



# Heat Pumping Technologies **MAGAZINE**

A HEAT PUMP CENTRE PRODUCT

## Digitalization as an enabler for a robust, flexible and sustainable energy system

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**HATEF MADANI, KTH, SWEDEN, AND AIT, AUSTRIA**

**"WE SHOULD START THE PROCESS BY IDENTIFYING  
THE MAJOR PROBLEMS AND CHALLENGES AND  
THEN USE DIGITALIZATION AS A TOOL TOWARDS A  
MORE SUSTAINABLE FUTURE."**

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# Heat Pumping Technologies MAGAZINE

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## In this issue

Digitalization is an enabler in many areas. And the energy system is, of course, no exception. With digitalization the energy system could become even more robust, flexible and sustainable. This issue of the HPT Magazine focuses on the possibilities of digitalization in relation to heat pumping technologies.

The Foreword points out that the term "digitalization" is commonly used, but not always strictly defined. And that such technologies might indeed improve the performance of more mature technologies, if we understand how to make them cooperate.

In one of the topical articles, digitalization is used for reaching energy costs savings. It describes a project where a control algorithm is developed, predicting solar energy gains. This leads to lowered costs for energy, keeping inhabitants' comfort intact. The other topical article investigates the so-called controller-in-the-loop approach to testing of heat pumping system controllers. This type of testing is less costly than prototype testing, and closer to real operation than software testing.

In this issue, you can also read about how the market for heat pumps is developing in China, in the Strategic Outlook. One driver is the coal-to-electricity project. The government is supporting the initiative, and the future for heat pumps in China looks good.

Don't forget to make room in your calendar for the 13<sup>th</sup> IEA Heat Pump Conference in April. It will also be available online!

### Enjoy your reading!

Johan Berg, Editor

**Heat Pump Centre**

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# Digitalization as a problem solving tool

The future energy systems are commonly associated with digitalization, large scale electrification, and increase in renewable energy deployment. The scenario of electrification and higher share of renewable energy can be strongly supported by fast growing diffusion of electrically driven heat pumps, electric cars, solar photovoltaics (PV), and wind turbines. However, the term digitalization is an overused buzzword that we have usually come across in events, scientific articles, and popular magazines, not only concerned with energy but also in all other sectors. Do we really know exactly what digitalization means? Can we digitalize our energy systems simply by adding sensors or switching our machines on/off via our mobile phones? Would it make that system “smarter”? I am neither able nor eager to answer this rather philosophical question here. But I would like to rephrase this question to ask “what major problems in the future energy systems can be solved through digitalization?” Seeing digitalization through the lens of problem-solving can support the emergence of innovative technical solutions and business models for our current and future challenges.



Heat pumps use a mature technology that provide both heating and cooling. There has been considerable improvement in design and operation of heat pumps at the component's level during the last decades. The efficiency improvement of the components over several decades has made heat pumps a competitive technology at the global level from a techno-economic perspective. Although innovation neither stops nor ask for permission, economic barriers discourage further minor improvements at the component level. However, there is a huge potential in system integration and control to gain higher efficiency and reach lower operating cost, where digitalization plays a pivotal role. Digitalization can enable the exploitation of the synergies between heat pumps and other components of urban energy systems, and couple the heating and cooling to other sectors in a more efficient way. It is necessary to facilitate better communication between energy grids and heat pumps in our future urban energy systems. The tremendous amounts of data and computing power embedded in the technologies that we use in our daily life opens new doors to more integrated, interactive, and adaptive solutions.

It is understandable that we are all fascinated by AI techniques, Machine Learning, IoT and other elements of the so-called hype cycle of emerging digital technologies. However, we should not forget that heat pumps, as well as all the technologies associated to “digitalization”, are merely tools to provide comfort, fulfilling our specific needs and solving our problems. Moreover, “big data” can be really useful only if we really know how to use it. We should all avoid to start the process by describing cool or innovative “digital” solutions. Instead, we should start the process by identifying the major problems and challenges and then use digitalization as a tool towards a more sustainable future.

**Hatef Madani**

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# Heat pumps are at the centre of the energy transition

The energy transition towards a decarbonized society sets challenges that sound like music for system integrators. Solutions need a holistic approach, which is much more than optimizing individual components or making all these components work nicely together. The value lies in the right concept, starting from the context and aiming for maximum well-being of people and nature.

At the building level, an example of such an extremely efficient, renewable and flexible concept is the focus of the EU project hybridGEOTABS (<http://www.hybridgeotabs.eu/>). A geothermal (GEO) heat pump is coupled to thermally activated building systems (TABS), and complemented by a fast secondary system, if the building or context demands this. This could be an air-source heat pump combined with local water/air coils, targeting a fossil-free concept. The ground acts as a renewable source that is automatically prepared for the next season, allowing highly efficient direct cooling in summer, and the heat pump works very efficiently since it is coupled to low-temperature heating and high-temperature cooling TABS (e.g. concrete core activation), which guarantees a comfortable indoor climate by using model predictive control. Thanks to the TABS' thermal inertia, these heat pumps can also offer flexibility to the electricity market by demand response. Sounds like the perfect marriage, doesn't it?

Whatever future-proof concept pops up, it is clear that the heat pump will play a crucial role. Will thermal networks push heat pumps out of the market? Not at all! Thermal networks and heat pumps go hand in hand, especially if we take the CO<sub>2</sub> emission reduction targets seriously, since these targets will require seasonal thermal energy storage (for city districts typically in a collective way) as well as upgrading heat/cold. Not only will the share in renewable energy sources increase significantly, but also residual energy sources will be upgraded and used, limiting thermal pollution. We group them together as Residual and Renewable Energy Sources, R2ES, the future-proof energy sources.

Moreover, being fed by electricity and generating heat/cold very efficiently, the heat pump connects multiple energy vectors in a natural way. As such, demand response measures only need the smart controllers and markets to be massively deployed. From an energy quality (exergy) point of view, the heat pumps and solar thermal collectors are the only logical choices to heat buildings or generate low-temperature industrial heat. Why burn fuels (even carbon-free) at high temperature to provide low-temperature heat? Let us keep these precious fuels for the processes that need them and that have no alternatives (such as some industrial processes, heavy road/maritime transport). It is not about choosing one technology or one energy vector, we'll need them all, each of them integrated in the global system and each of them optimized for the application it is best suited for. Together they'll be the solution.

It is up to us, academics and practitioners, to share our expertise, inspire each other and advise policy makers to make the right choices for the applications envisaged. We warmly invite you to the Building Simulation 2021 Conference ([www.bs2021.org](http://www.bs2021.org)) to get together, since together we stand tall.



LIEVE HENSEN

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WIM BOYDENS

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# Welcome to the 13<sup>th</sup> IEA Heat Pump Conference, 2021



## Online platform will be provided for the 13<sup>th</sup> IEA Heat Pump Conference

**The 13<sup>th</sup> IEA Heat Pump Conference (HPC2020) will take place on April 26-29, 2021, as announced in the previous issue of the HPT Magazine. The conference venue will be Ramada Plaza Hotel Jeju, Korea.**

However, due to the corona virus outbreak, there will also be an online platform for those who cannot attend the conference physically. Thus, we are aiming for a hybrid conference.

For authors, the full paper submission is due on November 30, 2020 as announced previously. So authors may submit new papers, and may also revise the submitted ones with additional information by this due date. This is the detailed submission schedule:

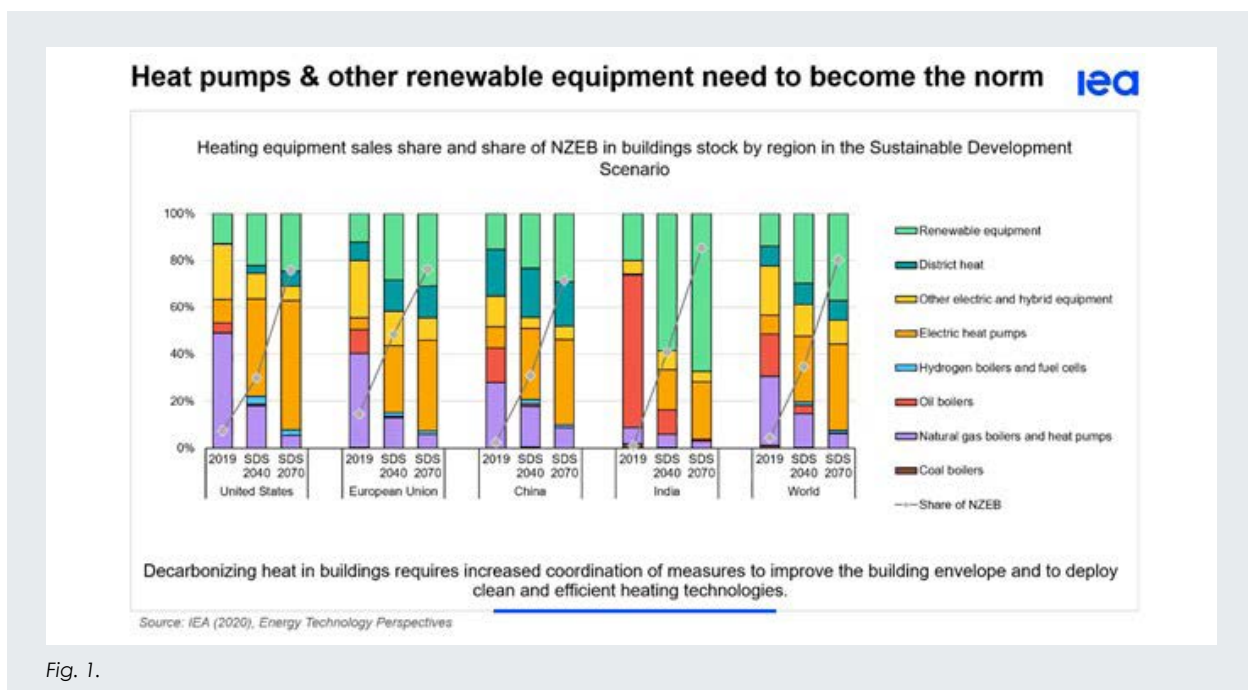
- » November 30, 2020 Full Paper Submission Due
- » December 20, 2020 Full Paper Review done, Announcement to authors of accepted papers
- » January 15, 2021 Final Full Paper Submission Due (for the new submitted papers)
- » February 28, 2021 Pre-registration Due

Still, a number of changes along with the transition of the conference are under discussion. Detailed updates and changes will be announced promptly on the conference website <http://www.hpc2020.org> and via [www.heatpumpingtechnologies.org](http://www.heatpumpingtechnologies.org).

Although the conference has changed several times, we appreciate your patience, understanding and strong support of the HPC 2020. We hope you stay safe and healthy, and we are looking forward to seeing you at the conference!



# The role of heat pumps in a net-zero emissions energy system



**At the recent meeting of the Executive Committee (ExCo) of the HPT, Thibaut Abergel made a presentation on the cooperation between the IEA and HPT. Part of this speech also focused on the recently released publication Energy Technology Perspectives 2020 (ETP 2020), in which the work of HPT was integrated to define the role of heat pumps in a net-zero emissions energy system.**

In ETP 2020, the IEA sets out a pathway to reach a net-zero emissions energy sector by 2070: a Sustainable Development Scenario, compatible with the Paris Agreement and other Sustainable Development Goals. The wealth of information that feeds into this scenario – including the analysis and modelling of over 800 technology designs – could have only been possible thanks to its Technology Collaboration Programmes, of which HPT provided significant input.

Achieving net-zero emissions buildings while ensuring energy security relies on three pillars, namely

- deployment of early adoption technologies;
- buildings integration with the energy system; and
- clean energy innovation.

Heat pumping technologies are at the forefront of pillar a). They are already well settled in the new construction market in many countries around the globe, and can be applied to many types of buildings and climates. Heat pumps also offer the possibility to enhance the flexibility

of heating provision and meet pillar b) objectives. Systems integrating storage units and/or controls can deliver on demand-side response services, while heat pumps in district energy systems can provide flexibility at the utility-scale. For pillar c), projects under HPT Annexes show how innovative heat pumps are essential to ensure scalability.

Sales of heating equipment for buildings still are dominated by fossil fuels today (Figure 1). However, heat pumps become the primary heating and hot water provider to residential and commercial buildings in the Sustainable Development Scenario at net-zero emissions.

The ETP also found that the demand for cooling will grow much faster than the demand for heating. Since heat pumps can be reversible, there is a great opportunity to take advantage of cooling demand growth, offering the end-user to use a single piece of equipment, with a dual function. Then, economies of scale could generate a “spill-over” benefit and make heat pump costs 15% lower than they would have been without this market push. Thus, there are a number of synergies to be exploited for the decarbonisation of heating and cooling.

Therefore, heat pumping technologies need to become the first heating provider for buildings, and policies fostering mass deployment, integration to the energy system and innovation are key to achieving this goal.

**THIBAUT ABERGEL**  
Desk officer for the HPT TCP, IEA



# Ongoing Annexes in HPT TCP

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

INDUSTRIAL HEAT PUMPS, SECOND PHASE	48	AT, CH, <b>DE*</b> , DK, FR, JP, UK
DESIGN AND INTEGRATION OF HEAT PUMPS FOR nZEB	49	AT, BE, <b>CH</b> , DE, NO, SE, UK, US
HEAT PUMPS IN MULTI-FAMILY BUILDINGS FOR SPACE HEATING AND DHW	50	AT, CH, <b>DE</b> , FR, IT, NL
ACOUSTIC SIGNATURE OF HEAT PUMPS	51	<b>AT</b> , DE, DK, FR, IT, SE
LONG-TERM MEASUREMENTS OF GSHP SYSTEMS PERFORMANCE IN COMMERCIAL, INSTITUTIONAL AND MULTI-FAMILY BUILDINGS	52	DE, FI, IT, NL, NO, <b>SE</b> , UK, US
ADVANCED COOLING/ REFRIGERATION TECHNOLOGIES DEVELOPMENT	53	CN, DE, IT, KR, SE, <b>US</b>
HEAT PUMP SYSTEMS WITH LOW GWP REFRIGERANTS	54	AT, DE, FR, IT, JP, KR, SE, <b>US</b>
COMFORT AND CLIMATE BOX	55	AT, CA, DE, FR, IT, <b>NL</b> , SE, UK, US
INTERNET OF THINGS FOR HEAT PUMPS	56	<b>AT</b> , FR, DE, NO, CH



NEW

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

The Technology Collaboration Programme on Heat Pumping Technologies participating countries are:

Austria (AT), Belgium (BE), Canada (CA), China (CN), Denmark (DK), Finland (FI), France (FR), Germany (DE), Italy (IT), Japan (JP), the Netherlands (NL), Norway (NO), South Korea (KR), Sweden (SE), Switzerland (CH), the United Kingdom (UK), and the United States (US).

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

ANNEX  
51ACOUSTIC  
SIGNATURE OF  
HEAT PUMPS**Introduction**

To further increase the acceptance of heat pumps, reduction of acoustic emissions is important. To minimize noise annoyance, more focus must be put on the acoustic emissions at steady state and on the transient behaviour of acoustic signatures during different operating conditions. Placement of the heat pumps is also of utmost importance, as sound emissions exhibit a pronounced directivity. Especially, air to water heat pumps provide a convenient and effective way to exploit potential energy savings and are often used in retrofit installations, making acoustic improvements crucial due to their noise producing components like compressors and fans.

During the course of the HPT Annex 51, members have convened at CETIAT (France), RISE (Sweden), DTI (Denmark) and ISE (Germany), followed by two online meetings with the last one on September 9, 2020. This was the final meeting which focused primarily on the publication of the promised deliverables, which will be available to download by the end of 2020 on the IEA HPT Annex 51 website.

Psychoacoustic tests have been carried out by the Acoustic Research Institute of the Austrian Academy of Sciences. These will give input to the test design used in Annex 51. A joint acoustic data set is currently being analysed

using psychoacoustic hearing tests. The interesting results will be summarised in a document which will also be available for free download.

A concluding webinar, guiding through the results of IEA HPT Annex 51, is planned to take place on November 30, 2020.

**Objectives**

- » Increase the acceptance of heat pumps for comfort purpose with respect to the noise and vibration emissions;
- » Increase knowledge and expertise at different levels;
- » Provide input to national and international standardization;
- » Preparation of seven Annex meetings; five meetings held (Austria Vienna 06-2017, France Lyon 01-2018, Sweden Borås, 06-2018, Denmark Aarhus, 01-2019, Germany Freiburg 10-2019), two online meetings (Internet, 03-2020 and 09-2020);
- » Workshop on acoustics of heat pumps at the ICR2019 in Montreal held; presentation published on the IEA HPT Annex 51 website;
- » Hold a concluding international webinar as a guide through the documents available at the IEA HPT Annex 51 website on Monday, November 30, 2020;
- » Worldwide dissemination to heat pump manufacturers;
- » Generation and distribution of Acoustic Guidelines for the different levels (Component, Unit & Application Level).

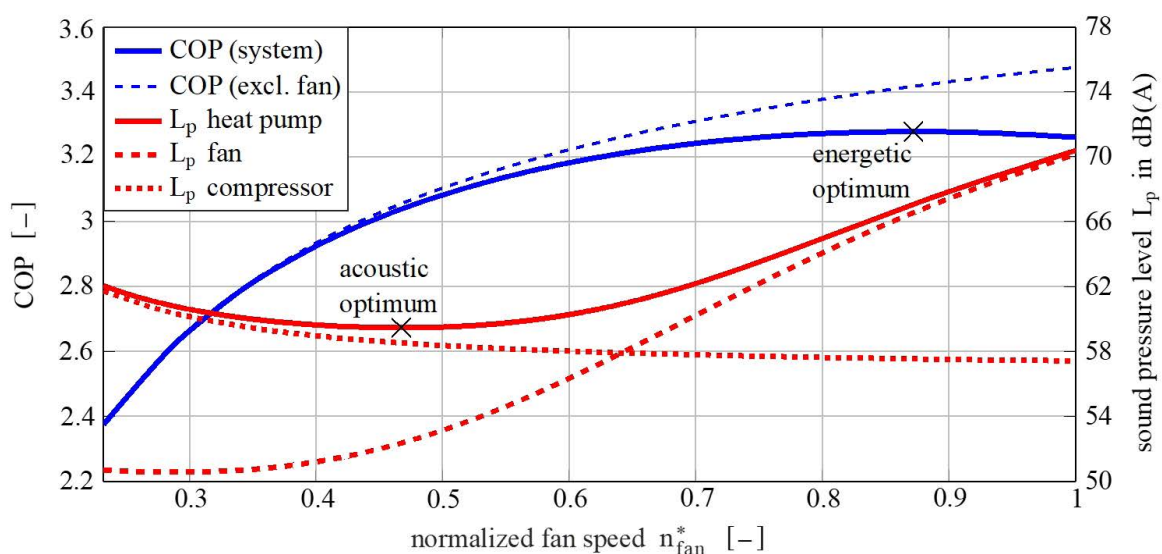


Fig. 1: COP as a result of the variation of evaporator fan speed while providing constant condenser heating capacity (outside air temperature 7 °C, heating water temperature 50 °C). [Source: RWTH Aachen, Germany]

## Results

### *Simultaneous assessment of energetic and acoustic heat pump performance*

Heat pumps are a key technology in the energy system transformation process in order to decarbonize the heat supply of the building stock. In addition to the energy and ecologic parameters, the acoustic properties are of importance since they are a crucial measure of comfort. Operating air-to-water-heat pumps requires a compressor and a fan. Due to their rotation, both have sound emissions that can be disturbing. Thus, it is necessary to develop both energy efficient and quiet heat pumps.

The following objectives have already been reached: the development of a dynamic simulation model for the acoustic evaluation of heat pumps, coupling of the acoustic and the energetic model, the parameterisation of the acoustic model to measurement data, and the reduction of acoustic emissions of heat pumps by optimising their operation.

The operation of heat pumps can be optimized regarding both energetic performance and acoustic emissions. Hence, we developed a simulation model that simultaneously determines both the thermodynamic performance of the refrigerant circuit and its acoustic emissions. The interface between the energetic and the acoustic model is the rotational speed of the compressor

and of the evaporator fan. Figure 1 shows this relationship for a normalized fan speed. At constant condenser heating capacity the evaporator fan speed is varied. The study concludes that the COP-optimal operating point does not coincide with the acoustically optimal operating point. This leads to a conflict of objectives between acoustically optimal and energetically optimal evaporator fan speeds. However, figure 1 also shows a pareto effect between energetic efficiency and of acoustic emission: by comparatively small deviations from the energetic optimum, the sound emissions can be reduced significantly. Details have been submitted to the HPC2021 conference.

## Annex website

<https://heatpumpingtechnologies.org/annex51/>

## Contact

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## INFORMATION

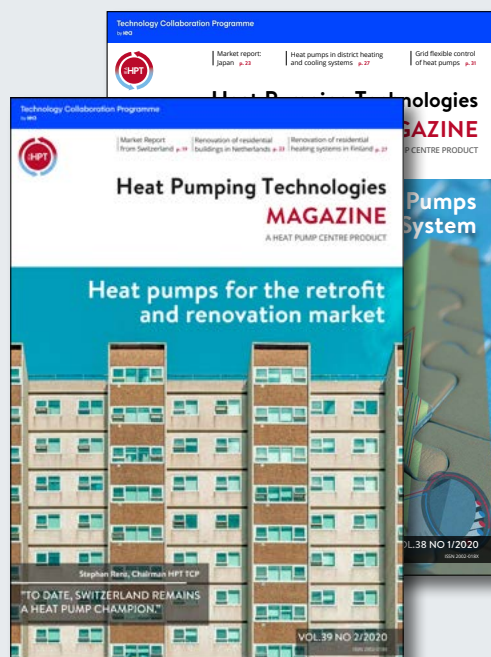
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**Read our Magazine and become a subscriber at:**

<https://heatpumpingtechnologies.org/the-magazine/>



ANNEX  
52LONG-TERM MEASUREMENTS  
OF GSHP SYSTEMS  
PERFORMANCE IN  
COMMERCIAL,  
INSTITUTIONAL AND  
MULTI-FAMILY BUILDINGS**Introduction**

With one year left to complete HPT Annex 52 the seven participating countries are compiling the results from the 40 case studies of long-term monitored GSHP systems into individual case study reports. The GSHP systems are all serving commercial, institutional or multi-family buildings with heating and/or cooling systems of varying degrees of complexity.

The outcomes from this annex will help building owners, designers and technicians to evaluate, compare and optimize GSHP systems. It will also provide useful guidance to manufacturers of instrumentation and GSHP system components, and developers of tools for monitoring, controlling and fault detection/diagnosis. This will lead to energy and cost savings.

To date, outcomes of the annex include a bibliography with published long-term performance analyses of larger GSHP systems and five published journal papers, of which open source measurement data are available for two of the published case studies. Four conference papers have so far been published; however, several more conference papers are written but not yet published as their congresses have been postponed till 2021 due to the corona virus pandemic.

**Objectives**

- » Survey and create a library of quality long-term measurements of GSHP system performance for commercial, institutional and multi-family buildings. All types of ground sources (rock, soil, groundwater, surface water) are included in the scope.
- » Refine and extend current methodology to better characterize GSHP system performance serving commercial, institutional and multi-family buildings with the full range of features shown on the market, and to provide a set of benchmarks for comparisons of such GSHP systems around the world.
- » Compile guidelines documents for instrumentation, data collection, analysis and reporting of key performance indicators for large GSHP systems.

**Recent progress**

Two of the annex deliverables are nearing completion – a guide to instrumentation used to measure performance and a guide to uncertainty analysis. The instrumentation guidelines cover measurement of fundamental variables: temperature, flow, electrical power and energy. Measurement of heat transfer rates and energy using heat meters is covered, as well as measurements of the heat pump performance using refrigeration cycle measurements. Measurement of downhole temperature using optical fiber is also treated. The uncertainty analysis guidelines cover propagation of errors from the measurement of fundamental



Fig. 1: Frölunda club house, the subject of one of the case studies. Photo: J. D. Spittler.



Fig. 2: Frölunda club house, detail of the heating system. Photo: J. D. Spitler.

variables to the final estimation of performance factors and other key performance indicators such as system efficiency index. A current focus for both guides is treatment of errors that come from sources other than the sensors – e.g. sensor placement.

A recent journal paper (Liu et al. 2020), analyzing three years of detailed performance data from a club house in south-west Sweden, is part of the Annex 52 work. Several conference papers describing Annex 52 results and case studies have had their publication delayed until 2021 due to the pandemic.

#### Annex website


<http://heatpumpingtechnologies.org/annex52/>

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## INFORMATION





ABOUT HPT TCP

Worldwide key player in generating and communicating independent knowledge on heat pumping technologies

HPT CONFERENCE

Save the date for the IEA Heat Pump Conference 2020

Welcome to Jeju, Korea in May 2020.


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

[heatpumpingtechnologies.org](http://heatpumpingtechnologies.org)

### Introduction

Air conditioning (AC) and refrigeration systems are responsible for a large share of worldwide energy consumption today, while demand is expected to increase sharply in the next 50 years, if no corrective actions are taken. IEA projects that AC energy use by 2050 will increase 4.5 times over 2013 levels for non-OECD countries and 1.3 times for OECD countries. Worldwide action, both near-term (e.g., increased deployment of current “best” technologies) and longer-term (RD&D to develop advanced solutions), is urgently needed to address this challenge. Annex 53 focuses on the longer-term RD&D need. Technologies of interest include vapor compression (VC) and non-traditional cooling approaches, including alternative advanced VC and thermal compression (TC) cycles.

The technical scope of Annex 53 is very broad by design. It is not likely that there will be only one, or even a few, “right” solutions to the challenge.

### Objectives

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

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

### Results

This update focuses on progress of advanced VC and TC systems R&D.

City University of Hong Kong has proposed a hybrid compression-assisted absorption thermal energy storage (CATES) cycle, Figure 1. This cycle can achieve enhanced energy storage performance under low charging temperatures. When charging, the compressor helps move refrigerant to the condenser tank until the desired sorbent/refrigerant concentration is reached. Then the valves V1/V4 close, V2/V3 open and the compressor assists in moving refrigerant from the evaporator tank. The two tanks have different roles in the two processes. With a heat input charging temperature to the system generator of 80 °C for cold storage, the energy storage efficiency and density reach 0.67 and 282.8 kW/m<sup>3</sup> for the proposed CATES cycle, compared to 0.58 and 104.8 kW/m<sup>3</sup> for the basic absorption cycle. Figure 2 shows a possible physical system configuration.

At Italy's National Research Council/Institute for Advanced Energy Technologies (CNR-ITAE), a new generation of components for low grade thermally driven ad-

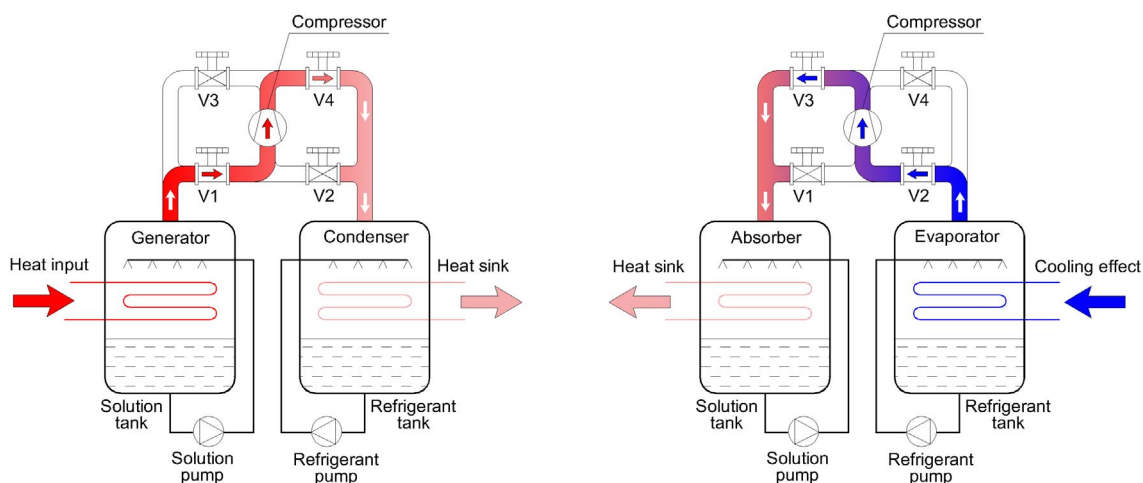


Fig. 1: CATES system operating cycle schematic - top, thermal storage charging process; bottom, thermal storage discharging process (courtesy of Wei Wu, City University of Hong Kong)

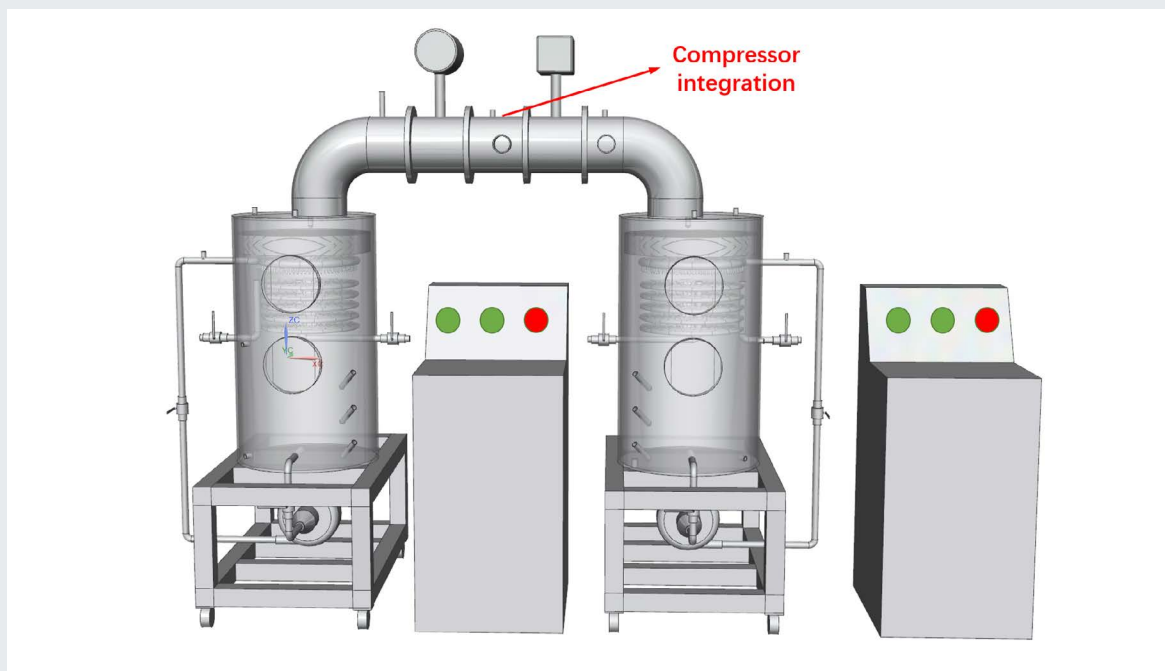


Fig. 2: CATES physical layout (courtesy of Wei Wu, City University of Hong Kong)

sorption cooling machines is being developed. New thermal compressors using advanced sorbents with tailored sorption properties and optimized heat exchangers realized by 3D prototyping techniques aim to cover the gap with other cooling technologies in terms of cooling power density and capital cost. A paper is being prepared that provides details on the development status.

University of Maryland is investigating the potential of stacked superelastic (SE) layers for an elastocaloric (EC) system. A single stage EC system test station is operational, Fig. 3. The compression cell has a high stiffness, as a result of the high Young's modulus of Ni-Ti, the total cross section and the short length of the cell. Due to this high stiffness of the compression cell, an extensometer was installed to compare the strain calculated based on

crosshead displacement and the direct local strain measurement. A set of tests is in progress to quantitatively determine the compliance of the frame and how compensate for it.

#### Annex website

<https://heatpumpingtechnologies.org/annex53/>

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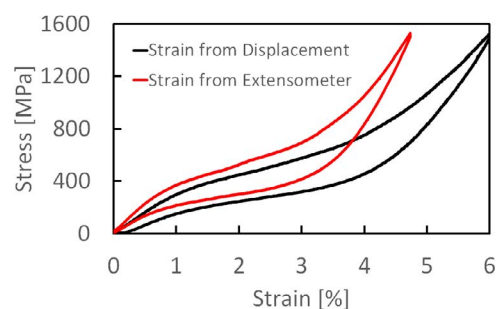


Fig. 3:a) View of the extensometer attached to a single tube in the cell; b) Effect of testing frame compliance in strain estimation and measurement (courtesy of Univ. Maryland, N. Emaikwu, D. Catalini)

# Heat pump market development in China

Lingyan Yang, China

Heat pumps can effectively use clean energy for heating, so they have been widely used in China. The coal-to-electricity project is an effective measure to reduce air pollution. The Chinese government has issued a series of policies to support the project. In this article, the development of air-source and ground-source heat pump markets in China are discussed. Using heat pumps is a good way to indirectly utilize electricity for heating, and heat pumps have a bright future in China.



**Download and share this article**

## Introduction

Air pollution caused by heating is a challenge for the Chinese government. As a clean energy heating measure, heat pumps have been applied rapidly. This paper will describe the changes of the heat pump market in China, driven by policies and demand.

Air source heat pumps have developed rapidly due to their convenient installation and good economy. Ground source heat pumps are mainly used in large projects, so the growth rate is gradually slowing down, although the cumulative application area is still increasing.

## Air source heat pumps

The most common heating method in China is to directly produce high-temperature water by coal-fired boilers. However, the heating efficiency is low and the combustion of coal gives rise to significant amounts of CO<sub>2</sub>. Also, the emissions of particles (such as PM<sub>2.5</sub>) and NO<sub>x</sub>

caused by coal combustion are considered to be one of the main factors leading to haze weather. During recent years, China has promoted clean energy heating, in order to reduce air pollution and energy consumption. A coal-to-electricity project is an effective measure taken by the Chinese government, based on requirements of clean energy heating in northern China, and relevant policies have been introduced gradually, such as the [Clean Energy Heating Plan for Winter in North China \(2017-2021\)](#).

Heat pumps are a good choice for heating under the support of these policies. The air source heat pump is mainly used for heating scattered residential buildings and rural buildings. The ground source heat pump is used for heating buildings with a central heating demand.

Considering the up-front investment, the economic advantages of air source heat pumps are obvious. The growth rate of air source heat pump application is high-

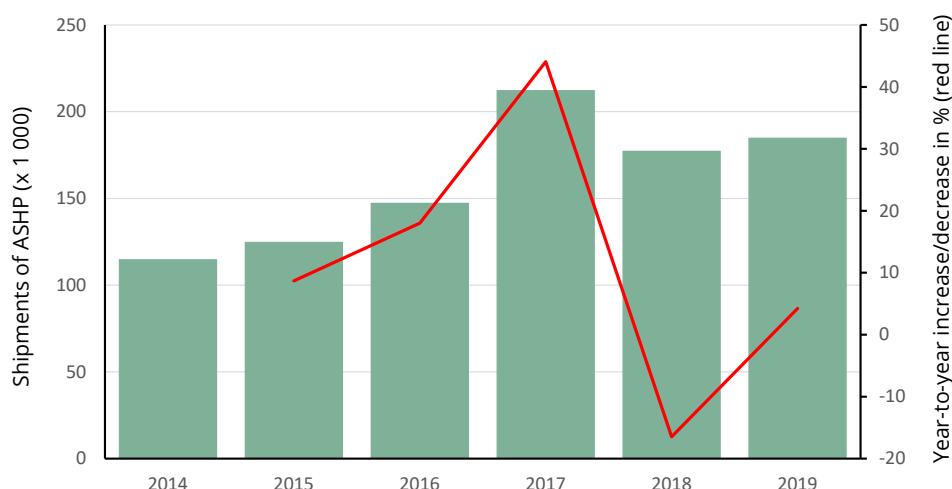


Fig. 1: Shipments of air source heat pump in China (x 1 000).

The red line shows the year-to-year increase/decrease in %, see the axis on the right. Source: Data.chinaiol.com

er than that of ground source heat pump. Fig. 1 shows the shipments of air source heat pumps in China. With the support of national policies and funds, the sales of air source heat pump increased significantly in 2017, and maintained a high sales volume during the next two years.

#### Recent policies on Air Source Heat Pumps:

##### 1. *Guidance on Promoting Electric Power Substitution*

The National Development and Reform Commission of China issued this to promote air source heat pump heating to replace coal-fired heating.

##### 2. *Work programme on air pollution prevention and control in Beijing, Tianjin, Hebei and surrounding areas in 2017*

The Ministry of Environmental Protection issued that Air-Source Heat Pumps (ASHPs) should be the main heating system for new residential buildings; coal-fired boilers should not be installed in these buildings.

Relevant financial subsidies for ASHP projects (currency conversion: 1 yuan = 0.15 USD, as of October 2020):

- » Beijing: 24,000 yuan/household (corresponds to approx. USD 3,600).
- » Tianjin: 29,000 yuan/household (corresponds to approx. USD 4,350).
- » Shanxi: 27,400 yuan/household (corresponds to approx. USD 4,100).
- » Hebei: 7,400 yuan/household (corresponds to approx. USD 1,100).
- » Shandong: 8,000 yuan/household (corresponds to approx. USD 1,200).

The application range of air source heat pumps is also extended from the Yangtze River basin to Northern China, even in areas with lower temperature in winter. The national standards for the application of air source heat pumps at low ambient temperatures have also been further improved. Air source heat pumps are required to be used at lower ambient temperature ( $-25^{\circ}\text{C}$ ) than before ( $-20^{\circ}\text{C}$ ). The national standard also requires that

the primary energy utilization rate of air source heat pump heating is higher than that of coal heating when the outdoor temperature is higher than  $-12^{\circ}\text{C}$ . In this way, it is ensured that ASHP is used more than coal combustion. This is advantageous, since the energy efficiency of ASHP is higher (and the greenhouse gas emissions are lower) than that of coal combustion.

#### Ground source heat pumps

Ground source heat pumps have been used in China for more than 20 years, and their cumulative application area change is shown in Fig. 2. By 2019, the cumulative application area of ground source heat pumps had exceeded 0.5 billion square meters, of which 70% were in borehole exchanger heat pump systems.

China's research on heat pump technology has undergone four main stages during which numerous technological and engineering breakthroughs have been reached:

1. 1980 to 2000: In this starting stage, the heat pump concept began to spread in the HVAC field and producers had only few and incomplete accessories. As a result, the application scale increased slowly.

2. 2000 to 2004: Turning into the promotion stage, heat pump application had increased to about 80 heat pump unit producers and system integration manufacturers. Still, heat pump technology was not well considered, due to the low technical level of installers and breakdowns caused by engineering inexperience.

3. 2005 to 2013: This is the rapid development stage, under the strong policy support which firmly emphasized energy conservation and carbon emission reduction. This laid a solid foundation for heat pump technology in renewable energy applications. Heat pump technology and facilities emerged across the country. By the end of 2012, there were 4000 heat pump unit producers and system integration manufacturers, with a total areas of 0.24 billion square meters. At the end of 2013, the

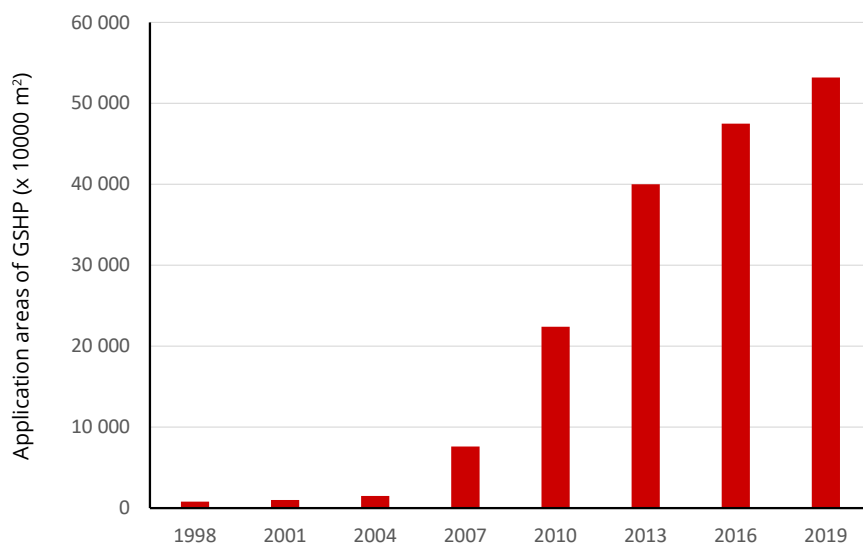


Fig. 2: Application areas of ground source heat pumps in China (x 10,000 m²).

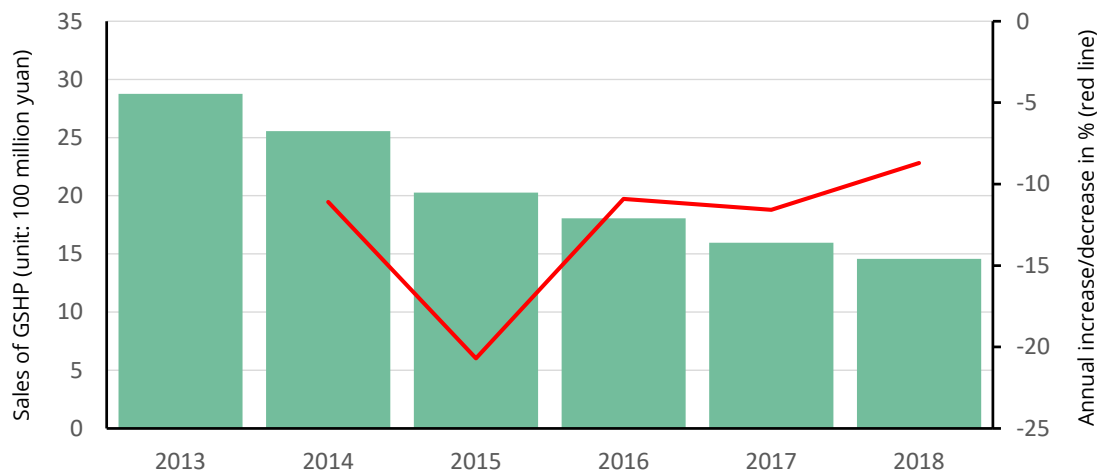


Fig. 3: Sales of ground source heat pumps in China (unit: 100 million yuan).

The red line shows the annual increase/decrease in %, see the axis on the right. Source: Data.chinaiol.com

total application areas of ground source heat pump had reached 0.4 billion square meters. 78% of the whole application projects were gathered in North China and the Southern region of North-East China, in Beijing, Tianjin, Hebe, Liaoning, Shandong, and Jiangsu, etc.

4. 2014 up to now: ground source heat pumps have entered into a steady developing stage. This is due to several factors, such as the great urgency of renewable energy application, high-efficiency clean heating, and the rigorous regulations of under-ground water usage. This current stage is characterized by a new focus and interests in shallow geothermal energy application in heat pumps, system design, controlling and optimization.

The development characteristics of ground source heat pumps (GSHPs) in China are as follows.

1. As a result of market surveys, GSHPs have been installed in residential buildings and public buildings. According to the summary data, almost all types of buildings can use ground source heat pump system for cooling and heating. There is a high proportion of borehole exchanger heat pump systems in public building projects, and boreholes make it is relatively easy to control the balance of heat absorption and discharge. Therefore, the proportion of GSHPs applied in public buildings is higher than that in other types of buildings.

2. There are various types of low-temperature heat sources of GSHPs, and the projects develop on a large scale. Soil, groundwater, surface water and so on can be used as low-temperature heat sources of GSHPs. In recent years, GSHP projects have been developed on a large scale, and a number of national, provincial and municipal key projects have been applied in large scale. The new office buildings of Beijing Municipal Government are heated and cooled by GSHP systems. The energy supply area reaches 3 million square meters.

3. The research and application of middle and deep borehole exchanger heat pump systems are very active. This is a new geothermal energy utilization technology. Because the rock and soil have the characteristics of gradually increasing downward temperature, this technology is suitable for one-way heat extraction for building heating. In recent years, there have been a number of demonstration projects in China, mainly using coaxial tube heat exchangers. The technology is also constantly improving, making it a hot spot of GSHP research in China.

China's ground source heat pump application area has been in the forefront of the world, but in recent years, due to a variety of factors, the growth rate has slowed down. According to Fig. 3, the sales of ground source heat pump units in China has decreased year by year after 2013.

The main reasons for the decline are as follows:

1. The application of groundwater source heat pumps has been greatly reduced

During the rapid development stage, ground water source heat pumps accounted for a large proportion of the application of ground water source heat pump. Due to the problems in design, construction, installation and operation of some of the projects, some problems have been gradually exposed. This includes the difficulty to recharge groundwater, which may cause water pollution, etc. As a consequence, a number of provinces and cities have recently issued policies to restrict the use of groundwater source heat pumps. Instead, borehole systems now dominate.

2. Impact of construction market

Ground source heat pump systems are widely used in buildings with both cooling and heating load requirements. They are widely used in public buildings. After 2013, the number of public construction projects de-

creased, and thus the amount of new ground source heat pumps also decreased.

### 3. Technology risk-affected user confidence

Some projects had many problems. For instance, the heat transfer capacity of ground source heat pumps may be insufficient due to improper construction, or the heat and cold accumulation caused by nonstandard design calculation results in the attenuation of heat exchange capacity of the system, affecting the energy efficiency of the system. It not only causes the loss of the project itself, but also leads to lower confidence in the ground source heat pump technology, leading to a decline in the number of new ground source heat pumps.

Policies regarding Ground Source Heat Pumps:

#### 1. 13th Five-Year Plan for GSHP Energy Development and Utilization

Established according to the 13<sup>th</sup> Five-Year Plan for Renewable Energy Development, this policy elaborates the guidance, goal, key tasks, major layout and operation measures of GSHP energy development and application which is the basic foundation for geothermal energy development.

#### 2. Accelerating the Development and Utilization of Shallow Geothermal Energy to Promote Coal-Reducing Substitution in the Northern Heating Area

This will promote the use of clean and efficient energy, for regional heating and cooling, in order to improve air quality.

Relevant financial subsidies for GSHP projects

- » Beijing: 30% of the initial investment in compensation engineering.
- » Jilin: 60 yuan/m<sup>2</sup> in accordance with the energy supply area.
- » Chongqing: 30-40 yuan/m<sup>2</sup> in accordance with the energy supply area.
- » Nanjing: Compensation for energy supply area is 35-70 yuan/m<sup>2</sup>.

## Conclusions

Heat pumps are an effective way to utilize renewable energy. Heat pumps have bright prospects in China in the future. With the continuous support of policies and funds, the application of heat pumps will continue to increase.

It was expected that the Chinese air source heat pump market would maintain a steady growth at an annual rate of more than 10%. However, this is not currently the case. The problem is how to improve the operation performance of the ASHP, so that it can be effectively used in coal power engineering.

Under the influence of many factors, such as changes in the construction market, the ground source heat pump market will be further affected, and the application growth rate is expected to decline for a period. However the decline rate will be further slowed down, and the accumulated application area will still be further increased.

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# A heat pump system control based on solar gain prediction

Davide Rolando and Hatef Madani, Sweden

The implementation of advanced system control strategies, able to achieve a considerable increase of the system efficiency, can represent a convenient solution to reduce the system operation costs while maintaining a desired level of comfort. A control algorithm developed within a Swedish national research project shows annual energy savings of 10%, through the prediction of the solar energy gains in single family house installations. In principle, the developed control algorithm does not require any hardware modification and can be implemented in both new and existing installations.



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## Introduction

The traditional and basic control approach for heat pumps in residential buildings adopted in Central and Northern European countries is based on the calculation of the supply temperature to the heating (or cooling) distribution system, which in turn is based on the outdoor temperature. The function that expresses the supply temperature is called “heating curve” and is typically defined as a piecewise function.

The heating curve has to be defined during the system installation phase. It depends on the building envelope characteristics, the heating distribution type (radiators or floor heating, for example) and the design temperature conditions for a given location. The approach is based on the idea that, for a given outdoor temperature, a supply temperature can be defined to balance the building heating demand in order to guarantee an indoor temperature that corresponds to the thermal comfort conditions. Considering the case of Sweden, the vast majority of the heat pump installations for residential buildings considers the heating curve as the only input for the system controller. The indoor temperature is in many cases monitored but not actively employed in the control logic implementation.

The project “Smart Control Strategies for Heat Pump systems” [1] was a research project co-funded by the Swedish Energy Agency, focused on the improvement of single-family house heat pump heating systems with traditional control based on the building heating curve. The project evaluated several possible adjustments to the building heating curve method that can be potentially implemented in both new and existing controllers of heat pump systems.

A thorough analysis has been performed to evaluate the impact that additional inputs to the heating curve control approach can have on energy saving and indoor comfort. More specifically, the prediction of user internal gains, ambient temperature, wind and solar radiation are among the inputs considered in the study for different types of single family buildings. A study on the potential control improvement based on perfect prediction

of weather forecast and user occupancy was presented at the IEA Heat Pump Conference in 2017 [2].

In this article, the results regarding the development of a control algorithm based on the prediction of the solar energy gain are briefly summarized.

## Heat pump predictive control

The traditional heat pump control approach is based on the building heating curve. The supply temperature to the heating (or cooling) distribution system is calculated as a function of the outdoor temperature.

The heating curve control algorithm is relatively easy to implement and setup, and is currently the most popular control approach in use for single family house installations. Despite this, a few well-known shortcomings of this approach are too often neglected.

First of all, the indoor temperature is not univocally related to the outdoor temperature. The solar radiation and the occupants’ activities, for example, represent energy gains that can significantly affect the indoor temperature and thermal comfort.

Simulation models of single-family house heat pump installations have been developed using the software TRNSYS in order to test advanced control strategies that could lead to minimizing the Heat Pump energy consumption while maintaining the overall thermal comfort. The results obtained through building simulations reveal that a significant energy saving could be potentially achieved by systematically modifying the heating curve on a daily basis depending on the predicted energy gains from the solar radiation during selected periods of the year.

The inspection of a typical daily solar radiation profile can help explaining how the daily solar radiation energy gain can be predicted. As an example, Figure 1 shows the solar radiation profile in Stockholm, Sweden, during one day. The clear sky radiation profile has been calculated by considering the relative position of the sun. This

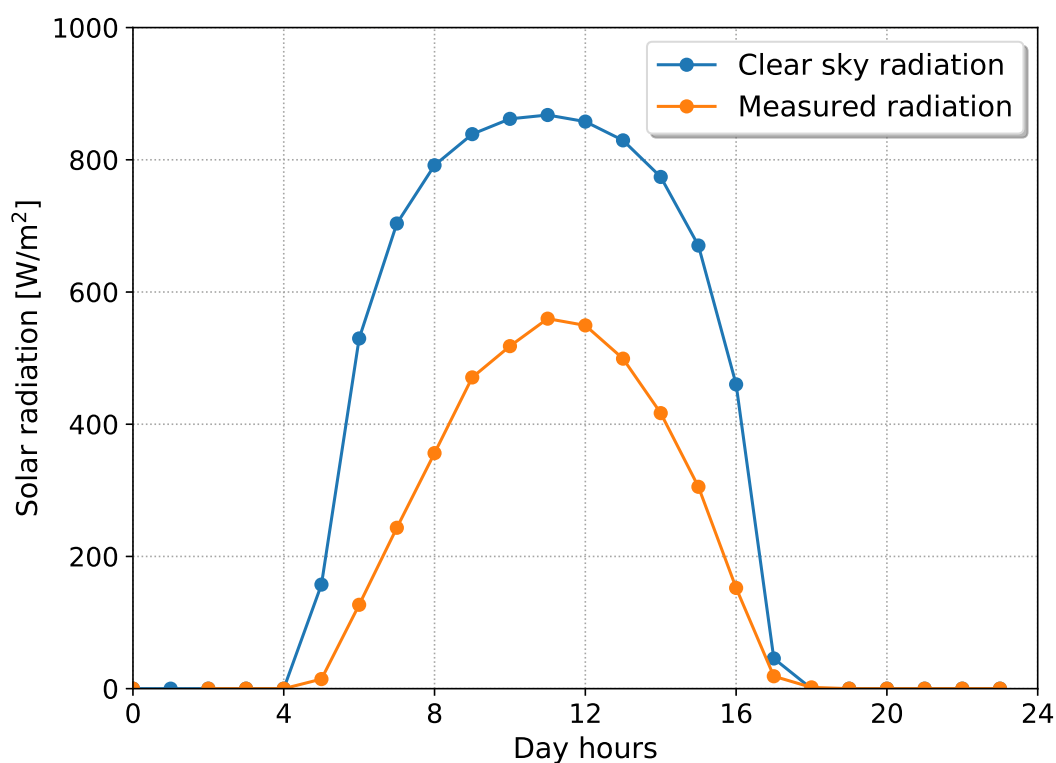


Fig. 1 Example of the solar radiation profile ratio of one day in March. The theoretical clear sky radiation profile is compared to the measured data.

calculation can be easily performed for any time at a given location and can be considered the same every year. In the same chart, the actual measured solar radiation is also plotted, showing what we call the solar radiation ratio. It is worth noticing that the area under the “clear sky radiation” curve represents the maximum energy provided by solar radiation during the selected day of the year at a given location. On the other hand, the area under the “measured radiation” curve represents the actual energy provided by solar radiation during the same day. Among the reasons that cause the solar radiation attenuation that is shown in Figure 1, the sky cloudiness is one of the most important factors. Intuitively, the more the sky is covered with clouds during the daytime, the more the actual solar radiation is reduced compared to the theoretical (clear sky) one.

Typically, over one year, there are months where the average ambient temperature is quite similar while the solar radiation is significantly different. In the case of Stockholm, for example, this can be shown considering November and April. A heat pump controller merely based on the heating curve would control the heating system in the same way both in April and November, since the ambient temperature are relatively similar. On the other hand, the effect of the solar radiation (significantly different between November and April) would lead to a possible overheating of the building, a waste of energy and a higher electricity consumption than needed.

For these reasons, a prediction model has been developed to allow the prediction of the daily solar radiation using the average cloudiness value provided by the

weather forecast. For each day, in particular, the predicted energy gain due to the solar radiation is calculated considering the theoretical solar radiation profile (easy to calculate and available for any location) and the average cloud coverage that is forecasted. This prediction model has been tuned and tested in the simulation models developed by our group.

It should be noted that the control described in the article is valid also for other types of heating (for instance district heating) and cooling systems.

Figure 2 shows the results obtained by the daily solar radiation prediction model in terms of energy consumption and energy savings for a single family house building of 125 m<sup>2</sup> located in Stockholm.

In Figure 2, the energy consumption of the heat pump system based on the traditional heating curve approach is labelled “basic control”. The energy consumption of the same system controlled considering the prediction of the daily solar radiation gain is labelled “proposed control”. The same figure shows the monthly energy saving obtained by the solar radiation predictive model over the traditional control approach.

The monthly energy saving profile is clearly not uniform since, as mentioned above, the highest energy saving potential occurs for relatively low ambient temperature and relatively high solar radiation gains. These conditions typically corresponding to the period between the end of winter and the spring months.

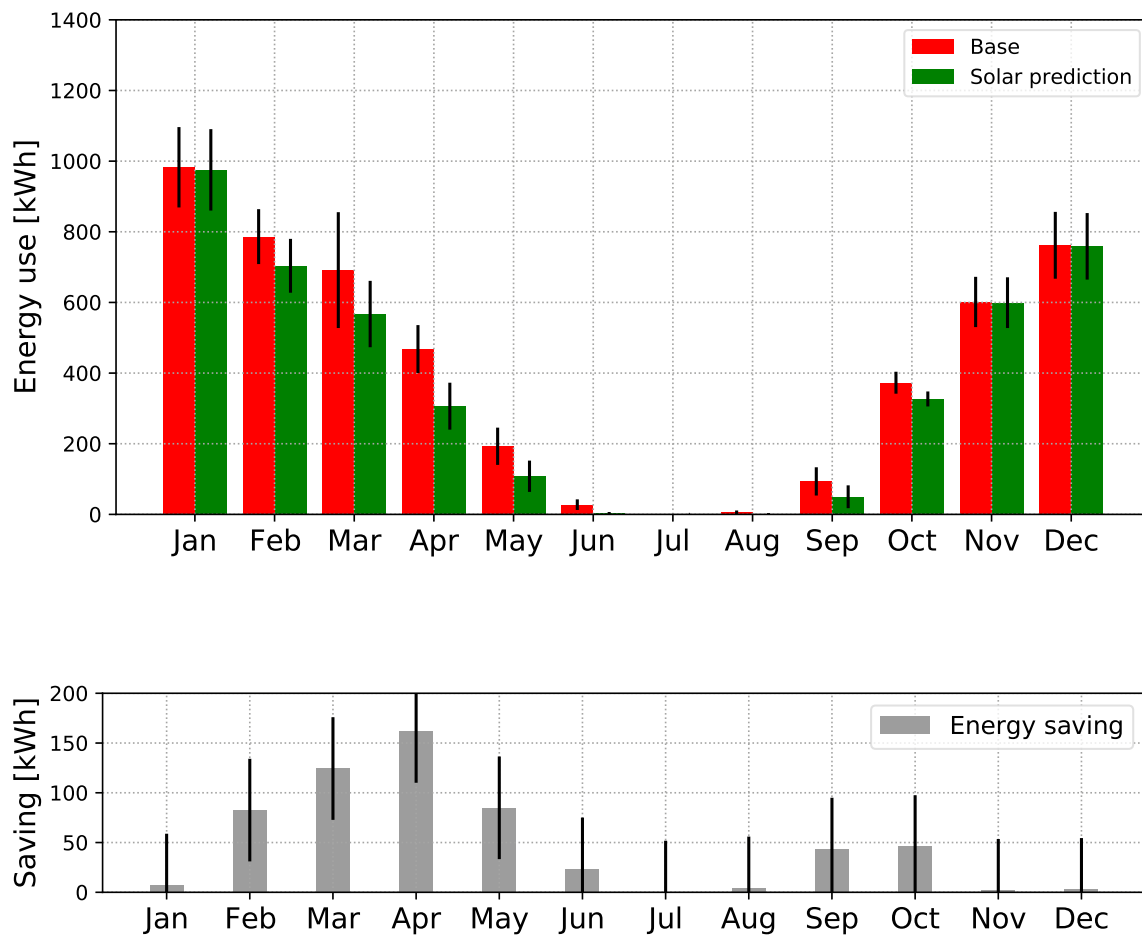


Fig. 2 Summary of energy consumption and energy saving profiles resulting from the simulations with weather data considering the period 2014-2017

The results have been obtained considering the weather data for Stockholm over the period 2014-2017 (sources: <http://slb.nu> and <https://openweathermap.org/>). For Stockholm, the monthly energy saving peak over this period always occurs over the month of April and can be up to 25%.

## Conclusions

In this study, starting from the common control approach adopted in the vast majority of the Swedish heat pump systems, the heating curve, additional input variables based on human behavior and weather information have been considered in order to investigate the energy saving potential of modified control algorithms. The results shown in this article focus on the significant energy savings that can be made by considering the prediction of the daily solar radiation gains.

Through building system simulations performed by means of the software TRNSYS, the study of a new con-

trol method has been developed to allow the prediction of daily solar radiation without requiring additional sensors to be installed in the system. The simulations have been performed to compare the developed control method versus the traditional control method.

The results obtained show that the annual energy saving that can be achieved is about 9% and monthly energy saving greater than 25% is possible. The highest energy saving for the modelled system will be typically obtained over the spring period.

It is worth noticing that the control strategies here presented can be implemented in both new and existing heating system installations. No direct measurement of solar radiation is required and no major modifications of the system are needed. The control algorithm can in fact be implemented by a controller software upgrade; no additional sensors or invasive hardware are required. Also, it should be noted that the control described in the article is valid also for other types of heating (for instance district heating) and cooling systems.

## Acknowledgements

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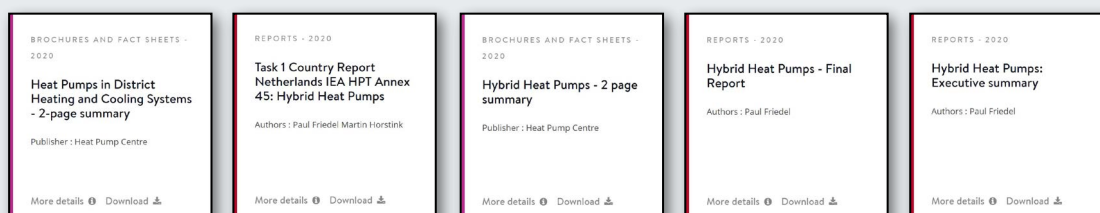
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# Controller-in-the-loop - New ways of optimizing costs and quality of heat pump systems

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Michael Lauermann, Austrian Institute of Technology GmbH

The complexity of heat pumps systems is constantly increasing, and refrigerants are evolving to comply with the F-Gas regulation of the European Union. As a result, the requirements of the heat pump system controllers are also growing. Thus, precise testing of such complex controllers will become more important. Controller tests are usually done regarding the software, or after the production of prototypes. Software tests can only partially map the real operation, whereas prototypes can cover it completely, but are very expensive and required changes to prototypes are very costly. To test the controllers without expensive prototypes, but with conditions very similar to real operation, the controller-in-the-loop (CIL) is suggested. This approach is explained in some detail and illustrated with a real example.



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## Introduction

The development in the heat pump technologies sector leads to increasingly complex systems. In addition to the complexity of the design, older refrigerants are phased out to comply with the F-Gas regulation [1] and new refrigerants are entering the market. Thus, the requirements for the control of such systems are also gradually becoming more demanding, and more components must be correctly controlled in different configurations and different operating states. This growing complexity also increases the probability of mistakes being made during the development of control concepts. Although the software of controllers are already being tested, real operation cannot yet be accurately represented by this type of tests. For example, the communication level,

which is usually done via MODBUS [2] or BACnet [3], and the time delays that occur both through communication and through the hardware installed in the real controller, are missing. It is also difficult to map disturbances caused by data collisions or losses. This leaves only the expensive development of prototypes for classic controller tests. In addition to the high costs, prototypes are difficult to adapt after construction. Therefore, already in the concept development phase, significant effort has to be made to develop a stable and efficiently controlled heat pump system. In order to avoid faulty prototypes, the development of new and innovative systems must be slowed down in favour of more stable systems based on conventional approaches.

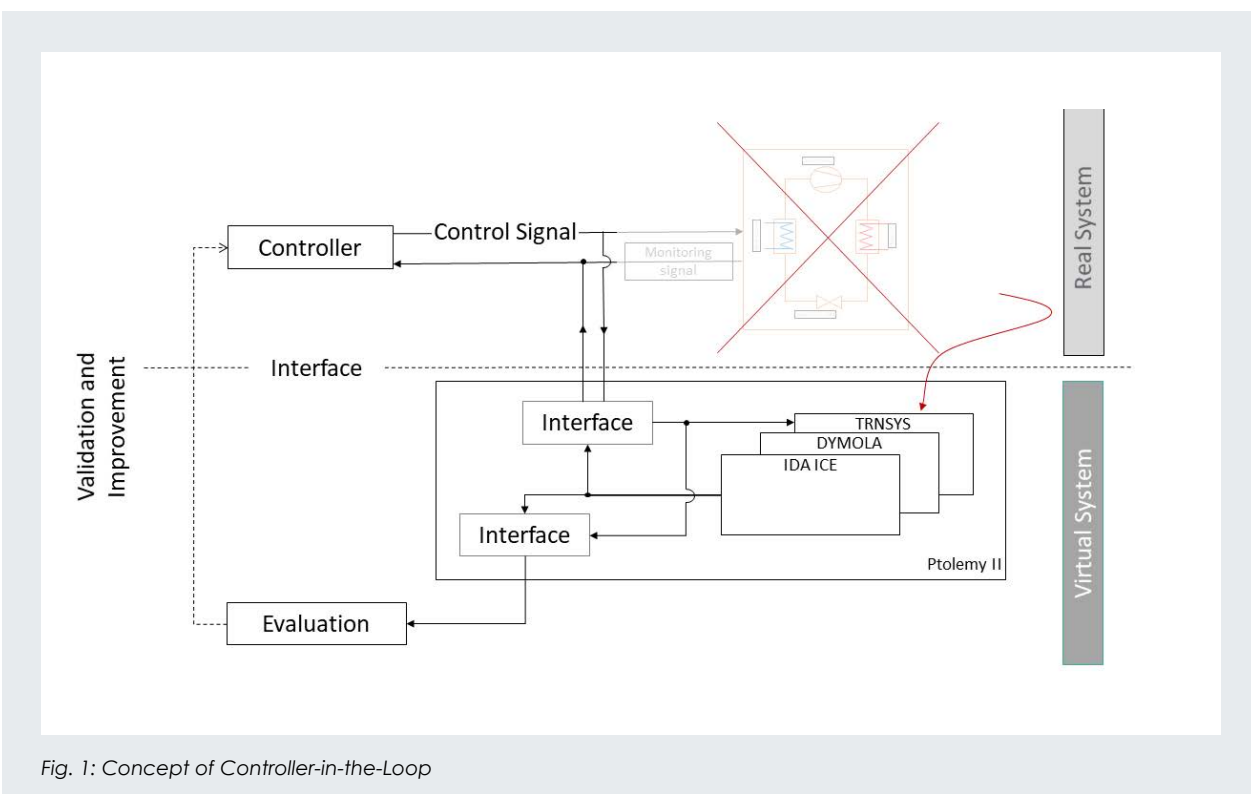


Fig. 1: Concept of Controller-in-the-Loop

In this article, the terms heat pump system and refrigeration system are used interchangeably.

One possible solution to these problems is the concept of Controller-in-the-Loop (CIL). This concept is based on the hardware-in-the-loop (HIL) [4] approach, except that in this case the controller is the physical element and the system to be controlled is the virtual one. This concept is used e.g. for test benches to connect the digital and real world with each other and to make use of their respective advantages. This allows virtual physical models of e.g. drive motors to be tested or further developed with real control electronics without having to build expensive prototypes or test benches. The same concept can also be used for the heat pump sector. Here, a virtual (part)-model of the refrigeration circuit is mapped in a suitable simulation tool and coupled with a real controller intended for this purpose. Furthermore, the controller behaviour can be checked for correct function before the actual initial operation. With the simulation of different test scenarios, e.g. varying source and sink capacities or components with other characteristics, investigations can be made about the behaviour of the refrigeration system and the associated control behaviour.

### Concept description

Within the CIL approach, the real environment is converted into a virtual environment, which is connected with a physical controller, see Figure 1. Hence, two different levels must be considered: the communication level and the simulation level. At the communication level, which is represented in Figure 1 as Interface, a connection between controller and computer must be established, where the data can be transmitted using protocols or direct connections. Hereby, different protocols are available for communication, for example Modbus RTU and TCP/IP as well as BACnet. Depending on the protocol used, the controller must be connected in different ways, for example Modbus RTU with a serial, Modbus TCP/IP and BACnet with a RJ-45 connection. After setting up a connection successfully, the respective protocol must be correctly parameterized on both sides, the master (PC) and the slave (controller). If the connection is analogue and the signals are transmitted directly without using a protocol, Data Acquisition Systems (DAQ) must be used, which convert the analogue signals into digital ones that can be decoded by the PC.

On the simulation level, different tools are available, which are appropriate for various systems. For example Energy Plus, IDA ICE and TRNSYS are well suited for building simulations and Dymola/Modelica [5] as well as MATLAB/Simulink for simulations on the component level. Once the real system has been modelled virtually,

it must be connected to the controller. Therefore a simulation environment must be used, whereby Simulink and the open source tool Ptolemy II are appropriate solutions for this purpose.

### Coupling of physical controller and numerical refrigeration circuit model

The CIL approach described above is demonstrated in the following by coupling a real Carel cPCO controller with a virtual refrigeration system. In this example all communication is done via Modbus RTU and a RS-485 to USB converter. For the simulation of a refrigeration circuit Dymola/Modelica was chosen as a suitable simulation environment. With this tool, the real system can be represented sufficiently accurately to simulate the system dynamics. Ptolemy II was used for the present example for coupling the virtual and the real world because of its simple extensibility, since own functions can be programmed and integrated in Java. In this way a Modbus RTU Reader and Writer were implemented.

Figure 2 shows the process starting from an enclosed heat pump model developed in Dymola/Modelica ending up in an interconnected model to the real environment and integrated into Ptolemy II. The heat pump is based on components from TLK Thermo's TIL library, where components of a compressor, condenser, expansion valve and evaporator for space heating and hot water are interconnected. This model represents the use case of building retrofitting with a brine-water heat pump. Table 1 shows the model parameters. A piston compressor with On / Off control at 50 Hz mains frequency is used. The operating limits are selected according to the application for domestic hot water and space heating, which means a maximum sink temperature of 60 °C and a minimum source temperature of -15 °C. The suction gas super heating temperature is set to 7 K. The circulation pumps on the source and sink side are on/off controlled. It should be noted that the numerical model does not have any control architecture implemented. The control mechanism is provided from the hardware controller.

After successful modelling, the virtual sensors and actuators, which are needed for the subsequent control, are defined as inputs and outputs of the model. Afterwards it is possible to create a Functional Mockup Unit (FMU) to add it to Ptolemy II. As a last step, the inputs and outputs of the DYMOLA FMU must be connected to the Modbus RTU communication blocks and communication with the physical controller is possible.

The controller will be tested in consideration of the above mentioned boundary conditions in terms of security

Table 1: Model parameters.

Refrigerant	Compressor	Heating capacity	Max. sink temperature	Min. source temperature	Suction gas superheating	Sink pump	Source pump
R1234zee (Low GWP)	Piston On/off	7kW @B0W35	60°C	-15°C	7K	On/off	On/off

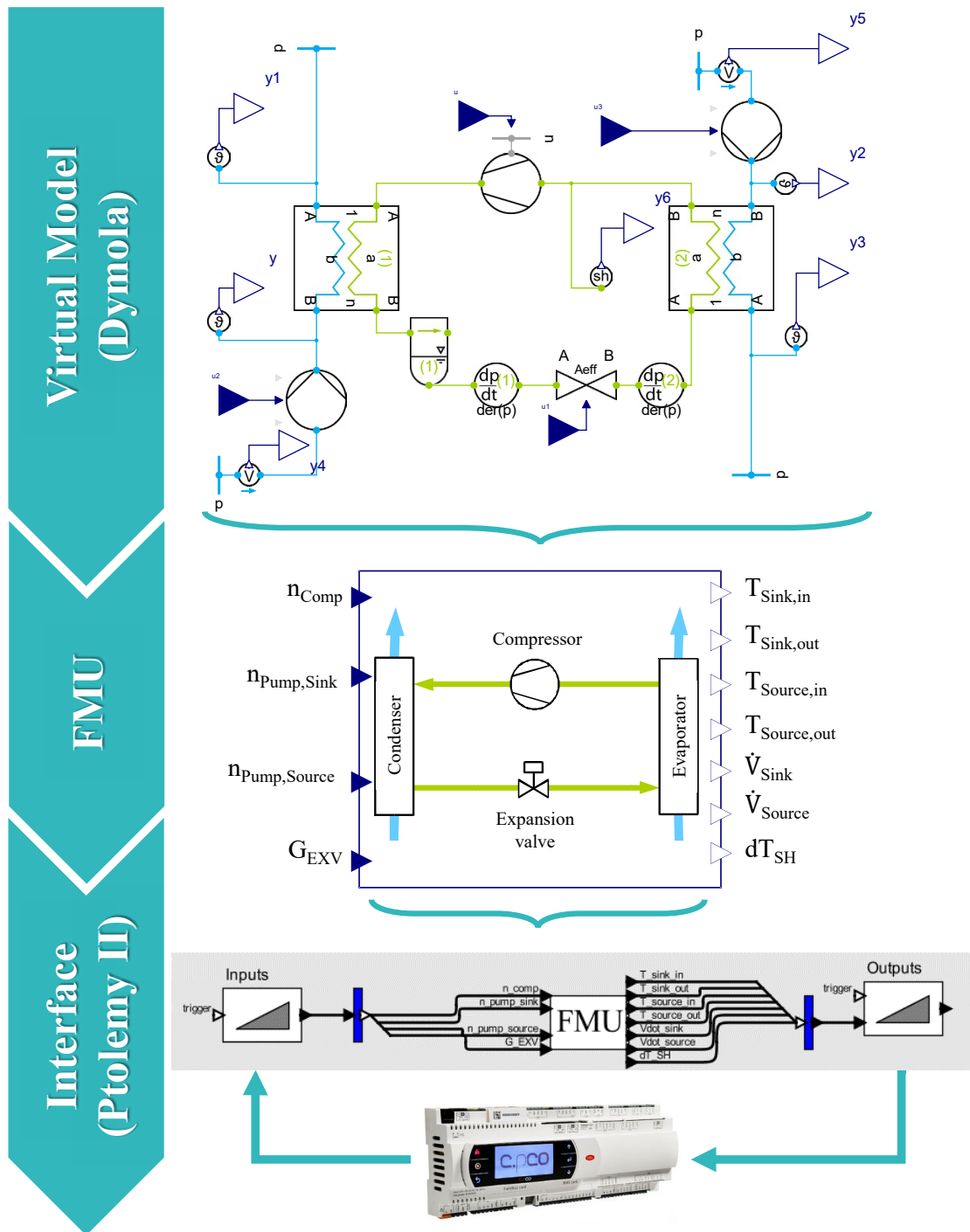


Fig. 2: Processing an enclosed Dymola/Modelica model into an interconnected model to the real environment and integrated into Ptolemy II.

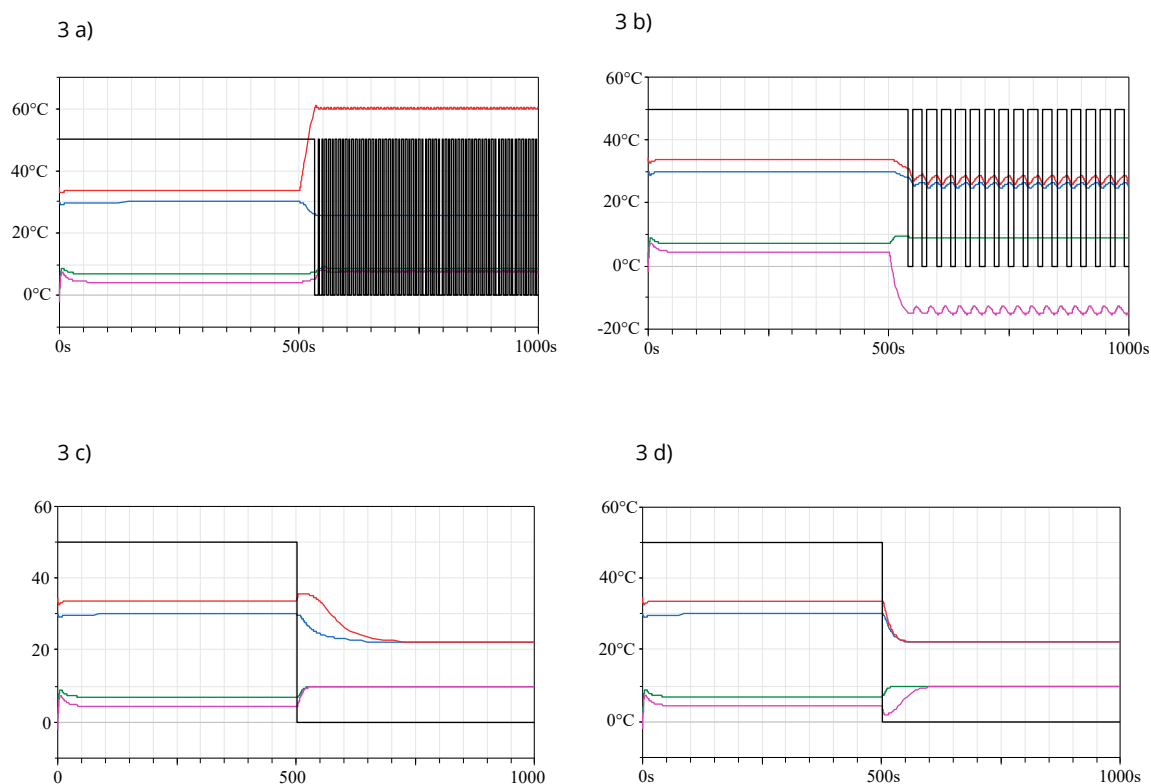


Fig. 3: Induced abrupt mass flow drop on sink/source side at 500 s

3a) Sink side, incorrect controller parameters. 3b) Source side, incorrect controller parameters.

3c) Sink side, corrected controller parameters. 3d) Source side, corrected controller parameters.

management. Following the heat pump test standards EN14511 [6] and EN14825 [7], the sink flow and the source flow are abruptly set to about 0 m<sup>3</sup>/h. If the controller parameters are set correctly, the minimum flow rate protection should switch off the compressor immediately preventing any damage to the system.

## Results

As an example of error detection, figures 3a-3d show the effects of abruptly reduced water-side volume flows on the sink (figs 3a, 3c) and source (figs 3b, 3d) side at 500 s, if the minimum volume flow rate protection was implemented incorrectly. Figs 3a and 3b show the effects of non-identification of the error.

On the sink side (fig 3a), the sink outlet temperature (red line) increases due to the strongly reduced water-side flow rate. A further protective mechanism intervenes and shuts down the compressor (black line) when the maximum allowed sink side temperature of 60 °C is reached. Once this temperature has dropped below the maximum sink temperature, the compressor is switched on again. This cycled operation leads to a significant

number of compressor starts in a short amount of time, which reduces the compressor lifetime. After identifying the error, the minimum flow rate has been adjusted and the controller shuts down the refrigeration circuit after error identification, (fig 3c).

A similar behaviour can be observed on the source side (figs 3b, 3d). Here, a minimum return temperature (pink line) must not drop below the minimum flow temperature (e.g. -15 °C frost protection in the piping), which again leads to an increased number of compressor starts (fig 3b). Here, the error is also corrected by adjusting the switch-off volume flow and the refrigeration circuit is shut down correctly (fig 3d).

## Conclusions

In this article, the CIL approach was explained in some detail and completed with a practical example. Due to the good availability of different protocols, which are already handled by every established controller manufacturer, coupling with a PC is quite uncomplicated. Even analogue signals can be converted into digital signals

with DAQ devices and made available on a PC. On the PC side, different well-established simulation programs are available to represent different systems virtually. These programs can be coupled to the real environment with different tools, if the protocols used are correctly implemented. By successfully coupling a real controller with a virtual plant model, errors could be identified and corrected without prototypes and without the risk of damaging the plant. In contrast to a purely software-based control strategy test, it was possible to test with a dynamic model and under consideration of all influences, e.g. communication delays. After such tests, the controllers can be connected directly to the real device without considering possible porting errors of the control software from the PC to the controller.

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## INFORMATION



## New HPT TCP Annex: Internet of Things for Heat Pumps

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

**Visit the Annex website for more information:**

<https://heatpumpingtechnologies.org/annex56/>

ANNEX <h1 style="font-size: 2em; margin: 0;">56</h1>	START DATE: <b>1 January 2020</b> END DATE: <b>31 December 2022</b>
<p><b>Internet of Things for Heat Pumps</b></p> <p>The Annex description: The IoT Annex focusses on the opportunities and challenges of IoT enabled heat pumps. Connected devices will play a major role in the future address...</p>	
<a href="#">Read more</a> ⓘ	<a href="#">Visit annex</a> ↗

# Events 2020/2021

Any updates about the situation regarding the Corona virus have been added, as of 10 November 2020.  
Please closely check the info of any Conference you plan to attend.

## 2020

**2-4 December**  
**51<sup>st</sup> International HVAC&R Congress and Exhibition**  
Virtual Conference  
<https://www.rehva.eu/news/article/the-51st-international-hvacr-congress-and-exhibition-is-going-online>

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

## 2021

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

**13-15 January 2021**  
**Compressors 2021**  
– 10<sup>th</sup> International Conference on Compressors and Coolants  
Virtual Conference  
[https://szchkt.org/a/conf/event\\_dates/49?locale=en\\_GB](https://szchkt.org/a/conf/event_dates/49?locale=en_GB)

**9-11 February**  
**ASHRAE Virtual Winter Conference**  
Virtual Conference  
<https://www.ashrae.org/conferences/2021-virtual-winter-conference>

**8-10 March**  
**2021 ASHRAE Virtual Design and Construction Conference**  
Virtual Conference  
<https://www.ashrae.org/conferences/topical-conferences/2021-virtual-design-and-construction-conference>

**April [exact date is not provided]**  
**The 10<sup>th</sup> Asian Conference on Refrigeration and Air-Conditioning (ACRA 2020)**  
Hangzhou / Shanghai, China  
<http://www.acra2020.org/>  
<https://file.aconf.org/conf/hz/2019/07/173386/docs/Notice%20on%20the%20Postponement%20of%20ACRA2020.pdf>

**20-21 April**  
**Cold climate HVAC & Energy**  
Virtual Conference  
<https://hvac2021.org/>

**26-29 April**  
**13<sup>th</sup> IEA Heat Pump Conference 2020**  
Jeju, South Korea & Virtual  
<http://hpc2020.org/>

**3-5 May**  
**Euroheat & Power**  
Vilnius, Lithuania & Virtual  
<https://www.ehpcongress.org/>

**13-15 May**  
**9<sup>th</sup> IIR Conference on Ammonia and CO<sub>2</sub> Refrigeration Technologies**  
Ohrid, North Macedonia  
<https://iifir.org/en/events/9th-iir-conference-on-ammonia-and-co2-refrigeration-technologies>

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

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

**16-18 June**  
**2<sup>nd</sup> IIR Conference on HFOs and Low GWP blends (HFO2021)**  
Mixed online and onsite Conference (Osaka, Japan)  
<https://biz.knt.co.jp/tour/2021/06/hfo/index.html>

**21-23 June**  
**Healthy Buildings, Europe 2021**  
Oslo, Norway  
<https://www.hb2021-europe.org/index.html>

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

**August 22-25**  
**International Sorption Heat Pump Conference 2021**  
Berlin, Germany  
[https://www.eta.tu-berlin.de/menue/ishpc\\_2021](https://www.eta.tu-berlin.de/menue/ishpc_2021)

**August 25-27**  
**8<sup>th</sup> International Building Physics Conference (IBPC)**  
Copenhagen, Denmark  
<https://www.ibpc2021.org/>

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

**1-3 September**  
**6<sup>th</sup> IIR Conference on Thermophysical Properties and Transfer Processes of refrigerants**  
Vicenza, Italy  
<http://static.gest.unipd.it/TTPR2021/>

**6-8 September**  
**12<sup>th</sup> International Conference on Compressors and their Systems**  
London, UK  
<https://www.city.ac.uk/events/conferences/compressorsconference>

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

## Postponed until further notice

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

**IN THE NEXT ISSUE**  
**Heat pumps in multi-family buildings**

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#### International Energy Agency

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

#### Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)

International collaboration for energy efficient heating, refrigeration, and air-conditioning.

#### Vision

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

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

#### Mission

To accelerate the transformation to an efficient, renewable, clean and secure energy sector in our member countries

and beyond by performing collaborative research, demonstration and data collection and enabling innovations and deployment within the area of heat pumping technologies.

#### Heat Pump Centre

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

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



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