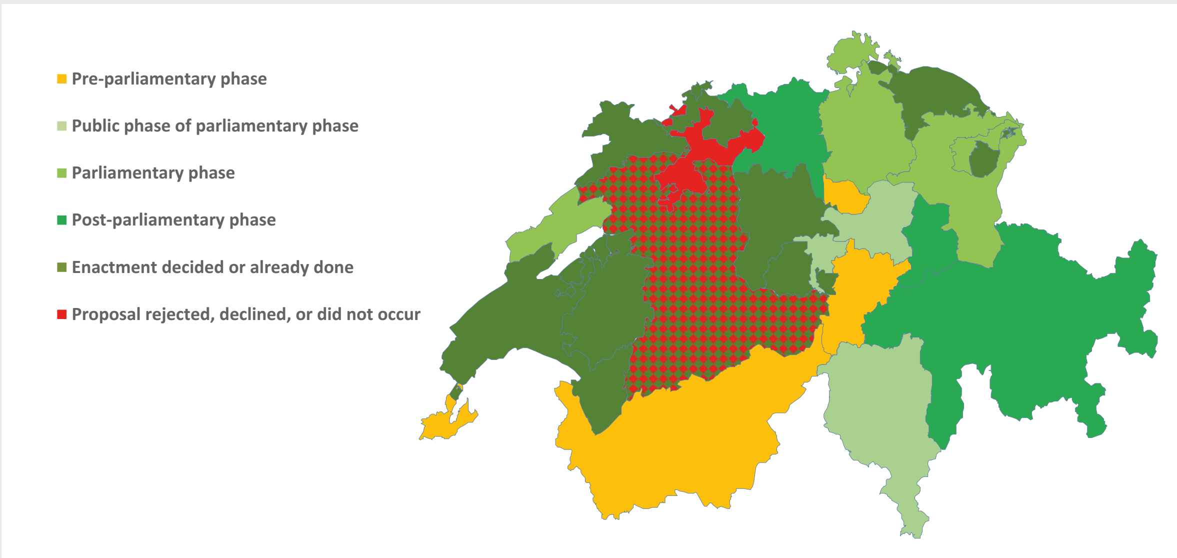

Fig. 3: Status of revisions to energy legislation in the 26 cantons in Switzerland [4]

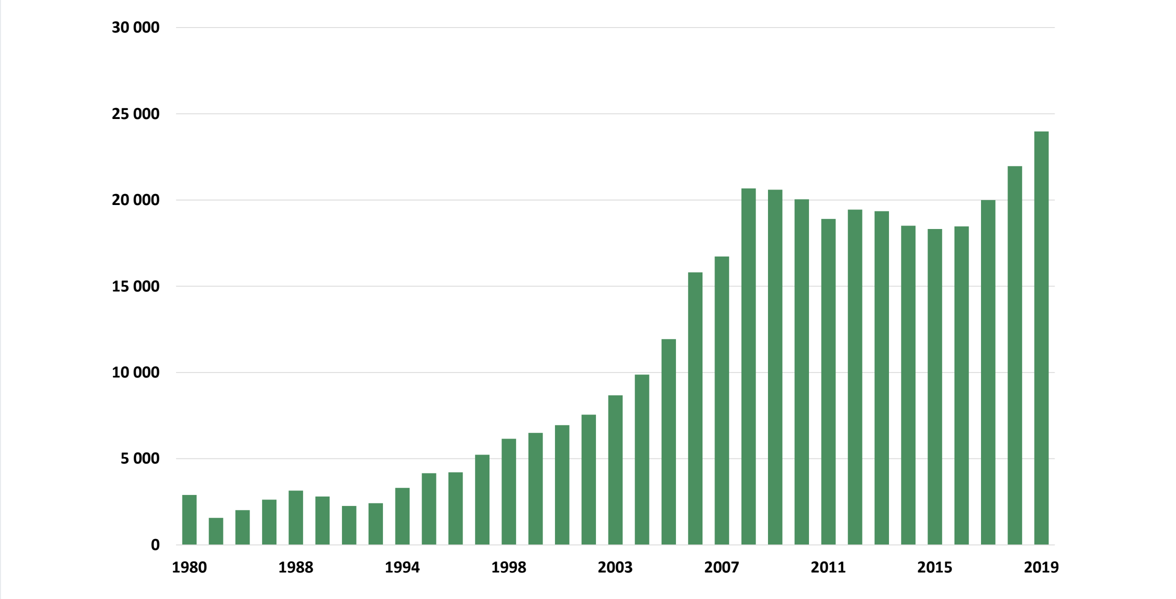

Fig. 4: Sales figures for heat pumps per year in the Swiss market [5]

71% of the heat pumps sold rely on air as a heat source and 28% on brine (figure 5). Ten years ago, the share of air-to-water heat pumps was only 59%. Heat pumps account for a very high proportion in the number of heating systems sold annually in Switzerland. In 2019, the figure was 40% (Figure 6).

Further analysis of sales figures shows that a large number of small heat pumps were sold. 85% of the units has an output of less than 20 kW (Figure 7). In the future, larger heat pump systems will need to be installed to effectively displace heating systems that rely on fossil fuels.

When multiplying the number of newly installed heating systems with the capacity of the units sold, it becomes clear that gas and oil dominate in the larger output categories (Figure 8). Cumulated numbers show that fossil fuel-based heating systems still cover a much larger share (1390 MW) of the heat supply than heat pumps (400 MW). The data points to the major challenge of introducing heat pumps in new and existing multi-family buildings and office buildings, especially in urban environments. [6, 7]

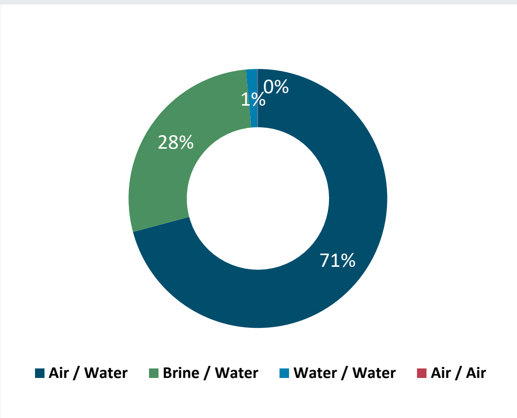

Fig. 5: Percentage distribution of heat pump sales by energy source in the Swiss market for 2019, [5]

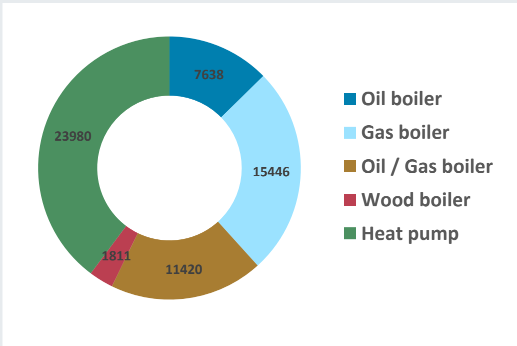

Fig. 6: Sales figures for heat generation units and oil/ gas burners in the Swiss market for 2019 [5]

Conclusions

Fossil fuels have been a driver for the development and sales of heat pumps in Switzerland, although in different ways: In the past, there were supply bottlenecks, and today it is the demand for decarbonisation of the energy system. In order to further promote heat pump sales, appropriate energy and environmental laws as well as incentives are needed.

Recent developments in energy policy had a favourable impact on heat pump sales figures. Compared to the previous year, sales increased by about 10% in 2019. To replace all fossil-fuelled heating systems by 2050, around 40,000 heat pumps would have to be installed each year, a two-fold increase compared to the last decade.

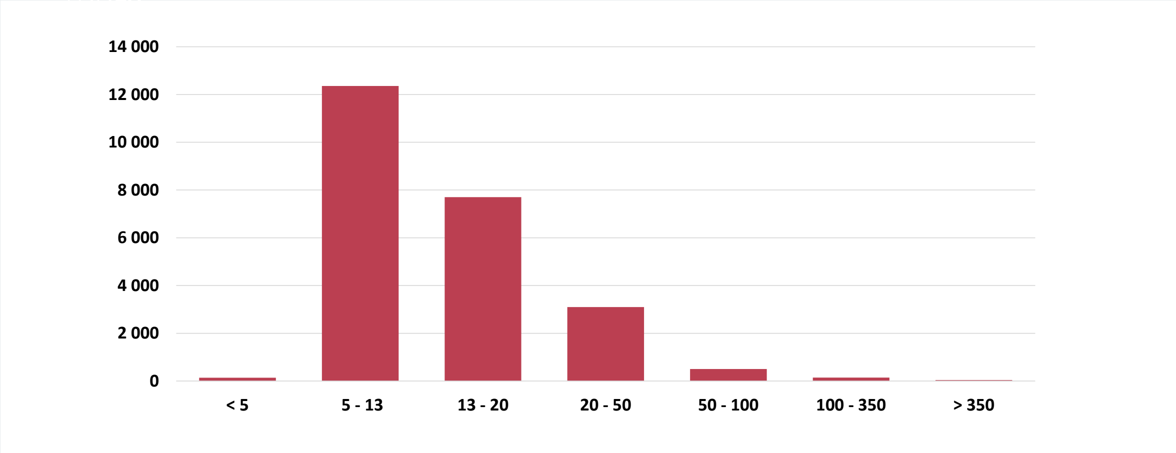

Fig. 7: Heat pump sales by power in kW in the Swiss market for 2019 [5]

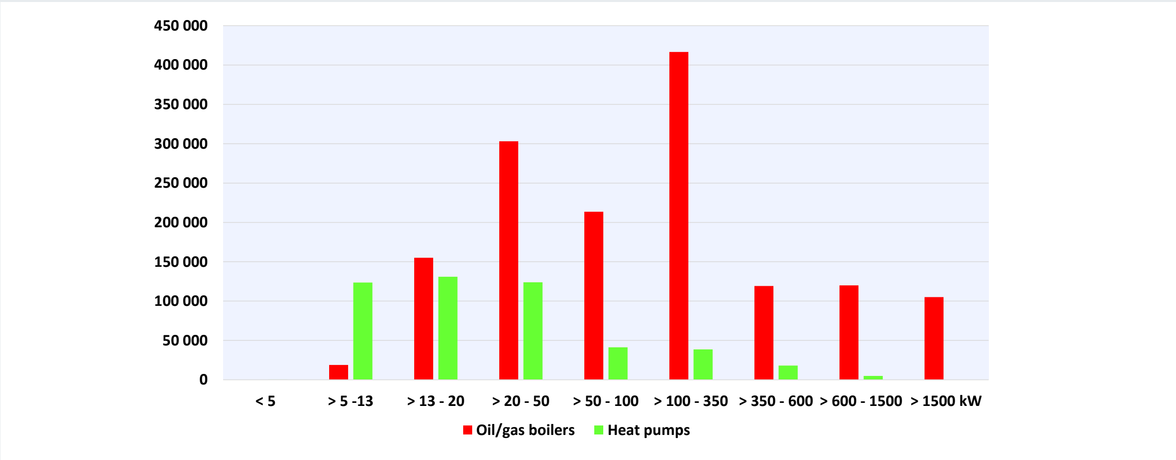

Fig. 8: Distribution of sales figures by power range for 2019 [5]

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https://doi.org/10.23697/3drk-tr91

Deep renovation of residential buildings owned by housing corporations

Bas Roestenberg, The Netherlands

For multi-family buildings renovation in the Netherlands, district heating is the dominant heating technology at the moment. Still, several housing corporations opt for 'deep renovation' as an alternative way to make dwellings 'Nul-op-de-Meter' ('Zero on the meter'). In these projects it is increasingly common to apply decentral 'plug & play' systems for heating and domestic hot water production. Once at the construction site, the pre-assembled parts of these installations can easily be connected. This method minimizes inconvenience for residents, eliminates installation errors and thus lowers the costs of installation, as proven by the three projects described in this article.

Introduction

A main target of the Dutch energy policy is to get one and a half million houses disconnected from the gas grid by 2030. In this context, housing corporations, suppliers of energy technology, homeowners and local authorities are challenged by finding economically viable concepts for fossil free heating and domestic hot water production in existing houses and apartments. District heating seems to be the dominant technology at this moment.

Renovation of the housing stock, especially houses owned by housing corporations, is a challenge. However, it also offers unique opportunities that are not available for individually owned single family buildings. One of these is that renovation projects are often on a larger scale, and can thus be executed as deep renovation projects, with the goal to upgrade the housing estate and increase the value. This type of projects often does not follow the traditional development process, where the choice of energy technology is secondary. More and more the technology manufacturers are involved from the start of the process, integrating it in the technology of the building structure and components which are pre-assembled at the factory and transported to the project [1]. In this article, three projects of this kind are described.

Paddepoel: the challenge of placing outdoor units [2]

At first glance, the renovated apartment block in the Paddepoel district of the northern city of Groningen looks deceivingly new, see Figure 1. Still, the 48 flats in the Voermanstraat and Pleiadenlaan are decades old and have undergone thorough renovation.

Fig. 1 The renovated apartment block in the Paddepoel district, Groningen [2].

Fig. 2: Hot water storage tank (100 litres) with smart metering inside storage cabinet in each apartment.

The retrofit of the Dutch housing stock is a real challenge. Apartments are hard to insulate and often lack enough space for the installation of solar panels and heat pumps. In Groningen, contractor Dura Vermeer, installer Klein Poelhuis, housing corporation Lefier and heat pump distributor Alklima/Mitsubishi Electric acted together to develop a solution. In this case, solar panels could easily be installed at the roof of the complex. However, the placing of 48 individual air-to-water heat pumps proved to be a real challenge.

New façade

In order to retrofit the building to 'Zero on the meter' it needed a new façade. This new façade was completely pre-fabricated and was installed in the shortest possible time frame, in order to minimise inconvenience for the inhabitants. After all, they stayed in their apartments during the renovation project. Both the front and rear façade were provided with insulated wall panels. The roof of the complex received additional insulation, triple glass was installed and the balconies were 'shifted inwards' to keep the winter cold outside.

Although the apartments have been equipped with low-temperature heat pumps, the existing high-temperature radiators could be maintained - which was a requirement for this project. Due to solid insulation, an airtight façade and the application of balanced ventilation with heat recovery, the combination of low-temperature heat pumps and high-temperature radiators could guarantee a comfortable indoor environment.

Challenges

The apartments in this project did not have enough floor space for the new technical installations. The heat pump indoor units and storage tanks – sized 100 or 150 litres – were slightly more spacious than the old replaced gas boilers. This problem was solved by installing a compact-build yet service-friendly system, see Figure 2. This new system does not need more floor space than the replaced gas boiler.

So far, so good. Still, one main issue remained: finding a spot with enough room for 48 outdoor heat pump units. They could not be placed on the roof, as this was already

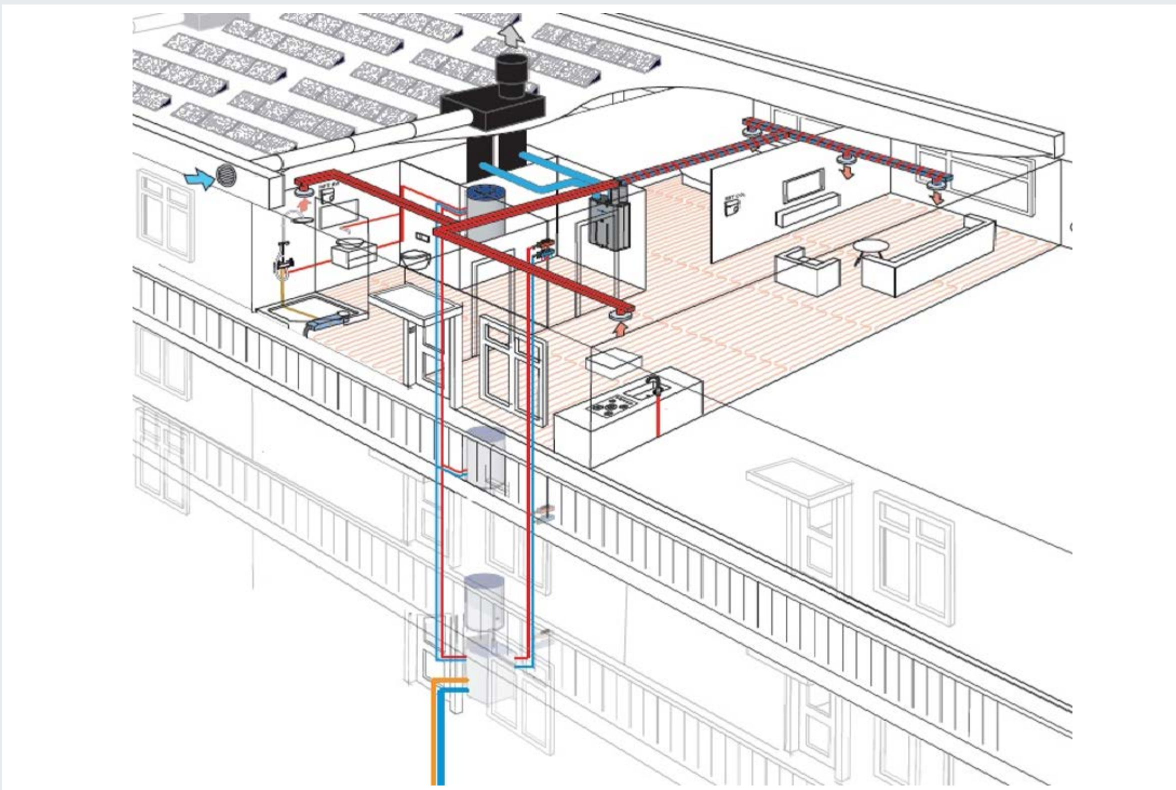

Fig. 3: Soendalaan, Vlaardingen, Netherlands, technical overview.

'reserved' for solar panels. A solution was found in the plinth of the building, where each column of three apartments has its own entrance to the garage units. At these spots, casings were mounted, enclosing the outdoor units of those three apartments. As extra benefits, these casings provide soundproofing and keep the units out of sight.

Soendalaan: apartment building with ground source heat pumps [3]

Housing corporation Waterweg Wonen, building company BIK bouw and the Technical University of Delft joined together in a unique renovation project in the city of Vlaardingen. Over here at the Soendalaan, twelve older apartments have been renovated into 'Zero on the meter'. 'Zero on the meter' is increasingly common in new buildings, but this was one of the first Dutch 'Zero meter' renovation projects for an old apartment building. From the start of the project, the residents of the apartments were actively involved, and they were eager to participate.

These 12 apartments were built in 1952 and no longer met the current standards. This 'Zero on the meter' renovation pilot was focussed on finding an optimal balance between sustainable renovation, living comfort and affordability – both for the tenant and the housing corporation. Thanks to the efforts of Waterweg Wonen and European and Dutch subsidies, the financial feasibility of the pilot was guaranteed.

Coat for the building

The modular concept that 'BIK bouw' applied is called '2nd Skin', referring to the additional insulating 'coat' that has been added to the façade. This second skin is designed as a lightweight plug & play construction that can easily be connected to the façade of an existing building. In addition, new frames with three-layer insulating glass has been installed, and the roof of the building is covered with solar panels. They provide sufficient energy for all domestic installations, including a demand-driven ventilation system with heat recovery, Figure 3.

The apartment building has three stories, which makes four columns of three apartments. Each of these columns is connected to one individual ground source heat pump that provides space heating, cooling and domestic hot water. The individual apartments are equipped with a 150 litres storage tank. Together with most other installation components, like the ventilation box, this tank is placed in a utility cabinet attached to the new skin of the building. In this way, precious indoor space has been saved. All these technical measures together made it possible to disconnect the entire building from the gas grid.

Fig.4: Soest, view of façade

Soest: energy modules for 70 houses

In collaboration with a housing corporation, the municipality of the Dutch city Soest set an interesting example for seventy terraced houses. Crucial elements in this 'Zero on the meter' project were the use of additional insulation and the installation of a plug & play energy module, containing an air source heat pump, storage tank and a ventilation box.

Before this module could be installed, the first step in the project was the attachment of insulation panels - including plastic window frames with three-layer glass - to the existing façades. Besides, the underfloor space has been insulated with special foam chips. Solar panels are installed on the roof, generating up to 5,600 – 5,800 kWh/year, sufficient to provide all household appliances (including lightning) and the heat pump with power. Thus, all the houses are disconnected from the gas grid. With the new façade panels, window frames and roof, they look like new build, see Figures 4 and 5.

Noise reduction

The next step in the process was the installation of the energy module, in a casing at the back of the houses. The project in Soest could benefit from 'lessons learned' in earlier, similar projects, resulting in a smaller and smarter energy module. It is optimized in order to reduce noise, so the residents can enjoy their backyard without being disturbed by their heat pump installation. The satisfaction level of the residents was an important factor. A critical condition for this project was the prior consent of at least 70 % of the residents. In small discussion groups the housing corporation explained that this type of renovation can result in significant costs savings when more energy is generated than consumed.

Plug & play heat pump

The energy module is equipped with a Mitsubishi Ecodan air-to-water heat pump. Alklima supplied the heat pumps to building corporation BAM. Their technical department made the heat pumps fully operational and connected them to the other components of the energy module turning it into an 'install ready' plug & play unit which can easily be connected at the renovation site. The new standardized module can be attached to the façade

Fig.5: Soest, front view of façade.

of most of the terraced rental houses in the Netherlands The heat pump uses the existing radiators for space heating, and provides sufficient domestic hot water for one daily shower of 45 minutes. The housing corporation instructed the residents how to use their new installation, with a specific focus on domestic hot water usage. The energy module offers several ways of monitoring, so residents can easily track their energy usage and have a real-time overview of the yield of their solar panels.

Teething problems

One year after completion of the renovation project the experience of the residents was investigated. About 1 out of 10 residents missed the radiant heat of a high temperature system. Some residents also mentioned the sound of the heat pump, which they could hear at night. This might be a matter of 'getting used' to it. Research at other projects shows that after a while residents do not experience this sound as 'disturbing' anymore. Despite these 'minor' complaints, the overall reaction of residents was positive, rating the renovation with 7.2 out of 10 points. They commended the increased comfort of the indoor climate and the new appearance of their houses. Negative comments were given on the duration of the project (it faced major delays).

Conclusions

These examples are just a few showcases of technical solutions for the challenges of deep 'Zero on the meter' renovation of existing dwellings. In recent years, an increasing number of housing corporations started pilot projects in order to assess the options for individual instead of (rather expensive and less flexible) centralised concepts for heating and tap water production. Obviously, new concepts have to deal with teething problems, and every pilot results in some lessons to be learned. Still, the overall results of 'Zero on the meter' projects in the Netherlands are promising. The Dutch Housing Research Centre (Centrum voor Woononderzoek) conducted research at various 'Zero on the meter' renovation projects. About 80 % of the residents of projects that have been surveyed are satisfied with the result of the sustainable transformation of their house or apartment.

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Renovation of heating systems in multifamily buildings in Finland

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Connecting to district heating is normally regarded as a good opportunity because of the high density of energy demand in inner-city areas with large 'one-point' demand in the substation of a multifamily building. However, due to relatively high costs for district heating, this may not be the case. In Finland, as in other Scandinavian countries, getting off of the district heating grid is a trend. Three examples are described. In the first, only the largest system losses were addressed by installing a domestic hot water heat pump. The two other examples show complete make-overs, where also space heating is generated by a collective heat pump.

Introduction

The total length of the district heating network in Finland at the end of 2015 was about 14,600 km. In cities and in other major population centres, the network covers virtually the entire area that can be connected economically to the district heating system. Especially the large and dense energy demand in inner cities with a great number of dwellings in apartment buildings is an interesting revenue model for energy companies.

However, there is also a growing trend in Scandinavian multifamily buildings to disconnect from the district heating network by installing individual air source heat pump water heaters or installing collective heat pumps in multifamily buildings. Significant reduction in the distribution losses and cost savings can thus be achieved. This is in line with the policy indicated by the City of Vienna in Austria, where it is advised, especially for domestic hot water, to generate the hot water at the location where it is needed to avoid distribution losses [1]. In the present article, three examples from Finland are shown, where heat pumps were installed in renovation projects by housing corporations.

The Jyväskylä project

A heat pump recovering exhausted air system was installed in January 2013 in one large apartment building in the city of Jyväskylä. This six-floor building was built in 1971, and district heating energy consumption was 750 MWh annually. The heat pumps (NIBE F145-40) are connected to the radiator heating circuit as well as to the domestic hot water (DHW) circuit via a buffer tank. Automation takes care of when heating of radiators is needed and when there is a need for DHW.

Although recovery of exhausted air with heat pumps is not a new, it has not been much used in large apartment buildings. Interest for this application has been raised

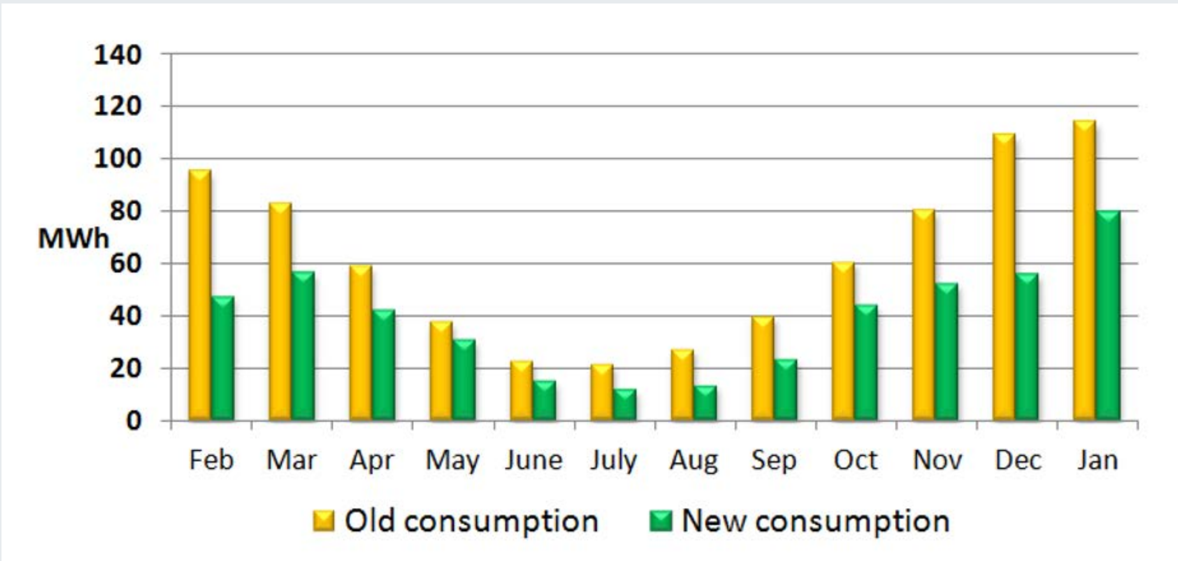

Fig. 1: Change in monthly energy consumption [2].

only during the last couple of years as energy prices for district heating have risen and awareness regarding potential savings of this application has been growing. Also, the reported savings in pilot installations, with high return of investment, has been positively received by the market.

After one year, the annual district heating energy has decreased by 45% (from 750 to 412 MWh) resulting in an annual reduction of 73 tonnes of CO_2 emissions, while the heat pumps used 61 MWh electricity corresponding to an annual increase of 13 tonnes of CO_2 emissions. Overall net energy consumption has decreased by 37% from 750 to 473 MWh; annual CO_2 emissions have decreased by 60 tonnes of CO_2. See Figure 1.

Energy costs have decreased from € 53 700 to € 34 800. The Return on Investment is 16% per year. The heat pump SCOP (Seasonal COP) is 3.8.

Thus, significant cost savings can be achieved by recovering the energy of the exhausted air and transferring it back to the building's heating system. With this method, the district energy consumption is nearly halved, and, when adding the energy needed by the heat pump, the net energy saving is typically around 40%. Depending on the energy prices the heating cost saving is typically between 30-40%. Additionally, the basic fee of district heating is also reduced by 50% as it is linked to the volume of energy used.

The Raisio project [3]

Completed in 1972, the real estate developer Sorolaisenmäki has a total of 90 apartments in Raisio connected to the local district heating network. The board of directors from the real estate developer wanted to keep housing costs under control, so that low-income retired people could live in their own homes. Thus, in 2015 Sorolaisenmäki decided in a renovation project to upgrade the building, abandoning district heating. Otherwise, housing costs would have increased every year simply because of district heating price increases. This was open-minded and unprecedented in Raisio. They were the first real estate developer to decide to abandon district heating. They were considered as a threat, and their calculations were suspected to be incorrect.

Ground source heat pumps were installed with nine geothermal wells, each 230 meters deep. The heat pumps centrally provide space heating and DHW. In connection with the renovation of the heat generation, the vertical pipes of the circulation system were renewed, and water meters for each apartment were installed. Heat recovery from the ventilation exhaust air was introduced. The ground source heat pump and heat recovery was covered by a treatment facility loan used by a few housing companies. It reduces the loan using savings on care fees for heating costs and, as a result, the purchase had no significant effect on residents. According to calculations the payback time of the geothermal system is about 9 years.

Project in Suvela, Espoo [4]

The Espoo housing company Jalmarin-Salva changed from district heat to geothermal heat three years ago, see figures 2 and 3. The continuous rise in the price of district heating caused the Espoo housing company to switch to geothermal heating. The project originated from an initiative of the shareholders. They wanted to get away from the rise in the price of district heating. The change did not happen in an instant. It took a couple of years to prepare and make decisions. The issue was discussed for a long time and voted on at two general meetings. There were many sceptics.

Fig. 2: In connection with the geothermal renovation, a heat recovery system was added to the mechanical exhaust ventilation of the Espoo apartment building company. The pipes in the system run on the roof of the house. Photo: K. Rautaheimo, Helsingin Sanomat.

Fig. 3: Geothermal heat is local heat, originating from the rock on which the houses are built. With these devices, heat is pumped from the earth's crust. Photo: K. Rautaheimo, Helsingin Sanomat.

The condominium consists of two buildings, each with seven floors and a total of nearly one hundred apartments. The renovation of the main buildings began in October 2016. Disturbances in the daily life of housing were surprisingly minor. District heating operated until *the ground source heat pumps with 12 deep ground sources were started. There was a break in the hot water supply for only a few hours.

The project has now been using geothermal energy for three years. The system has worked flawlessly since the initial challenges. During the first year, there were small problems especially in regulating the water temperature.

As the shareholders were not ready to borrow, the housing association implemented the project together with the Energy Service Company (EsCo) Lähienergia that owns the system and is responsible for its maintenance and sells heat to the housing association. The heat pump system with the ground sources requires maintenance and replacement of parts. It is estimated that the equipment will last 30 years, the compressors about 15 years and the boreholes and pipes more than 50 years. The functioning of a geothermal system requires not only expert planning but also monitoring and maintenance. In this case the system maintenance is outsourced in a monitoring and maintenance contract between the housing association and the EsCo. The contract is valid for eight years, after which the system is transferred to the housing association. In practice, the housing association gradually pays for the system with savings due to reduced heating costs. When a housing association moves from district heating to geothermal energy, the need for energy purchased for heating is significantly reduced or even altogether eliminated. The decrease in district heating cost was € 70,000–80,000 per year. It is estimated that after the investment is amortized, the savings will be nearly € 50,000 per year. Other energy-saving measures have included renovations of windows, balcony doors and facades. In addition, mechanical exhaust ventilation has been equipped with heat recovery.

Outlook: economic aspects

In other countries there is a growing tendency towards collective systems for new buildings and district heating for existing buildings, often in densely populated areas with social housing. This approach passes on costs on to third parties, with a lot of subsidies, and is not in the interest of those inhabiting the houses, often from the less fortunate social classes. Social housing has a long history associated with low-income households, traditionally housing vulnerable people and those that are disadvantaged within society.

Energy bills and energy costs per household reflects how the end user interacts with the provision of energy. Focusing on these costs therefore relates the energy need to the implications of meeting that energy need. Describing how households are affected by energy costs (a part function of housing quality), can be summed up in one term – fuel poverty. In energy terms, fuel poverty creates a base point upon which we can begin to target low cost heating deployment.

Conclusion

In Finland the process of multi-family houses choosing other heating than district heating continues, with about 500 new corresponding cases annually. The reasons for this are largely economic. In other countries, district heating for new buildings is common. This may have negative implications for those living in social housing buildings.

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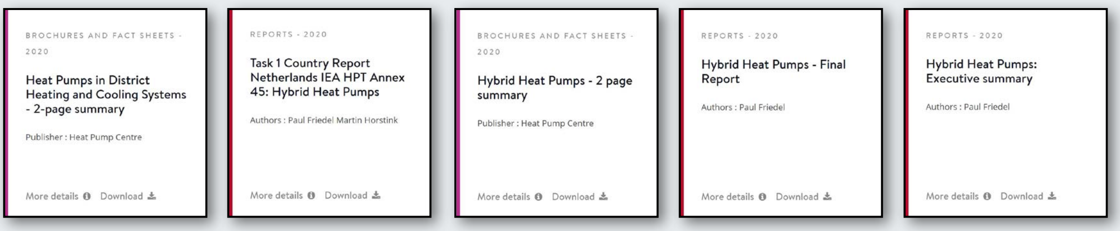
INFORMATION

Do you want to read more about the results and outcome of the HPT TCP Annexes?

Welcome to the HPT TCP publications database
Here you find the results of the projects implemented by the Technology Collaboration Programme on Heat Pumping Technologies, HPT TCP, and Heat Pump Centre, HPC.

Publication database:
https://heatpumpingtechnologies.org/publications



Events 2020/2021

Any updates about the situation regarding the Corona virus have been added, as of 6 April 2020. Please closely check the info of any Conference you plan to attend.

2020

14-15 September
Engineering Buildings, Systems and Environments for Effective Operation
Virtual Symposium
https://www.cibse.org/symposium

29 September -1 October
2020 Building Performance Analysis Conference Simbuild Virtual Conference
Virtual Conference
https://www.ashrae.org/conferences/topical-conferences/2020-building-performance-analysis-conference-simbuild

5-8 October
IRENA Innovation Week 2020
Virtual edition
https://www.irena.org/events/2020/Oct/IRENA-Innovation-Week-2020

13-14 October
BuildSim Nordic 2020 Conference
Virtual Conference
https://buildsimnordic2020.ibpsa-nordic.org/

13-15 October
Chillventa eSpecial
Virtual event
https://www.chillventa.de/en/especial

20-22 October
ATMOsphere America 2020
Virtual event
http://r744.com/events/view/atmosphere_america_2020

5-6 November
The Fourth International Conference on Efficient Building Design
Virtual Conference
https://www.ashrae.org/conferences/topical-conferences/the-fourth-international-conference-on-efficient-building-design

11-13 November
8th Iberian-American Congress of Refrigeration Science and Technology (CYTEF 2020)
Pamplona, Spain
http://www.unavarra.es/cytef2020/?languageId=1

23-25 November
23rd European Cold Chain Conference
Rotterdam, Netherlands
https://www.gcca.org/europeancoldchainconference

2-4 December
51st International HVAC&R Congress and Exhibition
Belgrade, Serbia
http://kgh-kongres.rs/index.php/en/

7-9 December
14th IIR-Gustav Lorentzen Conference on Natural Refrigerants (GL 2020)
Virtual Conference
https://biz.knt.co.jp/tour/2020/12/gl2020/index.html#attention

2021

10-12 January
Climamed 2020
Lisbon, Portugal
http://www.climamed.org/en/

13-15 January 2021
Compressors 2021 – 10th International Conference on Compressors and Coolants
Slovak University of Technology
https://szchkt.org/a/conf/event_dates/49?locale=en_GB

23-27 January
ASHRAE Winter Conference
Chicago, Illinois, USA
https://www.ashrae.org/conferences/2021-winter-conference-chicago

8-10 March
2021 ASHRAE Virtual Design and Construction Conference
Orlando, Florida, USA
https://www.ashrae.org/conferences/topical-conferences/2021-virtual-design-and-construction-conference

April *[exact date is not provided]*
The 10th Asian Conference on Refrígeration and Air-Conditioning (ACRA 2020)
Hangzhou / Shanghai, China
http://www.acra2020.org/

26-29 April
13th IEA Heat Pump Conference 2020
Jeju, South Korea
http://hpc2020.org/

13-15 May
9th IIR Conference on Ammonia and CO_2 Refrigeration Technologies
Ohrid, North Macedonia
https://iifiir.org/en/events/9th-iir-conference-on-ammonia-and-co2-refrigeration-technologies

23-27 May
Purdue International Compressor Engineering, Refrigeration & AC, High Performance Buildings Conferences
West Lafayette, Indiana, USA
https://engineering.purdue.edu/Herrick/Conferences/2020

6-10 June
9th International Conference on Caloric Cooling and Applications of Caloric Materials (Thermag IX)
College Park, Maryland, USA
https://ceee.umd.edu/events/thermag-ix

16-18 June
2nd IIR Conference on HFOs and Low GWP blends (HFO2021)
Osaka, Japan
https://biz.knt.co.jp/tour/2021/06/hfo/

26-30 June
ASHRAE Annual Conference
Phoenix, AZ, USA
https://www.ashrae.org/conferences/2021-annual-conference-phoenix

1-3 September
13th IIR Conference on Phase-Change Materials and Slurries for Refrigeration and Air Conditioning
Vicenza, Italy
http://static.gest.unipd.it/PCM2021/

13-15 September
IAQ 2020: Indoor Environmental Quality Performance Approaches - Transitioning from IAQ to IEQ
Athens, Greece
https://www.ashrae.org/conferences/topical-conferences/indoor-environmental-quality-performance-approaches

Postponed until further notice

International Symposium on New Refrigerants and Environmental Technology 2020
Kobe, Japan
https://www.jraia.or.jp/english/symposium/index.html

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International Energy Agency
The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an International Energy Programme. A basic aim of the IEA is to foster co-operation among its participating countries, to increase energy security through energy conservation, development of alternative energy sources, new energy technology and research and development.

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

Vision
Heat pumping technologies play a vital role in achieving the ambitions for a secure, affordable, high-efficiency and low-carbon energy system for heating, cooling and refrigeration across multiple applications and contexts.

The Programme is a key worldwide player in this process by communicating and generating independent information, expertise and knowledge related to this technology as well as enhancing international collaboration.

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

Heat Pump Centre
A central role within the HPT TCP is played by the Heat Pump Centre (HPC). The HPC contributes to the general aim of the HPT TCP, through information exchange and promotion. In the member countries, activities are coordinated by National Teams. For further information on HPC products and activities, or for general enquiries on heat pumps and the HPT TCP, contact your National Team at: www.heatpumpingtechnologies.org/contact-us/

The Heat Pump Centre is operated by RISE Research Institutes of Sweden.

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