2025-05-22

Version No. 3

Project 67

Digital services for heat pumps

1. Background

Ambitious climate, energy and environmental goals require the transformation of the energy system into an efficient and renewable system with low CO_2 emissions. Digitalisation is one of the key factors for this transformation. Intelligent, digital solutions are increasingly in demand to efficiently use various flexibility options such as power-based heat generation, the use of storage 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 saving 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 developed an action plan geared at developing a competitive market for digital energy services and digital energy infrastructure, that are cyber-secure, efficient and sustainable.[1] Digitalisation of the energy system is a political priority and is linked to the Green Deal[2] and the programme of the so-called Digital Decade 2030[3].

Heat pumps will play an important role in the energy system of the future. They are a versatile technology for the provision of space and process heat, for water heating 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 with the level of 2020[4]. As digitalisation 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.[5] 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 digitalisation and smart controls.[2]

In the Technology Collaboration Programme on Heat Pumping Technologies of the IEA, the Annex 56 of digitalisation and IoT for heat pumps was launched in 2020 and completed in 2022. In this collaborative project, researchers from Germany, France, Sweden, Norway, Denmark, Switzerland and Austria explored the opportunities and challenges of connected heat pumps. Both heat pumps in household applications that are typically mass-produced, as well as large heat pumps for industrial and district heating

[1] EC, Digitalising the energy system – EU action plan, 18.10.2022, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0552&qid=1666369684560

[2] EC, The European Green Deal, 11.12.2019, https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

[3] EC, Decision (EU) 2022/2481 of the European Parliamend and of the Council of 14 December 2022 establishing the Digital Decade Policy Programme 2030, 19.12.2022, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022D2481&from=EN

[4] IEA, Net Zero by 2050, IEA, Paris, 2021. https://www.iea.org/reports/net-zero-by-2050

[5] Task 1 report of Annex 56: https://heatpumpingtechnologies.org/annex56/wp-content/uploads/sites/66/2024/01/iot-annex-task-1-report.pdf

applications were included. Annex 56 had a broad scope looking at different aspects of digitalization and created a knowledge base on connected heat pumps to provide information for heat pump manufacturers, component manufacturers, system integrators and other actors involved in IoT. It summarized the most important aspects of digitalisation for heat pumps, the state of digitalisation in the participating countries and gives an overview on interfaces and communication, data analysis and business models and services.

The project "Digital services for heat pumps" is the follow up project of Annex 56 in the field of digitalisation. This Project will focus strongly on the heat pump specific digital services, in contrast to Annex 56, where connectivity, data exchange and interaction with other elements of the energy system was important.

The topic of digitalisation plays an important role in the IEA Heat Pumping Technologies TCP and is included in the current strategy in the RDD&D priority area of *System integration*. The use of digital technologies for heat pumps will also address aspects of *Robust, sustainable and affordable value chains* and *Extending operation range and applications*.

Digitalization is also an important topic in other TCPs, such as EBC or DHC. To be mentioned from EBC in this context are e.g., Annex 91 (*Open BIM for Energy Efficient Buildings*)[6] and Annex 82 (*Energy Flexible Buildings Towards Resilient Low Carbon Energy Systems*)[7]. As for the TCP DHC e.g. FAST DHC (*Feasibility Assessment Tool for District Heating and Cooling*) [8] and FlexVal (*Flexibility and DH value chain – advanced analysis & compatible pricing*)[9] are seen relevant. Collaboration with these projects is sought to exchange knowledge on methodologies and examples of successful application of digital services that can be transferred to the heat pump sector.

According to IEA, digitalization is one of the decarbonization enablers that is tracked continuously to show the progress towards the 2050 targets.[10] Digital technologies hold the potential to accelerate the energy transition and enable integration of renewable, efficiency increase and CO_2 emission reduction. The current status of the tracking shows that more efforts are needed. This project is a contribution to this target.

2. Description of technical sector; definitions

The project addresses the heat pump sector, it aims to investigate how to make use of digital services for heat pumps. There are several important developments in the last decade that are not yet commonly applied in the heat pump business, such as advanced modelling, big data methods, advanced process control, augmented reality and digital planning methods.[11] These digital services can play a vital role to tackle the challenge of the expected growth rates for heat pumps needed to comply with the climate targets (e.g. installation of about 600 million heat pumps covering 20% of building heating needs required by 2030[4]).

[6] https://www.iea-ebc.org/projects/project?AnnexID=91
[7] https://www.iea-ebc.org/projects/project?AnnexID=82
[8] https://www.iea-dhc.org/the-research/annexes/annex-xiv/annex-xiv-project-02
[9] https://www.iea-dhc.org/the-research/annexes/annex-xiv/annex-xiv-project-05
[10] https://www.iea.org/energy-system/decarbonisation-enablers/digitalisation#tracking
[11] Task 1 report of Annex 56: https://heatpumpingtechnologies.org/annex56/wp-content/uploads/sites/66/2024/01/iot-annex-task-1-report.pdf

3. Objectives and scope

The report on *Technology and innovation pathways for zero-carbon ready buildings by 2030*[12] that was recently published by the IEA, emphasizes the role of digitalisation for data harvesting and processing and to provide evidence base for planning instruments (holistic approach to local design and planning). In the policy recommendations, it is also mentioned to promote the development of open shared communication protocols for energy technologies and the need for smart systems integration and interoperability (e.g. heat pumps, PV, energy storage and mobility). These challenges require a systemic approach, as it is not so much related to the technical ability to communicate, but the orchestration of the different actors towards a common goal (e.g. grid balancing). Component manufacturers mentioned in the IoT Annex that they offer different interfaces and protocols, which are chosen based on the requirements of the higher level component or system. For the orchestration, the system is decisive, e.g. the building management system interacting with the district heating grid or the pool of heat pumps providing flexibility for the power grid.

The aim of this project is therefore not the orchestration of the higher level systems, but it **should focus on the heat pump and its components**. It should answer the question **how to make use of digital services for heat pumps in various fields of action during their life cycle**, in particular:

- **Product design** as a first step of the heat pump production, and **testing** to maintain high quality standards, e.g.,
  - Semantic modelling to generically describe heat pumps for modelling: This technique enables fast and efficient heat pump modelling,
  - Digital twins for the whole product life cycle to avoid repeated modelling,
  - Modelling (e.g., Modelica) and simulation focussed on the modular design of heat pumps for the change of components and adaption of the design in simulation tools, thereby avoiding unnecessary prototypes,
  - Hardware-in-the-loop (HIL) tests of heat pumps for dynamic conditions and interactions with emulated components and buildings enabling more realistic testing especially of the heat pumps' controls.

- Successful **integration** to reach high efficiency and ensure operator satisfaction, e.g.,
  - Augmented reality (AR) assisted placement of heat pumps for operators and planners, especially of outdoor units possibly causing sound emissions to neighboring properties,
  - Data based installation error detection for faster and more efficient commissioning of heat pumps.

- Digitalisation (models, controller) for the optimal **operation** of heat pumps with different optimization goals (e.g., lowest CAPEX, lowest CO_2 emissions, flexibility etc.), and efficient **maintenance**, e.g.
  - Data-based operation optimization by comparing real with ideal behaviour,
  - Model-based heat pump controls enabling different optimisation goals like lowest CAPEX, lowest CO2 emissions etc. incl. adequate user interfaces
  - Self-adapting models, e.g., including fouling
  - Ambient heat calculation and other KPIs to determine the quality of the operation
  - Fault-tolerant control
  - Flexible operation of heat pumps within operating limits

[12] IEA, Technology and innovation pathways for zero-carbon ready buildings by 2030, IEA, Paris, 2022, https://www.iea.org/reports/technology-and-innovation-pathways-for-zero-carbon-ready-buildings-by-2030

- Predictive maintenance to enhance reliability of installed heat pumps and reducing downtimes as well as maintenance costs
- Augmented reality (AR) technologies for, e.g., enhanced maintenance and efficient servicing
- Digital services for heat-as-a-service solutions

4. Means

The Participants shall share the coordinated work necessary to carry out the work required for this Project. Therefore, each participant is requested to contribute knowledge as well as problem-solving capacity to the identified fields of interest.

The work will be divided in several tasks, task leadership will be distributed among the participants.

The objectives shall be achieved by the following task-sharing activities:

Task 1: Design of the knowledge base

- Design of the knowledge base on the use of digital methods for heat pumps, including examples from research projects and methods/approaches already implemented
- Identification and definition of the relevant information for the knowledge base on examples of digital services
- Preparation of the presentation concept for the target audience, e.g., fact sheets
- Design of the survey in Task 2, creation of an adequate questionnaire
- Milestone 1: Questionnaire ready for the survey in Task 2

Task 2: Collection of information

- Gathering information (about digital methods for heat pumps, including examples from research projects and methods/approaches already implemented) by literature review, expert interviews, market research, and contributions from national research projects by using the questionnaire from Task 1.
- Milestone 2: Completed questionnaires available for synthesis in Task 3

Task 3: Synthesis of information

- Evaluation of the gathered information and derivation of findings (e.g., open development/research questions)
- Completing the knowledge base
- Preparation of the know-how transfer to the target audience
- Milestone 3: Knowledge base (on the use of digital methods for heat pumps, including examples from research projects and methods/approaches already implemented) completed

Task 4: Dissemination, communication, and reporting

- Dissemination and communication activities for the target groups including, e.g., the organisation of a concluding webinar,
- Collaborations with other related projects in other TCPs,
- Creation of a Project website as a knowledge base on the use of digital methods for heat pumps, including examples from research projects and methods/approaches already implemented,
- Reporting and project management

5. Target audience and Benefits

- Heat pump value chain, i.e., **manufacturers, planners and installers, operators:** knowledge about digital methods for optimised design and production of (modular) heat pumps; knowledge about resp. tools for optimized integration, maintenance, and operation to ensure maximum service life of heat pumps & components thereof and lowest possible operating costs and useability (acceptance) for heat pump operators.
- **Associations** (national HP associations, EHPA): targeted information for their members
- **Research community**: knowledge about latest scientific/technical developments in the participating countries; identification of possible research gaps.

6. Deliverables

The compulsory deliverables of the Project are:

- Final report of the Project according to template
- A public Project Website as a subsite to the HPT website
- Progress reports to ExCo meetings according to template for dash-board; once a year oral presentations (focusing on results, achievements and/or success stories) and twice a year management reports
- Content to at least 4 News per year, related to the Project, to be published on the HPT website and in the Heat Pumping Technologies (HPT) Newsletter.
- One article per year, topical or non-topical, to the Heat Pumping Technologies (HPT) Newsletter/Magazine
- Report to the HPT Annual report
- Text and pictures to a 2-page popular scientific summary of Project results to be freely disseminated;
- A webinar presenting the final results from the Project;

Further deliverables of the Project are:

- On the public Project Website a knowledge base on the use of digital methods for heat pumps, including examples from research projects and methods/approaches already implemented

7. Funding

(a) Working Meetings. The working meetings shall be hosted in turn by the several Participants. The costs of organizing and hosting meetings shall be borne by the host Participant.

(b) Publications: The cost of publishing the Final Report and summary assessments described in paragraph 6 above shall be equally shared by all the Participants.

(c) Individual Financial Obligations. Each Participant shall bear all the costs incurring in carrying out the Task activities, including reporting and travel expenses. Additionally, each Participant shall make a direct financial contribution to the Project Manager to cover co-ordination and report preparation expenses and other Project-related (e.g. Workshop) costs.

The table below shows the fees per participating country, based upon varying numbers of participating countries. Each Participant's fee shall be paid in 1 annual instalments.

No of participants	Participants' fees		
	2025	**2026**	**2027**
2	8.800	8.800	8.800
3	6.600	6.600	6.600
4	6.100	6.100	6.100
>4	5.500	5.500	5.500

8. Time schedule

It is proposed that this Project be conducted over a period of 36 months to begin Q1/2025. The following is a tentative work schedule for the different tasks.

Start Date	End Date	Activity
01/2025	01/2026	**Task 1: Design of the knowledge base**
10/2025	03/2027	**Task 2: Collection of information**
01/2027	10/2027	**Task 3: Synthesis of information**
01/2025	12/2027	**Task 4: Dissemination, communication, and reporting**

9. Specific obligations and responsibilities of the participants

(a) Each Participant shall nominate a representative to participate in the work under this Project.

(b) Each Participant shall carry out the equivalent of total three person months of task-sharing work during the programme period unless otherwise agreed by the Participants.

(c) Each Participant shall contribute to the working meetings and to a workshop on the results achieved through the activities conducted under this Project, including the identification of speakers and participants.

(d) Each Participant shall make a direct financial contribution to the Project Manager to cover co-ordination and report preparation expenses and other Project related (e.g. Workshop) costs.

10. Specific obligations and responsibilities of the Project Manager

The Project Manager shall:

(a) Develop, in co-operation with the Participants, a detailed work programme, a framework for the Final Country Report and a budget for all the activities carried out under this Project, including methodology and time schedule

(b) Provide the Executive Committee with periodic reports describing the progress of the work being accomplished under the Project, once a year oral (focusing on results, achievements and/or success stories) and twice a year a management report.

(c) Deliver the results as described in Section 6.

(d) Provide to the Executive Committee, within six months after completion of all work under the Task, a Final Report for its approval and transmittal to the Agency.

(e) In co-ordination with the Participants, use its best efforts to avoid duplication with activities of other related programs and projects implemented by or under the auspices of the Agency or by other competent bodies.

(f) Provide the Participants with necessary guidelines for the work they carry out, assuring minimum duplication of effort.

(g) Co-ordinate the efforts of all Participants and ensure the flow of information within the Task.

(h) Co-ordinate the work to ensure the compulsory deliverables to the HPC Newsletter/Magazine and to the website

(i) Provide general administration

The IEA Heat Pump Centre will assist in the establishment of the Project. Thereafter, the Heat Pump Centre will follow the Project to check that the routines are followed, that the status and progress reports are delivered in due time and the quality of them. They will also assist the OA in the publication of the final reports and compilation of the summary in the end of the Project. Therefore, it is the responsibility of the OA to follow the instructions of Heat Pump Centre.

11. Information and Intellectual property

(a) *Executive Committee's Powers.* The publication, distribution, handling, protection and ownership of information and intellectual property arising from this Project shall be determined by the Executive Committee, acting by unanimity, in conformity with Article 9 of the HPT Implementing Agreement and the terms of this Annex.

(b) *Right to Publish*. The Participants shall have the right to publish information provided to or arising from their Task, except for proprietary information, as defined in paragraph (c) below.

(c) *Proprietary Information.* For the purposes of this Project, proprietary information shall mean information of a confidential nature such as trade secrets and know-how (for example, computer programmes, design procedures and techniques, chemical compositions of materials, or manufacturing methods, processes or treatments) which is appropriately marked provided that such information:

(1) Is not generally known or publicly available from other sources
(2) Has not previously been made available by its owner(s) to others without obligation concerning its confidentiality; and
(3) Is not already in the possession of the recipient Participant(s) without obligation concerning its confidentiality.

It shall be the responsibility of each Participant supplying proprietary information, and of the Project Manager, to identify such information as proprietary and to ensure that it is appropriately marked.

The Participants and the Project Manager shall take all necessary measures in accordance with this paragraph, the laws of their respective countries and international law to protect the proprietary information provided to or arising from this Task.

(d) *Production of Relevant Information by Governments.* The Project Manager should encourage the governments of all Agency Participating Countries to make available or identify to the Project Manager all published or otherwise freely available information known to them that is relevant to the Task.

(e) *Production of Relevant Information by Participants.* Each participant agrees to provide to the Project Manager all previously existing information, and information developed independently of the Task, which can assist or is needed by the Project Manager to carry out its functions in this Task, which is freely at the disposal of the Participants, and the transmission of which is not subject to any contractual and/or legal limitations, under the following conditions:

> (1) The Participant will make such information available, at its own costs, provided that such costs are not substantial
> (2) If substantial costs are necessary for the Participant to make such information available, the Project Manager and all Participants will determine the charge of the costs for each participant, upon approval of the Executive Committee.

(f) *Use of Confidential Information.* If a Participant has access to confidential information which would be useful to the Project Manager in carrying out the studies, assessments, analysis or evaluations described in this Project, such information may be communicated to the Project Manager but shall not become part of any report or other form of documentation issued as part of this Task, nor shall it be communicated to the other Participants, except as may be agreed between the Project Manager and the Participant who supplies such information. This information has to be marked clearly as “confidential”.

(g) *Acquisition of Information for the Task*. Each Participant shall inform the Project Manager of the existence of information that can be of value to the Task, but which is not freely available, and each Participant shall endeavour to make such information available to the Task under reasonable conditions, in which event the Executive Committee may, acting unanimity, decide to acquire each information.

(h) Reports on Work Performed under the Task. The Project Manager shall prepare reports on all work performed under the Task and the result thereof, including studies, assessments, analysis, evaluations and other documentation, but excluding proprietary information, in accordance with paragraph 11(c) above.

(i) *Copyright.* The Project Manager, or each Participant for its own results, may take appropriate measures necessary to protect copyrightable material generated under this Task. Copyright obtained shall be the property of the Project Manager, for the benefit of the Participants provided, however, that Participants may reproduce and distribute such material, but shall not publish it with a view to profit, except as otherwise provided by the Executive Committee.

The Contracting Parties understand and agree that the name, acronym and emblem of the IEA has been communicated under Article 6ter(3)(b) of the Paris Convention for the Protection of Industrial Property as amended on 28 September 1979. The Contracting Parties further understand and agree that the IEA shall retain the rights to all background IEA work, materials or publications shared with the Participants by the IEA in connection with this Project. Should any joint work be carried out under this Annex between the IEA and one or more of the Participants in this Project, a separate written agreement will be necessary regarding the resulting intellectual property.

(j) Authors. Each Participant shall, without prejudice to any rights of authors under its national laws, take necessary steps to provide the co-operation from its authors required to carry out the provisions in this paragraph. Each Participant shall assume the responsibility to pay awards or compensation required to be paid to its employees according to the laws of its country.

12. Project Manager

The Austrian Institute of Technology GmbH based in Vienna, Austria, is designated as Project Manager.

Contact information for the Project Manager:

Name	Bernd Windholz
Affiliation	AIT – Austrian Institute of Technology GmbH
Postal address	Giefinggasse 4, 1210 Vienna, AUSTRIA
Telephone number	+43 664 2351933
E-mail address	Bernd.Windholz@ait.ac.at

13. Participants in this Project

The following table shows interested countries, there are no contracting countries yet:

Organisation	**Country**
The Federal Ministry of Transport, Innovation and Technology	Austria
Region of Belgium (Flemish Region)	Belgium
Danish Technological Institute	Denmark
Forschungszentrum Jülich GmbH	Germany
New Energy and Industrial Technology Development Organization	Japan
The Swedish Energy Agency	Sweden
Department of Energy	USA

14. Research organisations participating in this Project

The following table shows interested parties, there are no contracting parties yet:

Organisation, Name, address and website	Contact person, phone and e-mail	Country	Project NT leader (Y/N)
AIT – Austrian Institute of Technology GmbH, Giefinggasse 4, A-1210 Wien, AUSTRIA www.ait.ac.at	Bernd Windholz +43 664 2351933 Bernd.Windholz@ait.ac.at	Austria	Y
KTH Royal Institute of Technology, Sweden Department of Energy Technology Brinellvägen 68, SE-100 44 Stockholm, http://www.energy.kth.se	Davide Rolando drolando@kth.se	Sweden	
RI.SE Research Institutes of Sweden, Drottning Kristinas väg 61, Box 5604, SE-114 86 Stockholm, Sweden	Metkel Yebiyo metkel.yebiyo@ri.se	Sweden	
DTU Technical University of Denmark, Anker Engelunds Vej 101, 2800 Kongens Lyngby Denmark	Henrik Madsen hmad@dtu.dk José Joaquín Aquillera Prado jojap@dtu.dk	Denmark	
DTI Danish Technological Institute, Taastrup Gregersensvej 1, 2630 Taastrup Denmark	Jonas Lundsted Poulsen jlp@teknologisk.dk	Denmark	
ISE Fraunhofer - Institute for Solar Energy Systems, Heidenhofstraße 2, D-79110 Freiburg im Breisgau, Germany www.ise.fraunhofer.de	Danny Günther Danny.Guenther@ise-fraunhofer.de	Germany	
RWTH Aachen Mathieustraße 10, D-52074 Aachen, Germany www.rwth-aachen.de	Christian Vering cvering@eonerc.rwth-aachen.de	Germany	
KU Leuven Oude Markt 13 - bus 5005 3000 Leuven, Belgium www.kuleuven.be	Alessia Arteconi alessia.arteconi@kuleuven.be	Belgium	
ECOS Environmental Coalition on Standards, Rue du Commerce 31, 1000 Brussels, Belgium www.ecostandard.org	Luka De Bruyckere luka.debruyckere@ecostandard.org	Belgium	
EPRI Electric Power Research Institute , 3420 Hillview Avenue, Palo Alto, CA 94304, USA	Ammi Amarnath aamarnath@epri.com	USA	
CRIEPI Central Research Institute of Electric Power Industry, 2-6-1 Nagasaka, Yokosuka-shi, Kanagawa 240-0196, Japan	Takenobu Kaida kaida@criepi.denken.or.jp	Japan	

Participation is open from the approval of this legal text until 12 months after the start of the Project.