New HPT TCP member country: China p. 5

Waste heat recovery from steel mill to district heat and cheesemaking p. 23

Grid stability via demand response for demand side flexibility p. 27

Heat Pumping Technologies MAGAZINE

A HEAT PUMP CENTRE PRODUCT

Industrial Heat Pumps – Good examples from ongoing Annex

Rainer Jakobs, Operating Agent for Annex 48

”...INDUSTRIAL HEAT PUMP APPLICATIONS NEED TO BE ADAPTED TO UNIQUE CONDITIONS. IN ADDITION, A HIGH LEVEL OF EXPERTISE IS CRUCIAL.”

VOL.37 NO 2/2019

ISSN 2002-018X

Heat Pumping Technologies
MAGAZINE

VOL.37 NO.2/2019

In this issue

Even though heat pumps often are thought of as domestic products, they do have a large potential also in industrial implementations. However, such implementations may imply significant challenges. The challenges are connected to the fact that each solution often must be tailor-made to fit a specific application. Despite this, industrial use of heat pumps could be given much more credibility than what is currently done. This issue of HPT Magazine focuses on industrial heat pumps and shows examples of applications.

In the two topical articles stories are shared on how heat pumps are used to exploit excess heat from industries. The first one tells how two large heat pumps turn waste heat from a steel and rolling mill in Austria into an environmentally friendly energy source in the district heating network. The second one describes how a high-temperature heat pump converts waste heat from a data centre into process heat in a cheese factory in Switzerland.

The Foreword and the Column also focus on industrial applications for heat pumps. The Foreword gives some insights in past and present development and success in the field. The Column lists some main challenges for industrial heat pumps today, with suggestions for solutions.

The issue also carries articles outside of the focus area. A non-topical article covers how heat pumps can provide grid stability, using demand response. The new section highlights IEA's online overview Tracking Clean Energy Progress for heat pumps. Last but not least, the new HPT TCP member country China is welcomed into the collaboration programme!

Enjoy your reading!

Johan Berg, Editor

Heat Pump Centre

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

Published by Heat Pump Centre
c/o RISE - Research Institutes of Sweden,
Box 857, SE-501 15 Borås, Sweden
Phone: +46 10 516 55 12

Publisher:
Heat Pump Centre
PO Box 857, S-501 15 BORÅS
SWEDEN
Tel: +46-10-516 55 12
hpc@heatpumpcentre.org

www.heatpumpingtechnologies.org

Editor in chief: Monica Axell
Technical editors: Caroline Haglund Stignor, Tommy Walfridson, Markus Lindahl, Martin Larsson, Johan Berg, Ulrica Örnemar, Kerstin Rubenson,
- Heat Pump Centre.

Front page: Stockholm Exergi

ISSN 2002-018X
https://doi.org/10.23697/tt78-jv66

FOREWORD

Industrial Applications of Heat Pumps

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 and 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 industrial heat pump (IHP) applications need to be adapted to unique conditions. In addition, a high level of expertise is crucial. The main goal is to overcome the difficulties and barriers that still exist for the larger scale market for industrial applications.

The HPT TCP has contributed with four Annexes since the 1980s in the field of heat pumps for industrial applications. These are **Annex 09**: High Temperature Industrial Heat Pumps (before 1990); **Annex 21**: Global Environmental Benefits of Industrial Heat Pumps (1992-96); **Annex 35**: Application of Industrial Heat Pumps (2010-14), and **Annex 48**: Industrial Heat Pumps, Second Phase (2016-19). Whereas the first two Annexes contributed with a broad variety of research and development activities to the technology of IHPs, the last two Annexes have focused more on the practical application and integration of IHPs in many different industries around the globe.

The aim is to understand the worldwide activities of industrial heat pumps, which may contribute actively to the reduction of energy consumption and GHG emissions through the increased utilization in industry. The goal of Annex 48 is to concentrate on the development and distribution of condensed and clear information materials for policy makers, associations, and industries.

Industrial heat pumps 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, such as drying, washing, evaporation, and distillation processes. Industries that can benefit from this technology cover a wide field, such as food and beverage processing, forest products, textiles, machinery, and chemicals.

The latest outcomes of the work are the results from the members in Austria, Denmark, France, Japan, Switzerland, and United Kingdom. More than three hundred good practices have been collected.

Japan, as an example, has selected as the best practice “Simultaneous heating & cooling system in food production line” for the food industry; “Simultaneous heating & cooling in cutting and cleaning process” for the machinery industry; and “Introduction of hot heat pump with hot gas source in dry laminating process of package film” for the chemical industry.
Further results are

- One of the main barriers for application of IHPs is the very different situation concerning the energy prices in the countries. Especially the ratio of electricity/gas price is important. Sweden, Finland, Netherlands and France have favourable price ratios; Germany, Ireland and UK have unfavourable price ratios;

- The drying process is one of the very prominent applications for IHPs. The quality of the process could be improved, and in addition, the energy cost and the GHG emissions could be reduced.
Industrial heat pumps are today successfully integrated in a wide field of industries. The results of the Annex form the basis for a database which can provide decision-makers with information and knowledge about the installation of IHP technologies.

Rainer M. Jakobs
Operating Agent for Annex 48
Information Centre on Heat Pumps and Refrigeration, Germany

Challenges for the Industrial Heat Pumps

Increasingly clearly, research and practical applications show that industrial heat pumps (IHPs) are fit to provide heating and cooling for industrial applications and district grids. The latest outcomes of HPT Annex 48 show more than three hundred good practices of IHPs in a variety of applications, such as drying, washing, evaporation, and distillation processes. Industries that can benefit from this technology cover a wide field, such as food and beverage processing, forest products, textiles, machinery, and chemicals.

What are the challenges for IHPs today?

High temperature Heat Pumps (HTHPs)[1]. High temperature heat pumps with heat sink temperatures in the range of 100 to 160 °C are expected to become increasingly commercialized in the coming years. Major applications have been identified, particularly in the food, paper, metal and chemical industries, especially in drying, sterilization, evaporation, and steam generation processes. With the Kigali amendment to the Montreal protocol and the EU-F-Gas regulations there are not many options at hand regarding suitable refrigerants. Replacement fluids for the currently applied HFCs are required. The actual research gap in the field of HTHPs is to extend the limits of efficiency and heat sink temperature to higher values, while using environmentally friendly refrigerants.

Minimizing Refrigerant Charges[2,3]. Heat exchangers play a vital role in any energy-related system. This also applies to IHPs applications. It is strongly recommended to devise systems that require a minimum amount of refrigerant. By doing so, the price aspect and the potential damage from an accidental leak can be minimized to a greater extent.

Replacement of Steam Boilers[4]. In recent years, Japanese manufacturers have overcome the difficulty of commercializing heat pumps for industrial use, and installation examples have been reported. Among them, the only heat pump system capable of supplying steam with temperatures at 120 °C and above is the Steam Grow Heat pump (SGH), which was commercialized in 2011. These IHPs are today under development in different countries.

Integration in District Heating[5,6]. In Denmark, the political goal is to reach 0% CO_2 emissions in 2050 and about 55% renewable energy (RE) share in 2030, including 100% RE based electrical power including 100% phase out of coal in power production. District heating is used in 65% of all dwellings and will be a major contributor to reach this. As the energy system is transforming to be based on electrical power, heat pumps are a central technology. The political goals support the introduction of heat pumps to the market, and Danish research will develop more efficient systems. In a Swedish research project “Heat Pumps in District Heating Systems” new combinations of HPs and district heating systems have been investigated.

Drying Processes[7]. In industrial processes, 12-25% of the energy is used for drying. Inefficiency leads to 11.3 EJ of annual energy loss in the EU. Technically and economically viable solutions for upgrading idle waste heat streams to process heat streams at higher temperature levels up to 160 °C will be elaborated. The key elements are two high-temperature vapour compression heat pumps. The solution will be demonstrated and validated under real production conditions in operational industrial drying processes in three leading European manufacturing companies from the pet food, food and brick industries.

[1] High Temperature Heat Pumps, C. Arpagaus, NTB, University of Applied Science, Switzerland, Chillventa CONGRESS 2019, Nuremberg
[2] Minimizing refrigerant charge, Z. Ayub, Isotherm Inc., Texas, USA, Foreword, HPT Magazine Vol. 37 No.1/2019
[3] Low Charge Evaporators for Industrial Heat Pumps, Z. Ayub, Isotherm Inc., Texas, USA, HPT Magazine Vol. 37 No.1/2019
[4] Experimental performance evaluation of heat pump-based steam supply system, T. Kaida et al., 2015 Mater. Sci. Eng. 90 012076
[5] Industrial Heat Pumps in District Heating in Denmark, Lars Reinholdt, Chillventa CONGRESS 2019, Nuremberg
[6] New ways of combining Heat Pumps and District Heating , M. Lindahl, RISE, Sweden, HPT Magazine Vol. 36 No.13/2018
[7] DRYFICIENCY, http://dry-f.eu/, Project Coordinator Veronika Wilk, Scientist at AIT Austrian Institute of Technology

RAINER M. JAKOBS
Operating Agent for Annex 48
Information Centre on Heat Pumps and Refrigeration, Germany

HPT TCP Welcomes China into the Programme!

China is now a member country in the Technology Collaboration Programme on Heat Pumping Technologies, HPT TCP. The other member countries and the HPC team warmly welcome them into the programme.

After some time of dialogue, the membership procedure was finalized in May this year, and China formally entered the HPT TCP. This expansion means that the programme now includes 17 countries throughout Asia, The Americas, and Europe. As members, China are welcome to join Annexes, as well as come up with ideas for new Annexes. With this new member on board, hopefully even more opportunities for collaboration will emerge.

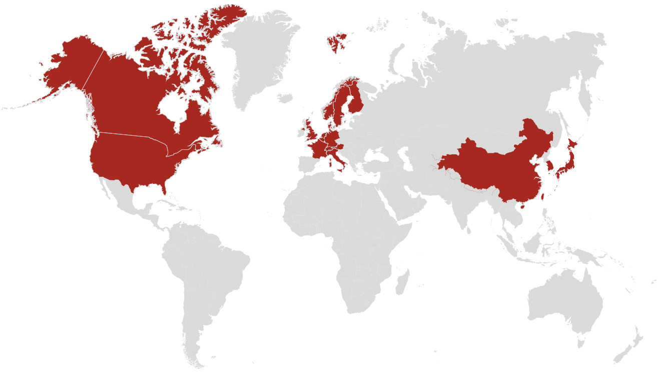
The timing for China to join the programme is excellent. The use of heat pumping technologies has been on the rise in the country during the previous years, and the future is also predicted to be bright. As an example, the market development between 2013 and 2016 for air-source heat pumps shows a tripling in sales value. Also, the market for air-to-water heat pumps is in the same order of magnitude as in Europe.

An important reason for the heat pump increase is their contribution to increased air quality in cities and rural areas. For example, when local coal boilers are replaced by heat pumps, the local pollution in form of particle emissions decrease.

The development is supported by governmental decisions and policies. At the political level, heat pumps are seen as part of the solution for clean energy, contributing to targets related to energy efficiency and renewable energy use. As an example, Northern China has an ambitious Clean Heating Policy stating that half of the heating shall be through clean energy by the end of this year. By 2021, this shall be increased to 70%, and at the same time, the combustion of coal will be reduced by 74 million tons.

In order to achieve these targets, clean technology for thermal energy will be adopted, based on local conditions. Heat pumps are mentioned as one of the important technologies. The transition towards clean energy will also include energy retrofitting of buildings and improved efficiency of the thermal energy networks.

Altogether, it is clear that there is both a political will and market readiness regarding deployment of heat pumps in China. As a member of HPT TCP, China has the opportunity to collaborate internationally to further push the development and implementation of heat pumping technologies in the country and worldwide.



Participating countries in the HPT TCP

Welcome to the IEA Heat Pump Conference in 2020

13th IEA HEAT PUMP CONFERENCE
2020 | JEJU KOREA

Save the date!
11-14 May Jeju, Korea 2020

January 1, 2019	Abstract submission open
June 30, 2019	Abstract submission due
November 1, 2019	Full paper submission due
February 15, 2020	Final paper submission due
May 11-14, 2020	13th IEA Heat Pump Conference 2020

The 13th IEA Heat Pump Conference will be held in Jeju Island from Monday, May 11th through Thursday, May 14th in 2020. With the theme 'Heat Pumps – Mission for the Green World', we aim to address global climate change and discuss necessary actions.

Previous Conferences

The upcoming conference will be the 13th of the series of conferences held by the International Energy Agency (IEA) Heat Pumping Technologies TCP (HPT TCP). Preceding conferences were held in Austria (1984), USA (1987, 2005), Japan (1990, 2011), The Netherlands (1993, 2017), Canada (1996, 2014), Germany (1999), China (2002), and Switzerland (2008). After successful histories in Japan and China, it is the fourth Heat Pump Conference to be held in Asia, and the first to be held in the Republic of Korea.

Conference Venue

The conference venue is Ramada Plaza Hotel Jeju, located in Jeju city, easily accessible from Jeju airport. Jeju Island is a famous holiday destination in Southeast Asia, with beautiful beaches, volcanic mountains, and extraordinary cuisine. Home to the natural World Heritage Site, Jeju Volcanic Island and Lava Tubes, participants and those accompanying will certainly enjoy visiting the beautiful island. In addition to sightseeing opportunities, a variety of technical tours are planned.

Conference Goal

Heat pumps, as a reliable and confirmed technology, is the key equipment for energy savings and greenhouse gas reductions with its wide range of application to various energy sources. The upcoming conference will serve as a forum to discuss the latest technologies in heat pumps, and exchange valuable knowledge in market, policy, and standards information on related technologies. Exhibitions will be held at the conference, to share products and technologies from domestic and foreign companies.

Conference Topics

Within the conference program, participants will encounter numerous cutting-edge presentations on the following issues:

- Recent Advances on Heat Pumping Technologies
- Environment-friendly Technologies
- Systems and Components
- Field Demonstration and Multi-disciplined Applications
- Research and Development
- Policy, Standards, and Market
- International Activities

Conference Structure

Within the conference program, participants will encounter numerous cutting-edge presentations on the following issues:

- Keynote and Plenary lectures by renowned researchers
- Oral and poster presentations on innovative heat pump technology, applications and markets
- Exhibitions of heat pump equipment
- Workshops on collaborative projects, connected to annexes in the HPT TCP
- Technical tours
- Sight-seeing programs
- Social gatherings

Paper Review Process

The abstract submission has been closed. The abstracts has been screened by a Regional Coordinator and authors have been advised of acceptance. Full paper submission is due by November 1.

Organization

The conference is organized by the International Organizing Committee (IOC) and the National Organizing Committee (NOC) on behalf of the Executive Committee of the IEA HPT TCP.

Per Jonasson	Chairperson IOC, Swedish Refrigeration & Heat Pump Association, Sweden
Sophie Hosatte	Vice-Chairperson IOC, CanmetENERGY, Canada
Hideaki Maeyama	Vice-Chairperson IOC, HPTCJ (Heat Pump and Thermal Storage Technology Centre of Japan)
Min Soo Kim	Chairperson NOC, Seoul National University, South Korea
Minsung Kim	Conference Secretariat, Chung-Ang University, South Korea

For further information, please refer to the Conference website of the 13th IEA Heat Pump Conference. http://www.hpc2020.org/

13th IEA HEAT PUMP CONFERENCE
2020 | JEJU KOREA

Welcome to the IEA HPT TCP National Experts' meeting 2019!

This one-day meeting (previously called the National Teams' meeting, NT meeting), will take place on Thursday 24 October 2019, at the Nürnberg Messe, Nuremberg, Germany, 09.00-16.30 (the day after the European Heat pump Summit 2019, https://www.hp-summit.de/en).

The purpose of the meeting is to stimulate the generation of new activities within the IEA Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP) according to our strategy plan (https://heatpumpingtechnologies.org/about/our-vision/). The outcomes from previous meetings have resulted in the start of several new international collaboration projects, so-called Annexes. Read about them here: https://heatpumpingtechnologies.org/ongoing-annexes/

At this year's National Experts' meeting, the following topics will be discussed

- Development of new ideas for Annexes within strategy area (e): New or special markets and applications, including automotive, industry and consumer products (e.g., white goods);
- "Comfort and Climate Box" for warm and humid countries;
- Heat Pumps in Positive Energy Districts/Blocks.

In order to make sure it will be a productive meeting, please invite researchers and industry representatives from your country!

Please let us know if you are going to attend the meeting as soon as possible! Send an e-mail to johan.berg@ri.se.

The Heat Pump Centre team

NT meeting in Nuremberg, 2017

Tracking Clean Energy Progress: Heat Pumps are not on Track

In a recent update of IEA's online overview Tracking Clean Energy Progress, heat pumps are pointed out as a technology that is not on track regarding market penetration, costs and performance.

Nearly 18 million households purchased heat pumps in 2018, up from 14 million in 2010. However, most of this growth is due to higher sales of reversible units that may not be used for heating. Globally, heat pumps provide only 3% of heating in buildings. To be in line with the SDS (Sustainable Development Scenario), this share needs to triple by 2030, the upfront purchase price needs to come down, and average heat pump energy performance needs to increase by 50% towards current best available technologies.

Heat pumps continue to represent a small share of total residential heating equipment, as more than three-quarters of sales globally were for fossil fuel or conventional electric technologies in 2018. At the same time, global heat pumps sales did rise by nearly 10% between 2017 and 2018 – double the 2016-17 growth rate.

Nearly 80% of new household heat pump installations in 2017 were in China, Japan and the United States, which together account for around 35% of global final energy demand for space and water heating in residential buildings.
Europe's market is expanding quickly, however, with around 1 million households purchasing a heat pump in 2017, including heat pumps for sanitary hot water production (135 000 units). Sweden, Estonia, Finland and Norway have the highest penetration rates, with more than 25 heat pumps sold per 1 000 households each year. Air-to-air heat pumping technologies dominate global sales for buildings, but purchases of other heat pump types such as air-to-water and geothermal heat pumps have also expanded in recent years.

The typical efficiency factor of heat pumps – an indicator of average annual energy performance – has increased steadily since 2010, approaching an estimated 3 today across the main heat pump markets. It is common to reach factors of 4 or 5 or higher, especially in relatively mild climates such as the Mediterranean region and central and southern China.

Conversely, in extremely cold climates such as northern Canada, low outside temperatures reduce the energy performance of currently available technologies to a factor of 2 or less (depending on the ambient temperature) – although this is still twice as efficient as an electric resistance heater or a condensing gas boiler. Regulations, standards and labelling, along with technology progress, have spurred improvement globally. For instance, the average efficiency factor of heat pumps sold in the United States rose by 13% in 2006 and 8% in 2015 following two increases in minimum energy performance standards.

Electric heat pumps still meet less than 3% of heating needs in buildings globally, yet they could supply more than 90% of global space and water heating with lower CO_2 emissions – even when the upstream carbon intensity of electricity is taken into account – than condensing gas boiler technology (which typically operates at 92-95% efficiency).

Ongoing policy progress regarding heat pump market penetration include energy efficiency programmes specific to heat pumps, regulations and labelling on heat pump energy performance, and technology-neutral performance requirements.

Recommended actions include addressing upfront costs and energy price dynamics, harmonising fuel prices, and improving energy performance standards and labelling.

Innovation gaps that need to be addressed include enhancing heat pump flexibility, raising heat pump attractiveness, and reducing costs of geothermal heat pump technologies.

What is Tracking Clean Energy Progress?

The IEA's Sustainable Development Scenario (SDS) offers a pathway for the global energy system to reach three strategic goals: the Paris Agreement's well below 2 °C climate goal, universal energy access and substantially reducing air pollution.
But based on existing and announced policies – as shown in the IEA's New Policies Scenario (NPS) – we are far from on track.
Tracking Clean Energy Progress (TCEP) assesses the status of 45 critical energy technologies and sectors and provides recommendations on how they can get 'on track' with the SDS.

Read more at the source:
https://www.iea.org/tcep/buildings/heating/heatpumps/

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.

FUEL-DRIVEN SORPTION HEAT PUMPS	43	AT, **DE**, FR, IT, KR, SE, UK, US
HYBRID HEAT PUMPS	45	CA, DE, FR, **NL**, UK
DOMESTIC HOT WATER HEAT PUMPS	46	CA, CH, FR, JP, **NL**, KR, UK, US
HEAT PUMPS IN DISTRICT HEATING AND COOLING SYSTEMS	47	AT, CH, **DK**, SE, UK
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, **DE**, FR, IT, NL
ACOUSTIC SIGNATURE OF HEAT PUMPS	51	**AT**, DE, DK, FR, IT, SE
LONG-TERM MEASUREMENTS OF GSHP SYSTEMS PERFORMANCE IN COMMERCIAL, INSTITUTIONAL AND MULTI-FAMILY BUILDINGS	52	FI, NL, NO, **SE**, US, UK, DE
ADVANCED COOLING/ REFRIGERATION TECHNOLOGIES DEVELOPMENT	53	DE, IT, KR, **US**
HEAT PUMP SYSTEMS WITH LOW GWP REFRIGERANTS	54	IT, JP, KR, **US**
◖ COMFORT AND CLIMATE BOX	55	AT, IT, **NL**

◖ 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 (CH), 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 45

HYBRID HEAT PUMPS

Recently, the final report for Annex 45 on hybrid heat pumps was presented. Participating countries were The Netherlands (Operating Agent), Canada, France, Germany, UK.

The goal of this annex was to develop knowledge on the technical development and the market opportunities for hybrid heat pumps.

Hybrid systems, consisting of a boiler or furnace in conjunction with a heat pump have been used in commercial buildings for quite some years now. Domestic applications are, however, still relatively new. Thus, this annex has served as a first comparative overview of the opportunities for hybrid HPs in the participating countries.

By combining an electrical HP with a fossil-fired boiler/furnace, it is possible to flexibly choose the optimal heating device. This allows to optimize heat production, e.g., according to CO_2-production, running costs, primary energy, grid congestion, or load balancing.

Additionally, a hybrid heating system may have lower investment costs than all-electric heat pump and will often fit within comparably tight spaces.

Because a fossil-fuelled heater is always available as a back-up, hybrid systems are enablers for the use of heat pumps in retrofit situations.

A growing wave of interest in hybrid HPs as an intermediate step towards renewable heating can be noticed in France, the Netherlands and the UK. Especially in the Netherlands, hybrid HPs make up a sizable portion (5 – 10% in 2019) of all newly installed heating installations.

KEY FINDINGS

Immediate CO_2-savings

Because hybrids can be applied in existing buildings, they provide a potential for significant CO_2-savings that can be tapped into immediately and on a large scale. This also allows for markets and users to get used to heat pumps, preparing for large-scale electrification of domestic heating within the next decades.

Figure 2 illustrates a Business as Usual route to 100% renewable heating (left), versus a hybrid route to 100% renewable heating. Hybrid systems enable quick action. Depending on the circumstances and developments within the next 10 to 15 years, hybrid systems may be replaced by all-electric HPs, or used in conjunction with renewable fuels (hydrogen, green gas, biogas). Both routes allow for low-carbon domestic heating.

Control strategy is of key importance

Basic control strategy is a key factor in determining the operating regime for hybrid heat pumps. Hybrid systems may be used to optimize heating for an individual house but can also be used to support grid load management, renewable production profile matching and other smart grid applications.

Because of the versatility in choosing control parameters, hybrid HPs can be made to support a variety of policy goals, depending on local circumstances and needs.

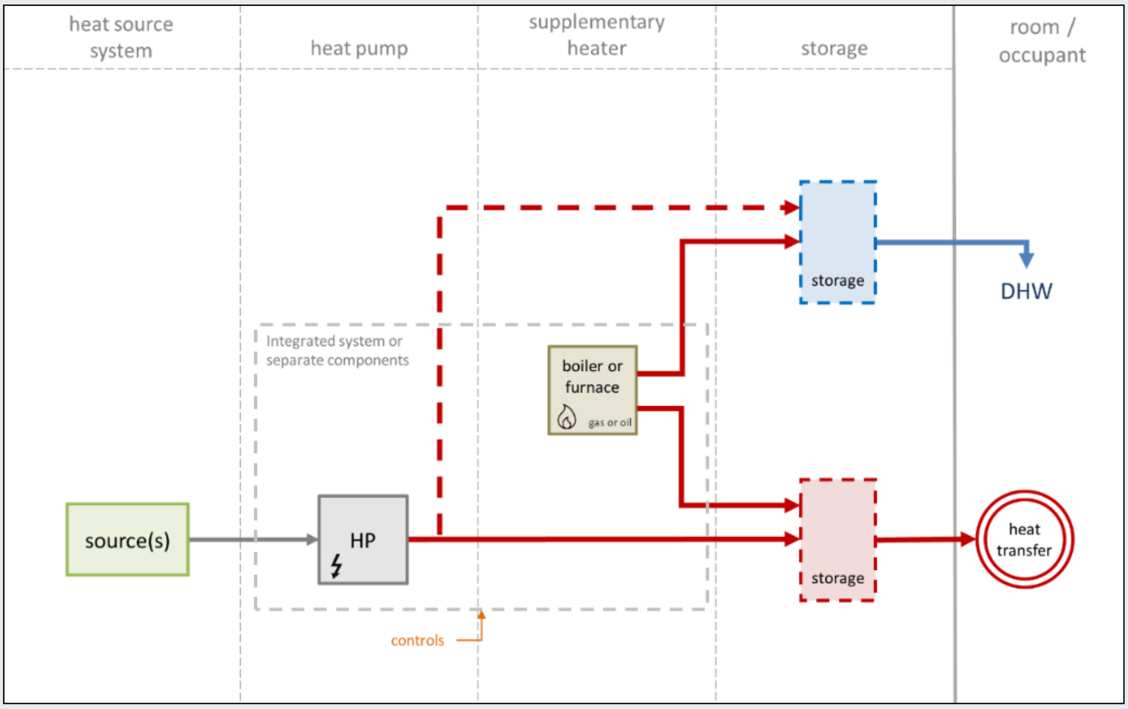


Fig. 1: General layout for a hybrid heat pump system (dashed components optional)

Ultimate flexibility

Hybrid heat pumps provide flexibility beyond time-shifting electricity loads. Because it is possible to switch from electricity to gas or oil, the HP electricity demand can be completely decoupled from the heating demand at any time, providing a structural solution for local grid congestion.

Strong sensitivity to energy prices

Energy prices form a major influence on market realization potential for hybrid heat pumps. Compared with standard boilers, hybrid systems may face strong competition on both investment and operation costs. Compared to all-electric systems, hybrids tend to be more favorable in both respects, albeit not universally so.

Use cases are very different according to local circumstances, policy goals and needs

There is a wide variety of hybrid setups and use cases across participating countries. Each country has a couple of appropriate use cases, while no single use case is relevant for all countries. Table 1 gives an indication of the typical use cases for hybrid HPs that may be expected in the participating countries.

A gateway to renewable heating

Hybrid heat pumps may serve as a gateway to low-carbon heating.

Through the use of hybrids, it is possible to immediately realize a partial transition of the heating system towards 100% renewable, even if the building itself has not yet been renovated. Depending on the availability of renewable fuels (e.g. hydrogen, syngas, biogas), hybrid HPs may become a permanent part of the energy system.

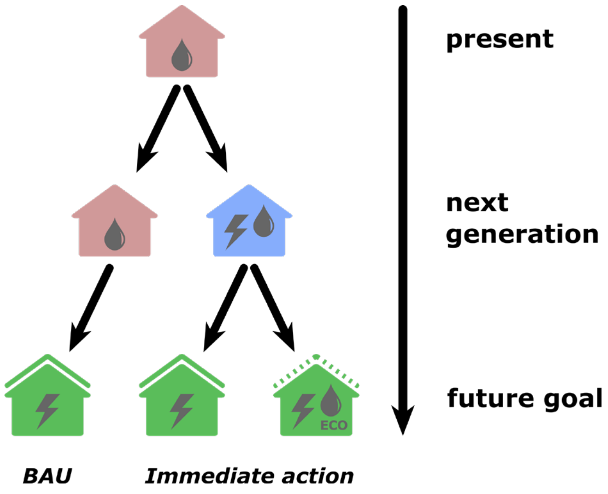


Fig. 2: Hybrid heat pumps (blue house symbol) allow for immediate action towards low-carbon domestic heating, because hybrid systems can be used in existing houses, often without renovation.

Annex website

https://heatpumpingtechnologies.org/annex45/

Contact

Operating Agent is Peter Wagener,
Business Development Holland b.v., The Netherlands
wagener@dhpa-online.nl

Situation	Problem/driver	Hybrid provides...	Applies to...
Collective heating / multi-family houses	Renewable energy with best business case.	Optimal balance between investment (€/$) and CO_2-savings.	NL, DE, IT
Houses with PV-installations	Maximize use of self-produced renewable electricity.	Hybrid systems can be optimized for hot water production during PV peak production.	DE, BE
Existing houses on gas grid or oil-fired boilers	CO_2-savings hard to achieve without renovation.	Immediate savings, without the need for building renovation. No "lock-in": future renovation will still provide extra savings on fossil fuels.	NL, BE, DE, CA, FR
Small houses	No space for hot water storage tank.	With hybrid, HP can provide at least baseload, boiler can still cover hot water.	NL, UK, BE
"Hard-to-treat" houses	Limited technical/architectural options for building-related measured. E.g. in monuments and old buildings.	Elegant way to provide at least a minimum amount of CO_2-savings, without necessitating (deep) renovation.	NL, UK, DE
Houses with LPG- or oil-fired boilers	Boiler fuel is expensive.	Immediate savings on fuel use.	BE, IT, DE, FR
Weak electricity grid or "end-of-the-line" grid connections.	Capacity of electricity grid too small for all-electric heat pump.	Maximal use of renewable energy with minimal peaks in grid load.	UK, CA, IT, FR
New built houses	Renewable targets / building regulation	Desired amount of renewable energy or energy performance	FR
Add HP to planned AC installation	Heating reference (furnace) is low-cost, AC installation needed	By choosing a reversible HP, with cooling as primary function, part of the heat demand can become low-CO_2 for a limited investment	CA
Enabler for large-scale grid management	Several grid-load issues: e.g. renewable production, electrical vehicles, mass-deployment of HPs, etc.	Electricity demand from hybrid systems can be switched off at will, providing plenty of smart grid potential.	Future development

Table 1: Overview of use cases for hybrids in participating countries.

ANNEX 48

INDUSTRIAL HEAT PUMPS, SECOND PHASE

Industrial heat pumps (IHP) 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. The aim of this Annex is to understand the world-wide activities of industrial heat pumps which contribute actively to the reduction of energy consumption and GHG emissions through the increased utilization in industry. The goal of Annex 48 is to concentrate on the development and distribution of condensed and clear information material for policy makers, associations, and industries.

Industrial energy demand in Austria, as an example

In figure 1, the energy use of the Austrian industry in 2016 is summarized. The pulp and paper industry consumed the most energy, followed by the chemical and petrochemical industry, stone and earth and glass production, as well as by the iron and steel production. In figure 2, the energy use of six different applications are compiled. A total of 109 PJ were consumed in industrial ovens, followed by steam generation, stationary engines, space heating and air conditioning, all of which are suitable for heat pump application.

Good practice in Japan, an example

In Japan, heat pumps have been applied in a project regarding automobile parts production, for cutting and washing processes. The project was done in a cooperation between Chubu Electric Power Co. and University of Tsukuba. The purpose was the reduction of steam generation. Before the instalment of heat pumps, the

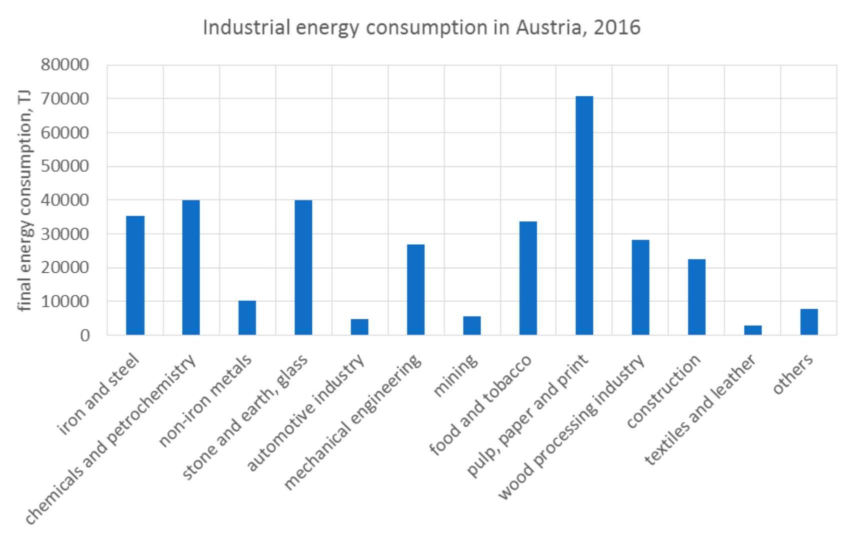


Fig. 1: Industrial energy use by sector (source: Statistics Austria)

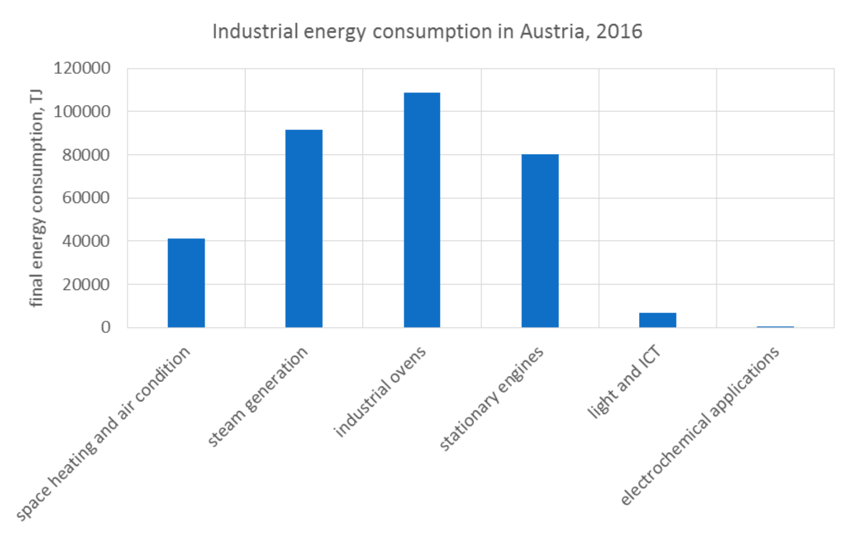


Fig. 2: Industrial energy use by application (source: Statistics Austria)

steam boiler used crude oil, see figure 3. The system with the heat pump is shown in figure 4: waste heat recovery heat pumps with a heating capacity of 22 kW, 6 units, and air-source heat pumps with heating capacity 44 kW, 8 units. Comparing cost before and after application of heat pumps, investment cost decreased by 33.2%; annual running cost decreased by 79.1%. See figure 5 for further details.

One main barrier

One of the main barriers for application of IHPs is the very different situation concerning the energy prices between different countries. Especially the ratio between the electricity and the gas price is important. Sweden, Finland, Netherlands and France have favourable price ratios for application of electrically driven heat pumps; Germany, Ireland and UK have unfavourable price ratios, see figure 6.

Meetings, past and future

Within the Annex, there have been very fruitful expert meetings twice a year, since the initiation of the Annex in 2016. In addition, a number of projects within the Annex have been presented at workshops and congresses, open to people outside of the Annex, such as industry representatives and policy makers. Workshops have been held in Nuremberg, Germany, at the Chillventa Congress, and in Tokyo, Japan. These workshops have covered the situation in the participant countries, and also presented issues such as high-temperature heat pumps, and good practices in various application sectors.

Further workshops, with presentations and discussions, will be held at the IIR International Congress of Refrigeration in Montreal, Canada, in August, and at the European Heat Pump Summit, Nuremberg, Germany, in October.

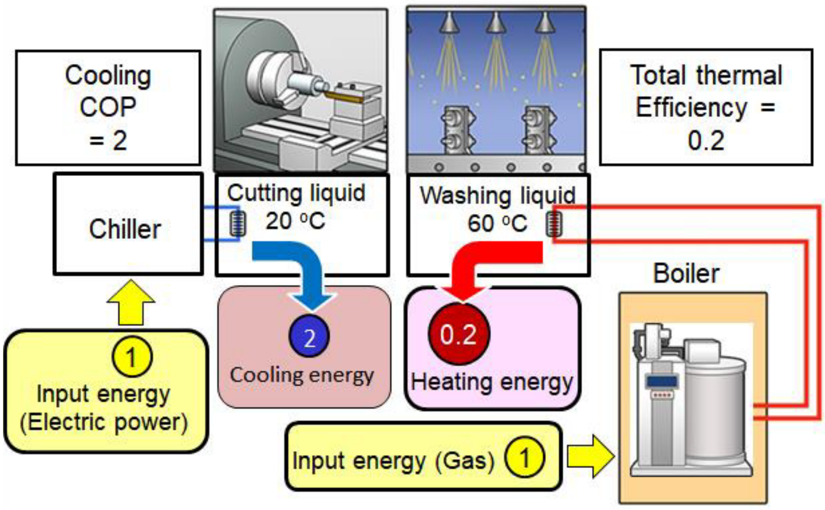


Fig. 3: Conventional system

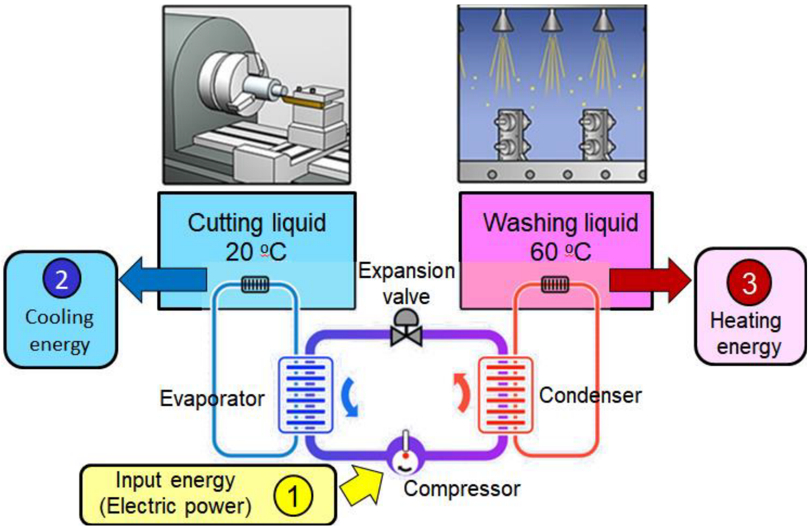


Fig. 4: Application of heat pumps for cutting and washing processes

	Before application heat pumps	After application of heat pumps	Reduction achieved
Power consumption (MWh/year)	193 (100%) <Boiler auxiliary equipment, Cooler>	570 (295%) <Heat pump>	+377 (+195%)
Fuel oil consumption (kilo Liters/year)	470 (100%) <Boiler fuel oil>	0 (0%) <Heat pump>	-470(-100%)
Water consumption (kilo Liters/year)	6,953 (100%) <Steam>	0 (0%) <Heat pump>	-6,953(-100%)
Energy saving (fuel oil equivalent, kilo Liters/year)	522 (100%) <Boiler, Cooler>	85 (16%) <Heat pump>	-437 (-84%)
CO_2 emissions (tons of CO_2/year)	1,364 (100%) <Boiler, Cooler>	270 (20%) <Heat pump>	-1,094 (-80%)

Fig. 5: Results: Effects of application of heat pumps

ELECTRICITY/GAS PRICE RATIO

Country	Households	Small enterprises	Large enterprises	Indicator
Sweden	1.2	1.3	1.0	⇧
Finland		1.8	1.2	⇧
Bulgaria	1.9	2.6	2.0	⇧
Netherlands	1.5	2.6	2.6	⇧
France	1.4	2.7	2.5	⇧
Slovenia	2.5	2.1		⇧
Portugal	2.1	2.5	2.4	⇧
Estonia	2.5	2.6	2.2	⇧
Austria	2.8	2.7	2.0	⇧
Poland	2.4	2.8	2.4	⇨
Lithuania	1.7	3.4		⇨
Croatia	2.6	2.6		⇨
Hungary	3.1	2.4	2.8	⇨
Latvia	2.2	3.5	2.7	⇨
Luxembourg	3.2	2.3		⇨
Slovakia	1.7	3.5	3.2	⇨
Denmark	4.2	1.9	2.7	⇨
Czech Republic	2.2	3.7	2.9	⇨
Spain	2.9	3.5	2.5	⇨
Greece	2.3	4.0		⇨
Italy	2.2	3.9	3.7	⇨
Romania	4.2	3.0	2.8	⇨
Belgium	2.8	4.0	3.2	⇨
Germany	3.0	4.0	3.5	⇨
Ireland	4.1	3.9		⇩
United Kingdom	2.8	4.2	5.1	⇩
EU-28	2.4	3.3	3.0	⇨

Fig. 6: Electricity/Gas Price Ratio in the European Union. Source: IER Stuttgart Stefan Wolf Chillventa CONGRESS 10.10.2016

Annex website

https://heatpumpingtechnologies.org/annex48/

Contact

Operating Agent is Rainer M. Jakobs, IZW e.V., Germany.
Jakobs@izw-online.de

ANNEX
49

DESIGN AND INTEGRATION OF HEAT PUMPS FOR nZEB

Nearly Zero Energy Buildings (nZEB) will be the future building standard in many countries. In the EU member states, nZEB requirement have to be fulfilled for all new public buildings since the beginning of 2019. By the beginning of 2021, the requirements are extended to all new buildings. Thus, there is a strong interest in building technology to fulfil nZEB requirements. IEA HPT Annex 49 is investigating heat pump application in nearly Zero Energy Buildings.

Task 1, the state-of-the-art analysis, the definite definition of nZEB, which has been fixed with the introduction of nZEB requirements for new public buildings by 2019, is considered. Further, work on a methodology for comparing the ambition level in the different participating countries has been initiated. This is complicated, since the definition differs both in criteria and limits between the countries. Therefore, a methodology would be helpful to characterize the ambition for high performance buildings in the different countries. The stepwise procedure based on national calculation methods and simulation of a common residential building has been elaborated, but will be further tested and developed.

Task 2, the integration of heat pumps in nZEB, and Task 4, design and control, are linked to each other. In the USA, a comprehensive simulation study on system configurations for the integration and design of heat pumps have been performed at NIST, for 12 different climate zones across the USA. The design of the solar PV system is adapted to meet the nZEB requirement in the different climate boundary conditions. Both the ventilation system and the heat pump type (air- and ground-source (AS, GS)) are evaluated in terms of energy and cost savings. In most of the USA ventilation with heat and enthalpy recovery (heat and moisture recovery) saves energy, except for the southern part of California and the Gulf coast. In the northern half of the USA, it also saves cost. GSHP yield large energy savings in the northern half of the USA and may save cost. In the southern part and the western marine climate, they only yield small to moderate energy savings. In southern California and Florida, ASHP use less energy.

Different other simulations studies are also ongoing in Tasks 2 and 4, which are partly linked to monitoring. Norway has made investigations on how heat pump modelling affects the results of heat pump simulations, and predictive control and PV self-consumption are topics in different projects. In Switzerland, evaluations on the design of capacity-controlled heat pumps in nZEB based on manufacturer information have been performed.

As the contribution of Austria to Task 2 and 4, the use of thermally activated building systems (TABS) as additional storage components, in order to increase the solar fraction for both solar PV and solar thermal components, is investigated at TU Graz. A solar loading of the DHW tank and the TABS may significantly increase the system SPF and reduce the electricity consumption from the grid, both for solar thermal and for solar PV, with a slight advantage for the combination with PV.

Moreover, at the University of Innsbruck, two multi-family houses in passive house standard have been simulated in order to optimise the building technology, which is also linked to a monitoring since several years. The energy demand has been successively reduced, but the nZEB balance remains a challenge in multi-family buildings due to limited space for energy generation by building envelope technology such as on-site solar PV generation.

At AIT, two projects on larger buildings are on-going. These are based on monitoring and simulation work. One project is linked to a group of buildings with different heat sources connected by grids and storages, the other project deals with a large office building that is investigated with regard to commissioning and control improvement. Lessons learned from the buildings are that an integral planning, including different part load scenarios and the thorough commissioning phase, facilitates the building operation. Monitoring helps to optimise the system performance in the operation phase. Commissioning should be a multi-stage process, where systems are commissioned in the right operation phase, e.g., the cooling system in summertime.

Task 3 deals with the prototyping and monitoring of dedicated heat pump developments for nZEB and field trials of marketable heat pumps in nZEB. As contribution to Task 3, a prototype of a façade-integrated heat pump for space cooling is developed at TU Graz. The objective is an autonomous cooling function for the building driven by PV. Also, in this project, TABS are considered as possible space heating and cooling emission system. TABS may buffer the thermal energy produced during PV operation hours, but the integration of an electrical battery is also considered. The system is field-monitored at the campus of TU Graz in two test boxes, as depicted in figure 1. In parallel, simulations are performed. The first results indicate that the system is suited for space cooling, but the heating capacity of 1-2 kW of the prototype system is too low to cover the entire space heating demand in the Graz region.

In the USA, different prototypes of highly integrated heat pumps have been developed for several years, of which some are already introduced on the market, but others are still investigated in field monitoring. At the University of Maryland, a prototype of a personal cooling device with integrated latent heat storage has been developed in different design steps.

Several other monitoring projects are also ongoing and starting in Task 3. In Germany, first monitoring results of 8 houses with central heating system using a thermal grid and decentral DHW production using a booster heat pump have been presented, showing high performance values in the range of 5. At TU Braunschweig, a monitoring of a single-family building over several years with changing storage integration has been accomplished, and first results of a multi-family house and a school have been presented. In Belgium, the integration of the heat source sewage water for larger buildings has been simulated, and monitoring in three office buildings in

Brussels starts during summer 2019. In addition, Norway and Switzerland have performed monitoring in different types of non-residential buildings, among others a hotel, a kindergarten, and a supermarket.

Results of the IEA HPT Annex 49 will be presented in a Workshop at the next IEA HP Conference in Jeju, South Korea.

Annex website
http://heatpumpingtechnologies.org/annex49/

Contact
Operating Agent is Carsten Wemhoener, for SFOE, Switzerland. carsten.wemhoener@hsr.ch

Fig. 1: Test boxes including a façade-integrated heat pump prototype for cooling. Two types of PV are tested at Graz Technical University campus.

INFORMATION

Be a Part of the Heat Pumping Technologies TCP

https://twitter.com/HeatPumpingTech

https://www.linkedin.com/groups/7412992/

Meet us in social media!

ANNEX
55

COMFORT AND CLIMATE BOX

In the first months of 2019, the foundation has been laid for a new Annex. This Annex will be a cooperation between the IEA Technology Collaboration Programmes (TCPs) HTP and ECES, and will concern optimal integration of heat pumping technologies and storage systems.

1 Comfort and Climate Box (CCB)

The central concept in this Annex is the so called 'Comfort and Climate Box (CCB). This concept denotes a combined package, consisting of a heat pump, and energy storage module and controls. This package may form an actual physical unit, but can also consist of separate modules that form an integrated 'virtual package'. A CCB should not just be a set of components that have been put together. Rather, all components of the CCB should be designed to work together in a modular fashion and should be operated under a dedicated and optimised integrated control strategy, figure 1.

1.1 Quality criteria

There are already several attempts to put CCBs on the market. However, market uptake is slow and hesitant. We analyze market success by looking at nine design criteria that play a role in developing CCBs.

Depending on the local market, available systems may need to improve performance with respect to one or several of these criteria. These criteria form our central reference to describe and measure CCB quality.

2 Goal of this Annex

This project is not meant to be a theoretical 'research Annex'. All contributing projects in the participating countries should aim to focus on developments that are 'almost market ready'.

The goal of this Combined Annex is 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 (TRL) upwards of at least 7) and have a high quality, adopted to their local market.

The work will be oriented around the nine quality criteria shown in 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 all the different climate zones.

By exchanging 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.

3 Work packages

To reach our proposed goals, five work packages have been defined.

WP 1 – Present state of the market and system types

For each participating country separately:

- Overview of systems presently on the market or close to commercialization
- Cases from already existing CCB concepts or products from participating countries, taking the Annex' scope into account

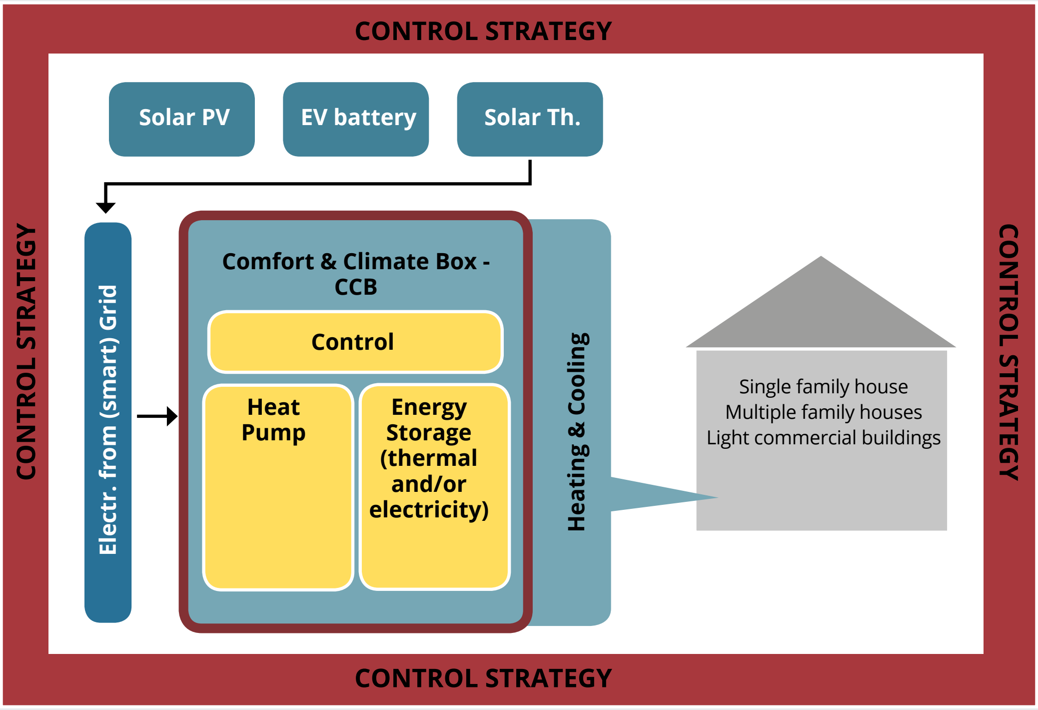


Fig. 1: Concept of Comfort and Climate Box (CCB).

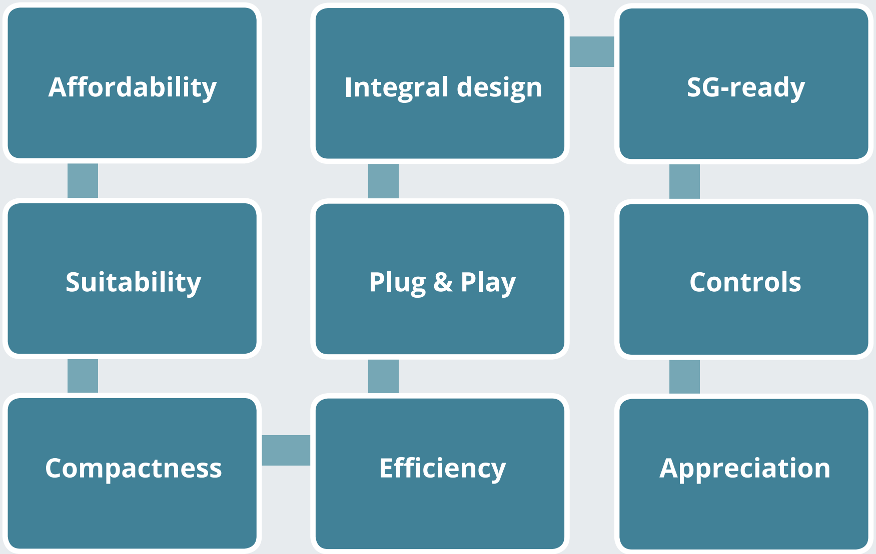


Fig. 2: Comfort and Climate Box: quality criteria

- Functional conditions and requirements for further improvement of CCBs for the local market

WP 2 – Prototyping
The scope and scale for this task is wholly dependent on the national support achieved by the individual countries.

- System specification building on the country-specific output from WP 1
- Control strategy development
- Building or assembling prototypes

WP 3 – Testing and pre-standardization

- Develop comparison metrics, i.e., critical performance indicators of packages, benchmarks for qualifying and quantifying packages.
- Carry out measurements under lab conditions
- Deployment of prototypes in field trials
  Note: Extensive measurements of applied systems in the field are not realizable within the time frame of this Combined Annex. However, these measurements will be initiated within the time frame.
- Recommendations for testing standards

WP 4 – Roadmap / Conditions for successful implementation

- Identify boundary conditions for optimal market development
- Overviews of barriers and stakeholder interests
- Overview of life cycle analysis (LCA) of CO_2 emissions and costs
- Recommendations for control interfaces: HP/Storage package <> heat/cold load <> HP <> Storage <>Renewables <> (Smart) grid
- Recommendations and guidelines for cyber-security aspects for monitoring and remote control of comfort climate box devices and configurations.
- Recommendations for industrial manufacturers
- Recommendations for policy makers
- Recommendations for standardization

WP 5 – Organization and dissemination

- Information exchange / input from other sources (i.e., other IEA Annexes, Horizon 2020 projects, European Heat Pump Association (EHPA), other international stakeholder platforms, etc.)

		WP 1 Market status	**WP 2 Prototyping**	**WP 3 Testing**	**WP 4 Roadmap**	**WP 5 Organization**
2019	Q1	Annex definition workshop				
	Q2	Formal start of combined Annex				
	Q3	🟦				
	Q4	🟦	🟦			🟦
2020	Q1		🟦	🟦	🟦	
	Q2		🟦	🟦	🟦	🟦
	Q3		🟦	🟦	🟦	
	Q4		🟦	🟦	🟦	🟦

- Expert workshops
- Annex meetings, communication, coordination
- Reporting
- Planning

4 Participant commitment

Participant commitment for this Annex will be quite strict. All participants are required to deliver at least one field trial project that will provide concrete results within the next two years. This will ensure that WP 2 and WP 3 will contribute optimally to the goals of this Annex.

Participation of industry partners is strongly encouraged and in many prospective participating countries, plans are developed to get industry partners involved. These business partners will be able to be at the forefront of the development of this new market, and are asked to make an open contribution to the Combined Annex research and information exchange.

Especially for work packages 2 and 3 on prototyping and testing, the possible results will strongly depend on active participation from the national teams and the funding that those parties will be able to secure.

The main leverage from this project will come from the successful implementation of prototypes and field trials (see below). Project funding for participating partners will have a critical impact on the number and diversity of field projects that will be realized.

5 Status

After the definition meeting early this year, a final working plan has been drafted, that has now been accepted by both HPT and ECES. At the time of writing, the first regular meeting for this project is planned to take place at the IEA headquarters in Paris, on 4-5 July.

Meanwhile, commitment from around half a dozen countries has been received to join this double Annex. Eventually, it is to be expected that around 10 to 12 countries will join the effort.

For most work packages, a prospective work package leader has already stepped forward. Precise scope and deliverables of each work package will be written in cooperation with the (prospective) package leaders during the Paris meeting.

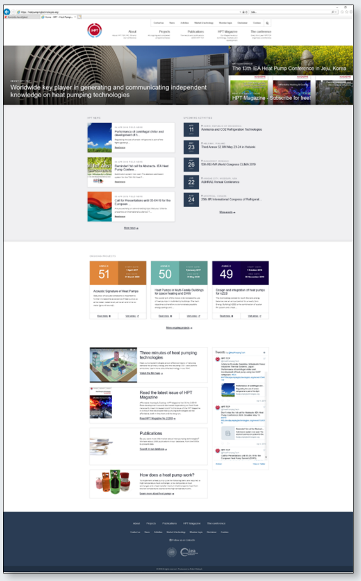
Annex website

http://heatpumpingtechnologies.org/annex55/

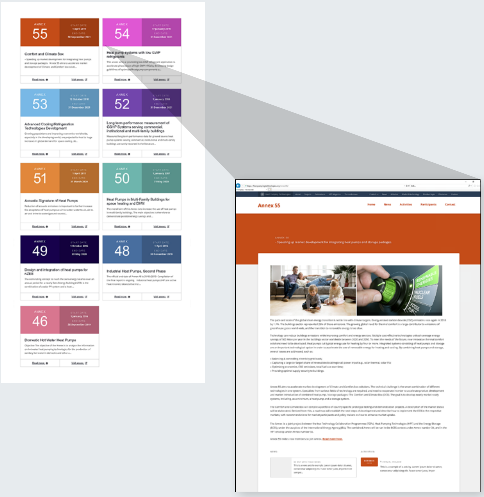
Contact

Operating Agent is Peter Wagener,
Business Development Holland b.v.
Wagener@dhpa-online.nl

INFORMATION



Ongoing Annexes



Always visit our website for news, the latest updates and more information:

heatpumpingtechnologies.org

Waste Heat Recovery at the Steel and Rolling Mill “Marienhütte”, Graz (Austria)

Alexander Arnitz, René Rieberer, Institute of Thermal Engineering, Graz University of Technology
Veronika Wilk, Austrian Institute of Technology GmbH
Helmut Unger, Peter Schlemmer, Energie Graz GmbH & Co KG
Austria

A long-standing cooperation between two companies, the energy service provider and district heating network operator Energie Graz GmbH & Co KG and the steel and rolling mill Marienhütte GmbH, has resulted in a project that is economically viable for both partners and ecologically valuable for the Graz region (Austria). Due to the installation of two highly efficient large heat pumps, waste heat from the steel and rolling mill Marienhütte GmbH can be used to deliver environmentally friendly heat to the existing district heating network in Graz.

Introduction

A long-standing cooperation between the two companies, the energy service provider and district heating network operator Energie Graz GmbH & Co KG and the steel and rolling mill Marienhütte GmbH, has resulted in a project that is economically viable for both partners and ecologically valuable for the Graz region. The core of this cooperation is the use of waste heat from the steel and rolling mill “Marienhütte” for district heating purposes. This cooperation began in 1992 with the direct use of waste heat at a temperature of up to 100 °C and has since then been continuously expanded. Due to the construction of a buffer storage facility, the direct delivery of waste heat to the district heating network was increased to about 60 GWh/year in 2011 (this is about 5% of the heat supplied by the district heating network in 2017).

A further expansion of this cooperation was inspired by Energie Graz through the construction of a central energy station at the company site of Marienhütte in 2015, and the commissioning of two heat pumps with a total heating capacity of up to 11.5 MW at this location in May 2016. These heat pumps use waste heat at a temperature of about 30 to 35 °C as heat source, waste heat which otherwise cannot be used for district heating purposes. Since the commissioning of these heat pumps, heat is delivered to the existing district heating network.

In 2017, the construction of the new low-temperature district heating network in the Reininghaus district of Graz was started and the first part of a modular and expandable thermal water storage tank was constructed, including the hydraulic connection to the heat pumps. According to [1], a district heating input of about 40,000 MWh/a into the existing heating network or about 46,000 MWh/a into the new low-temperature district heating network is expected. The heat pumps are supplied with electricity from renewable sources by a subsidiary of the Energie Graz, thus all the heat provided by the heat pumps is regarded as renewable. For this reason, CO_2 annual savings of up to 11.7 million kg can be reached, compared to the heat supply with a natural gas boiler (see figure 1).

System description

Energie Graz GmbH & Co KG ("Energie Graz") operates the district heating network in Graz and supplied around 70,000 households with a heating demand of about 1,200 GWh and a maximum heating capacity of 455 MW during 2017. The existing district heating network has a pipe length of more than 800 km and is operated with a supply temperature in the range 75 to 120 °C, depending on the outdoor temperature. The return temperature fluctuates between 55 °C (during winter) and 65 °C (during summer), with an additional temperature fluctuation of up to 3 K during a day.

Furthermore, the apartments, which will be built in the next years for about 12,000 inhabitants as part of the "Reininghaus" district development project, will be supplied with heat from a new district heating network. This new district heating network will be operated with a supply temperature of about 70 °C, which is required for hot water preparation all year round, and a return temperature of about 43 °C and will be "physically" decoupled from the existing district heating network. The required heat for this new district heating network will be provided mainly by the heat pumps commissioned at the central energy station in 2016. The modular, expandable thermal water storage tanks are used to bridge downtimes of the steel and rolling mill production. Furthermore, a heat exchanger is installed as a backup system to transfer heat from the existing district heating network to the new district heating network.

The **steel and rolling mill Marienhütte GmbH** ("Marienhütte") is the only manufacturer of ribbed structural steel in the form of bars or rings in Austria. Further products are plain bar steel and metallurgical ballast. In total about 400,000 tons of steel are produced per year. Electricity and natural gas are used as energy sources for the steel production. The high temperature needed for steel production requires active cooling to avoid overheating. For this purpose, three closed cooling circuits at high temperature (up to 100 °C), which are used to supply heat to the existing district heating network, and two open cooling circuits at low temperature (about 30 °C) are used. One open cooling circuit, the

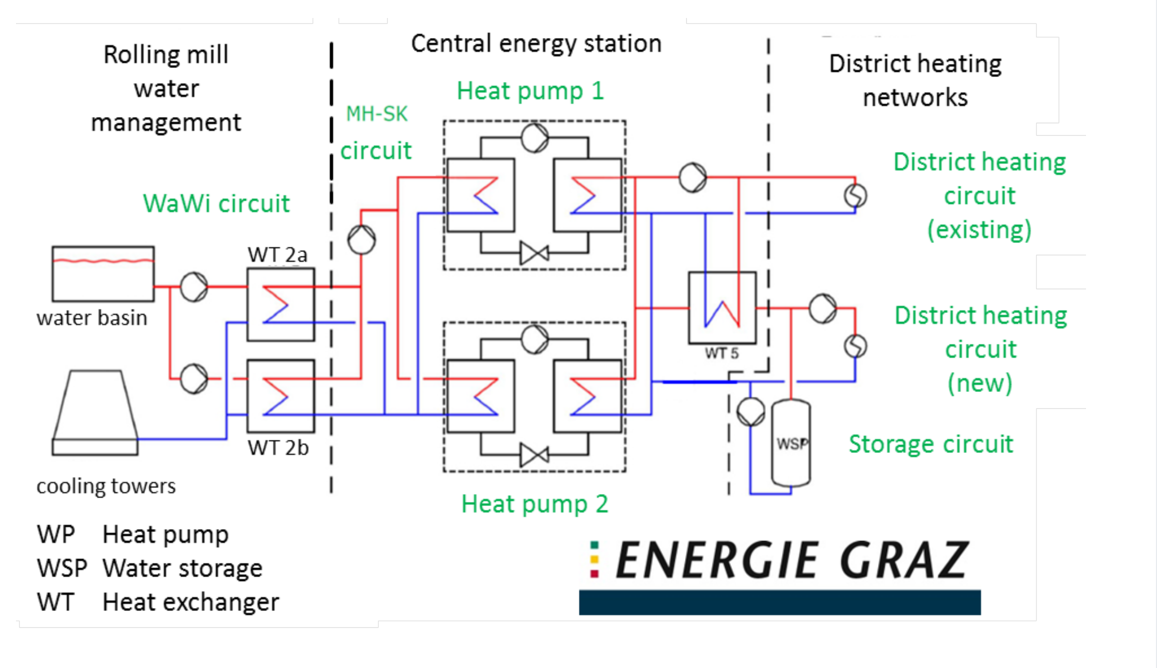


Fig. 1: Hydraulic connection of the heat pumps to the WaWi cooling circuit of the steel and rolling mill and the connection to the existing and the new district heating network (simplified illustration)

so-called water management circuit (WaWi), is used as heat source for the heat pumps

The hydraulic connection of the heat pumps

Figure 1 shows a simplified scheme of the hydraulic connection of the heat pumps to the heat source and sink. The heat pumps use waste heat from the rolling mill water management (WaWi) circuit as a heat source. The connection to the evaporators of the heat pumps is realized using an additional circuit (MH-SK circuit) which is separated from the WaWi circuit with two heat exchangers (WT2a and WT2b). The evaporator inlet temperatures are between 32 and 35 °C and the evaporator outlet temperatures are between 25 and 29 °C. The circulation pumps and a mixing valve can be used to control the temperature in the evaporator circuit (MH-SK circuit).

The separation of the evaporator circuit from the WaWi circuit of the "Marienhütte" ensures an independent operation of the internal cooling circuits when the heat pumps are not in operation (e.g., in case of no heat demand, service of the heat pumps, etc.). In this case the heat transfer to the district heating network is interrupted and the waste heat is dissipated to the environment using the existing cooling towers. With this integration concept the costs for the necessary heat removal from the "Marienhütte" are minimized while the heat pumps are in operation without any risk for the production waste.

The water of the existing district heating network or the water of the new low-temperature district heating network flows directly through the condensers of the heat pumps. In addition, in Fig. 1 the storage circuit and the heat exchanger for the transfer of heat from the existing district heating network to the new low-temperature district heating network (WT5) are shown.

The heat pumps

The installed R1234ze heat pumps are two large heat pumps of the type Unitop produced by the company Friotherm (see figure 2). The dimensions of one heat pump are 8.2/3.7/3.3 m (L/W/H) with a weight of about 30 000 kg. In each heat pump, two turbo compressors are installed which can be operated in parallel or serially. The maximum useful water temperature at the condenser outlet is 95 °C, which can be reached in serial operation of the turbo compressors. In serial operation of the turbo compressors and temperatures at the condenser inlet/outlet of 63/90 °C, a heating capacity of about 3.42 MW per heat pump can be reached. In parallel operation of the turbo compressors and temperatures at the condenser inlet/outlet of 43/69 °C, the maximum heating capacity increases to about 5.64 MW per heat pump. The design temperatures at the evaporator inlet/outlet are 33.8/29 °C in serial operation and 33/25.8 °C in parallel operation. Further information can be found in table 1.

Until the completion of the new low-temperature district heating network, heat will be supplied to the existing district heating network. When the construction of the low temperature district heating network is completed and the first buildings require a heat supply via the network, the heat supply may be provided by one heat pump depending on the heat requirement. In this case the second heat pump can still supply heat into the existing district heating network. The lower supply temperature of 70 °C in the new low-temperature district heating network, compared to the supply temperature of about 95 °C in the existing district heating network, leads to an improvement of the COP from 3.3 to 4.5, which is an improvement of 36%.

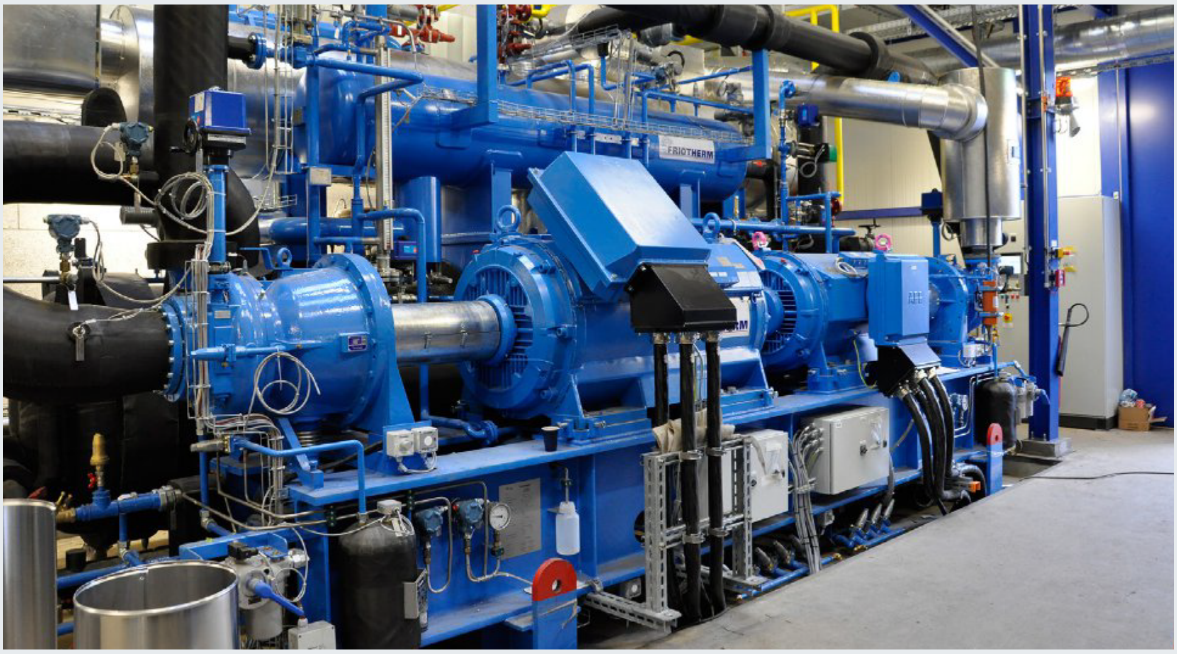


Fig. 2: One heat pump at the location of the "Marienhütte" [1]

Table 1: Information about the heat pumps

Heat pump manufacturer	Friotherm			
Heat pump type	Two Unitop 28CX-71210U			
Compressor	Turbo-Compressor			
Refrigerant	R1234ze			
Heat source temperature in °C (in/out)	34/29	34/29	34/29	33/26
Heat sink temperature in °C (in/out)	90/63	95/57	83/65	69/43
COP$_H$	3.41	3.28	3.71	4.54
Condenser capacity of two heat pumps in MW	6.84	6.76	6.54	11.27
Evaporator capacity of two heat pumps in MW	4.83	4.70	4.78	8.79

Conclusions

Two large heat pumps are installed by "Energie Graz" for district heating purposes at the company site of the steel and rolling mill "Marienhütte" in Graz (Austria). The heat pumps can be used to supply heat to the existing district heating network as well as to a new low-temperature district heating network. The heat pumps are able to supply heat at a temperature up to 95 °C. They use waste heat from the steel and rolling mill at a temperature of about 30 to 35 °C as heat source that would otherwise be dissipated to the environment. The efficiency of the heat pumps achieved during operation is satisfactory.

References

[1] Götzhaber, W., Meißner, E., Moravi, G., Prutsch, W., Schlemmer, P., Schmied, R., Slivniker, E., Zimmel, M., 2017, Wärmeversorgung Graz 2020/2030 – Wärmebereitstellung für die fernwärmeversorgten Objekte im Großraum Graz – Status Report 2017, Grazer Energieagentur Ges.m.b.H.

[2] Unger, H., 2018, Energiemodell Reininghaus – Abwärmeauskopplung Marienhütte durch Energie Graz, Technical report

RENÉ RIEBERER
INSTITUTE OF THERMAL ENGINEERING, GRAZ UNIVERSITY OF TECHNOLOGY
Austria
rene.rieberer@tugraz.at
https://doi.org/10.23697/hh8p-e074

HELMUT UNGER
ENERGIE GRAZ GMBH & CO KG
Austria
h.unger@energie-graz.at
https://doi.org/10.23697/hh8p-e074

From Waste Heat to Cheese

Cordin Arpagaus, Switzerland

In the idyllic Appenzell village of Gais, Switzerland, the mountain cheese factory processes almost 10 million litres of milk annually. A high temperature heat pump converts waste heat from the neighboring data centre into process heat to heat and process the milk. This saves the mountain cheese factory around 1.5 million kWh of natural gas per year.

Introduction

Mountain cheese factory Gais

The cheese factory Gais is located at 919 m above sea level in the hilly Appenzellerland between Lake Constance and Säntis mountain in Switzerland [1]. The factory produces various semi-hard and mountain cheese specialities, as well as raclette cheese [2]. The milk is supplied by approximately 60 milk suppliers from the Appenzellerland region.

The key energy data of the cheese factory with the temperature levels of the process heat are as follows:

- Energy demand: approximately 1,800 MWh per year
- Milk processing: approximately 10 million litres of milk per year
- Temperature levels:
  - Waste heat recovery (i.e. from ice water production and refrigeration, for preheating washing water, ventilation heating,): < 42 °C
  - Space heating and hot water (i.e. for cheese storage house): 65 °C
  - Process heat 1 (i.e. for cheese vats, cleaning water): 92 °C
  - Process heat 2 (i.e. for multi-purpose heater, pasteurisation): 105 °C

Fig. 1: From Waste Heat to Cheese [3]. Data centre (Rechenzentrum Ostschweiz) built by the St. Gallisch-Appenzellische Kraftwerke AG in Gais Appenzell [1] feeds the waste heat into a district heating network. The mountain cheese factory uses this waste heat as a heat source in a high temperature heat pump to generate process heat for cheese production.

Waste heat from the neighboring data centre as heat source

Next to the mountain cheese factory is the new data centre of Eastern Switzerland, which offers the highest levels of energy efficiency and security. It belongs to the St. Gallisch-Appenzellische Kraftwerke AG and the St. Galler Stadtwerke. The building is completely redundantly connected up to every single server rack. The availability standard of 99.998% is at bank level (Tier IV). With an area of 2 x 450 m^2 it offers space for 2 x 150 racks.

Thanks to photovoltaics and a sophisticated adiabatic cooling system, the data centre is the most energy efficient data centre in Switzerland. The Power Usage Effectiveness (PUE) value, which is the ratio of the total energy consumption of the data centre to the energy consumption of the server racks installed, is 1.15. Thus, only 15% additional energy is needed for cooling and heat exchange. The server racks set up in the data centre are cooled with fresh outside air thanks to its location at high altitude in Gais. On hot days, the heat exchangers are additionally sprayed with water from a rainwater and groundwater system [1]. Facade and roof surfaces cover a photovoltaic system, which generates 230,000 kWh of electricity annually. This corresponds to the energy requirements of about 50 single-family houses [1].

At 100% capacity utilisation of the data centre, the adiabatic cooling system generates approximately 1.5 MW of waste heat, which feeds it into a district heating network (water circuit). The temperature level of the waste heat is approximately 20 °C [1].

The neighbouring mountain cheese factory is connected to the district heating network and uses part of the waste heat as a heat source for a high-temperature heat pump (figure 2) to heat and process the milk. The water exits the heat pump at 14 °C before it flows back into the heating network. This way, the cheese factory replaces the energy of around 1.5 million kWh of natural gas per year.

The heat produced by the heat pump is temporarily stored in a stratified storage tank [3]. The capacity of the heat pump is regulated by the storage tank charge state. The management of the water stratification within the storage tank is accomplished by controlling the loading and unloading profiles. The individual processes in the cheese production are supplied with heat from this storage tank. The lower heat levels of the storage tank are used for hot water heating and space heating.

Amstein+Walthert St. Gallen AG was responsible for the overall planning of the building services engineering [3]. In order to achieve high operational reliability for 100% redundant processes, two gas boilers with 620 kW and 220 kW heating capacity were installed, in addition to the heat pump. These gas boilers can be turned on if required. Nevertheless, the general operational goal is a long running time of the heat pump with few switching on and off cycles, as well as a minimum gas consumption for the boilers [3].

In addition to the cheese factory, the waste heat from the data centre is used for heating and hot water production of another 150 households in the neighbourhood or, if

Fig. 1: From Waste Heat to Cheese [3]. Data centre (Rechenzentrum Ostschweiz) built by the St. Gallisch-Appenzellische Kraftwerke AG in Gais Appenzell [1] feeds the waste heat into a district heating network. The mountain cheese factory uses this waste heat as a heat source in a high temperature heat pump to generate process heat for cheese production.

Table 1: Technical data of the high temperature heat pump installed at the mountain cheese factory.

Heat pump manufacturer	Ochsner Energie Technik GmbH
Heat pump type	IWWHS 570 ER6c2 I: Industrial heat pump W: Water heat source W: Water heat sink H: High temperature heat pump S: Screw compressor 570: Heating capacity range in kW E: Economizer cycle R: Shell and tube heat exchanger 6: Refrigerant R1234ze c2: 2-stage compressor
Heating capacity	approx. 520 kW
Heat source temperature (in/out)	18/14 °C
Heat sink temperature (in/out)	82/92 °C or 55/65 °C
Heat source	Cooling water (waste heat) from the neighboring data centre (about 16 to 20 °C)
Compressor type	Screw
Refrigerant	R1234ze(E) (130 kg, safety group: A2L, mildly flammable)
First operation	2020/21 (using waste heat from the data centre)

required, used by other companies. This makes the data centre a major thermal power plant for the Gais region. This sector coupling creates a synergy between the companies.

At the moment, the new building of the cheese factory is still under construction and the data centre is underutilised to supply enough waste heat to its new neighbours. For the waste heat application of the data centre, St. Gallisch-Appenzellische Kraftwerke AG implements an energy-contracting model with the users. The official start-up of the new cheese factory with the high temperature heat pump and waste heat integration from the data centre will take place at the end of 2020 and beginning of 2021.

Results

High temperature heat pump in the mountain cheese factory

Table 1 lists some technical data of the high temperature heat pump and Table 2 shows performance data of the heat pump at high (W18-14/W92) and low (W18-14/W65) temperature conditions in partial load operation. The dimensions of the high temperature heat pump are 4.1 x 1.4 x 2.4 m (L x W x H) with a weight of about 4 000 kg.

The heat pump incorporates a highly efficient and compact semi-hermetic two-stage screw compressor, which has no oscillating components, offers low vibration levels and is wear-free. The effective performance level of 50%, 75%, and 100% is controlled via a slide valve. Efficient forced lubrication guarantees continuous and maintenance-free operation. When the compressor is switched on, a mechanical start-up relief is provided by pressure equalisation. The use of solid shell-and-tube heat exchangers

Table 2: Performance data of the heat pump at high (W18-14/W82-92) and low (W18-14/W55-65) temperature conditions [3] (experimentally tested data, ** extrapolated).*

Operating point: High temperature (W18-14/W82-92)

Part load (%)	100*	75**	50**
Effective part load (%)	100	81	62
Condenser capacity (kW)	520	419	321
Condenser water flow rate (m^3/h)	44.7	36.0	27.6
Temperature difference condenser (K)	10.0	10.0	10.0
Evaporator capacity (kW)	338	264	195
Evaporator water flow rate (m^3/h)	82.7	82.7	82.7
Temperature difference evaporator (K)	3.5	2.7	2.0
Compressor power (kW)	182	155	126
COP_H (-)	2.85	2.70	2.55

Operating point: Low temperature (W18-14/W55-65)

Part load (%)	100*	75**	50**
Effective part load (%)	97	75	54
Condenser capacity (kW)	505	390	279
Condenser water flow rate (m^3/h)	43.4	33.5	24.0
Temperature difference condenser (K)	10.0	10.0	10.0
Evaporator capacity (kW)	385	293	205
Evaporator water flow rate (m^3/h)	82.7	82.7	82.7
Temperature difference evaporator (K)	4.0	3.0	2.1
Compressor power (kW)	120	98	74
COP_H (-)	4.20	4.00	3.75

as evaporator and condenser enable maximizing service life and operational safety.

Low global warming potential HFO (hydrofluoroolefin) refrigerant R1234ze(E) (GWP100 of 6) is applied, as an alternative to R134a (GWP100 of 1,430). The refrigerant charge is about 130 kg. The slight flammability of the refrigerant (safety class A2L) influenced the positioning of the technical room for the heat pump in the building. In order to comply with the standards for heat pumps from 400 kW or 600 kW capacity, various measures were implemented for fire protection and escape routes.

The heat pump has an economizer cycle with vapour injection into the two-stage screw compressor, which is an efficient solution for high temperature lifts as part of the condensate flow is expanded to a medium pressure level. The resulting liquid-vapor mixture is then evaporated to saturation by subcooling the remaining condensate and injected into the screw compressor. The economizer cycle provides the following main advantages:

1. High refrigerant mass flow at compressor outlet, resulting in high heating capacity (i.e., even at high temperature lifts and low evaporation temperatures).
2. Reduced compressor outlet temperature, which is positive with regard to the compressor temperature limits.
3. Strong subcooling of the condensate to increase the COP.

The heat pump provides approximately 520 kW heating capacity at 100% part load and temperatures of up to 100 °C on the heating side. The heating capacity is slightly higher with a higher temperature lift, as an effect of the economizer cycle with a two-stage screw compressor. The COP is between 2.55 and 2.85 at 74 K temperature lift and between 3.75 and 4.20 at 47 K lift [3]. In part load operation, the COP reduces slightly due to the lower decrease of the compressor power relative to the heating capacity. This is a well-known effect of slide valve control.

Conclusions

The mountain cheese factory Gais transforms waste heat from the neighbouring data centre with a high temperature heat pump to process heat levels of up to 100 °C in order to process the milk. Waste heat of around 1.5 MW at 20 °C is fed from the data centre into a local district heating network. This way, the cheese factory saves the energy of around 1.5 million kWh of natural gas per year. Depending on the operating conditions, the COP of the heat pump is between 2.55 and 2.85 at 74 K temperature lift (W18-14/W82-92) and between 3.75 and 4.20 at 47 K lift (W18-14/W55-65). The economizer cycle of the heat pump with vapour injection into the two-stage screw compressor enables an efficient solution for high temperature lifts.

This case study shows how large amounts of heat can be exchanged across industries in the small Swiss village of Gais. It is hoped that such synergies for heating and cooling will also be recognised at other locations in order to further decarbonise the Swiss industry.

References

[1] Website: http://www.rechenzentrum-ostschweiz.ch

[2] Website: http://www.bergkaeserei.ch

[3] Schneider, Raphael, 2018. "Aus Abwärme wird Käse, Amstein+Walthert St. Gallen AG". Ochsner Symposium: Energieeffizienz mit Praxisdiskussion, May 3, 2018, Windisch, Switzerland.

[4] Amstein+Walthert, 2018. "Bergkäserei Gais: Mitarbeiter Remo Niederöst im Interview". August 28, 2018, available online: https://www.blog-amstein-walthert.ch/2018/08/28

CORDIN ARPAGAUS
DR. SC. TECHN.
NTB University of Applied Sciences of Technology Buchs, Institute for Energy Systems, Buchs.
Switzerland
cordin.arpagaus@ntb.ch

https://doi.org/10.23697/f615-5t27

INFORMATION

The Added Value of Heat Pumps for Grid Stability via Demand Response

A. Uytterhoeven, G. Deconinck, A. Arteconi, L. Helse, Belgium

As a consequence of the energy transition, the share of electricity generated from variable, intermittent (and hence less manageable) renewable energy sources (RES) is rising considerably. In order to still guarantee the required quasi-instantaneous balance between supply and demand, there is a clear need for demand side flexibility. One interesting application field offering a great potential for demand side flexibility is the residential heating sector, with heat pumps (HP) coupled to thermal energy storage (TES) as one of the key technologies. This article aims at illustrating what can be done in terms of demand response (DR) with heat pumps, by discussing results from research, demonstration projects, and even commercial cases.

Our energy system is transforming…

Efforts to mitigate climate change are leading to major transformations of our energy system. In the past, at the supply side, large fossil-fired and nuclear power plants produced electricity. At the demand side, passive end-users were simply paying the electricity bill. Nowadays, there is a strong push for renewable energy sources and local production (prosumers) on the one hand, and a transition towards more sustainable and conscious energy use – for example by using energy-efficient electric heat pumps or decarbonized electric vehicles – on the other hand. In other words, the electricity production becomes more variable, unpredictable, and local, and the electricity demand is rising.

… leading to some important challenges

These trends give rise to some important challenges. Firstly, it becomes harder to balance the rising electricity consumption with the unmanageable production. Secondly, the electrification and the resulting peak demand and supply can lead to increasing congestion or voltage issues in the distribution grid.

How can we cope with this?

In the past, balancing supply and demand was fairly easy, because of the dispatchable electricity generation. Due to the emergence of variable, uncontrollable RES, this is not possible anymore. However, the rising electricity demand, provoked by the energy transition, can offer a solution. Rather than letting supply follow demand, balancing can now be performed the other way around, by exploiting demand side flexibility. This flexibility can stem from two different sources, being demand response and energy storage.

Figure 1 shows in an illustrative way how demand side flexibility can solve the balancing problem. The left side shows the current problematic situation. When focusing for instance on electricity generation by photovoltaic panels (PV), the supply profile shows a clear peak around noon, when solar radiation is maximal. The traditional demand profile, on the other hand, is concentrated around the morning and evening period. Consequently, supply and demand don't match, an imbalance that cannot be tolerated by the grid.

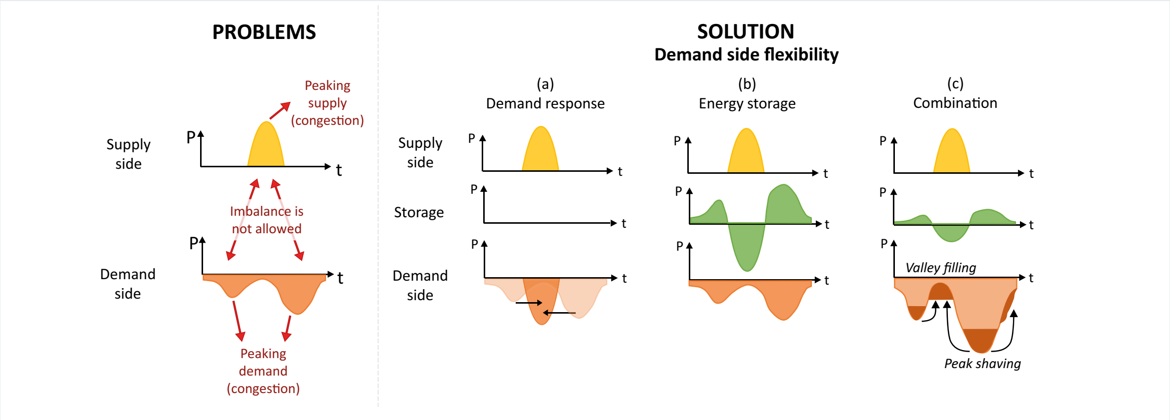


Fig. 1: Solving balancing and congestion problems via (a) demand response, (b) energy storage, or (c) a combination of both.

One possible solution to this problem is the curtailment of the renewable electricity production, and the use of traditional dispatchable power plants to cover the demand. However, this option is highly unsustainable. A more favourable solution is the application of DR. The demand profile is then changed to better match the available supply. For the considered case, the electricity consumption is shifted towards noon, in order to instantly consume the electricity generated by PV. Another possibility is the implementation of energy storage, such as a battery system. Note that in this case the traditional demand profile does not have to be changed, since storage allows for a decoupling of demand and supply.

Also the second challenge, i.e., the demand and supply peaks and related congestion, can be tackled by relying on demand side flexibility, as also shown in figure 1 (c). Combining DR and energy storage can bring about a desirable shift of the consumption from the peak periods towards the valley at noon (coinciding with the peaking PV generation), thereby flattening the demand profile.

DR with heat pumps

What can be done in terms of DR with heat pumps? Currently, the application of DR and the participation in the spot market is mostly limited to large, industrial consumers. Due to the energy transition, however, a new market is emerging, namely the small-scale flexibility of residential consumers. Heat pumps are particularly suited for DR, because of their significant share in electricity consumption and because heat demand is not that time critical, thanks to the available thermal storage in the building mass. This allows for a shift (advance) of the electricity consumption needed to generate heat, as an anticipation towards for example rising electricity prices, without jeopardizing thermal comfort, as shown in figure 2.

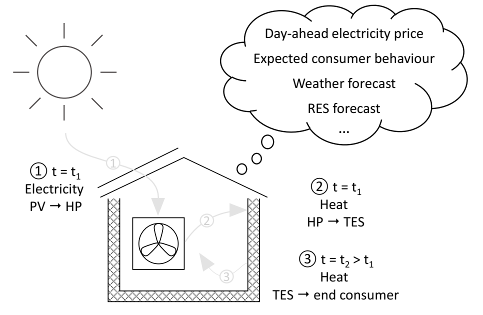


Fig. 2: Demand response with heat pumps.

A lot of work has already been done proving what is possible in terms of DR with heat pumps, ranging from research to demonstration projects, and even commercial cases.

Proof-of-concept in research

Patteeuw has done some valuable simulation studies showing the expected impact of a large-scale implementation of heat pumps participating in DR programmes [1-5]. Some interesting results of his work are shown in figure 3.

In a methodological, illustrative case study, Patteeuw showed the general trends and impacts of implementing heat pumps and using them for DR [1]. This is done for a fictitious energy system. The considered generation mix is very diverse, and the demand side is characterised by a large number of heat pumps, with an electricity demand equal to one fourth of the total demand. The impact of DR can be seen at two different levels: at the building level, as experienced by the consumers, and at the system level, as experienced by society.

Figure 3 shows the profile of the indoor air temperature and the electricity consumption by the heat pump without (top) versus with (bottom) DR for one single building. The application of DR results in a shift of the heat pump operation towards periods characterised by low electricity prices. Hence, the heat pump already starts to preheat the room prior to the instance where heat is really required to ensure thermal comfort. Consequently, a slightly higher final energy use is obtained, due to higher operating temperatures and related storage losses, but at a lower cost. Note that the electricity price profile changes when the share of heat pumps participating in DR increases. This is due to the fact that large-scale application of demand response can impact the generation mix, and thus the resulting electricity prices, as will be discussed further.

When looking at the system level, rather than at the building level, the most important impact of DR is the influence on the overall demand profile and the generation mix needed to cover this demand, as can be seen in figure 4. By applying DR, the combined effect of peak shaving and valley filling leads to a flattened demand profile. Consequently, the need for expensive peak power plants disappears, and also the curtailment of RES is reduced.

These research results demonstrate the expected advantages related to the application of DR, which benefits both end consumers and society. However, demonstration projects are needed to prove that these advantages also can be realised in practice.

Demonstration project

If we shift from theory to practice, an inspiring demonstration project is the smart grid project ‘Energy Frontiers’, implemented in the neighbourhood Heerhugowaard in the Netherlands [6]. The main research question is how decentralized flexibility can be used in a flexibility market to support the energy system. 203 households participated, with different types of smart appliances, from heat pumps to electric boilers and fuel cells. All houses had a smart meter and a smart thermostat, and all appliances were automatically controlled. At the end of the first phase of the project (2015-2016), some very promising results were obtained. Thanks to the flexible smart appliances, 15 power outages were avoided. Figure 5 shows the impact of exploiting flexibility in more detail. The height and duration of (the majority of) the power peaks could be reduced, shifting

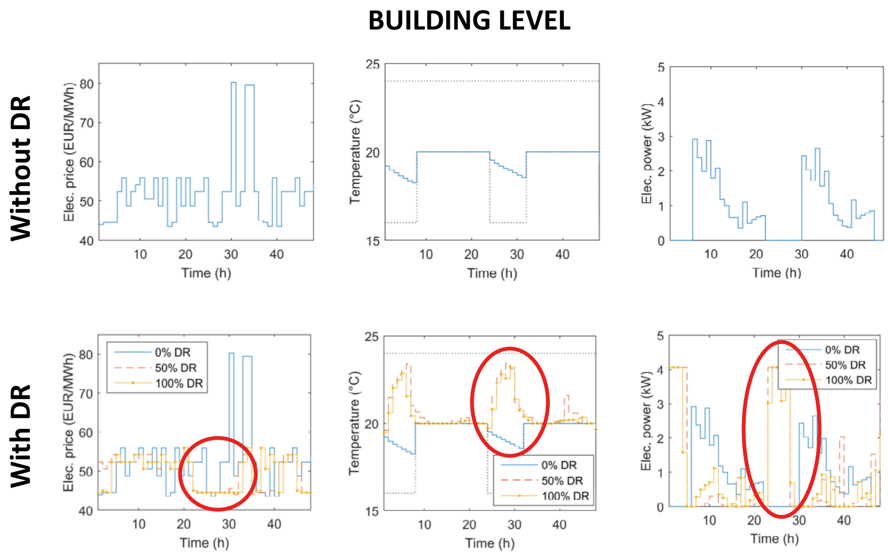


Fig. 3: The impact of DR on building level.

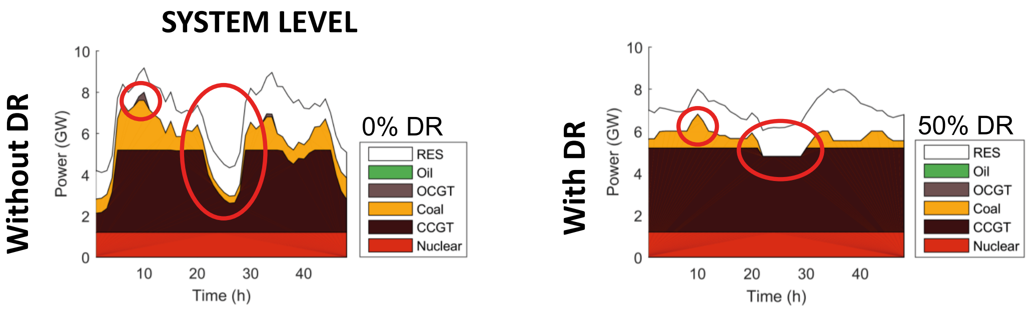
from the upper right corner, the area of power outage or damage, to the lower left corner, the safe area.

Commercial case

In addition to demonstration projects, commercial cases can be found. One commercial success story is TIKO in Switzerland. TIKO is one of the few initiatives already commercially exploiting the value of DR with heat pumps [7,8]. It is a kind of virtual energy storage network, that already in 2017 connected more than 10 000 electric heating devices, both from residential and industrial buildings, of which more than 5 000 devices were heat pumps. Today, the total connected capacity amounts to more than 100 MW. The aggregated flexibility is used to provide services to the Swiss balancing market. All connected devices are controlled in an On-Off manner whenever flexibility is – or is not – needed. The commercial success of this project, applying a rather simple control strategy, is very promising regarding implementation of demand response in practice.

Conclusion

Existing research projects, demonstrations and commercial success stories indicate that demand response with heat pumps offers interesting (and indispensable) possibilities to tackle the challenges of the future energy system – think about the balancing and the grid congestion – but also to exploit the opportunities of that same future energy system – think about the reduced curtailment of renewables. Consequently, it is expected that heat pumps will have a crucial role to play in the future. However, if we come back to here and now, the number



OCGT: Open Cycle Gas Turbine
CCGT: Combined Cycle Gas Turbine

Fig. 4: The impact of DR at system level.

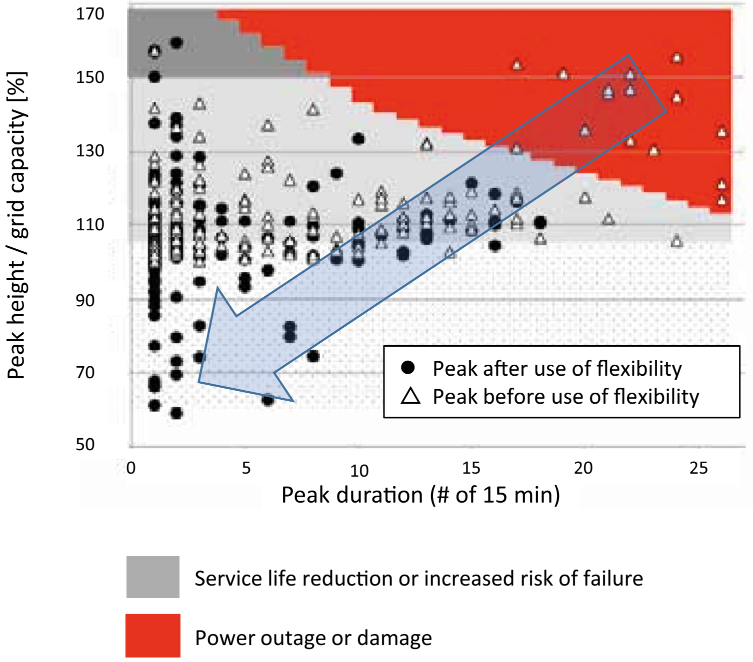


Fig. 3: The impact of DR on building level.

of houses equipped with a heat pump is still very limited, let alone that households are engaging to offer their flexibility. There is still a long way to go... A challenge we all have to take!

Acknowledgements

This article is based on the presentation entitled 'The added value of heat pumps for grid stability via demand response' presented by Anke Uytterhoeven on the Flemish Heat Pump Platform Symposium in Ghent (Belgium) on October 10, 2018.

The authors would like to thank the funding of the University of Leuven (KU Leuven) for the research work presented in this article through the GOA Project 'Fundamental study of a greenhouse gas emission-free energy system' and the C2 Project 'Energy Storage as a Disruptive Technology in the Energy System of the Future'.

References

[1] Patteeuw, D., Bruninx, K., Arteconi, A., Delarue, E., D'haeseleer, W., Helsen, L., 2015. "Integrated modeling of active demand response with electric heating systems coupled to thermal energy storage systems". Applied Energy, 151, 306-319.

[2] Patteeuw, D., Reynders, G., Bruninx, K., Protopapadaki, C., Delarue, E., D'haeseleer, W., Saelens, D., Helsen, L., 2015. "CO_2-abatement cost of residential heat pumps with active demand response: demand-and supply-side effects". Applied Energy, 156, 490-501.

[3] Patteeuw, D., Henze, G.P., Helsen, L., 2016. "Comparison of load shifting incentives for low-energy buildings with heat pumps to attain grid flexibility benefits". Applied Energy, 167, 80-92.

[4] Patteeuw, D., Helsen, L., 2016. "Combined design and control optimization of residential heating systems in a smart-grid context". Energy and Buildings, 133, 640-657.

[5] Patteeuw, D., 2016. "Demand response for residential heat pumps in interaction with the electricity generation system". PhD Thesis, KU Leuven, Belgium.

[6] Energiekoplopers, 2016. "Final report - Flexibility from residential power consumption:
a new market filled with opportunities". Arnhem. Retrieved from https://www.energiekoplopers.nl/wp-content/uploads/2017/01/EnergieKoplopersEngels_FinalReport_2016_vs4.pdf.

[7] Geidl, M., Arnoux, B., Plaisted, T., Dufour, S., 2017. "A fully operational virtual energy storage network providing flexibility for the power system". 12th IEA Heat Pump Conference, (p. 0.2.4.4). Rotterdam. Retrieved from http://hpc2017.org/wp-content/uploads/2017/05/O.2.4.4-A-fully-operational-virtual-energy-storage-network-providing-flexibility-for-the-power-system.pdf.

[8] http://www.tiko.ch

ANKE UYTTERHOEVEN
PHD CANDIDATE
KU Leuven, Department of Mechanical Engineering, Division Applied Mechanics and Energy Conversion, Leuven, Belgium.
Belgium
anke.uytterhoeven@kuleuven.be
https://doi.org/10.23697/fyxj-gd21

Events 2019/2020

This section lists workshops, conferences etc. related to heat pumping technologies.

2019

2-4 September
Building Simulation 2019
Rome, Italy
http://buildingsimulation2019.org/

9-11 September
11th International Conference on Compressors and their Systems
London, UK
https://www.city.ac.uk/compressors-conference

11-13 September
Japan Society of Refrigerating and AirConditioning Engineers (JSRAE) Annual Conference
Tokyo, Japan
https://www.jsrae-nenji.org/nenji2019/en/index.html

25-27 September
2019 ASHRAE Building Performance Analysis Conference
Denver, Colorado, USA
https://www.ashrae.org/conferences/topical-conferences/2019-ashrae-building-performance-analysis-conference

22-23 October
European Heat Pump Summit 2019
Nuremberg, Germany
https://www.hp-summit.de/en

24 October
HPT TCP National Experts' meeting
Nuremberg, Germany
For more information, please contact your HPT National Contact (https://heatpumpingtechnologies.org/contact-us/) or Johan Berg, HPC (johan.berg@ri.se)

4-5 November
REHVA Brussels Summit 2019
Brussels, Belgium
https://www.rehva.eu/events/details/rehva-brussels-summit-2019

19-21 November
7th International Conference On Energy Research and Development
State of Kuwait
https://www.ashrae.org/conferences/topical-conferences/7th-international-conference-on-energy-research-development

4-6 December
50th International HVAC&R Congress and Exhibition
Beograd, Serbia
https://www.ashrae.org/conferences/ashrae-endorsed-conferences/international-hvac-r-congress-and-exhibition

9-12 December
2019 Buildings XIV International Conference
Clearwater Beach, Florida, USA
https://www.ashrae.org/conferences/topical-conferences/2019-buildings-xiv-international-conference

2020

1-5 February
ASHRAE Winter Conference
Orlando, Florida, USA
https://www.ashrae.org/conferences/2020-winter-conference-orlando

15-17 April
6th IIR Conference on Sustainability and the Cold Chain (ICCC 2020)
Nantes, France
http://www.iifiir.org/clientBookline/recherche/NoticesDetaillees.asp?VIEWALL=TRUE&ToutVisualiser=1&INSTANCE=exploitation&iNotice=7&ldebut=

11-14 May
13th IEA Heat Pump Conference 2020
Jeju, South Korea
http://hpc2020.org/

7-10 June
9th International Conference on Caloric Cooling and Applications of Caloric Materials (Thermag IX)
College Park, Maryland, USA
https://www.ashrae.org/File%20Library/Conferences/ASHRAE%20Endorsed%20Conferences/DRAFT_Thermag2020-3_VA1_Redlined.pdf

27 June – 1 July
ASHRAE Annual Conference
Austin, Texas, USA
https://www.ashrae.org/conferences/2020-ashrae-annual-conference

13-16 July
Purdue International Compressor Engineering, Refrigeration & AC, High Performance Buildings Conferences
West Lafayette, Indiana, USA
https://engineering.purdue.edu/Herrick/Conferences/2020

26-29 July
Rankine 2020 Conference – Advances in Cooling, Heating and Power Generation
Glasgow, United Kingdom
http://www.iifiir.org/clientBookline/recherche/NoticesDetaillees.asp?VIEWALL=TRUE&ToutVisualiser=1&INSTANCE=exploitation&iNotice=7&ldebut=

14-16 September
Indoor Environmental Quality Performance Approaches - Transitioning from IAQ to IEQ
Athens, Greece
https://www.ashrae.org/conferences/topical-conferences/indoor-environmental-quality-performance-approaches

6-9 December
14th IIR-Gustav Lorentzen Conference on Natural Refrigerants (GL 2020)
Kyoto, Japan
http://www.iifiir.org/clientBookline/recherche/NoticesDetaillees.asp?VIEWALL=TRUE&ToutVisualiser=1&INSTANCE=exploitation&iNotice=10&ldebut=

IN THE NEXT ISSUE
Cooling for the Future
Volume 37 - NO 3/2019

National Team CONTACTS

AUSTRIA
Mr. Thomas Fleckl
Austrian Institute of Technology
Tel: +43 50550-6616
thomas.fleckl@ait.ac.at

BELGIUM
Ms. Jozefien Vanbecelaere
Beleidsmedewerker PVen
Warmtepompen
Tel: +32 2 218 87 47
jozefien.vanbecelaere@ode.be

CANADA
Dr. Sophie Hosatte Ducassy
CanmetENERGY
Natural Resources Canada
Tel: +1 450 652 5331
sophie.hosatte-ducassy@canada.ca

CHINA
Prof Xu Wei
China Academy of Building Research
Tel: +86 10 84270105
xuwei19@126.com

DENMARK
Mr. Svend Pedersen
Danish Technological Institute
Tel: +45 72 20 12 71
svp@teknologisk.dk

FINLAND
Mr. Jussi Hirvonen
Finnish Heat Pump Association
Tel: +35 8 50 500 2751
jussi.hirvonen@sulpu.fi

FRANCE
Mr. Paul Kaaijk
ADEME
Tel: +33 4 93 95 79 14
paul.kaaijk@ademe.fr

GERMANY
Dr.-Ing. Rainer M. Jakobs
Informationszentrum Wärmepumpen
und Kältetechnik - IZW e.V
Tel. +49 61 63 57 17
email@izw-online.de

ITALY
Dr Maurizio Pieve
ENEA, Energy Technologies Dept.
Tel. +39 050 621 36 14
maurizio.pieve@enea.it

JAPAN
Mr. Tetsushiro Iwatsubo
New Energy and Industrial Technology Development Organization
Tel +81-44-520-5281
iwatsubotts@nedo.gojp

Mr. Hideaki Maeyama
Heat Pump and Thermal Storage
Technology Center of Japan (HPTCJ)
Tel: +81 3 5643 2404
maeyama.hideaki@hptcj.or.jp

NETHERLANDS
Mr. Tomas Olejniczak
Netherlands Enterprise Agency (RVO)
Tel: +31 88 60 233 17
tomas.olejniczak@rvo.nl

NORWAY
Mr. Rolf Iver Mytting Hagemoen
NOVAP
Tel. +47 22 80 50 30
river@novap.no

SOUTH KOREA
Mr. Hyun-choon Cho
KETEP
Tel: +82 2 3469 8872
energykorea@ketep.re.kr

SWEDEN
Dr. Emina Pasic
Swedish Energy Agency
Tel: +46 16 544 2189
emina.pasic@energimyndigheten.se

SWITZERLAND
Mr. Stephan Renz
Beratung Renz Consulting
Tel: +41 61 271 76 36
renz.btr@swissonline.ch

UNITED KINGDOM
Mr. Oliver Sutton
Department for Business, Energy &
Industrial Strategy
Tel: +44 300 068 6825
oliver.sutton@beis.gov.uk

THE UNITED STATES
Mr. Van Baxter – Team Leader
Building Equipment Research
Building Technologies Research &
Integration Center
Tel: +1 865 574 2104
baxtervd@ornl.gov

Ms. Melissa Voss Lapsa – Coordinator
Building Envelope & Urban Systems Research
Building Technologies Research & Integration
Center
Tel: +1 865 576 8620
lapsamv@ornl.gov

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 on the address above.

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

Heat Pump Centre
c/o RISE Research Institutes of Sweden
P.O. Box 857
SE-501 15 Borås
Sweden
Tel: +46 10 516 55 12
hpc@heatpumpcentre.org

www.heatpumpingtechnologies.org