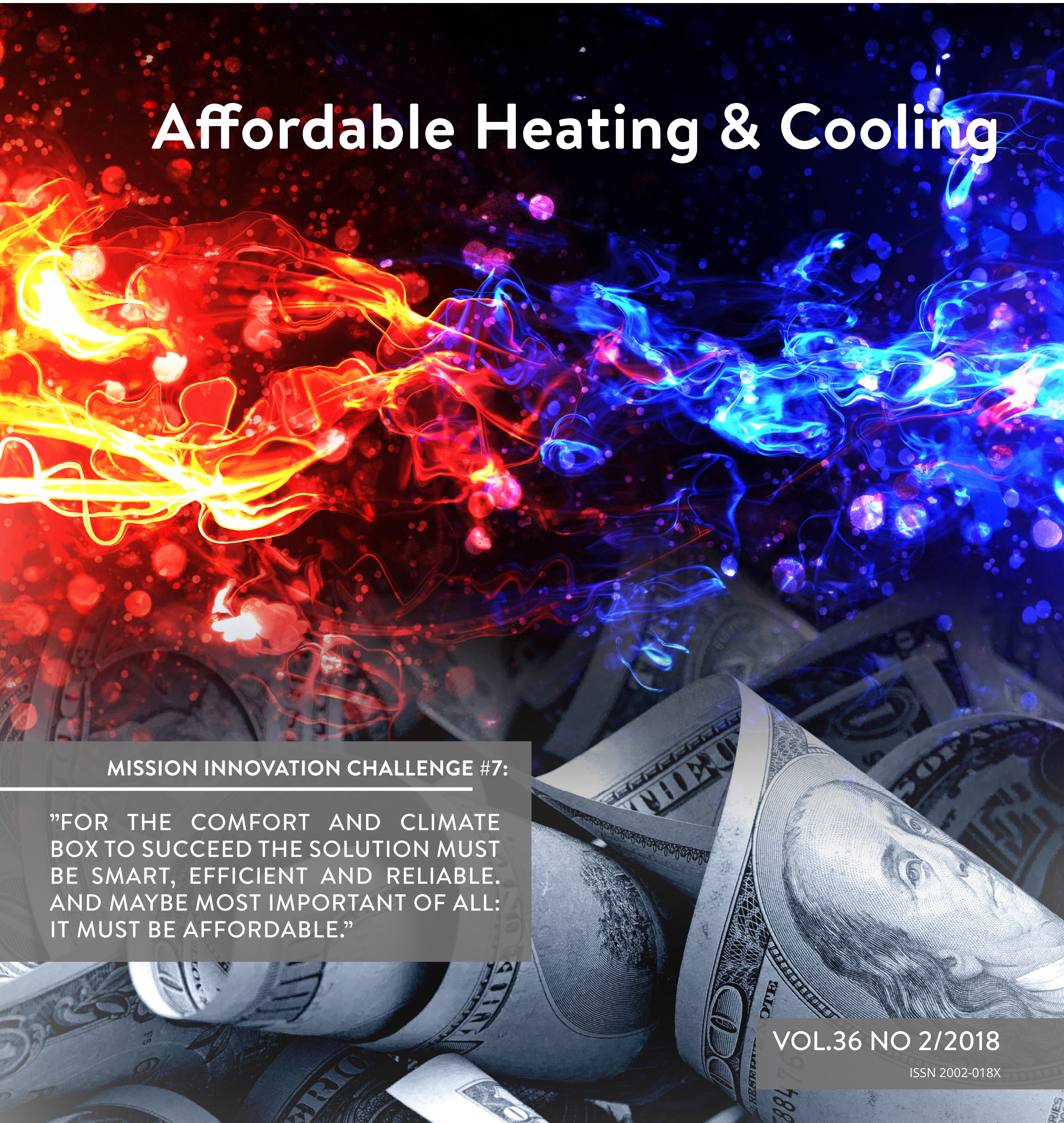
Heat Pumping Technologies MAGAZINE

A HEAT PUMP CENTRE PRODUCT



Affordable Heating & Cooling

MISSION INNOVATION CHALLENGE #7:

"FOR THE COMFORT AND CLIMATE BOX TO SUCCEED THE SOLUTION MUST BE SMART, EFFICIENT AND RELIABLE. AND MAYBE MOST IMPORTANT OF ALL: IT MUST BE AFFORDABLE."

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Heat Pumping Technologies
MAGAZINE

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In this issue

The development of heat pumping technologies shows us a path towards decreased dependency on fossil fuels. But development often means increased costs; costs that the market is not necessarily willing to pay. In this issue of the HPT Magazine it is shown that these developed heat pumping technologies can be affordable, both in the short and the long run.

The Foreword focuses on the term "affordable", recognizing also its implications beyond the strict economical interpretation. In the three Topical articles, aspects of affordability are described for three different heat pumping applications: booster heat pumps in low-temperature district heating networks, decentralized reversible heat pumps in district heating and cooling networks, and hybrid heat pumps allowing for flexibility regarding energy carrier.

The Column describes how deployment of heat pumps fits into the national policies of South Korea. This is written by the Chair of the National Organizing Committee of the upcoming 13th IEA Heat Pump Conference in Jeju, South Korea in 2020. Further, you will find summaries of heat pump-related events during the Nordic Clean Energy Week held in Denmark and Sweden in May. With the purpose to accelerate the clean energy revolution, that week gathered energy ministers from across the globe for the 9th Clean Energy Ministerial (CEM9) and 3rd Mission Innovation (MI3). The News in focus tells the good news about EU's Energy Efficiency Directive and the Energy Union Governance Regulation that hopefully will make heating and cooling a top priority within the EU.

Enjoy your reading!

Johan Berg, Editor

Heat Pump Centre

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

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FOREWORD

Affordable Heating and Cooling

'Affordable: Being within the financial means of most people', not that my English is not good enough to understand the meaning of the word, but just to be sure I did a short search for a definition, and this is what Merriam-Webster came up with.

Do not worry, I won't search for the heating and cooling definition, as it could take us much too far. However, bringing affordability back to only the financial aspects did not satisfy me at all, and feels like a much too narrow economic view.

In a further synonym search of 'to afford' the sentence 'to be able to do something without risk of adverse consequences' crossed my eyes. And this really opens up our entire and maybe also "entired" eyes. We should indeed look deeper into quantifying the cost of those adverse consequences, or inspire experts in that field to do so. Knowing what the fair level playing field of the heat pump technology should be is as essential as what we mostly do; we try hard to optimize the investment cost and the running efficiency of heat pump technologies. As that is exactly what governmental bodies and energy administrations urge us to do. They like the solution, but they do not accept the price.

It puts our sector under a pressure that maybe costs us some motivation from time to time, but also leads us very far in the optimization challenge. We are doing cost-optimization research on the component and construction levels, on the level of design and sizing, on the use of advanced control systems, on the optimal combination with thermal storage in water tanks, building structures and underground. We are even searching for integrated optimal design and control procedures and bring predictive control to the table. We are using dynamic system simulations intensively and we extend our research to larger and larger systems, leading to optimal integration, sizing and operation of those systems. Not many sectors are pushed as far as we are. We are evolving from heat pump researchers and developers to excelling energy system analysts. The back side is that we are also evolving from a 'keep it simple and stupid (KISS)' concept towards an integrated and smart system. However, this is an increasingly complex system.

A consequence of this increasing complexity is that we do need to communicate largely and clearly, even sometimes a little bit simplified in our story telling, to keep the attention of our society and policy makers in order to carry on our course forward. Awareness of the adverse consequences is a focus. Thus, even in countries where external factors, such as the price gap between fossil fuels and grid electricity, are counterproductive, the additional merits of the HP technology (assisting in reducing the risk for adverse effects) should be recognized. For example in countries where the share of renewable electricity in the grid could increase, the acceleration effect of HP technologies is encouraging simultaneous (grid and building) steps forward. Even in countries with high gas grid density, combining greening of the electricity grid with the mass implementation of heat pump technology can significantly contribute to the climate goals and outdoor air quality control (more than only CO_2 emissions, by far).

Not achieving those goals is a price of adverse consequences that future generations surely cannot afford, in the sense of my first sentence above…

WIM BOYDEN
PROFESSOR, CSTO BOYDENS ENGINEERING, BELGIUM

Saving Energy and Protecting the Environment Through the Promotion of Heat Pump Systems

Energy and the environment – two topics that are always of great concern to human beings. This is because we know that there are limited energy resources and our environment will continue to get worse unless we put in a considerable amount of effort. Heating and cooling play a great role in our daily life, as we cannot live in conditions that are too hot or too cold. We use a tremendous amount of fossil fuels for heating and cooling, – both in the past and still today – and we will do similarly for several decades to come. The problem is that their supply will not increase forever, but will soon peak – indicating that the supply will then diminish. It is therefore essential that we find alternatives to replace them or at least compensate for their loss, and develop various methods for using existing energy sources in a rational manner.

Renewable energy sources are currently attracting a great deal of attention. This is a good thing in terms of reducing the use of fossil fuels, considering the limited reserves, and finding a long-lasting supply of energy instead. Solar power, hydroelectric power from rivers and seas, geothermal power, wind power, air source and others are regarded as renewable energy sources, and these are being intensively investigated for a great variety of applications. When changing temperature levels using substantial energy input, a heat pump is always recommended as an optimal tool. The heat pump can provide a pleasant and comfortable environment when heating and cooling are required. There are many issues involved in increasing the performance of a heat pump system, making system components compact and efficient, and controlling the system in a way that minimizes energy consumption while maintaining the comfort level. In the near future, heat pump systems will connect to the internet by means of the Internet of Things (IoT) technology and lots of (big) data will be collected for fault detection and prompt diagnosis, which will elevate service and management. Thus, any problems will be possible to identify and remedy instantly, and future issues can be predicted, proactively.

In Korea, our government has a major focus on renewable energy and is implementing significant related policies to increase the proportion of renewable energy used. Wind power and solar photovoltaic electricity generation are being widely promoted. Renewable energy subsidies are helping to establish initial markets. However, when it comes to heat pumps, only geothermal heat pumps and those with heat supplied by seawater are treated as renewable energy. This should be opened up more widely to include solar heat pumps, water source heat pumps (including river and lake sources), and air source heat pumps, which should be positively promoted as heat pump systems because these energy sources are all inherently renewable. Type-by-type certification as a renewable device makes no sense, since various different types of hybrid heat pump systems are available – such as solar + geothermal, solar + air, geothermal + water, water + air etc. One thing to note is that efficiency is essential, since low-efficiency equipment will ultimately consume much more energy resources. Regulation based on device efficiency or seasonal efficiency is therefore a very logical way to disseminate the use of heat pump systems as a means of utilizing renewable energy in Korea.

With this in mind, we are delighted to take on the challenge of hosting the 13th IEA Heat Pump Conference in 2020 (HPC2020). Considering the varied applications of heat pump systems in the residential, building and industrial fields, this major conference with over 500 participants will definitely broaden the horizons of our heat pump community. We on the organizing committee will do our best to promote the conference and make it a successful one. The theme, ***"Heat Pumps – Mission for the Green World"***, will make all the researchers proud that we really are creating a Green World together through research and development for a better future.

MIN SOO KIM
Chair, National Organizing Committee of the 13th IEA Heat Pump Conference
Professor, Seoul National University, KOREA

Welcome to the IEA Heat Pump Conference in 2020

Night view of Ramada Plaza Hotel Jeju

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 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 Technology
- 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

Call for Paper

The abstract submission system will be opened from January, 2019. The abstracts will be screened by an appropriate Regional Coordinator and authors will be advised of acceptance. Important dates are given below.

Abstract submission open	January 1, 2019
Abstract submission due	June 30, 2019
Full paper submission due	December 1, 2019
Final paper submission due	February 15, 2020

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.

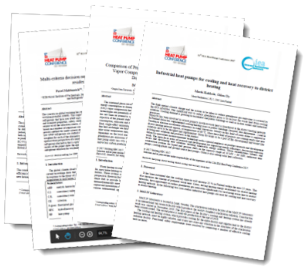
Per Jonasson	Chairperson IOC, Swedish Refrigeration & Heat Pump Association, Sweden
Sophie Hosatte	Vice-Chairperson IOC, CanmetENERGY, Canada
Hiroshi Okumura	Vice-Chairperson IOC, HPTCJ (Heat Pump and Thermal Storage Technology Centre of Japan)
Min Soo Kim	Chairperson NOC, Seoul National University,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

For further information, please refer to the Conference website with the 1st announcement of the 13th IEA Heat Pump Conference.

https://hpc2017.org/next-iea-heat-pump-conference-2020/

Get Updated from the last IEA Heat Pump Conference 2017 in Rotterdam

The 12th IEA Heat Pump Conference took place in Rotterdam 2017 with over 500 participants from 34 countries. The three day conference program contained interaction between researchers, industry and market representatives, policy makers etc. Much of the presented work during the sessions were directly related to the work in past, running and future Annexes under the HPT TCP but also work performed by people outside the program was presented.



Order Full Papers from the 12th IEA Heat Pump Conference

You can now order **all** Conference Proceedings (Full Papers) from the 12th IEA Heat Pump Conference in Rotterdam. **Price: 300 €**
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The Conference Proceedings (Full Papers) will be delivered on a USB flash drive (USB memory stick), after your payment is done.

Papers from previous conferences can be downloaded free of charge at: https://heatpumpingtechnologies.org/publications/?search=&term-17=on

The EU Negotiators Finally Succeed in the Energy Talks on the Energy Efficiency Directive and the Energy Union Governance Regulation

On June 20, the final deal on the Energy Efficiency Directive (EED) and the Energy Union Governance Regulation was achieved with an overall EU-wide energy efficiency target of 32.5 % by 2030, non-binding. This is planned to be reviewed in 2023. The deal on the energy union governance regulation agreed to aim for a quick transition towards a net-zero economy, with a carbon budget and national strategies for 2050. Therefore, under the governance agreement, the Commission needs to work on update of 2050 low-carbon energy roadmap until the end of 2018.

Of special importance for the heat pump industry, there is also a final decision on the future Primary Energy Factor (PEF) for electricity. The default PEF will be 2.1, with a revision every 4 years. This number can be used in the upcoming revision of Ecodesign regulations 813/2013, 814/2013 (lot 1 and lot 2).

Thomas Nowak, Secretary General of EHPA (European Heat Pump Association), commented on the Energy Efficiency Directive and Energy Union Governance Regulation: "I personally applaud the negotiators for the work done over the past weeks and months. They have set the frame for decarbonising Europe. The agreements reached on energy files in the last hours have set the foundation for a new EU energy framework (32.5 % Energy Efficiency / 32 % Energy from Renewable Sources in 2030) to be reviewed in 2023. Most important is the agreement to reaching net-zero emissions as soon as possible, hopefully even before 2050. This makes the deployment of renewable and efficient thermal technologies essential. The industry is ready to face the challenge of faster growth in the coming years. Also, the new set of policy instruments (renovation strategies in EPBD, renewable heating and cooling obligation scheme, accurate PEF for electricity, national decarbonisation plans) – will be helpful to accelerate the energy transition.

In the context of next steps, we need to prioritise action with the highest impact. Decarbonising the EU is not possible without decarbonising the heating and cooling sector that is covering half of Europe's energy needs. Thus, it is timely to focus on the heating and cooling sector to achieve both more renewables and energy efficiency. We, therefore, urge EU and national policy makers to be more vocal on heating and cooling in their upcoming policy work. Heating and cooling must become EU's new top policy priority!".

Source:
http://www.ehpa.org/about/news/article/press-release-the-next-step-in-aligning-eu-energy-legislation-with-the-paris-agreement-good-framew/

https://www.rehva.eu/news/news-single/article/eu-negotiators-finally-succeed-energy-talks-on-eed-and-energy-union-governance-r.html

The Energy World Gathered in the Nordic Countries:

Nordic Clean Energy Week

The Nordic Clean Energy Week took place in Copenhagen, Denmark and Malmö, Sweden in May, with a large number of events and activities. As part of the week energy ministers from major economies across the globe met for the 9th Clean Energy Ministerial (CEM9) and 3rd Mission Innovation (MI3) to accelerate the clean energy revolution. Below you will find some summaries of events relevant for heat pump technologies.

Nordic Clean Energy Week

Report from the Arena for Sustainable Heating and Cooling and Key Messages to the Clean Energy Ministerial Meeting

On the 22nd of May, during the Clean Energy Week in Malmö, Sweden, an Arena for Sustainable Heating and Cooling was arranged, where representatives from industry, policy and research organizations met to inform each other and discuss sustainable solutions for low carbon and fossil free heating and cooling. This was a triple helix meeting point for a wide range of participants who are actively working on transition of energy systems using interactive models for innovation.

Among the topics of the day were the success story of heat pumps in Sweden, the initiative of creating a fossil free energy district introducing a local digital market place for energy – the FED-project, decarbonizing of heating and cooling by a very low temperature thermal grid in combination with heat pumps and replication of innovative affordable solutions in cities through demonstration and a city network.

The success story of heat pumps in Sweden

In Sweden, with a population of 10 million inhabitants, there are today 1.7 million heat pumps installed, of which 0.5 million are ground source heat pumps. Most of the others are air source heat pumps. Primarily, heat pumps have been installed in residential buildings, but lately the number of commercial heat pumps has increased, for example in IKEA warehouses and ICA supermarkets. Heat pumps have also been installed in several hospitals, university buildings and other public buildings. The result has been that the oil consumption for space and domestic hot water heating has decreased by 97 % since 1987! However, although so many electrically driven heat pumps have been installed, the corresponding electricity consumption has decreased by 35 % since 1987.

The Fossil free Energy District project (FED)

In this project, funded by the Urban Innovation Actions program (UIA) within EU, a smart district energy system will be demonstrated. This system includes heating, cooling, electricity and a digital market place, where the different actors within the district can trade in various energy flows. Different aspects studied within the project are how to interact with local production,

Introduction of the session organized by the Heat pump Centre and the IEA HPT Network in collaboration with Mission Innovation.

Audience during panel discussion.

like for example heat pumps, solar energy, biobased CHP plants (combined heat and power) and how to use energy storage. The local district grid is connected to the city grid and the aim of the project is to use energy efficiently, by trading between the actors, and to minimize fossil fuel peaks by avoiding to buy from the city when the oil burners are on in the city grid.

Decarbonizing of heating and cooling by a very low temperature thermal grid in combination with heat pumps

In order to adapt to the transformation of the energy sector, from few large producers to a variety of small producers, the large utility company E.ON has developed a concept of a small local low temperature thermal grid for heating and cooling, consisting of plastic pipes, similar to ordinary water pipes. This will be an interlinked system of heat pumps and cooling machines, which will not be completely balanced at all times. Therefore, it can be connected to a traditional district - heating system, a geothermal energy system or a river, etc. The new concept will very soon be implemented in Medicon Village in Lund, Sweden, a research and innovation centre with 120 companies (with 1600 people work force) and 200 apartments.

Replication of innovative affordable solutions in cities through demonstration and a city network

In the trans-European project CELSIUS, a number of smart energy systems were demonstrated in the cities of Gothenburg, Rotterdam, London and Genoa. In addition, a network of 60 follower cities was established. The aim of the project was knowledge transfer by demonstration, and a digital toolbox was created. A smart city is a city that copies smart solutions and replicates them, following the leader of the project. For example, the audience learned about a case where heat was recovered from the ventilation air of the London Underground and used by a heat pump to heat apartments and schools.

Panel discussions

During the panel discussions the question about what needs to be done to reach the two-degree scenario was raised. The answers from the panels were that many of the technical solutions already do exist, we just have to implement them. For that to happen we need to collaborate more to develop integrated solutions where the advantages from different technologies are combined, implement new business models, increase the awareness of sustainable solutions and make them fancier. In addition, we need policies that promote what we want! We must be aware that companies need to protect their investments. However, fuel poverty is an issue that need to be considered. In many places policy does not dare to set taxes on fossil fuel, since this could result in people not being able to afford heat. Therefore, there must be focus on improving the affordability of clean heating and cooling solutions.

Making low carbon heating and cooling available for everyone

During one session, organized by the Heat pump Centre and the IEA HPT Network in collaboration with Mission Innovation, the challenge of making low carbon heating and cooling available for everyone was discussed. In order to target a mass market, the solution must be affordable, efficient, robust, easy to install and attractive for end user. In addition, there must be solutions targeting both cold climates, medium climates, and hot and humid climates.

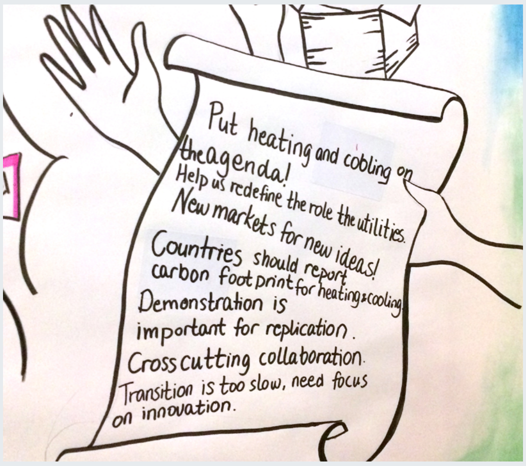
The Technology Collaboration Programmes on Heat Pumping Technologies (HPT TCP) and the one on Energy Storage (ECES TCP) will start a new joint collaboration project aiming at developing a "Comfort & Climate Box" – an affordable heating and cooling solution where heat pumping and storage technologies are combined, in order to meet the Innovation Challenge 7 (IC#7) of the Mission Innovation initiative (http://mission-innovation.net/) – Affordable heating and cooling in buildings. This is the very first project within this Innovation Challenge (IC#7) and the aim is to construct a solution that can be used by various types of residential buildings all over the world. For this to succeed the solution has to be smart, efficient and reliable. And maybe most important of all: it has to be affordable.

Panel discussion with live illustrator.

Though the end result of the Comfort and Climate Box project may not be an actual box, it will be an integrated heating and cooling solution targeted for a large market. It is not realistic, though, to search for a "one-size-fits-all" product and hence the solution has to be scalable to various markets and adjustable for, for instance, single and multi-family houses. For this, the industry must be on board, and that is one of the tasks of the project.

Key messages to the ministerial meeting
The key message from the Arena to the ministers on the ministerial meeting was the following:

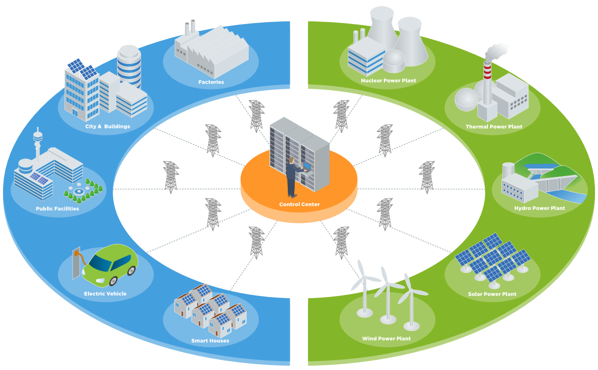
- Put heating and cooling on the agenda!
- Help us redefine the role of the utilities;
- New markets for new ideas are needed;
- Countries should report carbon footprint for heating and cooling and set up targets to be followed up;
- Demonstration are important for replication, in order to minimize the risk when implementing new innovations;
- Cross-cutting collaboration is important and necessary;
- The transition to sustainable heating and cooling is too slow, we need to focus on innovations.



Key message from the Arena.

Nordic Clean Energy Week

Arena: Smart Grids – Unlocking the Renewable Energy Future



Arena: Smart Grids – Unlocking the Renewable Energy Future gathered a wide range of stakeholders interested in the evolution of the energy landscape. The day consisted of presentations, panel discussions and dialogue with the audience. In the panel discussions of *Accelerating innovation for local energy grids*, organized by RISE (Research Institutes of Sweden), the panel discussed the foreseen central role of local energy grids in the energy system, something that heat pumps will be an important part of.

A Swedish example of a local energy system was presented – the Simris energy system, which is one of six industry-scaled demonstrators in the InterFlex EU project. The panel further discussed key drivers for innovations targeting the grids and concluded that regulatory changes are necessary to enable innovations in the local grids – initially facilitated by introduction of policy labs and arenas. However, the regulations and policies should be flexible enough to support, and not slow down, a transition to a smarter grid.

In the session *Battery storage: transforming the power landscape*, the panel discussed the falling prices of batteries which now make it possible to convert this niche solution into a large-scale battery deployment. This is a development that will have a large impact on the power sector. Bo Normark, InnoEnergy, meant that battery storage may be a cheaper and quicker solution than traditional grid investments. For example, he stated that if you install a 1 kWh battery per apartment, you could reduce peak demand by 40 %. With a 3 kWh battery you could reduce it with 80 %!

In the *final panel discussion of the day*, a panel consisting of business leaders, politicians, government agencies and academia shared their insights on how to speed up the transition to smart grids. The panel agreed regarding a number of issues, but above all they concluded that it is time to move on from the pilot phase of smart grids – we are ready for market expansion! They further concluded that the decentralization and digitalization is only a first phase of the transition, and that the dynamic feature of an accelerated transformation must be recognized, but also adapted to.

Altogether, the future for smart grids looks bright – and with heat pumps as part of the system the smart grids will meet their full potential.

The 3rd Mission Innovation Ministerial delegates.

Nordic Clean Energy Week

Report: The Third Mission Innovation Ministerial in Malmö, Sweden

On May 23, 2018, the Third Mission Innovation Ministerial (MI-3) took place in Malmö, Sweden, with the aim to accelerate the pace of innovation and make clean energy widely affordable.

Mission Innovation (MI) is a global initiative of 22 countries and the European Commission (on behalf of the EU) partnering to revitalize and accelerate clean energy innovation with the objective of making clean energy more widely affordable. At the Third Mission Innovation Ministerial in Malmö, the international community discussed actions to enhance public and private investment and collaboration on clean energy research and innovation.

Significant progress and new funding

Significant progress has been made by members through the initial five-year commitment to MI. An additional $4 billion of public sector funding in clean energy innovation has been invested since 2015; nearly forty new international research and innovation partnerships have been initiated; and the MI Champions programme was launched to recognize change-making innovators. MI members were also pleased to welcome Austria as the 24th member of MI and to announce enhanced cooperation with both the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA).

New Action Plan for 2018-2020:

The 3rd Mission Innovation Ministerial meeting marks the halfway point in Mission Innovation's initial five-year commitment. The Action Plan sets out four goals with a number of ongoing and proposed key activities that will benefit from international collaboration:

Goal 01

A substantial boost in public-sector investment in clean energy R&D at the national level of MI members.

Goal 02

Increased private sector engagement and investment in energy innovation, particularly in key Innovation Challenges.

Goal 03

Many new or strengthened voluntary cross-border networks and partnerships on energy innovation, greater engagement from innovators, and accelerated progress in addressing specific Innovation Challenges (IC).

Goal 04

Greater awareness amongst MI members and the wider clean energy community of the transformational potential of energy innovation, the progress being made, and the remaining critical clean energy innovation gaps and opportunities.

Next Ministerial

The Third Ministerial was co-hosted by the European Commission, together with Denmark, Finland, Norway, Sweden and the Nordic Council of Ministers. The next MI Ministerial will be hosted by Canada, in Vancouver, in May 2019.

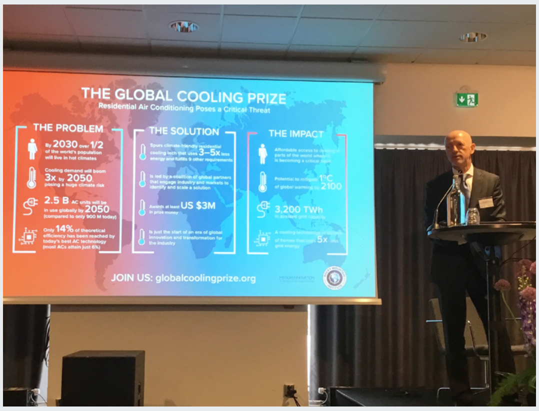
Source:

http://mission-innovation.net/mi-3/

http://mission-innovation.net/wp-content/uploads/2018/05/MI3-Action-Plan.pdf

Nordic Clean Energy Week

Visions and Solutions During the MI3 Solutions Summit



Mr Iain Campbell, managing director at Rocky Mountain Institute,

The Solutions Summit was arranged as a side event to Mission Innovation (MI3). The Summit offered a series of inspirational presentations and discussions. Solutions presented ranged from air transport to steel production; in addition, innovation and the process when solutions are created were addressed.

The audience was challenged already from the start. The Swiss visionary and explorer Bertrand Piccard – responsible for the first airplane circling the Earth without fuel – stated that there is no urgent need for more innovation. Instead, immediate challenges can be met with innovations already made. He also aimed at challenging the idea on how innovations are created: "Innovation doesn't come when you have more ideas, but when you have less beliefs", indicating that in order for true innovation to happen you need to put aside all your ideas on what is possible and not.

Then Mr Iain Campbell, managing director at Rocky Mountain Institute, presented the Global Cooling Prize. He has seen that the AC industry does not develop the most energy efficient air conditioner, but rather the cheapest products that meet current regulations at important markets. Therefore, a prize like this is needed. There are also a lot of initiatives going on, and for investors it is difficult to be aware of them all. "Through the competition the needles in the hay stack will find us", as he put it.

Focusing on solutions for cooling is highly relevant, since a as massive increase in cooling demand is anticipated over the upcoming decades. This is positive for the individuals getting improved living conditions, but negative for the earth due to increased climate emissions. The Global Cooling Prize aims to find a way to cool homes without heating the world.

The initiative now seeks innovators to develop affordable cooling solutions that use only one fifth of the electric energy that the standard products of today use. This is done through a two-year competition: the Global Cooling Prize. During these two years the most interesting ideas get support for development, and then the winner gets support for commercialisation and scaling. This successful technology, when scaled up, will have the potential to save 100 gigatons of carbon by 2050. This in turn will prevent 1 °C of global warming by 2100. At the same time, the technology allows for a better standard of living for people around the globe.

Among the solutions presented during the Summit can be mentioned waste management and energy challenges in India and beyond, Estonia-based development of energy storage solutions based on graphene, and a large-scale prototype of an airship for transport, where the biggest challenges are solved. So there is not a lack of ideas, there is not a lack of solutions. Now regulations and the market need to catch up!

Nordic Clean Energy Week

Action Taken for Sustainable Cooling

The event Delivering Sustainable Cooling in a Warming World was arranged as a side event to the Clean Energy Ministerial (CEM9). Organized by the International Energy Agency and the Kigali Cooling Efficiency Program it focused on how to deliver sustainable cooling in developing countries.

There is a real need to expand the focus from heating and include also cooling. Fatih Birol, Executive Director at the IEA, stated that "Cooling is a blind spot in the international energy debate". This is especially needed in developing countries and emerging markets, where a steadily increasing number of people can afford air conditioners.

The real challenge, as expressed by the panel members, is that the increased demand for cooling often is met with a supply of cheap products. The sustainability factor is rarely a base for decisions. Also, there is a need for standards that push the development in a sustainable direction.

Naturally, standard cooling technologies have the same sustainability challenge as heat pumps for heating: the use of highly climate-potent F-gases. The Kigali Cooling Efficiency Program is an attempt to address this challenge. With 38 member countries, the program envisions a world where sustainable cooling is widely accessible, not least in developing countries.

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, NL
ACOUSTIC SIGNATURE OF HEAT PUMPS	51	**AT**, DE, DK, FR, IT, SE, DE
LONG-TERM MEASUREMENTS OF GSHP SYSTEMS PERFORMANCE IN COMMERCIAL, INSTITUTIONAL AND MULTI-FAMILY BUILDINGS	52	BE, NL, **SE**, US, UK

FINALIZED 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), 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 49 DESIGN AND INTEGRATION OF HEAT PUMPS FOR nZEB

Nearly or Net Zero Energy Buildings (nZEB) are the objective in many countries both in Europe and in North America and Asia as a future standard of high performance buildings. In Europe, deadlines for the introduction are quite near, since already from the beginning of 2019 all new public buildings shall comply with this requirement, followed by all new buildings in the beginning of 2021. The Annex 49 is thus to evaluate the operation of heat pumps in nZEB. The work schedule of the Annex has been divided into four tasks:

Task 1: State-of-the-art of heat pumps in nZEB
Task 2: Integration options for heat pumps in nZEB
Task 3: Prototype development and monitoring
Task 4: Design and control of heat pumps for nZEB application.

Thereby, the scope of the Annex 49 has been defined to include all building technology services as required in the respective countries, and to include groups of buildings and neighbourhoods, in addition to single buildings (residential and commercial).

In Task 1 the state-of-the-art of heat pumps in nZEB has been reviewed in the participating countries, based on results of the preceding Annex 40. It was confirmed that definitions of nZEB in the single member countries vary, and in some countries there is no definition available yet. Moreover, the required limits, e.g. for primary energy, are based on specific national calculation methods and national boundary conditions. Consequently, the ambition level for high performance buildings cannot easily be compared between countries. In Estonia a method to compare the different nZEB definitions based on modelling and simulation has been proposed, which is presently tested in the Annex in order to compare the requirements in different countries (see the HPT Magazine 3/2017, page 31-37. This issue also covers other national contributions to Annex 49). These simulation models are also meant to be used in the Tasks 2-4 in order to compare system concepts.

In Task 2 integration options for the heat pump with other building technologies are further developed. Since the building envelope is typically equipped with solar components, such as PV or solar thermal systems, the combination with the heat pump is investigated. In Switzerland, the integration of solar collectors for multifunctional operation as heat source and sink in combination with the heat pump is investigated. Moreover, thermal and electrical storage can improve the economy and the demand response of the heat pump system. In Germany and Norway, the improvement of self-consumption of on-site produced energy are investigated with simulations. In Estonia, different options for ground integration are investigated by simulations. In Belgium, the integration of wastewater heat recovery as source for the heat pump for a larger building is evaluated.

Some of the simulation projects are also linked to the monitoring in Task 3. Austria has simulated two multifamily passive houses, which are currently also monitored. In Norway, a single family house on the campus of the NTNU serves as living-lab to evaluate advanced control strategies for the improvement of demand response and energy flexibility. Moreover, various larger NZEB, among them a conference hotel and a new office building are in monitoring, and other projects, e.g. of the Research Centre of Zero Emission Neighbourhoods, are linked to the Annex 49 work. In Sweden, two identical houses have been monitored, one equipped with capacity-controlled heat pump and the other with conventional on-off control.


Monitoring projects Vögelebichel (AT), Black & White (CH)

In Switzerland, a building with mixed residential and office use has been monitored. Results confirm that despite a good system performance the nZEB balance may be a challenge for larger buildings dependent on the balance boundary, since on-site PV production is limited by the building envelope. In the USA building concepts are tested in the so-called Net Zero Energy Residential Testing Facility (NZERTF), a real NZEB building with tunable loads on the NIST campus.

Based on the simulation and monitoring, Task 4 is dedicated to an evaluation and development of design criteria for nZEB as well as to further development of the control of heat pump systems to enhance performance and energy flexibility. In Germany, model predictive control is tested in a Hardware-in-the-loop environment, and in Norway, a control concept is studied in the living-lab on the NTNU campus.

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

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Monitoring project Scandic Hotel in Trondheim

Monitoring project Herzobase

ANNEX 50 — HEAT PUMPS IN MULTI-FAMILY BUILDINGS FOR SPACE HEATING AND DHW

The building sector plays a significant role in energy consumption and in emission of greenhouse gases in every country. New single-family houses are often built with a potential for application of renewable energy technologies, such as heat pumps. For multifamily buildings, however, the challenge to apply heat pump technologies is more complex. Among the member countries of the IEA Heat Pumping Technologies TCP, there is a large variation between the countries regarding ownership as well as regarding heat demand characteristics.

There are still technical and non-technical barriers hindering the broad implementation of heat pumps in multifamily buildings, in both new and existing buildings. In addition to the above mentioned aspects, obstacles include potentially limited space for the heat source, the control of bivalent systems, as well as the high investment costs (longer terms of investment than for other heat sources).

Annex 50 focuses on solutions for multi-family houses, with the aim to identify barriers for heat pumps and how to overcome them. Given the demands of the participating countries, both new buildings and retrofit are considered, along with buildings with higher specific heating demand.

Results
One of the most successful additions are the best practice sheets that were created in order to give an overview of all installations. They are standardised sheets which give information about a description of the best practice, previous insights, key facts and a description of technical concepts. In addition to the sheets, a map (see figure 1) was created on the official HPT-website of Annex 50. This map represents each example for best practices in different countries. Everyone can get access via: http://heatpumpingtechnologies.org/annex50/sample-page/best-practices/

Users can click on a dot that each represent an example of a best practice and can get more information about why this example is successful. After clicking on the dot to get more information, a best practice sheet is available and can also be downloaded as a pdf file (see figure 2). The sheets consist of a general description of the best practice, of lessons learned, of key facts and a description of a technical concept. The aim is to have as many examples as possible. This aim should be achieved by getting in contact with different institutions and partners that possibly have examples to show.

In addition, a uniform energy flow scheme (see figure 3) was established. The illustration serves as an example of an energy flow scheme that has already been implemented.

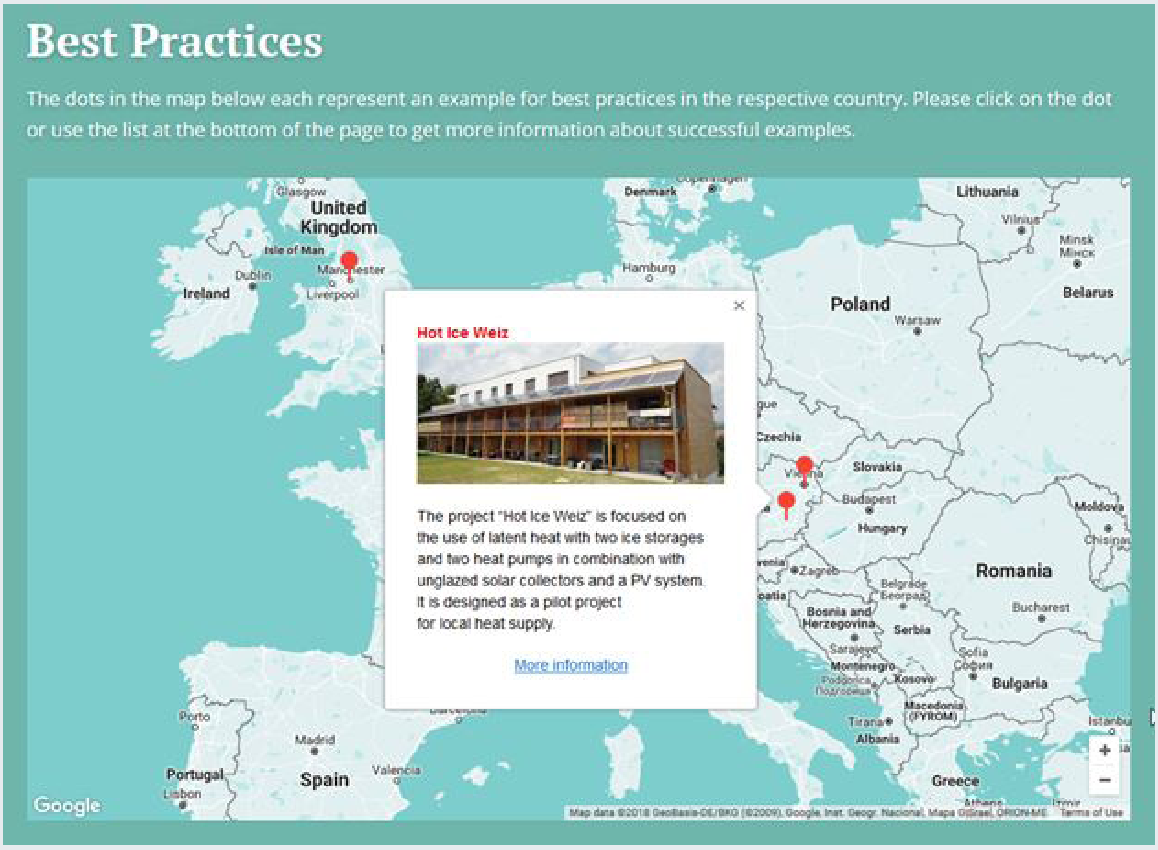

Fig. 1: Screenshot of online map representing each example for best practices in different countries at: http://heatpumpingtechnologies.org/annex50/sample-page/best-practices/

Fig. 2: Best practice sheet, PDF download.

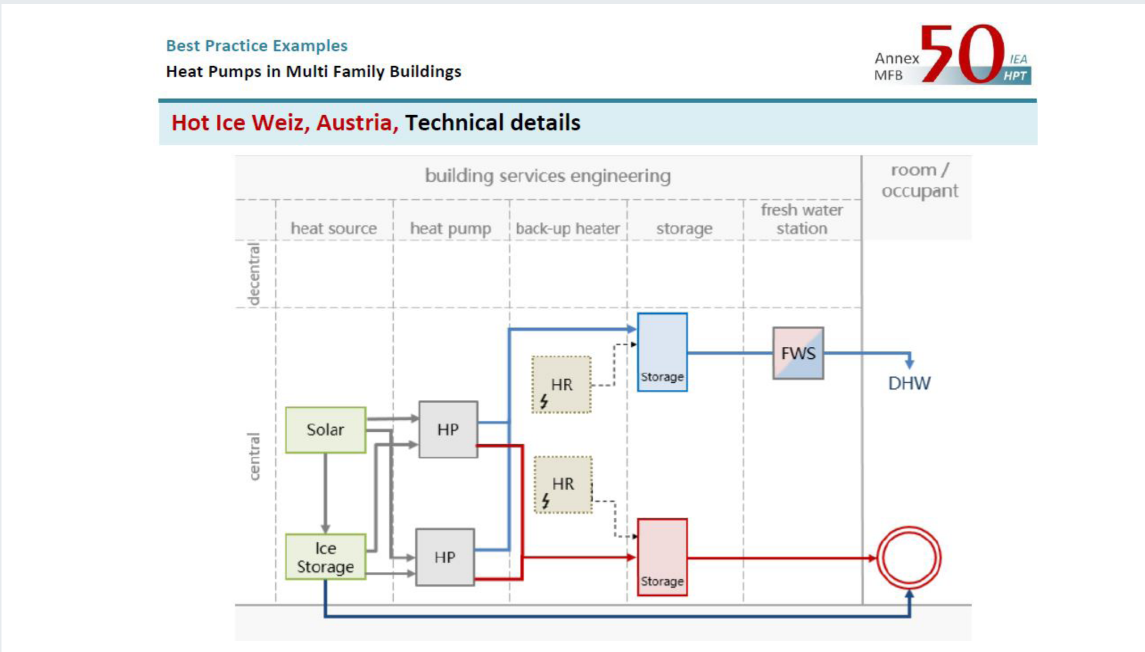

Fig. 3: Uniform energy flow scheme

Annex website
http://heatpumpingtechnologies.org/annex50/

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ANNEX 52

LONG-TERM MEASUREMENTS OF GSHP SYSTEMS PERFORMANCE IN COMMERCIAL, INSTITUTIONAL AND MULTI-FAMILY BUILDINGS

More than 20 international experts met in Malmö, Sweden, for the Annex 52 kick-off meeting on May 24th -25th. Within this annex, entitled Long-term measurements of GSHP system performance in commercial, institutional and multi-family buildings, a large number of ground source heat pump systems will be monitored and analyzed from a long-term performance perspective. The emphasis will be on heat pump and system performance, e.g., determining coefficients of performance, seasonal performance factors and system efficiency indices. This annex will extend the system boundary definitions presented by the SEPEMO EU-project.

Eight countries, of which Sweden, the Netherlands and the USA have formally joined the annex, were represented at the experts' meeting in Malmö. Belgium, Germany, Finland, Denmark and the UK took part as observers and potential participants, while they are still working on securing funding for their participation and work. The deadline for joining Annex 52 is October 2019, and the annex is open to participation from countries that belong to either of these IEA Technology Collaboration Programs: HPT, ECES and Geothermal. Interested participants should contact the operating agent, Signhild Gehlin.

So far, some 20 GSHP performance-monitoring case studies, located in Sweden, Netherlands and the USA, are confirmed to be part of the Annex 52 work. 17 of these case studies are located in Sweden and cover a range of building types, system applications and ground sources. These include large residential, commercial and public buildings, high temperature storage for an industrial application, a district heating system, residential buildings combining GSHPs and sewage heat recovery, and an office building combining cooling provided by a borehole energy storage without heat pumps with district heating. The Dutch case studies are mainly groundwater systems and the US case study is a high profile office building with a distributed GSHP system. Another 15 case studies in Europe were presented at the meeting by the countries that have yet to formally join the annex. These additional case studies include applications such as energy piles, GSHP systems in combination with PV, PVT, and biomass. Locations and systems types for confirmed and potential cases studies are shown in Figure 1.

One of the challenges in long-term performance monitoring is managing extremely large data sets, and ensuring that the data are of high quality. A certain amount of "data janitor" work needs to be done to deal with issues such as missing data points, sensor failures and aggregation of data points. As long-term performance data may contain hundreds of millions of data points, suitable tools and procedures for this janitor work will be identified and tested. The annex participants use a variety of such tools for their data handling, and several data analytics tools were presented at the meeting. The annex work aims at finding ways to provide uniform and comparable data sets for the included case studies.

With all these different system applications included, Annex 52 will provide unique experience and information on GSHP system performance, and give guidance on instrumentation, monitoring, data analytics, performance analysis and suitable performance indices based on international experience.

The second Experts' meeting will take place in the USA in November. Updates on the Annex 52 work and results will be continuously posted on the Annex web site.

Annex website
http://heatpumpingtechnologies.org/annex52/

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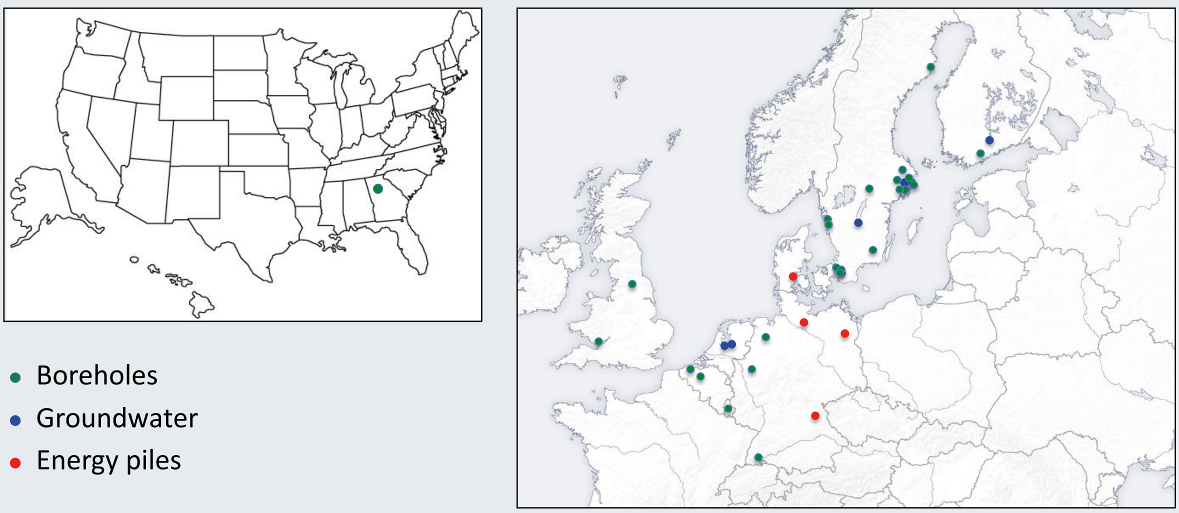

Fig. 1: Map with points for the measurement object. Illustration: Signhild Gehlin

The French (hi)story of Heat Pumps

Thierry Nille, AFPAC, France

The heating markets in Europe, especially for products using fossil fuels, like boilers, have been stable for decades. Some technological improvements have been made, such as the condensing technology, gas-adaptive devices, or connectivity, but this never impacted the market volumes dramatically. Of course, this stability also applies to the French boiler market. But one segment that has not followed this trend, however, is the French heat pump market, as described in this article.

Pre-history

The French Heat Pump market emerged in the eighties. Back then, it was very much of a niche market: very few manufacturers, limited product ranges, high prices, low general knowledge of the product from installers, etc. The price of fossil energy did not favour heat pumps. Gas became the new source of energy, being affordable, convenient, and available.

Things started to change in the beginning of the 2000's. Energy prices were rising (and perhaps more importantly, were seen as unstable and volatile!) and led consumers to seek alternative technologies for heating. At that time, solar thermal systems became popular, but they had limitations for heating. People started to consider heat pumps again. Geothermal products appeared, with local specialists leading the market. Water-to-water and direct expansion products were developed, mainly in new build, where it was easier to install a network outdoors.

But heat pumps still remained a niche: in some regions with milder climates, in a specific type of home (more high-end), attracting customers with a different approach to heating and energy. And heat pumps, in the early 2000's, were still sold only at a few thousand units a year.

And then ...

It was not until 2008 that the situation changed drastically. That year made history for the French heat pump market. Particularly, the air-to-water heat pumps boomed in an unexpected way. The market for those units jumped from 51 000 in 2007 to 131 000 units in 2008 (Figure 1)! Volumes could have been even higher if the manufacturers had been able to deliver products, and installers to fit them.

This success was linked to a combination of factors. The most important one was the energy crisis, with the price of oil reaching unprecedented levels. This caused panic in the market, especially with home owners using oil as a main heating source (more than 3 million homes in France, back then). French electricity, already the cheapest in Europe, was suddenly becoming even more attractive, particularly with COPs of 3 or 4.

The Grenelle de l'Environnement, the new national program to tackle environmental issues, was being implemented. One of the measures was a tax credit (Credit d'Impôrts), which enabled home owners to claim 50 % of the price of the heat pump (excluding installation costs) as a tax reduction.

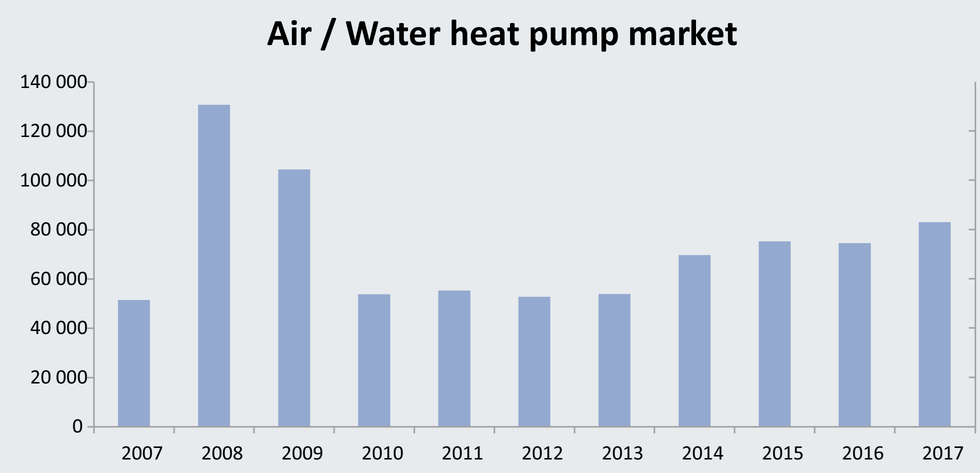

Fig. 1: Air/Water heat pump market

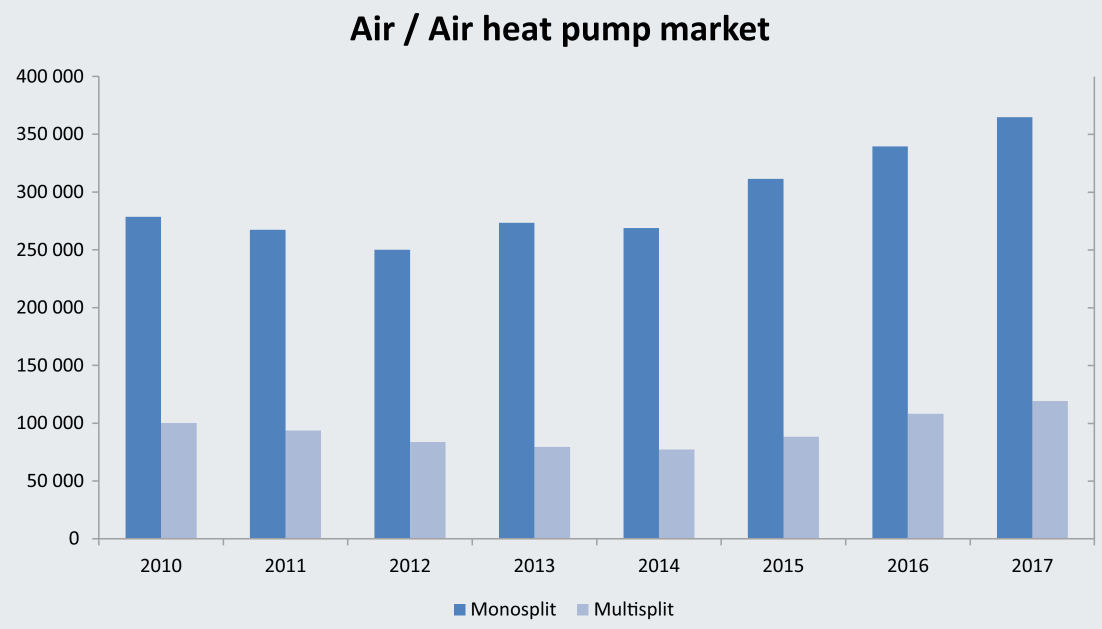

Fig. 2: Air/Air heat pump market

In addition to this, air conditioning actors entered the market *en masse,* with affordable, reliable, good quality split systems. Boiler manufacturers started to launch their own ranges, taking advantage of their installer network, good levels of service, and good brand awareness with professionals. Installers saw the opportunity and started to fit heat pumps. Some specialists appeared in the market, some without much knowledge of what a heating system was. Education of installers was developed and Quali'PAC certification implementation ensured good quality of heat pump installations. The media also played the game and helped the success of the product. Geothermal applications also benefitted from this new fashion, but in a more modest way (around 20 000 pieces sold in 2008).

At the same time, Thermodynamic Water Heaters also developed. Those dedicated applications fit well as a complement of heat-only fossil fuel boilers, which could then be turned off during the summer season.

But some issues occurred...

Products at that time were fitted mostly as a back-up of oil boilers, to reduce the household global energy bill. But some mistakes were made, both on geothermal or on air-source installations. Sometimes sizing was wrong, leading to loss of comfort. Sometimes the oil boiler was removed, leading to high electrical costs the following winter.

In 2009, oil prices dropped again. The most passionate end-users had bought their equipment. Subsidies were eventually reduced. Therefore the market became realistic and returned to more "normal" levels for 2010, around 54 000 air-water heat pumps.

A new market emerged ...

The heat pumps market was then stable for a couple of years. It was until the application of the RT 2012 (new thermal legislation for the new build in France, transposition of the European EPBD), that Heat Pumps found a second (or actually, third) youth. This time, the new build market would represent fantastic opportunities.

For many years, the new build market in France was dominated by electric systems (dry) such as convectors and underfloor electric heating. The new legislation would not favour those any longer, applying a penalty factor for the electricity production and distribution losses. Back then, the RT 2012 was one of the most stringent legislations in Europe for buildings. In particular, it set a strict limitation for the energy consumption of the building for heating and domestic hot water. It made usage of renewable energy compulsory in individual houses. The road was paved for heat pumps to be the perfect solution (Figures 2, 3, and 4).

Heat pumps also offered other advantages in the new build. It meant that a second energy source (like gas), with an additional subscription, could be eliminated. What's more, connection to the gas network is sometimes complex to achieve. And gas is not always available in rural areas, as the network is not expanding today as it was some years ago.

Heat pumps are also seen by the market as a clean solution, without local emissions, and using, in France, mostly nuclear-based electricity (although not always the case during the winter season).

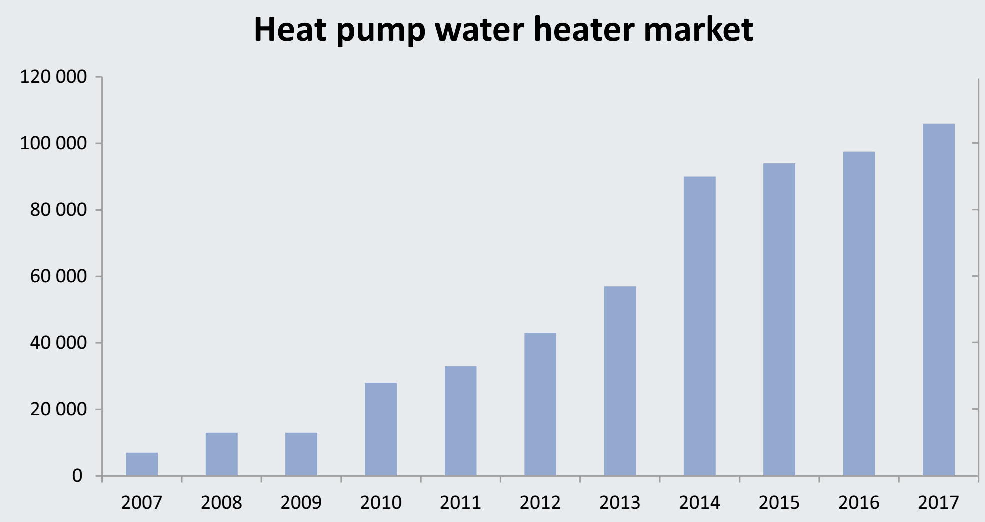

Fig. 3: Heat pump water heater market.

Heat pump models even offered integrated hot water production (with a hot water tank, generally around 100 litres). This solution was very easy to fit, and brought sufficient comfort, both on heating and on hot water needs. Compact versions are perfectly adapted to the new build, and can even be fitted in a standard cupboard.

All manufacturers offer heat pumps in their portfolio today, namely dedicated versions for the new build, ranging from 4 to 8 kW. Most installers have learned to install them by now, and therefore heat pumps can be seen as a mainstream solution in the new build. As a result, more than 40 % of new houses are equipped with a heat pump today. Air-water products are highly competitive (with attractive prices to house builders) and the level of insulation of the house enables those to warm up the house without problems. The market for air-water heat pumps has therefore reached satisfying levels in the 70 000 - 80 000 units range, and keeps increasing at a steady rate. Another significant point in favour of heat pumps, especially in the new build, is their capacity to “refresh” the house in the summer, often with underfloor cool water circulation, a common issue in air-tight new build, especially in the southern regions.

In the meantime...

Unfortunately, all heat pump types did not follow the same trend. Particularly geothermal products dropped down to very low volumes, a couple of thousands of units per year (Figure 5). This can be explained by the pop-

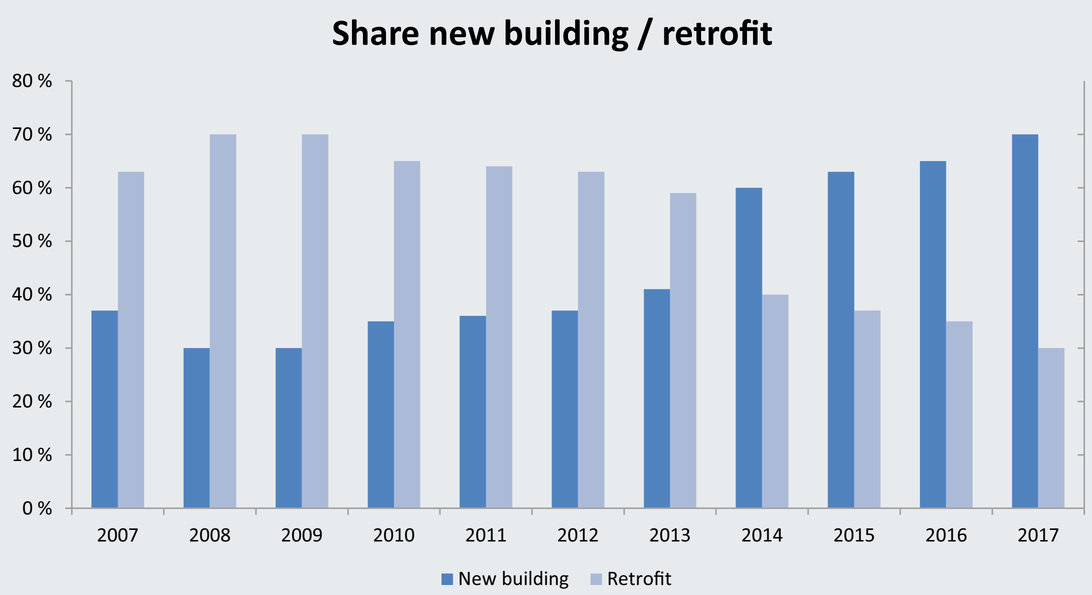

Fig. 4: Share new building/retrofit

ularity of the air-based solutions that are perfectly suitable and well-known, without having the same constraints as geothermal solutions (which are more expensive, more cumbersome to install, have a more limited offer, etc.). Geothermal products may have a revival in the coming years as they remain a solution with high efficiency, and without the downside of an outdoor unit.

What's next

One may think that the heat pump market is very dynamic in France and that these products have a very bright future. However, in the current energy context, making a forecast on such a volatile market is difficult.

Heat Pumps should continue to be a preferred solution in the new build. Air-based solutions (air-air), offering more cooling capacity, could develop for the new build, as air could become an interesting carrier in new homes, enabling air treatment as well as ventilation, etc.

What will happen in the existing buildings market will be interesting to follow. In a context of rising fossil energy prices again (political instability, price of oil going up, application of the Carbon Tax) electricity is still an attractive source of energy.

We can expect a new generation of products to appear. Smaller units, more compact, with lower output, intended for apartments could develop in some locations where space (indoor and outdoor) allows it. Collective solutions for commercial applications in small buildings could emerge.

Hybrid products combining a heat pump with a boiler could be an appropriate product for the transition period. Gas-driven heat pumps could also be a good compromise between the output delivered by gas and the efficiency of the thermodynamic cycle, for the renovation of existing houses. One thing is for sure, heat pumps offer many advantages that will make them highly popular in France for some years. However, it remains difficult to predict exactly which applications that will develop, and at what speed.

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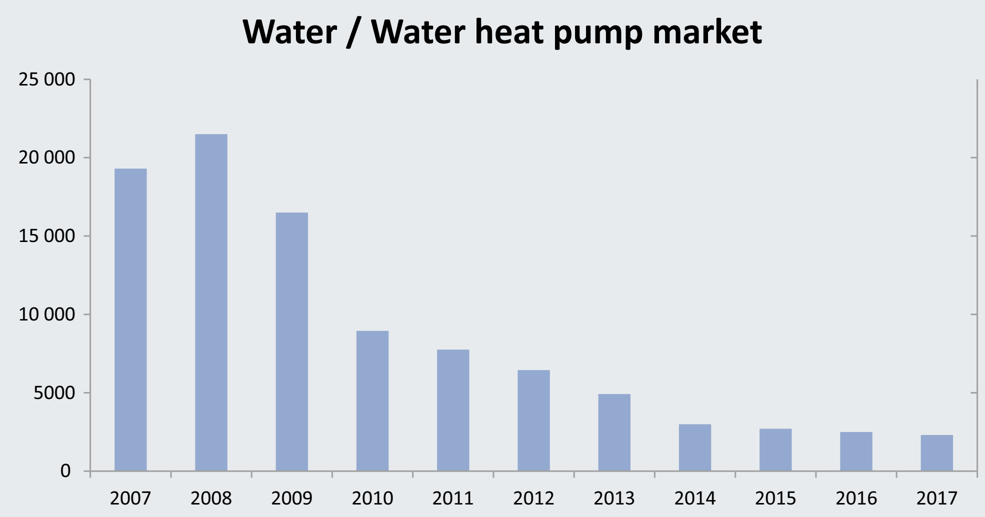

Fig. 5: Water/Water heat pump market

Thermodynamic Performance and Economic Feasibility of Booster Heat Pumps in Low-Temperature District Heating

Chulwoo Roh, Korea Institute of Energy Research (KIER), South Korea

Fossil-fuel-based district heating (DH) has no long-term future because of the transition to renewable energy systems. However, many renewable energy sources often have a lower temperature than fossil fuels; next-generation DH systems should therefore be designed to allow a lower forward temperature than at present. We compared piping layouts for the booster heat pump (HP) in South Korean operating conditions. We found that the price level of electricity and thermal energy have a complementary effect on economic feasibility. An affordable level of heating and electricity prices was analysed based on the heat demand of a household.

Introduction

District heating (DH) infrastructure has been developed to help improve the energy efficiency of space heating. A DH network connects energy centres (centralized energy plants) and buildings in a city or town, allowing widespread use of combined heat and power that utilizes heat from waste-to-energy and various heat sources as well as geothermal and solar thermal heat. Future DH infrastructures should be designed for the future energy system. The problem is that many renewable and new energy sources often have lower temperature than fossil fuels. This is one of the reasons that the next generation of DH infrastructure should have a lower forward temperature than at present [1]. By lowering the DH forward temperature, DH grid heat losses can be decreased and electric power generation efficiency in DH centres can be improved.

In this article we present piping layouts for booster heat pumps (HPs) for DH with a low forward temperature (80 °C). A booster HP has been discussed for next-generation DH as a possible solution if the grid temperature is low or DH needs to be stored in large buildings. We compared piping layouts for the booster HP and optimized operating conditions for current Korean DH operating circumstances. We also discuss R245fa and R134a as refrigerants for booster HPs.

Methods and results

The Korean peninsula lies in the region between 33°N and 43°N, and has a mean annual temperature of 8 to 14 °C. It belongs to both the continental and the subtropical climate zones [2]. In winter, the average temperature of South Korea is -2.4 °C (in January). Space heating starts in October and continues until April. The Korean government established a public utility, the Korean District Heating Corporation, in 1985 in order to expand DH nationwide, focusing on new satellite cities in metropolitan areas. The DH has been provided for existing apartments, replacing individual heating systems, and newly planned cities are constructing new DH plants. Korean residents usually prefer DH to individual heating systems because of three aspects. Firstly, the operating cost of DH in winter is about 30 % cheaper than that of an individual heating system. Secondly, DH does not need an individual boiler system in each dwelling, so the living space can be used efficiently and safely. Finally, the overall value of real estate equipped with a DH system tends to be higher than a house with no DH system. We assumed a general Korean household energy consumption model that represents the average winter energy demand for heating (space heating and hot water supply). The assumed household needs 2.09 MWh/month for space heating and 0.497 MWh/month for hot water supply (average for the winter season). The current Korean DH system's forward temperature is around 110 °C and the return temperature to a DH centre is around 60 °C.

Previous studies indicate that the booster HP is the key factor in the success of next-generation low-temperature DH systems. Köfinger et al. [3] indicated that a booster HP is a possible solution if the grid temperature is too low or DH needs to be stored in larger buildings. Meanwhile, Zvingilaite et al. [4] analysed low-temperature DH in combination with small booster HPs for the purpose of supplying DH with a forward DH temperature below the required DH temperature. Elmegaard et al. [5] investigated low-temperature DH combined with booster HPs using the dynamic network analysis framework. These analyses are also based on the combination of a combined heat and power system and DH, and are furthermore based on yearly average consumption rates and not a high temporal resolution. The feasibilty of booster HPs is highly related to the mix of all energy provision in a specific area.

Østergaard and Andersen [6] found that conventional systems with higher temperatures in the grid offer better utilization than low-temperature solutions, as the decrease in heat loss does not compensate for the electricity demand to cover the energy consumption. Their contradictory findings indicate that the additional electricity demand for the thermal energy short-age in winter is the key to understanding the economic feasibility of low-temperature DH and its core terminal facility, a booster HP.

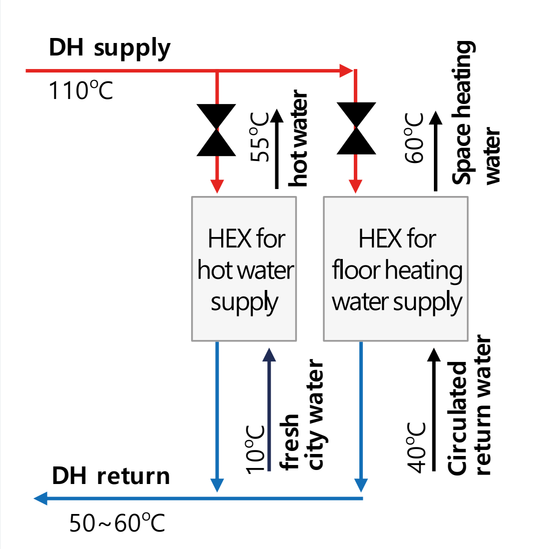

Fig. 1: Schematics of conventional Korean DH system and temperature conditions for an apartment complex in winter.

Fig. 1 shows the conventional DH system of Korean apartment housing and its temperature conditions for the fresh city water supply, hot water supply and space heating supply and its return stream during the winter. Fig. 1 is a kind of third generation of DH that was introduced in the 1970s and took a major share of all extensions in the 1980s and beyond. Pressurized water is still the heat carrier, and the supply temperatures are often below 110 °C. Typical components are prefabricated, pre-insulated pipes buried directly in the ground, and compact substations using plate stainless steel heat exchangers [1].

As shown in Fig. 1, the temperature difference between the DH supply (110 °C) and consumption in households (55 °C and 60 °C) is quite huge. This big temperature difference mainly originates from a limited amount of the mass flow rate of DH. If an adequate flow rate cannot be secured, as compared with the thermal energy demand, a DH provider should increase the supply temperature. The elevated forward temperature increases heat loss in the grid and the central power station's heat sink temperature should be also increased. These are factors in the deterioration of overall energy efficiency in DH grids.

A simplified HP model is applied. To compete with a standalone boiler or electric water heater, the booster HP should be fairly cheap. A simplified structure of HP is a necessity, not an option. The compressor's efficiency is assumed to be 60 %. The heat exchanger's effectiveness is assumed to be 90 %. HP cycle simulation is carried out, with the degree of superheat at 10 °C; the degree of sub-cooling is assumed to be 17 °C. R245fa and R134a are considered as refrigerants of booster HPs. The booster HP can be installed in the basement of a large building or an apartment complex with the piping structure shown in Fig. 2(a) and 2(b).

Fig. 2(a) uses the energy from the DH supply directly to evaporate the refrigerant of the booster HP. In contrast, Fig. 2(b) uses the energy from the returning water to the DH centre. The evaporating temperature in Fig. 2(a) is higher than that in Fig. 2(b), so it may be anticipated that the coefficient of performance (COP) for the booster HP in Fig. 2(a) is better than that in Fig. 2(b). The final temperature of returning water to the DH centre can be predicted to be higher in Fig. 2(a). In this article, the reduced forward temperature is assumed to be 80 °C.

Conventional DH energy consumption in winter for the assumed Korean household is 86.3 kWh per day. As shown in Table 1, the booster HP consumes the DH's thermal energy, 70.4–78.4 kWh. This means that the booster HP can directly reduce the DH energy consumption by about 9–18 %. The booster HP raises the temperature of the water supplied to the house, but from the viewpoint of energy as a whole, it has the effect

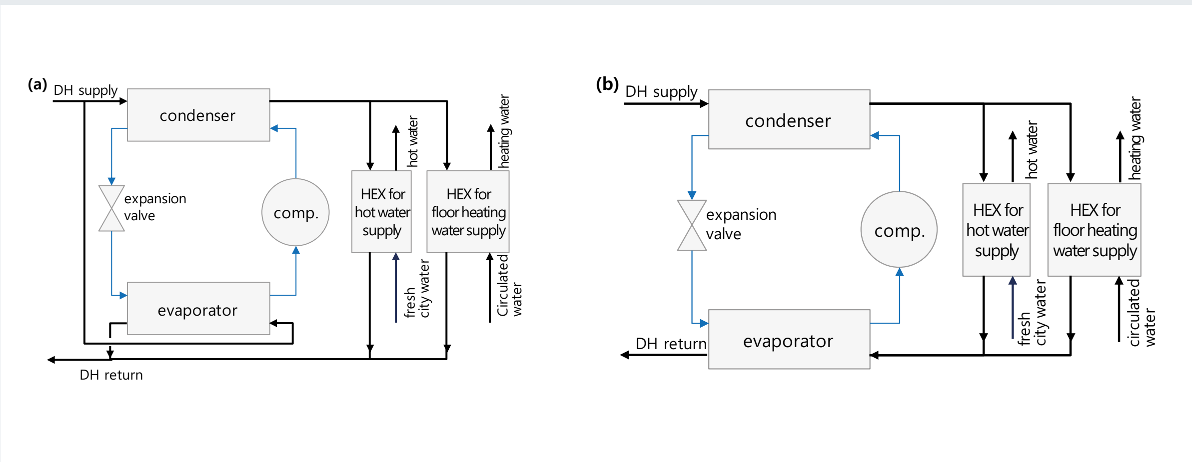

Fig. 2: Schematics of proposed HP booster concepts for Korean 4th generation DH system; (a) high returning temperature(HRT) case, (b) low returning temperature(LRT) case.

Characteristics	R245fa-HRT case	R245fa-LRT case	R134a-HRT case	R134a-LRT case
Compressor's power consumption (kWh)	9.4	13.7	6.2	16.4
Evaporating capacity (kWh)	36.8	28.2	36.8	28.0
Condenser capacity (kWh)	42.2	41.6	42.4	44.4
COP of heating	4.5	3.0	6.8	2.7
Compression ratio	3.6	6.9	1.8	4.6
Consumed DH energy (kWh)	78.4	70.4	78.1	71.6
Preference in terms of performance	★★★	★★	★★★★	★

Table 1: Cycle performance characteristics of simulated HP boosters to meet a household's daily heating energy demand.

of switching 9–18 % of the heating energy from district heating to electricity. Another aspect is that combining an HP booster with DH can be an option for reducing excessive heat demand in winter. This is a kind of demand dispersion (or control) function that allows a DH operator to turn on a peak boiler less.

Figures 3a and 3b shows the results of economic feasibility analyses in terms of energy monthly charges to meet the heat demand of the household (86.3 kWh per day, with an exclusive area of use of about 100 m^2). Since the booster HP consumes electricity to compress refrigerant, electricity consumption increases rather than the DH saving energy. As shown in Fig. 3, economic feasibility varies depending on the price of electricity.

The DH price must inevitably be discounted to some extent. From a common sense point of view, the energy price of the low-temperature DH is expected to be reduced since the temperature is lower than in the current systems. For DH companies, the booster HP and low-temperature DH operations may cause a decrease in heat sales and a decrease in business revenues.

The economic feasibility of the booster HP is also strongly influenced by the efficiency of the heat pump system itself. If the price of electricity is high, the low efficiency of the booster HP makes a critical negative difference to its economic feasibility. Considering the hot water temperature range of general houses, R134a is more suitable than R245fa. This indicates that further optimization studies are needed to increase the efficiency of the booster HP. The optimization study should take into account temperature ranges, the availability of hot water storage, electric power and thermal energy usage patterns depending on various applications.

Fig. 3(b) shows the parity point of the R134a booster HP at an electricity price of $0.18/kWh. The lower the heat price of district heating, the greater the range over which electric power charges can vary. The average marginal

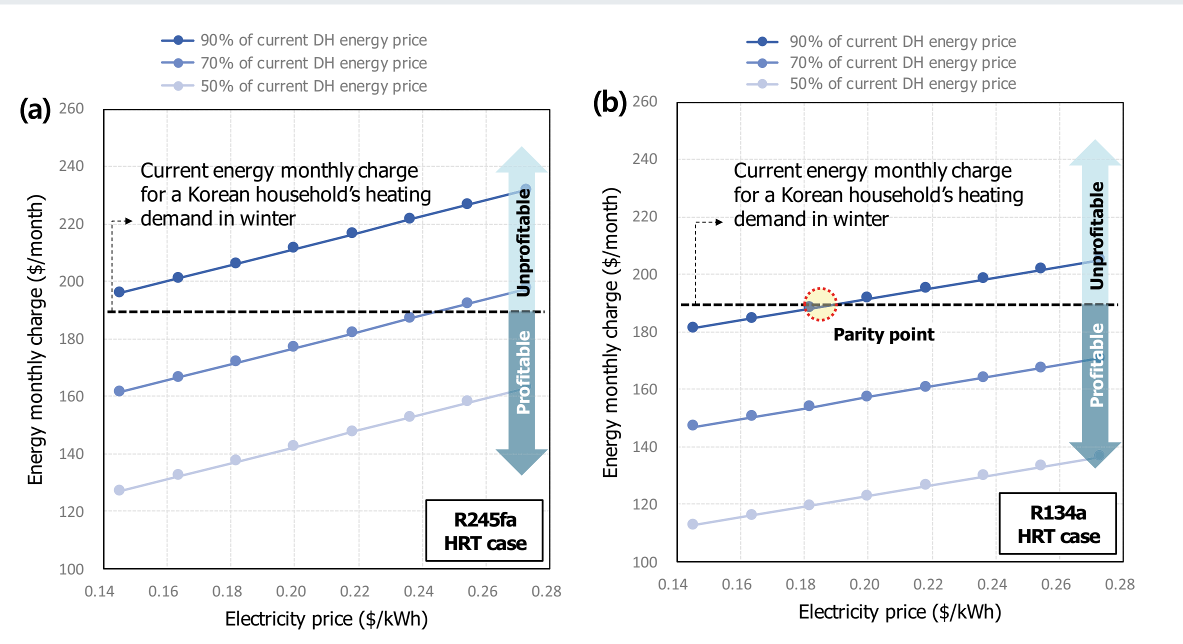

Fig. 3: Economic feasibility of the HP booster for a Korean household's heating demand in winter; (a) R245fa case, (b) R134a case. Note) Average system marginal price of Korean Electricity market: 0.08 $/kWh.

price of electricity in the Korean system is $0.08/kWh. The average electric power charge for a Korean residential house is $0.11/kWh. It is clear that the booster HP and low-temperature DH system can effectively reduce the monthly energy charge. To achieve a payback period of five or six years for the booster HP, the initial cost of the HP – one per household – should be less than $3,200. This value is based on operation in winter only (October to April, seven months). If the booster HP system can operate in summer for cooling, the payback period can be decreased to three or four years.

Conclusions

By using a booster HP in DH grids, the lower forward temperature of DH can be produced economically. From the perspective of the end-users in energy infrastructure, the booster HP is economically feasible as an energy-saving technology. However, a decrease in heat sales by DH companies is also predicted. Since the electrically powered booster HP consumes electricity, this helps to increase the sales of the electric power company. This raises the question of who is responsible for starting the large-scale transition to next-generation low-temperature DH. It is not a convincing enough argument to say that the booster HP is necessary simply because it can reduce peak boiler operation in winter.

A decreased forward temperature in the DH system can improve power generation efficiency in the DH centre using a CHP system and can also decrease the rate of use of peak boilers. Thus HP booster technology spurs DH companies on to produce electricity more efficiently than just generating large amounts of heat. Although it is relatively easier to produce more heat than to generate electricity more efficiently, it is obvious which direction should be chosen for the efficient use of energy from a national point of view. The HP booster is not an accessory device for realizing low-temperature fourth-generation DH, but the key to efficient utilization of energy and to optimizing heat supply for the next generation of DH. Further investigations should be carried out into optimizing and improving mechanical component design, as well as an hourly economic analysis of operation against an energy spot market. Such discussions are relevant to national energy policy and strategy.

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District Heating and Cooling Networks Based on Decentralized Heat Pumps: Energy Efficiency and Reversibility at Affordable Costs

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District heating and cooling networks based on decentralized reversible heat pumps offer the possibility of balancing heating and cooling demands and exploiting low-temperature waste heat sources. This enhanced "energy recycling" can bring significant environmental benefits. On the economic side, however, the energy savings are offset by higher investment costs. This article shows how it is possible to identify realistic scenarios where economic figures for this technology are similar to or even better than those of traditional solutions, while greatly reducing carbon dioxide emissions.

Introduction

The residential heating and cooling sector is the subject of continuous research in the field of energy efficiency. Significant attention is being focused on district solutions, where heating or cooling is supplied to a large number of buildings through a piping network. Several studies (e.g., Ref. [1]) address this technology as one of the most promising for a significant impact on the future energy system. Traditional district heating and cooling (DHC) systems, however, also involve a few drawbacks which can limit their application in certain cases. For example, they are run at temperatures relatively far from the ambient temperature (e.g., a supply temperature of 90 °C for heating), giving rise to non-negligible thermal losses. Moreover, the concept of district heating relies on the availability of some "convenient" centralized energy source (the same condition, but with reversed energy flow, is required for district cooling). This convenience may be either economic or environmental in nature. Typical examples of convenient sources include cogeneration units, industrial waste heat and incinerators, where heat is a by-product generated by other applications. However, such sources are not always available. In their absence, traditional district heating networks can be less sustainable than decentralized individual solutions.

The urban environment actually offers several other options of waste heat, though at lower temperatures. A simple example is refrigeration units in shopping malls. In principle, these systems could also be connected to a high-temperature network through a high-temperature heat pump. However, this type of source alone typically does not justify the installation of a traditional district heating network. An alternative option to consider is a low-temperature network, with average operating temperatures of around 20 °C.

The concept of a low-temperature network coupled to decentralized HPs is the subject of the FLEXYNETS project, supported by the Horizon 2020 European research programme. This approach, with some preliminary economic estimates, is described in Ref. [2]. Its main advantages are the decrease in thermal losses (and/or the possibility of using cheaper pipes), the reversibility of the network and the possibility of directly recovering low-temperature waste heat. On the other hand, two main criticalities are present: electricity needed by HPs comes at a higher cost (and has a higher primary energy factor) than thermal energy, and investment costs for substations based on HPs are higher than for traditional systems. These effects are exemplified below by a few simple scenarios.

Considered scenarios

We provide an estimate of the feasibility of a FLEXYNETS network, comparing five different scenarios. To include in our evidence the role played by the reversibility of the system, we consider a case with significant cooling needs – as expected for typical Southern European climates.

We start from a reference scenario with individual heating and cooling, and contrast this with scenarios based on traditional district heating or FLEXYNETS. The general conditions, valid for all scenarios, comprise a typical Southern European climate (namely that of Rome) and a city zone with 500 small multifamily houses of 500 m^2 each, with an overall land area of 1 km^2. This corresponds to a plot ratio (ratio between floor area and land area) of 0.25 – not a very demanding value in terms of building density. We assume the availability of various amounts of low-temperature waste heat in the area. This could be provided by the refrigeration units of a medium-sized shopping mall. Both the presence of such a facility and the chosen plot ratio are compatible with common city outskirts.

For the scenario based on individual systems, we assume that all the buildings are equipped with gas boilers and electric cooling units. While cooling systems are currently not always present in buildings, their spread is a constantly growing trend. Increasing demand for building comfort and increasing outdoor temperatures suggest that full penetration of cooling systems could be realistic in the near future. The main costs of this "Individual" scenario are the investment costs for individual

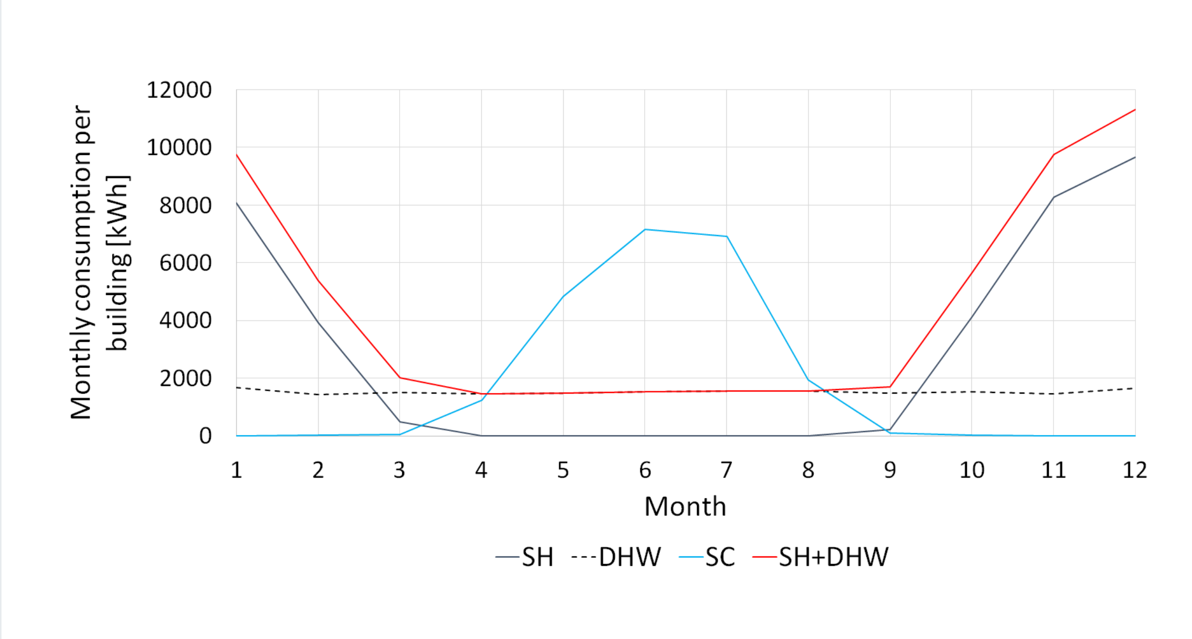

Fig. 1: Typical monthly consumption profiles for a single building of 500 m². The different curves correspond to space heating (SH), domestic hot water (DHW), total heating (SH+DHW) and space cooling (SC).

boilers and chillers, plus corresponding gas and electricity costs. Residential prices must be applied in this case.

As a first variation from this scenario, we consider the substitution of individual boilers with traditional district heating (DH) while keeping individual cooling units. Hence cost changes apply only to the heating element. Investment costs for individual boilers are replaced by investment costs for the network, substations and a centralized boiler (as no other high-temperature sources are assumed). Gas costs now have to be evaluated as for industrial customers. The traditional network is assumed to operate with a supply temperature of 80 °C and a supply-return temperature difference of 30 K.

Finally, we consider three FLEXYNETS scenarios (FL), where the network replaces both individual heating and cooling systems. The three different scenarios include, respectively, 0 % of waste heat, 35 % of waste heat, and finally 60 % of waste heat (referring to the share of the network heat supply). This could also be seen as representing the progressive integration of new waste heat sources. The network supply temperature is set at 30 °C, with a supply-return temperature difference of 10 K. Industrial prices are assumed for both gas and electricity.

The modelling approach

Each of the above scenarios is analysed in terms of costs and emissions using a simplified model. The model takes into account yearly profiles with a time slicing approach: a characteristic daily profile is coupled with monthly energy consumption to simulate an entire year. The monthly profiles considered for a single building are reported in Figure 1. The corresponding specific annual consumption is 70 kWh/(m²·year) for space heating, 37 kWh/(m²·year) for domestic hot water, and 45 kWh/(m²·year) for space cooling. The total yearly consumption (i.e., for the 500 buildings) for each scenario is 27 GWh/year for heating and 11 GWh/year for cooling. The overall performance, including estimates for network thermal losses and pumping costs where applicable, is then estimated with energy balances in an Excel model. For the scenarios where a district network is considered, the model includes sizing rules to estimate pipe lengths, diameters, and capacities of centralized units.

For the waste heat availability, a constant profile is assumed. For large shares, this implies a surplus of heat during summer. Two waste heat penetration cases are considered: one with an availability of 15 GWh/year, where 8 GWh/year can be exploited (yielding a 35 % share of the network supply), and another with an availability of 28 GWh/year, with an exploitation of 13 GWh/year (60 % share).

For economic calculations , the investment costs and the operating and maintenance costs for equipment and piping are based on values provided by the Danish Energy Agency – a valuable reference for DH data. Comparisons of individual costs with Italian values do not show critical differences. Energy prices representative of the Italian case are chosen: a residential gas price of €80/MWh, an industrial gas price of €35/MWh, a residential electricity price of €200/MWh, and an industrial electricity price of €100/MWh. Costs of low-temperature waste heat are considered only for FLEXYNETS scenarios. A simple business model is assumed: all the available heat is absorbed by the network, for a price of €10/MWh, excess heat being dissipated by a centralized cooling tower. All investment costs are converted into annualized costs using the annuity method, with an interest rate of 3 % and lifetime values depending on the equipment chosen.

To estimate CO_2 emissions, specific values are assumed to be 0.250 t/MWh for gas and 0.377 t/MWh for electricity, compatible with recent Italian grid values.

Results

The overall costs of the five scenarios considered are shown in Figure 2. We can see the significant role played by cooling costs. The lower cost of district solutions compared with individual ones is also apparent. It should be noted, however, that district costs do not include personnel costs and indirect costs, or other company revenues.

A few major effects can be observed. When moving from individual heating to DH, a substantial reduction in gas costs is achieved due to the significant difference between residential and industrial gas prices. Moreover, investment costs for centralized boilers are significantly lower than for individual boilers. On the other hand, district solutions involve network costs. These costs are similar for all district scenarios: indeed, the cost variations due to the larger diameters and lower insulation levels required in FLEXYNETS are opposite to each other, and basically balance out. For FLEXYNETS scenarios, the largest cost item is heat pump investment costs – here taken from the Danish Energy Agency data for individual installations. Alternative market investigations and the possibility of exploiting economies of scale suggest that these costs could be roughly halved, with the significant impact shown in the figure. Finally, we can see that the introduction of waste barely affects economic performance. This is due to two main aspects: the mismatch between waste heat and heating profiles, and the chosen business model. Under such conditions, in order to raise the waste heat share, one also has to increase the amount of excess heat to be bought and dissipated – almost balancing out gas savings and additional costs.

Environmental performance is reported in Figure 3. Here the outcomes are quite different. When moving from individual heating to traditional DH, emissions increase. Indeed, in the absence of particularly efficient sources, DH only introduces higher thermal losses. In contrast, by moving to FLEXYNETS scenarios higher and higher emission savings can be achieved. This highlights the advantage of having a reversible network – with some balancing between heating and cooling demands – and of including waste heat.

Conclusions

Summarizing, five different scenarios related to a Southern European climate and a city zone with 500 small multifamily houses were analysed. The FLEXYNETS approach was compared to traditional individual and district systems, under the assumption of no "convenient" high-temperature sources in the surroundings. Different shares of low-temperature waste heat were instead considered.

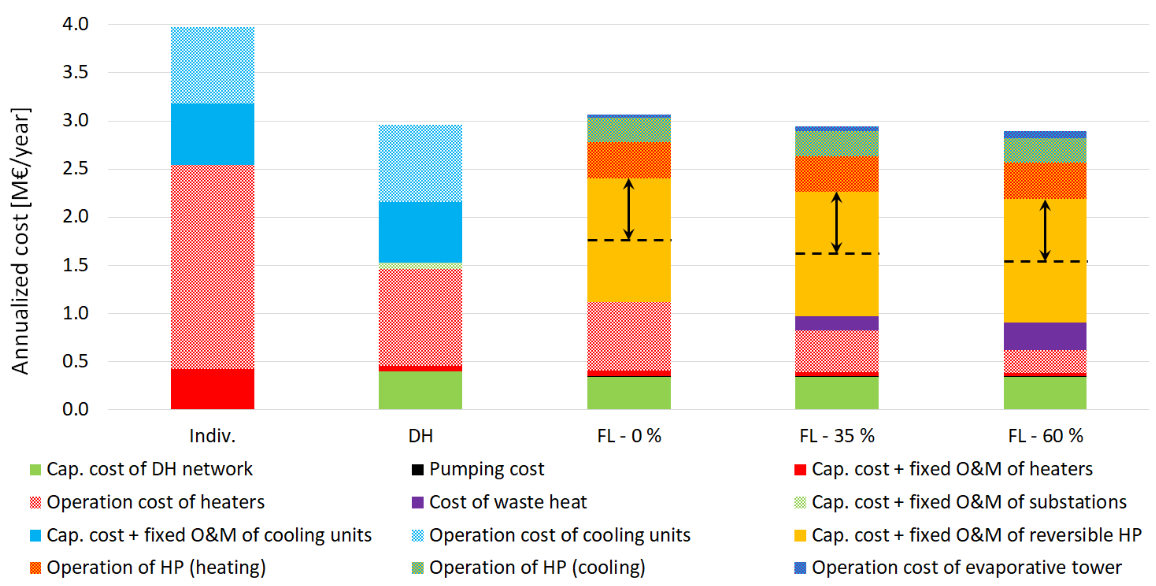

Fig. 2: Annualized costs for the different scenarios. Investment, operation and maintenance, as well as energy costs are fully included. Personnel and additional company revenues for the district scenarios are instead not considered. Investment costs for HPs are taken from reference values for single installations. Black arrows indicate the expected potential decrease of HP investment costs on the basis of alternative market investigations and economies of scale.

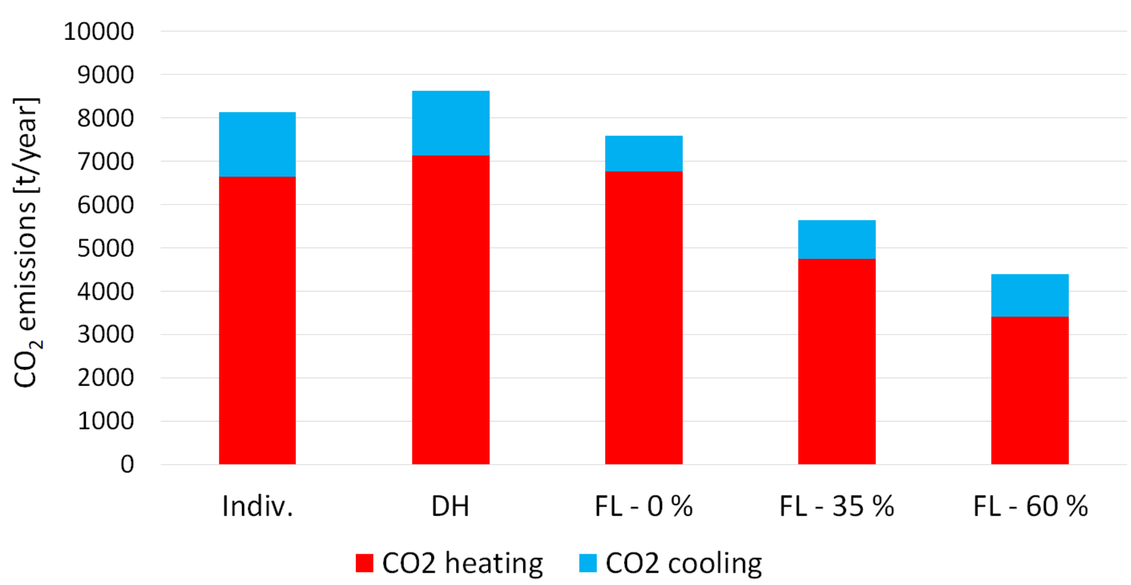

Fig. 3: Carbon dioxide emissions for the different considered scenarios. Emissions for heating and cooling needs are shown separately.

The main evidence is that, in spite of the high costs for HPs, a FLEXYNETS system can be economically feasible without great cost differences from traditional approaches. On the other hand, it can greatly improve environmental sustainability. It must be emphasized that different geographical conditions could change this picture: a non-negligible cooling demand is indeed an important requirement for exploiting the potential of reversible systems. Nevertheless, these general estimates show that investigating this option further is of interest.

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Hybrid Heat Pumps Minimize Emissions and Overall Costs

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Heat pumps are more attractive than (many) conventional heating methods, mainly due to their efficiency. This article describes the impact of heat pumps on the energy chain – not just in residential homes, but also on infrastructure and emissions. Hybrid heat pumps offer advantages in the sense that the carrier can be varied depending on specific circumstances, thereby further improving efficiency and reducing emissions with only limited impact on energy infrastructure costs. This can be achieved by the following means. Switching to gas where heat pump efficiency is poor reduces energy bills and also reduces electric peak load (reducing electricity infrastructure costs). Also, at times when electricity emission factors are poor, a switch can be made to gas as energy carrier. Switching to electricity during periods of abundant availability of clean electricity also reduces emissions. Switching to gas at very low outside temperatures avoids installing low-temperature radiators in existing homes, thereby reducing costs.

Introduction

The most important aim of energy transition is to reduce CO_2 emissions. This article will focus on this aim for the residential heating sector: how can we reduce CO_2 emissions with minimal overall costs, while maintaining the current levels of comfort and security of supply?

Specifically, we will investigate the impact of residential energy decisions on the energy chain as a whole: the costs and emissions of generation, transmission, distribution and appliances. Only by looking at the whole energy chain can sensible choices be made that benefit both customer and society. This research was conducted by the gas infrastructure company Gasunie in cooperation with partners.

Emission reduction as target

Both the EU and its member states individually have set targets to reduce CO_2 emissions due to their impact on global warming. To support these targets, the EU has developed an Emissions Trading System. Emissions in the residential sector do not fall under this scheme, however. National policies have been developed to support emission reduction in this market sector. In this article, emission reduction has been defined as an overall emission reduction, whether or not it falls within ETS.

The residential heating market in the Netherlands is currently mainly supplied by natural gas. The standard used for reliability is a 1-in-50 winter, which means that the infrastructure must be able to cope with the demand

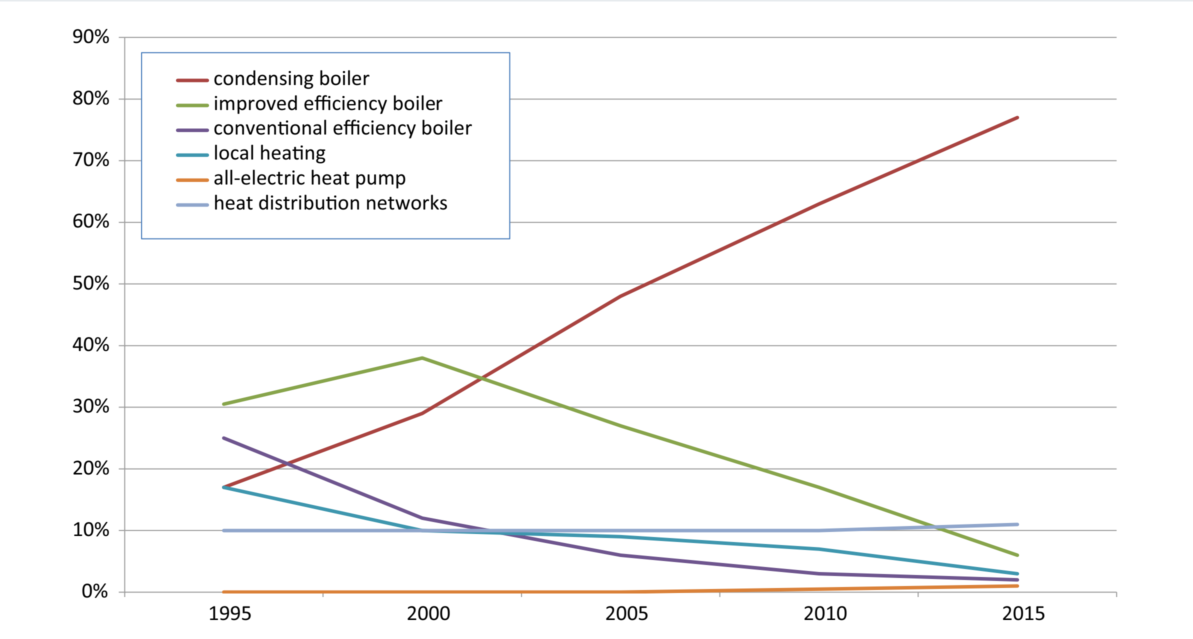

Fig. 1: Market share of heating systems in the residential sector in the Netherlands.

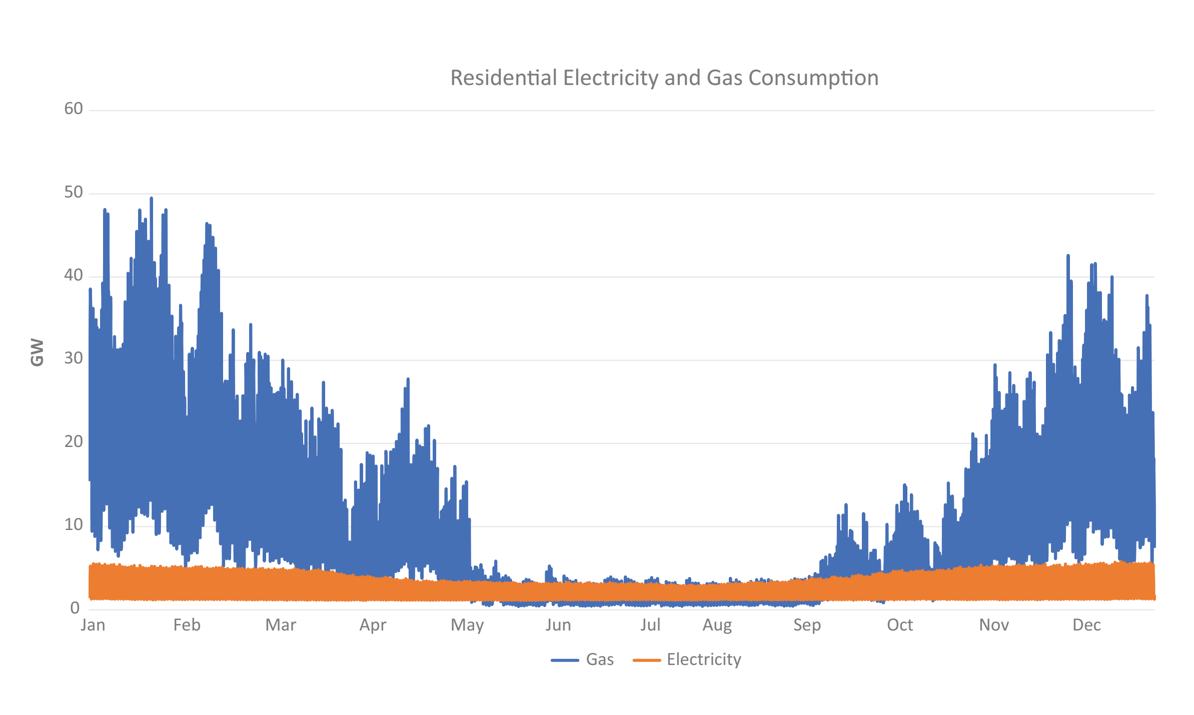

Fig. 2: The peak demand of gas and electricity in the residential sector in the Netherlands. Note the large difference during winter.

of a winter day that happens once in 50 years, with an average effective daily temperature of -17 °C. This study assumes that this standard will also be applied to any other future energy infrastructure for the residential heating market. Results presented in this article are specifically applicable to the Dutch residential heating market, but are also of general value.

Characteristics of the residential heating market

As mentioned previously, residential heating in the Netherlands is almost completely supplied by natural gas. Condensing boilers are currently the most common heating appliances, with an 80 % market share – up from approximately 20 % some 20 years ago (see Figure 1). The market share of heat pumps is currently only 1.5 %, but is increasing. The residential heating market is very temperature-dependent. Figure 2 shows this behavior for 2017. In this winter a peak gas demand of about 50 GW was observed for the residential heating market, with a peak electricity demand of just 5 GW.

In severe winter conditions, with lower temperatures, the peak gas demand will be even higher. Since this is the characteristic demand profile of the residential heating market, any alternative energy carrier taking over this role from natural gas will have to be able to cope with this profile.

In this article we specifically compare a transition from condensing boilers to either all-electric heat pumps or hybrid heat pumps – the first being a mix of air source heat pumps, mainly for existing homes, and ground source heat pumps, mainly for new homes, while the latter are defined as an air source heat pump combined with a condensing boiler. In a hybrid heat pump, both electricity and gas can be used (the choice made can be varied from hour to hour) to generate the required heat for space heating and domestic hot water.

One option for winter months (which have a limited supply of renewable energy in the residential sector, so rely heavily on fossil fuels) is the use of all-electric heat pumps. Unfortunately, the efficiency of air source all-electric heat pumps is heavily dependent on outside air temperatures – see Figure 2. At times of low outside temperatures, heat demand will be highest when the efficiency of the heat pump is low. All-electric heat pumps will greatly increase the required electrical energy load, requiring electricity generation and grids to be expanded. Moreover, homes have to be equipped with underfloor heating when using an all-electric heat pump. This comes at a high cost for existing homes. All the abovementioned reasons put severe limitations on the applicability of air-based heat pumps.

In contrast, hybrid heat pumps can choose between two energy carriers. A smart choice of carrier could reduce the load on electricity generation and grids, and make expansion investments unnecessary. Hybrid heat pumps do not require any changes to home radiators, since they can easily deliver high-temperature water during cold winters – making them an extremely attractive option. They also reduce emissions and costs, as explored in more detail in section 3.

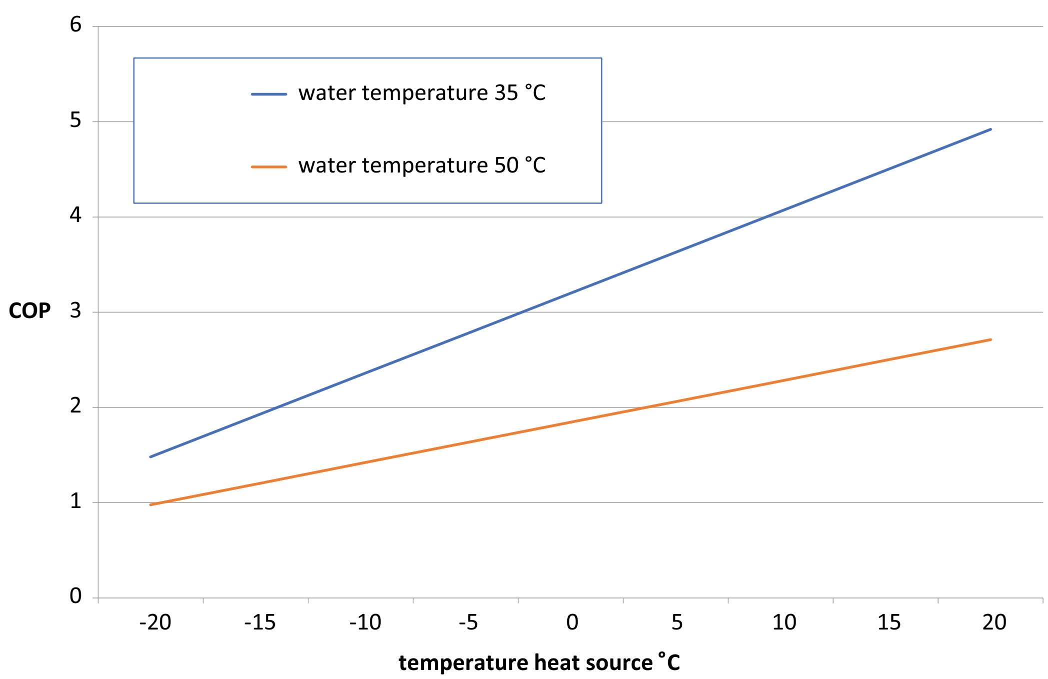

Fig. 3: Figure 3 Efficiency of air-sourced heat pumps.

Figure 3 indicates (using a currently observed emission factor for electricity of 0.586 and for gas of 0.183 kg CO_2/kWh) that with poor efficiency it would be better to use natural gas to achieve lower carbon emissions.

Overall costs

The costs of home refurbishment and changes to heating appliances are important when considering how to reduce CO_2 emissions from residential heating. Infrastructure costs are often overlooked, however. A transition from natural gas to electricity represents a tremendous hidden cost for electricity transportation, distribution and power generation.

An extensive study conducted recently [2] looked at the costs of residential heating. In this study six scenarios are used, consisting of two insulation levels (medium and high) and three heating technologies (condensing boilers, all-electric heat pumps and hybrid heat pumps). The total costs in each scenario were calculated, consisting of energy, infrastructure and home adaptations (such as insulation, radiator surface, ventilation and appliances). Costs are calculated on an annual basis with an expected lifetime of 40 years for infrastructure and insulation and 15 years for appliances. A condensing boiler with a medium insulation level is used as a reference.

The results are shown in Figure 4. The hybrid heat pump/medium insulation scenario is marginally more expensive (+17 %) compared to the current condensing boiler. In contrast, switching to an all-electric scenario more than doubles the cost, in large part due to the excessive infrastructure investments required for the all-electric/medium insulation scenario. This can be explained as follows. Infrastructure reinforcements (and thus costs) are caused by electricity demand under peak conditions on a very cold winter day. Under these temperature conditions, the COP of air source heat pumps becomes very poor (see also Figure 3). A combination of high thermal demand and low efficiency causes an extreme peak in electricity demand and thus a heavy load on the electricity infrastructure. Hybrid systems can be operated in such a way that, in circumstances of high thermal demand, gas will be used as an energy carrier – putting less pressure or no pressure on the electricity grid infrastructure.

Next we investigated the CO_2 emission reductions of all-electric versus hybrid heat pump systems. To arrive at these results, future expected emission factors of 0.25 and 0.17 kg CO_2/kWh were used [2] for electricity and gas respectively. We find that hybrid solutions offer higher emissions reductions than condensing boiler and all-electric solutions (see Figure 5).

Comparing both graphs provides insight into the costs of realizing further emission reductions using a condensing boiler/medium insulation home for comparison. See Table 1.

Taking a home with medium insulation equipped with a condensing boiler as a reference (which is the situation in the Netherlands), it can be seen from Table 1 that the next step in CO_2 emission reduction should be to install a hybrid heat pump and then insulate from here to a further, higher level. That way, the greatest re-

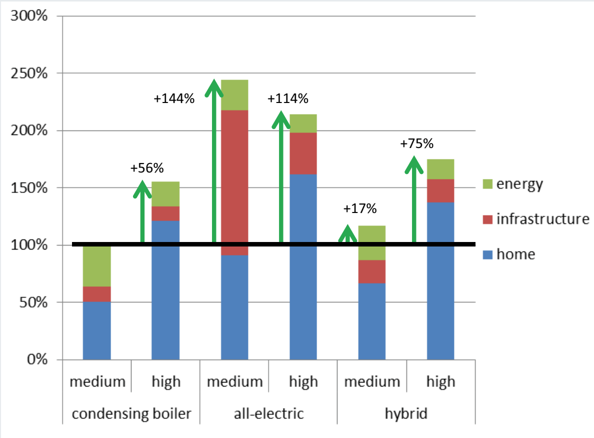

Fig. 4: Costs of insulation and appliances on an annual basis.

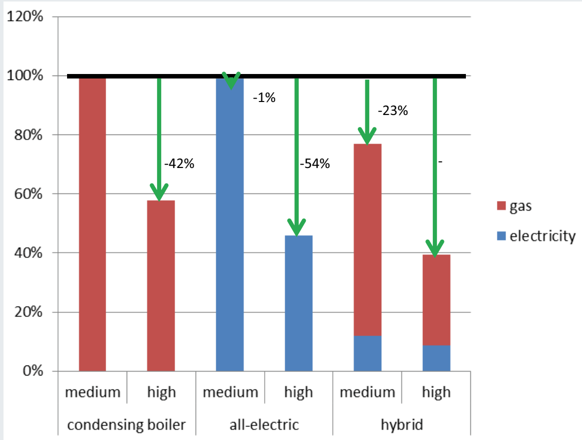

Fig. 5: CO_2 emissions at medium and high insulation levels and three heating appliance technologies.

	Condensing boiler		**All-electric heat pump**		**Hybrid heat pump**	
	medium	high	medium	high	medium	high
Costs (€/ton CO_2)	-	€716	€79500	€1149	€411	€676

Table 1: Costs of realizing further emission reductions. "Medium" and "High" refers to the levels of insulation.

duction is achieved for the lowest cost. Looking at the table, it is also very clear that installing an all-electric heat pump in a medium insulation home is extremely expensive (mainly due to high infrastructure costs, which are currently socialized) and barely reduces emissions.

Note, too, that even if the residential sector were part of ETS (which is not the case), current CO_2 prices will never incentivize the residential sector to reduce CO_2 emissions.

Conclusions

Residential space heating and domestic hot water demand represent a large share of energy consumption and greenhouse gas emissions.

Currently, natural gas as the main energy supplier is a low-cost and highly flexible solution in Central European countries. As an alternative energy carrier, electricity cannot offer these advantages since both transport and storage are much more expensive. A combination of energy carriers must therefore be pursued in order to achieve "the best of both worlds". Hybrid appliances are capable of accommodating both gas and electricity as energy carrier and of reducing emissions for the lowest overall costs.

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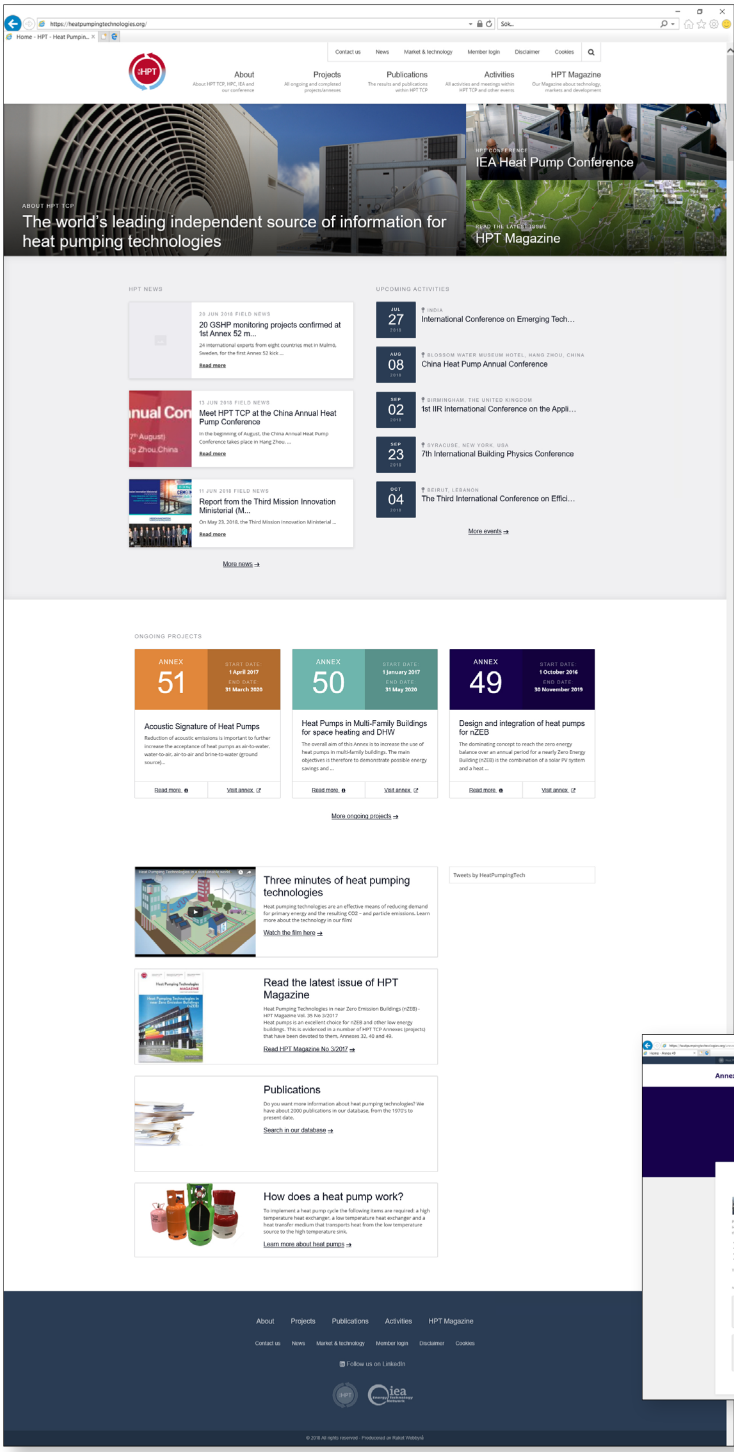
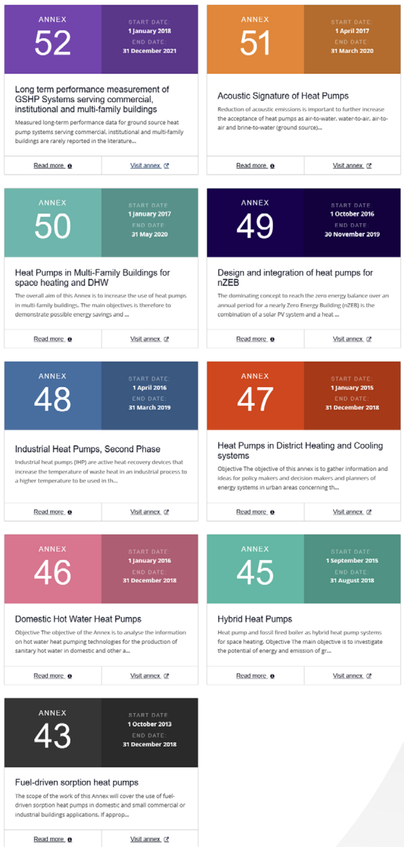
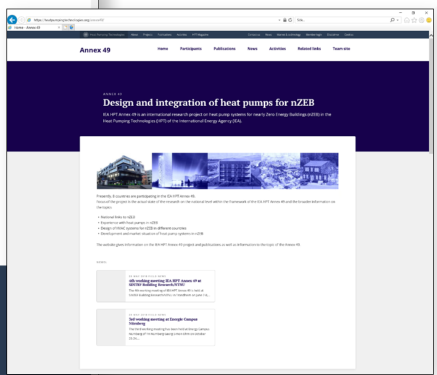


Ongoing Annexes





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http://r744.com/events/view/atmosphere_europe_2018

5-7 December
49th International HVAC&R Congress and Exhibition
Belgrade, Serbia
http://kgh-kongres.rs/index.php/en/

6-7 December
The 13th International Symposium on New Refrigerants and Environmental Technology 2018 (Kobe symposium)
Kobe, Japan
https://www.jraia.or.jp/english/symposium/index.html

2019

12-16 January
ASHRAE Winter Conference
Atlanta, Georgia
https://www.ashrae.org/conferences/winter-conference

11-13 April
Ammonia and CO_2 Refrigeration Technologies
Ohrid, Republic of Macedonia
https://www.mf.edu.mk/web_ohrid2019/ohrid-2019.html

22-26 June
ASHRAE Annual Conference
Kansas City, Missouri
https://www.ashrae.org/conferences/ashrae-conferences

24-30 August
25th IIR International Congress of Refrigeration
Montreal, Canada
http://icr2019.org/

2020

1-5 February
ASHRAE Winter Conference
Orlando, Florida
https://www.ashrae.org/conferences/ashrae-conferences

11-14 May
13th IEA Heat Pump Conference 2020
Jeju, South Korea
https://hpc2017.org/next-iea-heat-pump-conference-2020/

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

iea Energy Technology Network

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

Vision
The HPT TCP is the foremost worldwide source of independent information and expertise on environmental and energy conservation benefits of heat pumping technologies (including refrigeration and air conditioning). The HPT TCP conducts high value international collaborative activities to improve energy efficiency and minimise adverse environmental impact.

Mission
The HPT TCP strives to achieve widespread deployment of appropriate high quality heat pumping technologies to obtain energy conservation and environmental benefits from these technologies. It serves policy makers, national and international energy and environmental agencies, utilities, manufacturers, designers and researchers.

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.

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