



# Digitalization and IoT technologies for Heat Pump systems



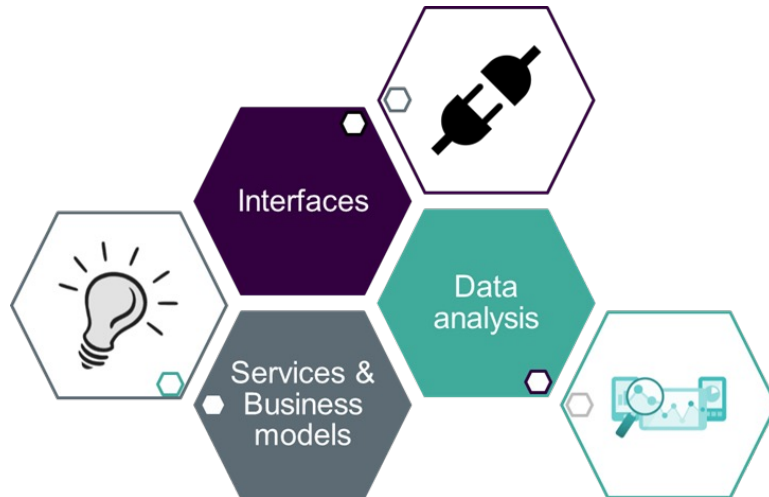
**IEA HPT Annex 56**



Presented by  
Davide Rolando, KTH

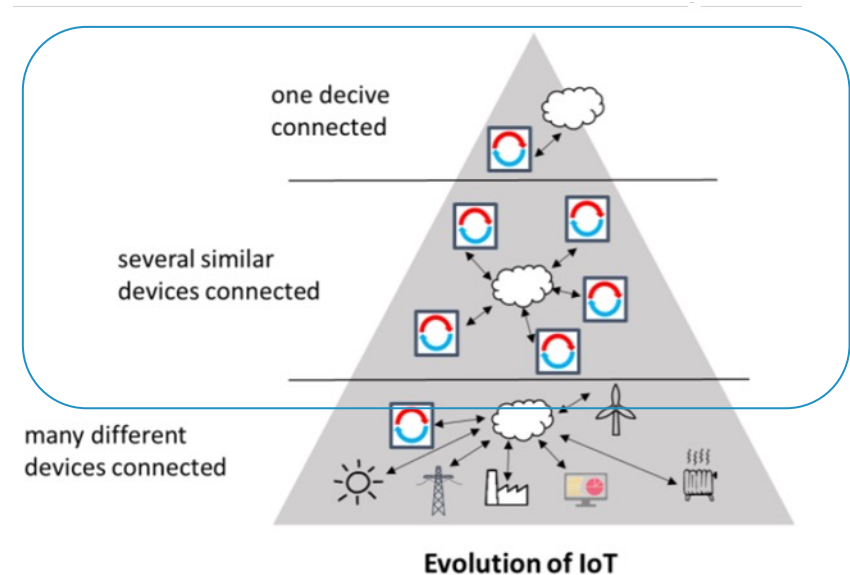
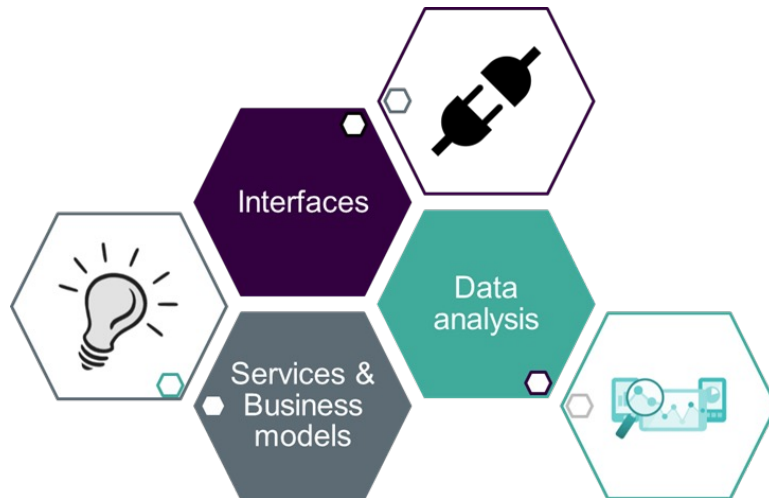
IEA HPT Annex 56 Digitalization and IoT for Heat Pumps

## Digitalization and IoT for Heat Pumps



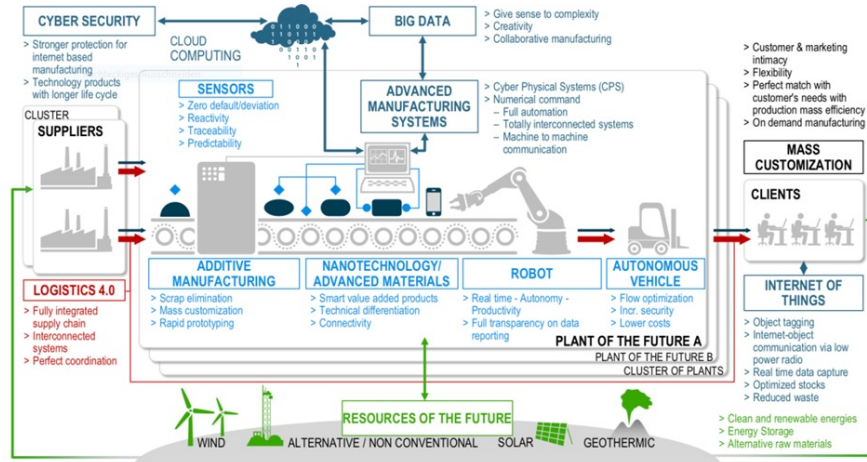
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## Digitalization and IoT for Heat Pumps

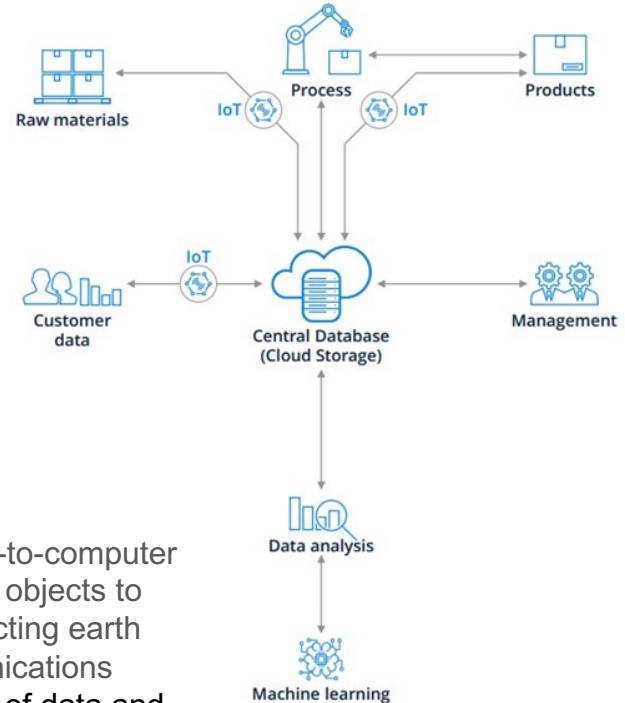


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# State of the art



(Blanz, 2012)



(Statista, 2019)

Internet of Things: “Machine-to-machine communications and person-to-computer communications will be extended to **things**, from everyday household objects to sensors monitoring the movement of the Golden Gate Bridge or detecting earth tremors. Everything from tyres to toothbrushes will fall within communications range, heralding the dawn of a new era, one in which today’s internet of data and people gives way to tomorrow’s Internet of Things.” (ITU, 2005)

# State of the art



(Blanz, 2012)

Industrial Ethernet fieldbuses: Modbus, KNX, BACnet, ...

Session layer protocols: AMQP, MQTT, ...

...

# IoT use cases

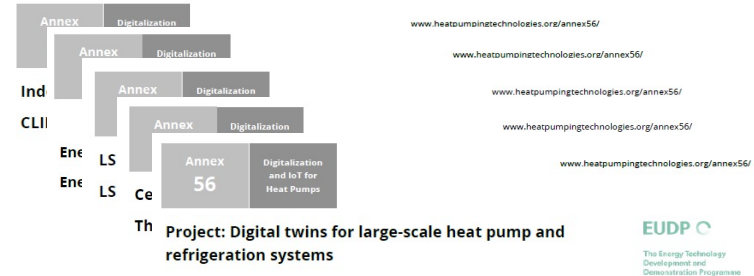
44 use cases collected

- Products and services (19)
- Research projects (25)

## Categories

- Heat pump operation optimization
- Predictive maintenance
- Flexibility provision
- Heat pump operation commissioning
- Heat as a service

Factsheets available on the IoT Annex website



Project: Digital twins for large-scale heat pump and refrigeration systems

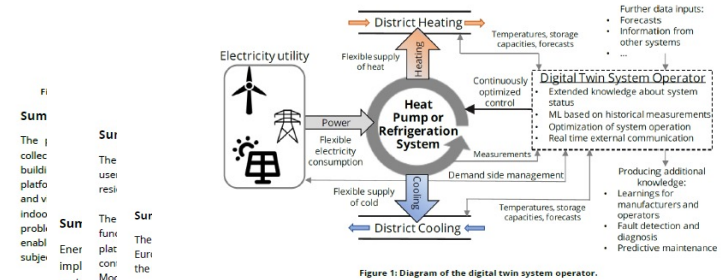


Figure 1: Diagram of the digital twin system operator.

### Summary of IoT case

Digital twins can be described as adaptable models that are able to adjust their structure based on measured data from the system they represent. This project aims to reduce the effort to develop digital twins for large-scale heat pump and refrigeration systems. The target groups are supermarket refrigeration systems as well as heat pumps for district heating systems.

On the other hand, data-driven models are comprised of statistical models and machine learning. Such models will be especially useful to describe performance degradation of components, predict system performance and optimize set points as well as operation schedules.

Two large-scale heat pump systems are applied as case studies to develop and test the digital twins. These systems have rated heating capacities of approximately 4 MW and

# IoT use case example: ZEB Lab

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## BAC in Action: Connected heat pumps in the ZEB Laboratory building

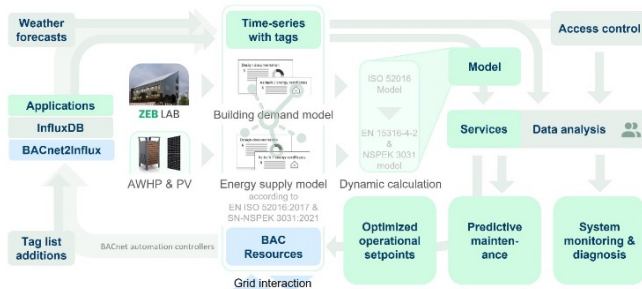


Figure 1: The project is the first to use data processing pipelines from the new ZEB Laboratory to develop applications.

<https://zeblab.no/>

## Data infrastructure

- Time series database (InfluxDB)
- BACnet automation controllers
- Sub-system protocols: Modbus and Mbus
- Weather forecast input
- ...



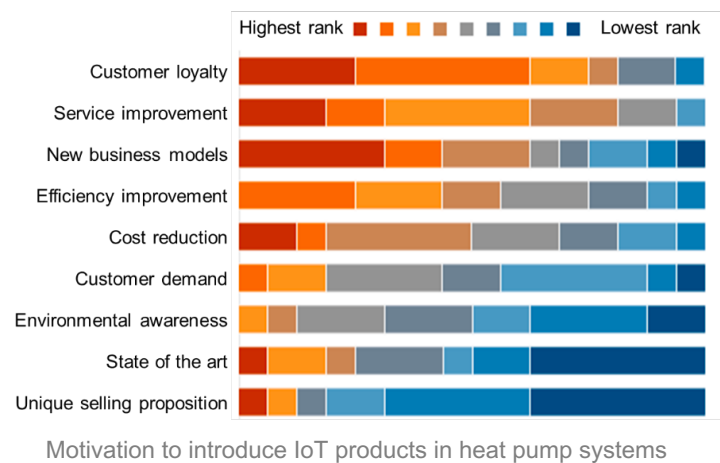
# Manufacturer survey (Austria)

About 50 questions to gather and evaluate the general sentiment on the importance of IoT

A total of 16 companies participated in the survey

## Challenges

- Data security
- Data protection guidelines
- Increase of system complexity
- Availability of qualified personnel





# Expert interviews (Sweden)

Expert interviews involving leading heat pump manufacturers, IoT companies, associations, and consultants.

Opportunities:

- Innovative business models
- Predictive maintenance

Challenges

- Lack of guidelines
- Need for demonstrators

Motivation to introduce IoT products in heat pump systems

- Reduce operating cost
- Service and repair improvement



# IEA HPT Annex 56: Final reports



## Digitalization and IoT for Heat Pumps

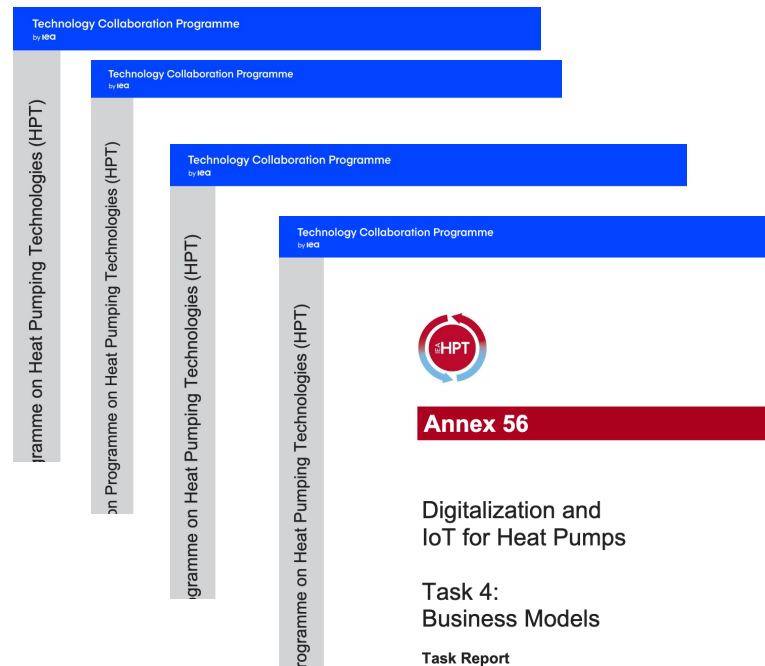
[Task 1 Report: State of the Art](#)

[Task 2 Report: Interfaces and platforms](#)

[Task 3 Report: Data analysis](#)

[Task 4 Report: Business Models](#)

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## Data-driven soft sensors

Modern heat pump systems are equipped with sensors that help gathering a significant amount of operational data.

However:

Many heat pumps installed over the past decades lack key measurement points.

Issue:

- incomplete measurements
- difficult/impossible to track system performance

DN DEBATT

*DN Debatt. ”Till stora kostnader samlas data in som aldrig används”*



PUBLICERAD 2021-05-02

**”At a huge cost, data is collected but never used”**

<https://www.dn.se/debatt/till-stora-kostnader-samlas-data-in-som-aldrig-anvands/> (2021-05-02)

# Data-driven soft sensors: motivation

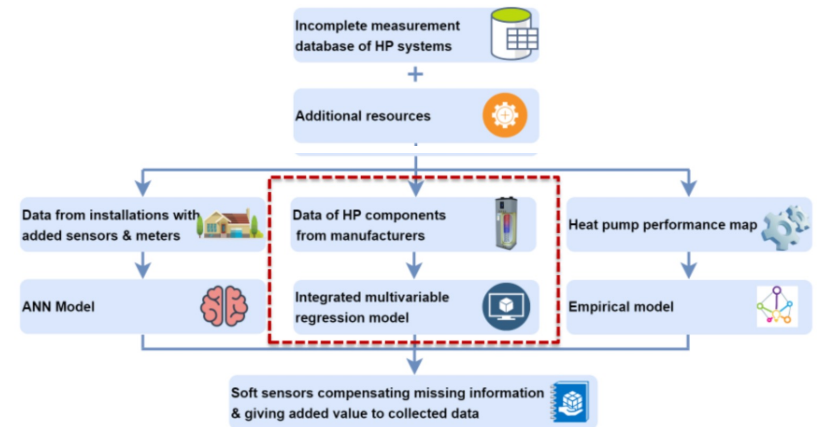
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However:

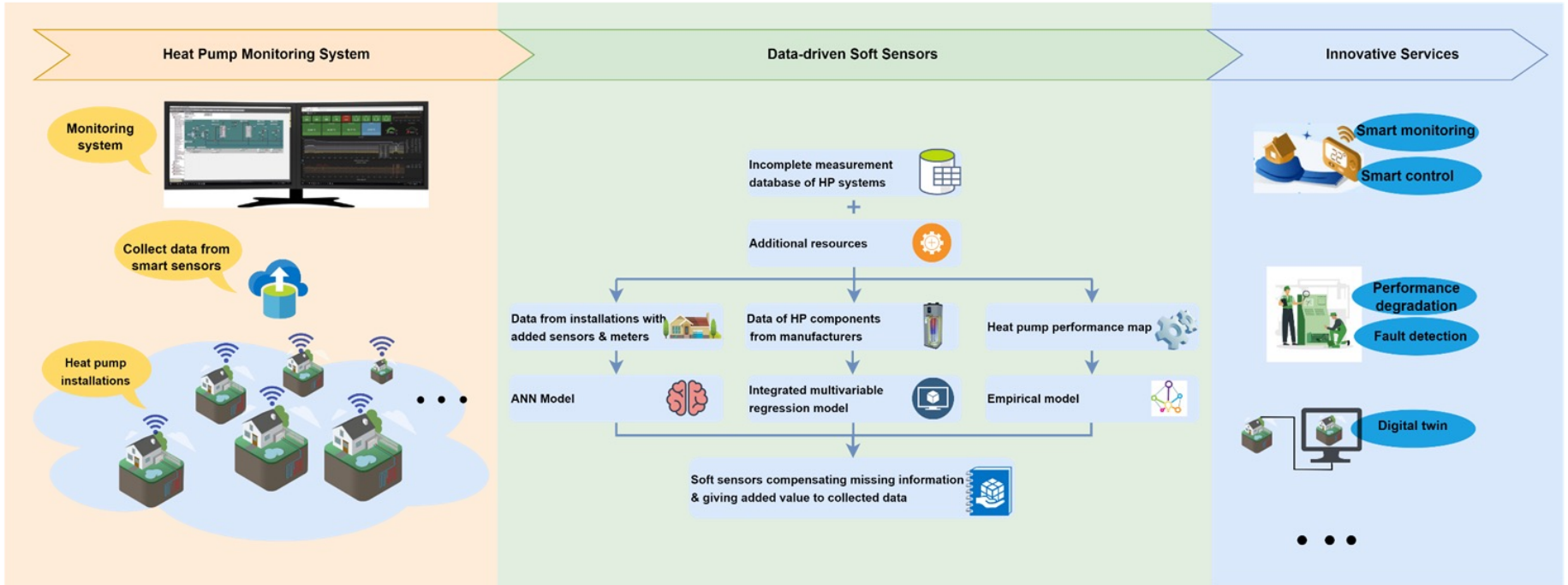
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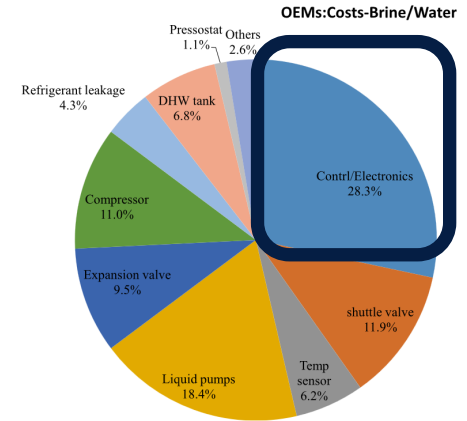
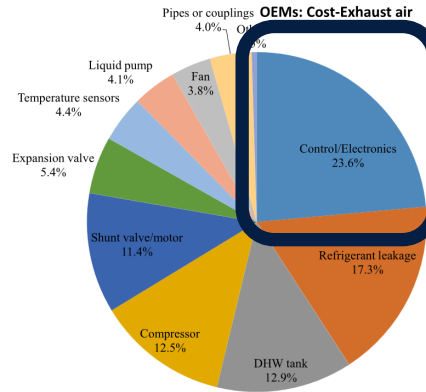
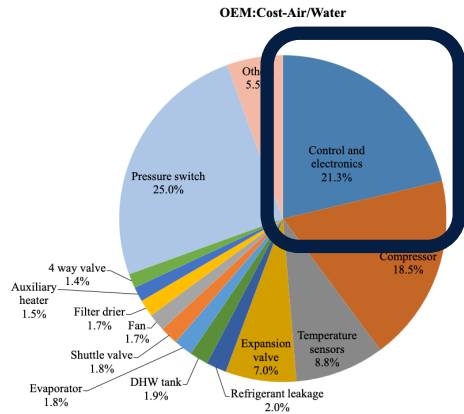
- incomplete measurements
- difficult/impossible to track system performance



# Heat pump monitoring systems



# Cost share of faults reported to HP manufacturers



INTERNATIONAL JOURNAL OF REFRIGERATION 48 (2014) 19–25



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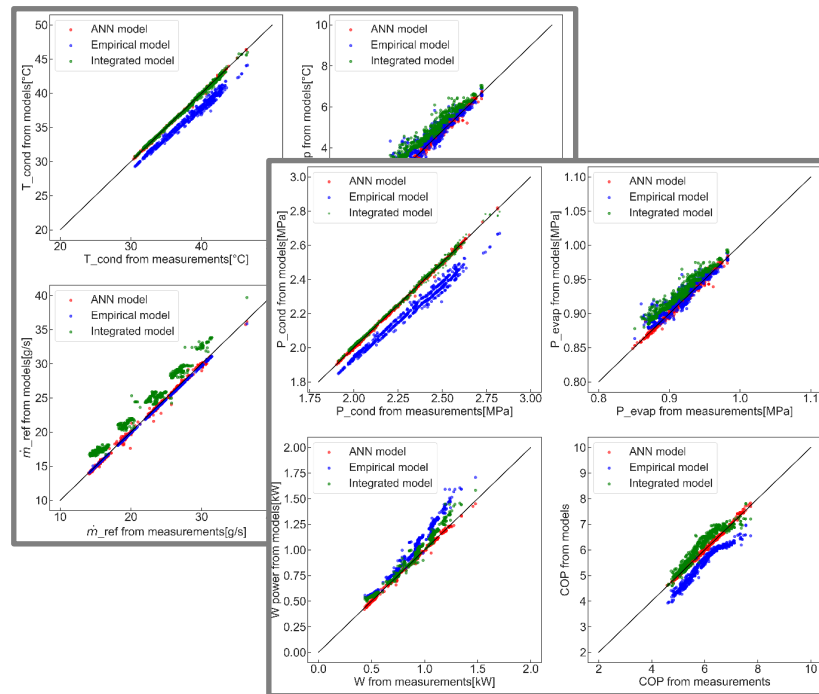
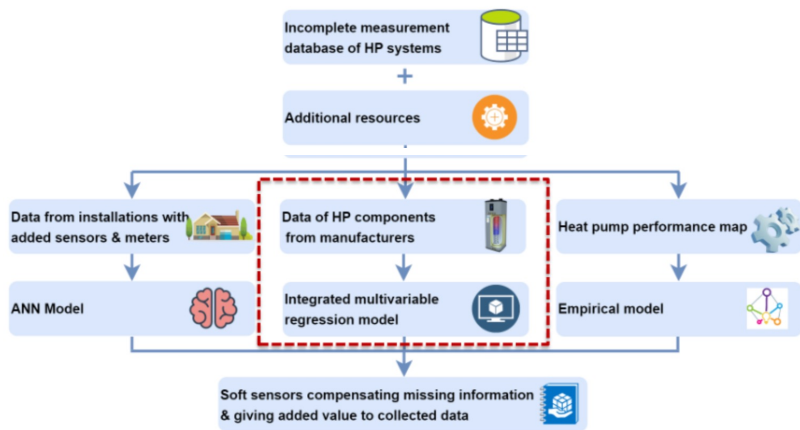
## A comprehensive study on the important faults in heat pump system during the warranty period



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Department of Energy Technology, Division of Applied Thermodynamics and Refrigeration, KTH Royal Institute of Technology, Brinellvägen 68, SE-100 44 Stockholm, Sweden

# Data-driven soft sensors targeting heat pump systems: results





# PhD Project: Data-Driven Lab for Heat Pump Systems

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Co-supervisor: Davide Rolando (davide.rolando@energy.kth.se)



(link)

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Contents lists available at ScienceDirect

**Energy Conversion and Management**

journal homepage: [www.elsevier.com/locate/enconman](http://www.elsevier.com/locate/enconman)

**Data-driven soft sensors targeting heat pump systems**  
 Yang Song<sup>a</sup>, Davide Rolando<sup>a</sup>, Javier Marchante Avellana<sup>b</sup>, Gerhard Zucker<sup>a</sup>, Hatéf Madani<sup>a,c,\*</sup>

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**Estimating electric power consumption of in-situ residential heat pump systems: A data-driven approach**  
 Yang Song<sup>a</sup>, Monika Peskova<sup>a</sup>, Davide Rolando<sup>a</sup>, Gerhard Zucker<sup>b</sup>, Hatéf Madani<sup>a,b,\*</sup>

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**P089 Development and validation of data-driven soft sensors for heat pumps**  
 Yang Song<sup>a</sup>, Davide Rolando<sup>a</sup>, Gerhard Zucker<sup>b</sup>, Hatéf Madani<sup>a,b,\*</sup>

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# Thank you!



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