

Avoidance of Heat Pump Efficiency Losses by Digital Operation Analysis (DIBA-WP)

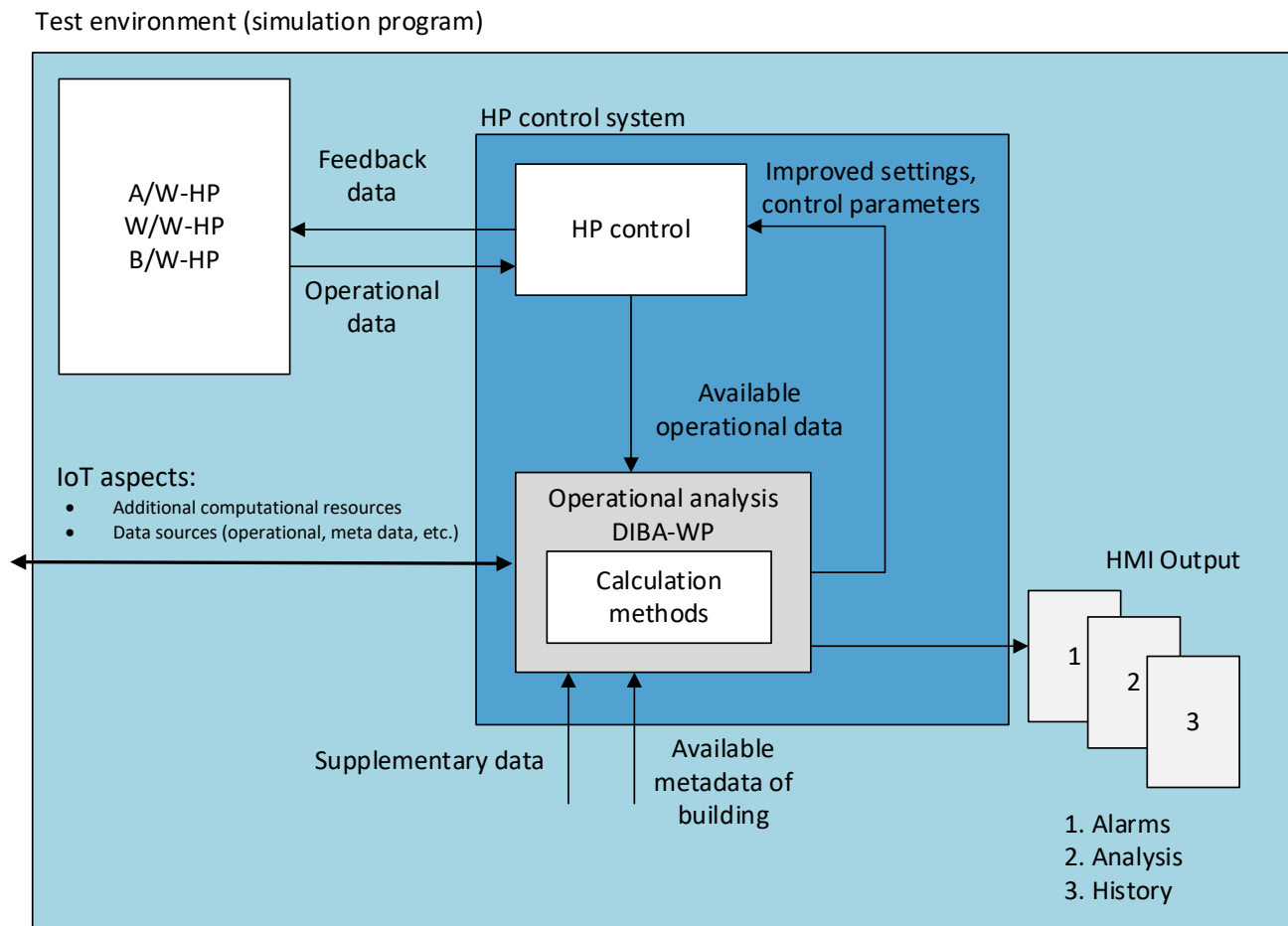


Figure 1: Overview of the DIBA-WP Topology

Summary of project

In Switzerland roughly 30% of the end energy demand is used for space heating and domestic hot water [1]. Until 2050 most of this is expected to be covered by heat pumps [2]. While this already increases the efficiency of the energy system significantly, the optimal operation of these heat pumps is gaining relevance in respect to their impact on the energy system. The research project "Avoidance of Heat Pump Efficiency Losses by Digital Operation Analysis", supported by the Swiss Federal Office of Energy, aims at minimizing efficiency losses in heat pump operation. The underlying motivation of the project is the presence of wrong parameter settings that cause

efficiency losses and that are often not recognized by the end use because they do not have an impact on the comfort for the user.

"As long as there is no loss in comfort noticed by the user, the heat pump settings are often never analyzed which leads to unnecessary efficiency losses. (Beat Wellig, Professor, Lucerne University of Applied Sciences and Arts)"

The aim is to create the foundations for a digital operation analysis of heat pump systems in single family and smaller multi-family houses. This is achieved by collecting typical faults of heat pump systems in the field and evaluating their relevance by the means of system simulations with Modelica. The resulting simulation data is used for identifying detection methods, and such methods are derived based on thermodynamic principles and statistics. These methods are again tested with system simulations. The results from the methods are to indicate to the user which settings should be controlled and corrected. In a later stage the results can also enable automatic correction of the setpoint settings [3].

One key error that is well known is the suboptimal setting of heating curves. If the heating curve of a heat pump is set too high, the heat pump provides the heating water at a higher than necessary temperature and thus runs with a lower efficiency. The system simulation shows the effect of this incorrect setting in Figure 2.

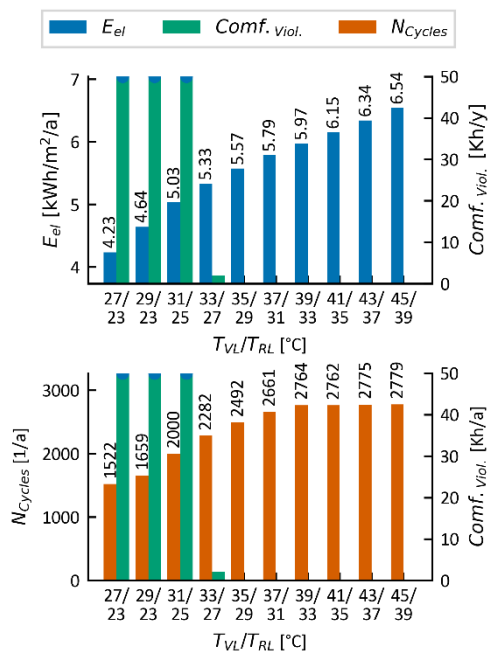


Figure 2 Effect of heating curve setting in a single-family house with a ground source heat pump using a parallel buffer storage. The blue bars show the energy demand, while the orange bars show the number of operation cycles and green is the comfort loss.

The necessary analysis to detect wrongful settings was found to be computationally demanding for local execution on heat pump controllers. The Internet of Things (IoT) framework would be relevant in addressing this challenge using cloud computing resources for the execution of the analysis. Furthermore, IoT enables connection of multiple components (e.g., the HP with the room heating controllers) leading to a reduction of measurement equipment.

Learnings and results

The main conclusions can be summarized as follows:

- Suboptimal settings have a significant impact on the energy efficiency of heat pump systems.
- Their detection should be based on physical principles that are to a minimal extent dependent on the effective implementation.
- The most significant errors can be detected with appropriate analysis methods using operation and meta data.

FACTS ABOUT THE PROJECT

IoT Category: Optimize heat pump operation

Goal: Efficiency increase and cost reduction

Beneficiary: User and manufacturer

Data required: Operation data, meta data

Analysis method: Visualization, thermodynamic principles, statistical methods

Modelling requirements: Quasi-steady-state models

Quality-of-Service: Deferreable

Project participants: Lucerne University of Applied Sciences and Arts, Competence Center

Thermal Energy Systems and Process Engineering, Alera energies AG

Time schedule: 2019-2022

Technology availability: TRL 3

Link to webpage:

www.hslu.ch/tevt

Sources

[1] A. Kemmler and T. Spillmann, "Analyse des schweizerischen Energieverbrauchs 2000–2020 nach Verwendungszwecken," Bundesamt für Energie BFE, Bern, 2021.

[2] S. Peterhans, R. Dott, W. Eugster, M. Freymond, M. Generelli, G. Guggenheim, P. Hubacher, and C. Müller, "FWS Jahresbericht 2019," 2019.

[3] R. Agner, M. Etterlin, D. Troxler, L. Gasser, and B. Wellig, "Vermeidung von Effizienzeinbussen von Heizungswärmepumpen durch digitale Betriebsanalyse DIBA-WP: Schlussbericht," Bundesamt für Energie BFE, Bern, 2022.

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