Data-driven labs targeting heat pump systems

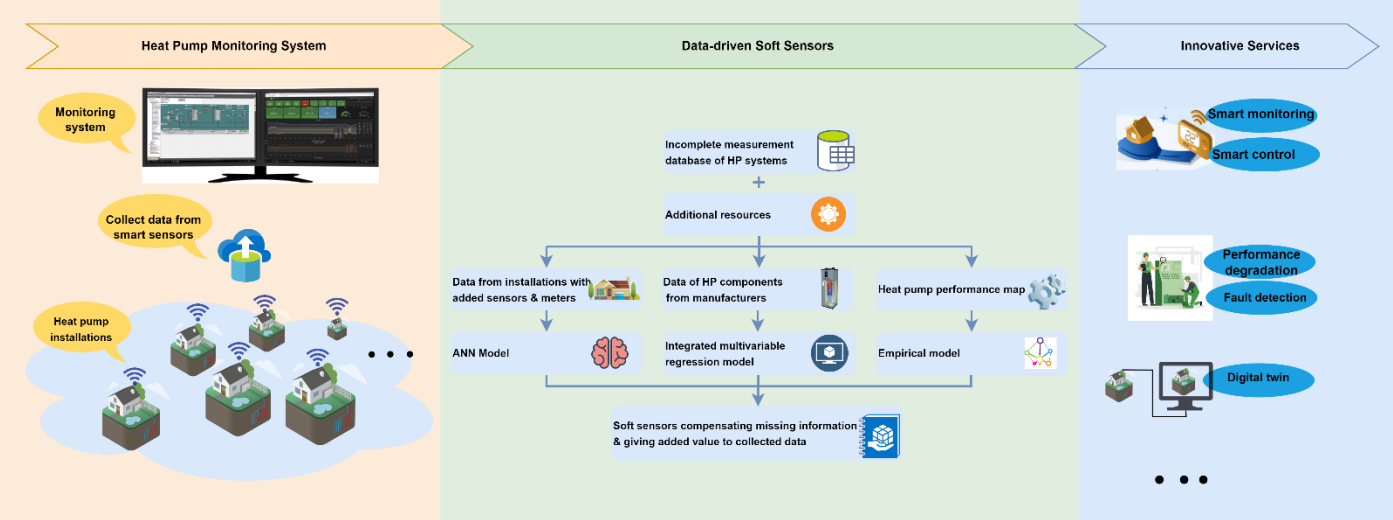

Figure 1: Framework of soft sensors utilization targeting heat pump monitoring systems.

Summary of project

Modern heat pump systems potentially generate a large amount of data every day that can be stored in databases. Appropriate analysis of the information collected in measurement databases facilitates the development of different innovative services. In a common project between KTH Royal Institute of Technology, AIT Austrian Institute of Technology and heat pump manufacturers, a data driven lab is being developed for heat pump systems, which acts as a virtual platform to improve heat pumps control strategies, fault detection and diagnosis and communication with local energy grids.

At the current situation, this highly valuable and abundant data with billions of entries every month is merely collected by heat pump manufacturers and is neither processed nor used for any innovative service mainly due to data incomplete. For example, in this project monitoring data from a large number of heat pump installations throughout Sweden suffers from missing information mainly due to sensor or meters economic barriers. The use of the data is nowadays mostly limited to the instantaneous visualization of the measurements and only a shallow and limited analysis is performed to help the development of enhanced devices or improved control strategies.

The collected data, if processed and coupled to other sources of information (e.g., dynamic real time measurement data from the relevant systems and sub-systems, steady-state field data including the technical specifications of the system, and supplementary laboratory measurement data) in an appropriate way, encompasses a lot of valuable information. The information can give added value to monitoring data, investigate innovative monitoring and control approaches, enable innovative services from data, and inspire better monitoring design.

Compensating for missing information is the first and essential step in making the database ready for system analysis, which can be accomplished by developing soft sensors. A multi-model approach for soft sensors in heat pump systems is proposed. To be more specific, ANN model, integrated multivariate polynomial regression model, and empirical model are developed considering the availability of different supplementary data/ information. It has been demonstrated that the great potential of soft sensors to substitute several costly physical sensors, which can provide economical solutions for incomplete monitoring systems.

Based on the data-complete measurements after the process of soft sensors, this project goes towards to providing innovative services including but not limited to: the end-users and manufacturers including but not limited to smart monitoring, smart control, performance degradation, fault detection, and digital twins.

Learnings and results

- Monitoring data from a large number of heat pump installations throughout Sweden suffers from missing information because of economic barriers. To resolve this obstacle so that the monitoring data can be fully utilized for system analysis, three different types of data-driven soft sensors have been developed based on different additional resources. The results of data-driven soft sensors have been validated against data from field test installations and show good performance for all compensation variables.

- Currently, every heat pump installed in every building acts as an isolated island, without any communication with other stakeholders. With the heat pump power consumption, heating and cooling capacity accurately compensated by soft sensors, the data-driven lab can be exploited at city/district levels and establish communication not only between heat pumps but also with the local electric grid, district heating and cooling, and the third parties to realize smart energy control and advanced energy management.

- Advanced fault detection and diagnosis, predictive performance degradation services can be realized based on the excellent performance of virtual mass flow meters and pressure sensors. Possible refrigerant leakage, fouling or frosting in heat exchangers can be exactly detected through mass flow rates or pressure change.

FACTS ABOUT THE PROJECT

IoT Catagory: Optimize heat pump operation, Predictive maintenance or Performance benchmark

Goal: To fully utilize heat pump monitoring systems for advanced services.

Beneficiary: End-user and manufacturer

Data required: Operational data from heat pumps

Analysis method: Data analysis and modelling

Modelling requirements: Data-driven, Softsensors

Quality-of-Service: Real-time and hourly for online monitoring and control.

Project participants: KTH, AIT

Time schedule: 2019-2023

Link to webpage:
https://www.energy.kth.se/applied-thermodynamics/key-research-areas/integrated-energy-sy/data-driven-lab-for-building-energy-

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