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Interconnected heat pumps in Austria: A technology implementation survey

Veronika Wilk[a*], Reinhard Jentsch[a], Tilman Barz[a]

[a] AIT Austrian Institute of Technology GmbH, Giefinggasse 2, 1210 Vienna, Austria

Abstract

Heat pumps become increasingly connected devices enabled to participate in the Internet of Things (IoT). Such heat pumps, both in domestic and industrial applications, allow for operation optimization to reduce energy consumption, to reduce the carbon footprint, to realize economic benefits or to increase comfort. They also enable grid services, which is of increasing importance due to the rising share of renewable energy. This contribution presents results of a survey among companies of the Austrian heat pump industry which was conducted to gather and evaluate the general sentiment on the relevance of interconnected heat pumps, state-of-the-art use cases, market availability and selected technology trends. The collected feedback clearly indicates significant progress in technology implementation. All participating companies offer both, IoT products (e.g. heat pumps with connectivity or intelligent components such as compressors or sensors), and related services (e.g. marketing of flexibility, remote service, monitoring, etc.). While two thirds of these products are already available either in the product portfolio of the companies, or in a large number in use, another third is currently under evaluation, under development or in a pilot phase. IoT technology is expected to bring significant changes in product development, business models and maintenance. For IoT enabled heat pumps this means that instead of being an autonomous smart component, they will be increasingly integrated and will be part of connected energy systems in the future.

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Keywords: products; services; data transmission protocols; communication interfaces; trends

1. Introduction

Ambitious climate, energy and environmental goals require the transformation of the energy system into an efficient and renewable system with low CO_2 emissions. Digitalization is one of the important factors for this transformation. According to the IEA, digitalization is the increasing interaction and convergence between the digital and physical worlds. The digital world comprises data (digital information), analytics (the use of data to produce useful information and insights) and connectivity (exchange of data between humans, devices and machines) through digital communication networks. Digitalization is driven by increasing volume of data due to the declining costs of sensors and data storage, rapid progress in advanced analytics and computing capabilities, and greater connectivity with faster and cheaper data transmission. [1] Intelligent, digital solutions are increasingly in demand to efficiently use various flexibility options such as power-based heat generation, the use of storage facilities or e-mobility as well as to safely control the electricity grid. The EU has high expectations for digital technologies in the energy transition, as they should unlock the full potential of flexible energy generation and consumption. Digital technologies enable system optimization, operational savings and savings in network infrastructure, as they should provide the necessary data to match supply and demand both locally and system wide. Therefore, the EU Commission has adopted an action plan in October 2022 that aims to contribute to the EU energy policy objectives by the development of a sustainable, cyber-secure and competitive market for digital energy services and digital energy infrastructure. Main pillars are the

* Corresponding author. Tel.: 0043 664 6207794; fax: 0043 50550 6679.
E-mail address: veronika.wilk@ait.ac.at

establishment of a common European energy data space for sharing and using energy data, a code of conduct for interoperability, enhanced participation in demand-response schemes for energy-smart appliances and strengthening cyber security and resilience of the energy system. [2]

Heat pumps are a versatile technology for the provision of domestic hot water and process heat, and for cooling of buildings and processes. According to the IEA's Net Zero by 2050 report, a total of 1800 million heat pumps have to be installed in buildings world-wide to provide more than half of the heating needs. It is a tenfold increase compared to the level of 2020 [3]. The EU aims at doubling the current deployment rate of individual heat pumps, resulting in a cumulative 10 million units over the next 5 years to be installed. [4]

As digitalization progresses, heat pumps increasingly become connected devices that participate in the Internet of Things (IoT). They can be designed to intelligently meet demand, enabling real-time energy efficiency, flexible use of electricity, optimized load profiles and an optimized compromise in terms of comfort and operating costs. IEA's Net Zero by 2050 report also elaborates on the impact of digitalization on emission reduction. Advances in technology, e.g. smart thermostats or other smart appliances lower carbon emissions, as they reduce the necessity for people to play an active role in energy savings. It is expected that emissions from the building sector will be reduced by 350 Mt CO_2 by 2050 due to digitalization and smart controls. [3]

Recently, the impact of digitalization was assessed for Austria and Germany. The Austrian study analyzed the potential for reducing energy consumption and GHG emissions through applications of digitalization by 2040. It was found that, taking into account the increased energy consumption of the necessary ICT infrastructure, effective savings of 4 – 9% of energy consumption can be reached by 2040. This is equivalent to a 2-10% reduction of greenhouse gas emissions and reductions of up to 2.3 million t CO_{2eq}. The highest net effect on energy consumption can be realized by process automation in industry, smart homes, simulation and digital twins in industry and building automation in the service sector. [5] Similar high potential was identified for Germany, where digitalization could contribute up to 34% of the CO_2 emission reduction that is required according to the climate targets for 2030 (up to 126 Mt CO_{2eq}). The highest reductions can be achieved in industrial production, mobility, energy, and buildings. Important technologies in buildings are intelligent energy management and intelligent HVAC components. [6]

In the Technology Collaboration Programme on Heat Pumping Technologies of the IEA, the IoT Annex project was launched in 2020. In this collaborative project, researchers from Germany, France, Sweden, Norway, Denmark, Switzerland and Austria explore the opportunities and challenges of connected heat pumps. Both, typically mass-produced heat pumps for household applications, and heat pumps with large capacities for industrial and district heating are included. The Annex project has a broad scope looking at different aspects of digitalization and aims to create a knowledge base on connected heat pumps to provide information for heat pump manufacturers, component manufacturers, system integrators and other actors involved in IoT. This contribution presents the results of a survey among companies of the Austrian heat pump industry to assess the relevance of interconnected heat pumps, state-of-the-art use cases, market availability and selected technology trends.

2. Manufacturer Survey in Austria

2.1. Methodology

The purpose of the survey was to collect feedback from companies in the heat pump market segment to gather and evaluate the general sentiment on the importance of IoT. The survey had more than 50 questions, which were single and multiple choice, rating and ranking as well as free text questions. The average time for completing the survey was about 20 min. The survey was divided in two different parts. The first part was equal for all participants. The second part was different for participants active either on the residential, commercial and office buildings market, or on the industrial heat pump market, with specific questions relevant for each group.

The questionnaire was designed after conduction of interviews and focus groups with domain experts in residential and industrial heat pump technology, buildings automation, data security and electricity market from the IEA HPC Annex 56 expert group. Companies were contacted by the Austrian Heat Pump Association "Wärmepumpe Austria" (WPA) and asked for their participation in the survey. WPA covers the entire value chain of the heat pump industry in Austria and includes heat pump manufacturers, as well as all electricity supply companies, component suppliers and drilling companies as well as planners, installers and engineering companies. Answers were collected from May to June 2022.

2.2. Survey participants

A total of 16 companies participated in the survey. 13 participants answered all questions in the survey, 3 participants only answered a part of them (76%, 84% and 91% completion). All company sizes, from small SME to large companies are covered by the survey: 6 companies have less than 50 employees, 5 companies 50 – 250 employees, and 5 companies have more than 250 employees.

Most companies identified themselves as heat pump manufacturers and heat pump vendors (8), three are heat pump installers (thereof 2 also vendors) and 3 component manufacturers (thereof 1 also heat pump manufacturer and vendor), see Fig. 1. Among the current members of WPA, there are 44 companies that manufacture or import heat pumps, thereof 17 that manufacture a part or all of their products in Austria and 12 component manufacturers. From the numbers of participating companies, it can be concluded that 53% of the heat pump manufacturers, 37% of the vendors and 17% of the component manufacturers were reached.

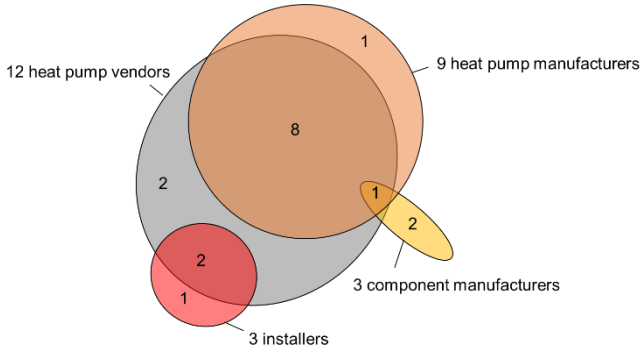

Fig. 1: Participants in the Austrian IoT survey

Activities in market segments: All 16 companies are active on the residential heat pump market including commercial and office buildings. From these 16 companies only 6 have indicated that they are also active in the industrial and district heating market segment (Fig. 2). However, because this second market segment is smaller, and because it is likely that not all companies address this second market segment, no direct conclusions can be drawn about different relevance of IoT in the two different market segments.

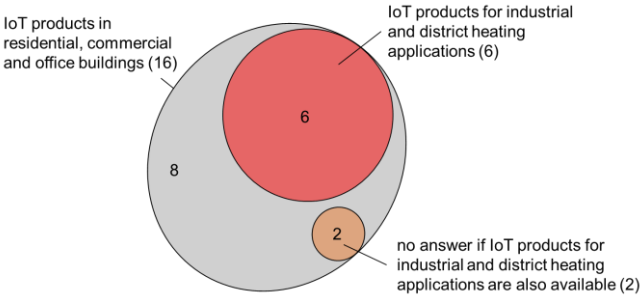

Fig. 2: Market segment covered by the participating companies

2.3. Availability of products and services

The feedback clearly indicates that participating companies have IoT products and services. 66 % are available, which means either in their product portfolio (in implementation), or in a large number in use (extensive implementation). 33% are currently under evaluation, under development or in a pilot phase. All companies offer both IoT products (e.g. heat pumps with connectivity or intelligent components such as compressors or sensors) and services based on IoT products (e.g. marketing of flexibility, remote service, monitoring, etc.). In 56% of the companies, the product and service portfolio have the same maturity level, in 31% the services are further developed than the products and in 13% the products are more advanced and the services still under development.

2.4. Relevance and implementation of IoT related products and services

A self-assessment and comparison to international competitors revealed that 2 companies identify themselves as a pioneer in offering IoT products. The remaining answers from manufacturers are more conservative, 8 regard their products as state of the art, 6 companies see development needs. With regard to the use of IoT services, the feedback is very similar, 1 company regards itself as a pioneer, 7 regard services as state of the art, 8 see development needs.

The feedback on the question who deals with IoT in the company is expectedly diverse, considering the different company sizes among the participants. It ranges from external developers and individual employees, as found in small companies to dedicated IoT departments and company-wide digitalization strategies in medium and large companies. Most commonly, project teams or a part of the development department deals with IoT.

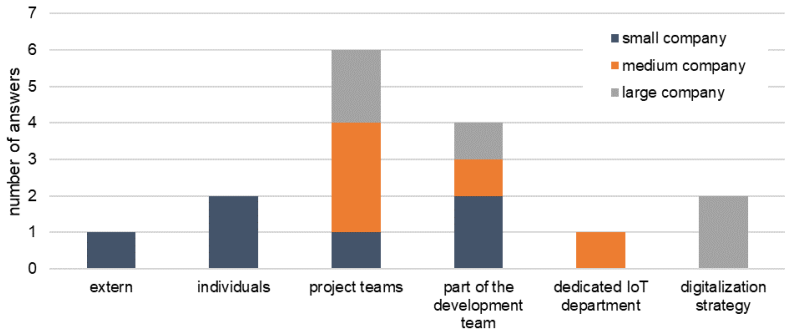

Fig. 3: IoT development by company size

Asked about the motivation for adopting IoT products, the top three selected answers were customer loyalty, service improvement and new business models, see Fig. 4. Cost reduction has been ranked higher than environment awareness. For most companies, IoT products are not seen as a unique selling proposition.

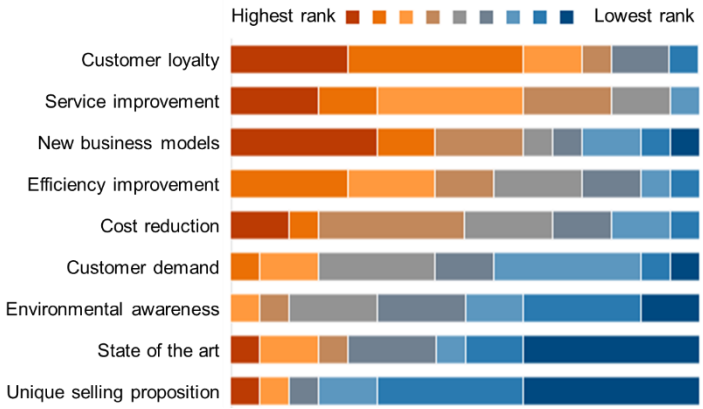

Fig. 4: Motivation to introduce IoT products

2.4.1. IoT in residential, commercial and office buildings

Operation data is collected locally at the heat pump or in a cloud service. For residential, commercial and office buildings, 50% of the companies use both, local storage and the cloud, 31% use the cloud and 13% only local storage. All these companies offer data-based features for the customers, such as operation monitoring and control, visualization of operation data and historic data and integration in a home automation system. To access these features, 93% of the companies provide an app for the customers, 73% have a control panel on the heat pump, 73% provide access to a website and 67% allow for integration in a home automation system. 47% of the companies offer all four ways of access.

The most common interface to collect operation and field data is LAN (81% of the companies), followed by WLAN (63%). 31% offer all interfaces that were mentioned: LAN, WLAN, local wireless, local wired, GSM, interfaces for smart grid ready. The most common transmission protocol is Modbus (75%), followed by

KNX (50%). Data security, transmission security and availability are most frequent reasons to choose the transmission protocol.

On the one side, certain IoT features are explicitly requested by customers. The participants confirmed that the following features are important for their customers: monitoring; interfaces for home automation; interfaces for smart tariffs and marketing of flexibility; coordinated operation with local PV and storage; and optimized maintenance intervals. On the other side, the companies confirm that the following IoT features are of great and almost equal importance for themselves: efficiency improvement; anomaly detection and operational monitoring; installation error detection; improved service offering (e.g. PV or price optimization); and product improvement and development. Interestingly, those IoT features which are seen as important by the companies are also those features which are already in use. A total of 88% of the companies apply data analytics for the following applications: installation error detection; efficiency improvement; anomaly detection and operational monitoring; product improvement and development.

2.4.2. IoT in industrial and district heating applications

For industrial and district heating applications, heat pump data is collected in the cloud and locally, most of the companies have both types. All of them offer integration of the data in the process control system and provide access to features in the cloud. The features comprise visualization of operation and historic data, monitoring and control and integration in the process control system. This is in good agreement with the IoT features requested by the customers. Unlike residential applications, smart tariffs are of less importance in industry.

The most common interface to collect operation and field data is LAN, which is used by all companies, (100%), followed by WLAN (67%). The most common transmission protocol is Modbus (83%), followed by OPC-UA and BACNET (each used by 50% of the companies). The reason to choose the transmission protocol are similar to the residential applications (data security, transmission security and availability).

2.5. Trends and future developments

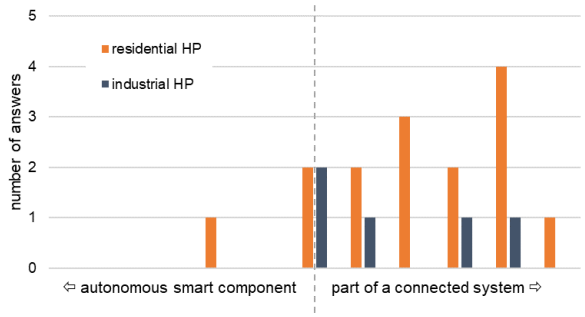

Fig. 5: IoT enabled heat pumps in the energy system

Generally, most participants agree that IoT technology brings significant changes. These changes are especially expected in product development, business models, maintenance and partially in sales. Less or insignificant impact is anticipated in the customer segment, production, installation, and supply. Most companies (except one) explicitly foresee the option to add or change IoT features through software updates after heat pump installation. This can be accomplished mainly via internet or manually by service personal. Three participants state that customers can also manually do software updates.

Clearly, IoT enabled heat pumps are expected to be rather a part of a connected system in the future than an autonomous smart component. As shown in Fig. 5, this was found for both residential and industrial heat pumps. The most important barriers for IoT technologies are the availability of qualified personnel, data protection and legal requirements as well as lack of standards. There is less concern about communication protocols and interfaces and the availability of suitable hardware.

It should be noted that IoT technology is seen as one of several digital transformation technologies to which a high importance is attached for the future. According to Fig. 6, equal or similar importance is attached to machine learning, predictive maintenance and building information modelling. Privacy requirements are ranked neutrally. In contrast, asset administration shell, semantic modeling and digital twin are considered as less important.

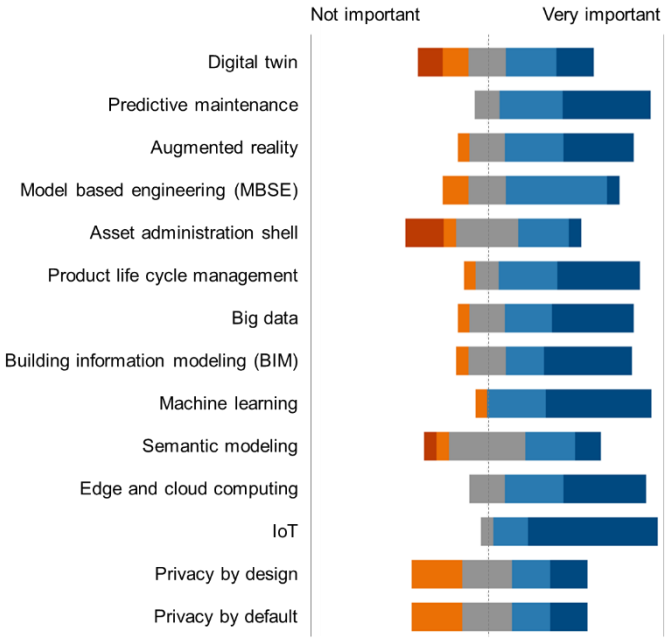

Fig. 6: Importance of digital transformation technologies for the future

3. Conclusions and outlook

A survey on the importance of IoT was carried out among companies of the Austrian heat pump industry. The participants represent 53% of the Austrian heat pump manufacturers and 27% of the heat pump vendors allowing for meaningful results. All companies offer both, IoT products (e.g. heat pumps with connectivity or intelligent components such as compressors or sensors), and services based on IoT products (e.g. marketing of flexibility, remote service, monitoring, etc.). Two thirds of the evaluated products are available, which means either in their product portfolio (in implementation), or already in a large number in use (extensive implementation). Another third is currently under evaluation, under development or in a pilot phase.

Most commonly, IoT products and services are developed by project teams or by a part of the development department. The main drivers for these products and services are customer loyalty, service improvement and new business models. The most important barriers for IoT technologies are the availability of qualified personnel, data protection and legal requirements, as well as lack of standards. There is less concern about communication protocols and interfaces and the availability of suitable hardware. The general expectation shared by all participants is that IoT technology will bring significant changes in product development, business models and maintenance. Moreover, IoT enabled heat pumps are expected to be a part of connected systems, and IoT technology is seen as one of several important digital transformation technologies for the future.

Digitalization is an important factor in the transformation of the energy system. It is expected to facilitate matching of supply and demand with increasing volatile energy production and to significantly contribute to end energy savings and CO_2 emission reductions. Connected heat pumps will play a vital role in the future energy system. Important fields of action are the establishment of common standards and interoperability of the appliances in the energy system. This is now also addressed in the latest EU action plan aiming at a common European energy data space for sharing and using energy data, a code of conduct for interoperability, enhanced participation in demand-response schemes for energy-smart appliances and strengthening cyber security and resilience of the energy system.

Acknowledgements

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References

[1] IEA. Digitalization & Energy. Paris: International Energy Agency, 2017
[2] EU Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Digitalising the energy system - EU action plan. COM(2022) 552 final, October 2022, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0552&from=EN
[3] IEA, Net Zero by 2050, IEA, Paris, 2021. https://www.iea.org/reports/net-zero-by-2050
[4] EU Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. REPower EU Plan. COM(2022) 230 final, May 2022, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483
[5] Baumann M, Eggler L, Pauritsch G, Rohrer M. Auswirkungen der Digitalisierung auf Energieverbrauch und Klima in Österreich, D4.1 Quantifizierung der Szenarien. 2022, https://www.energyagency.at/fileadmin/1_energyagency/projekte/digitalisierung/digat/digat2040_d4.1_modelergebnisse_final.pdf
[6] Accenture. Klimaeffekte der Digitalisierung. Studie zur Abschätzung des Beitrags digitaler Technologien zum Klimaschutz. Bitkom, 2021. https://www.bitkom.org/sites/default/files/2021-10/20211010_bitkom_studie_klimaeffekte_der_digitalisierung.pdf