GreenHeat The Next Generation of AI-based Services for Heat Pumps

GreenHeat (FFG Nr. 899931)

DiLT Analytics leverage intelligence

TU Graz
Institute of Software Technology
Institute of Thermal Engineering

SOLARFOCUS

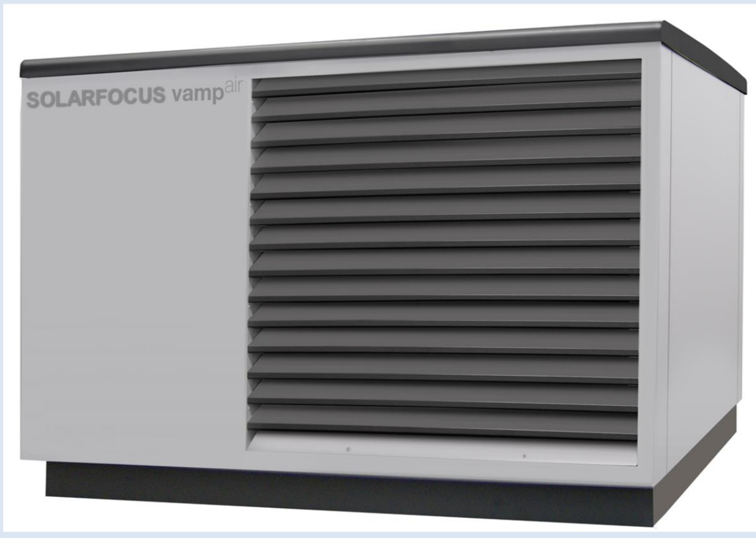
Key Messages

- Heat pumps (HP) play a **crucial role** in future heating systems and the shift **to renewable energy sources**
- However, current HPs face **challenges** in balancing energy efficiency and comfort
- **Artificial Intelligence** can enhance HP performance and help to detect failures early
- A collaboration between **computer science** and **thermal engineering** is essential for a successful implementation of AI in HP systems

Stakeholder Consultations

General optimization potentials

- Systems often oversized to "play safe"
- Immature monitoring concepts
- Lack of quality assurance during commissioning can lead to underperformance



Challenges

- different interfaces and communication protocols
- no standardized data formats
- data availability and lack of labelled data
- transition to natural refrigerants requires adaptation of system technology

Monitoring

- Errors are often only detected through user feedback (e.g., no warm water) or if there is an obvious defect
- Easy-to-understand feedback to users on the performance
- Continuous performance monitoring of overall system is challenging in practice
- Finding optimization potentials
- Key virtual sensor: Coefficient of Performance (COP)

Fault detection and diagnostics

- Fault-prone components: compressor, inverter, seals, and 3-way valves
- Serious failures trigger an alarm
- Soft failures are difficult to detect
  - Component performance degradation over time
  - Sensor drift
  - Creeping refrigerant loss

Predictive maintenance

- Too few data sets available for research institutions
- Building up knowledge about component service life is difficult, but manufacturers can provide this data

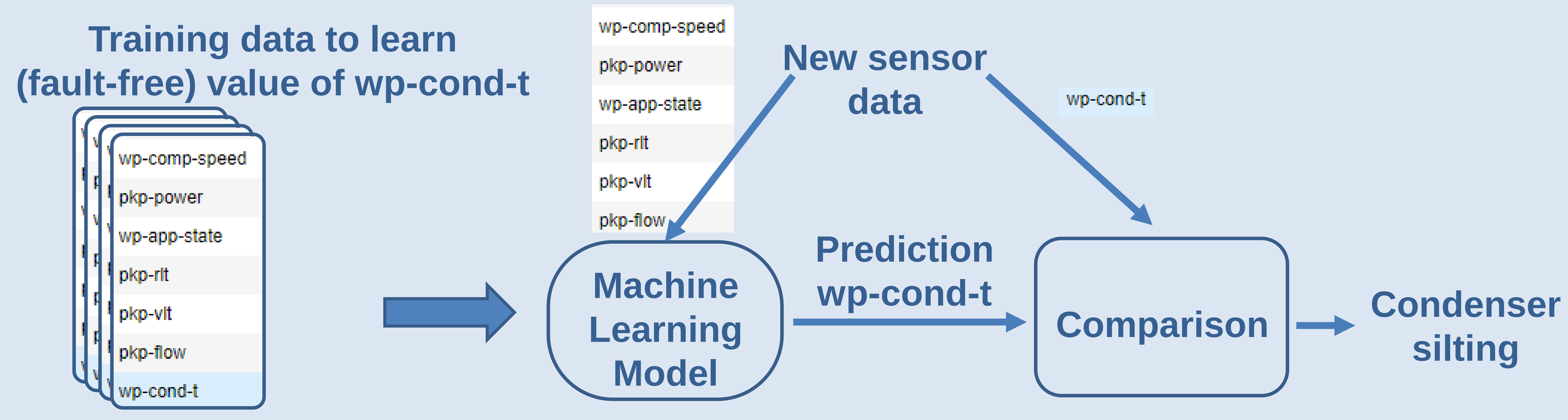
Predictive control

- Currently only system-specific implementations
- Scalable systems need "plug & play" commissioning
- Target values for single-family homes/residential buildings: flexible electricity tariffs and ideal building temperature control based on weather forecasts
- Industrial sector has less potential for load scheduling

AI-based Fault Detection and Diagnosis

Approach 1

- **Goal:** Detection of soft faults, such as condenser silting
- **Data:** only fault-free data available
- **Method:**
  - Supervised learning to predict condensation temperature
  - Comparison of measured and predicted temperature

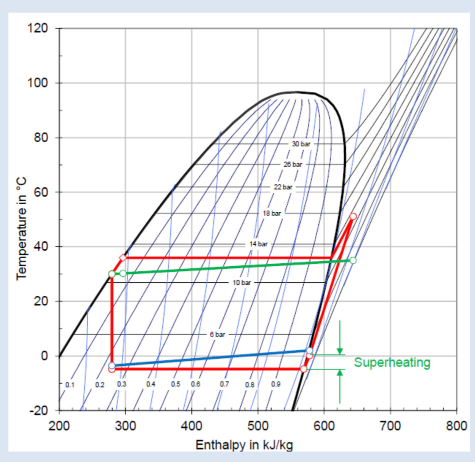


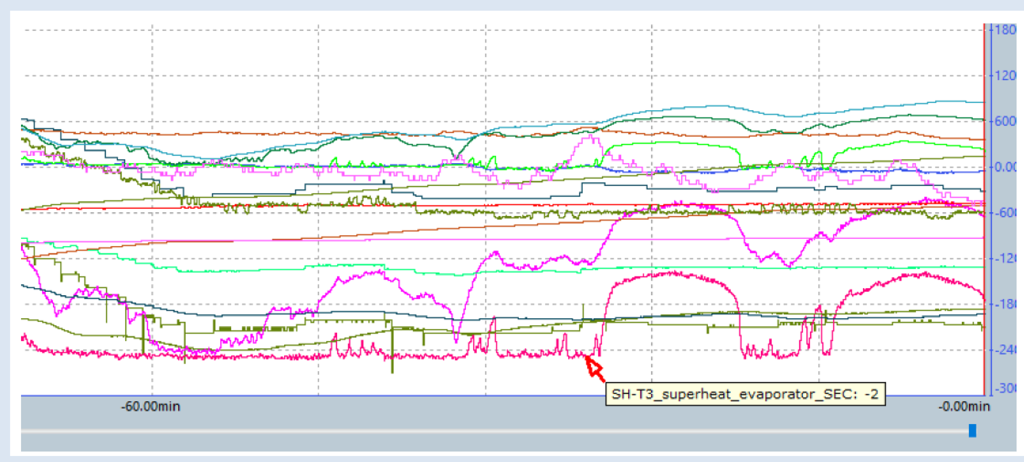
Approach 2

- **Goal:** General anomaly detection (COP drop)
- **Data:** 9 features, binary labels (faulty/non-faulty)
- **Method:** Fine-tuned LLMs (DistillBert)

Adaptive Control for LSPI

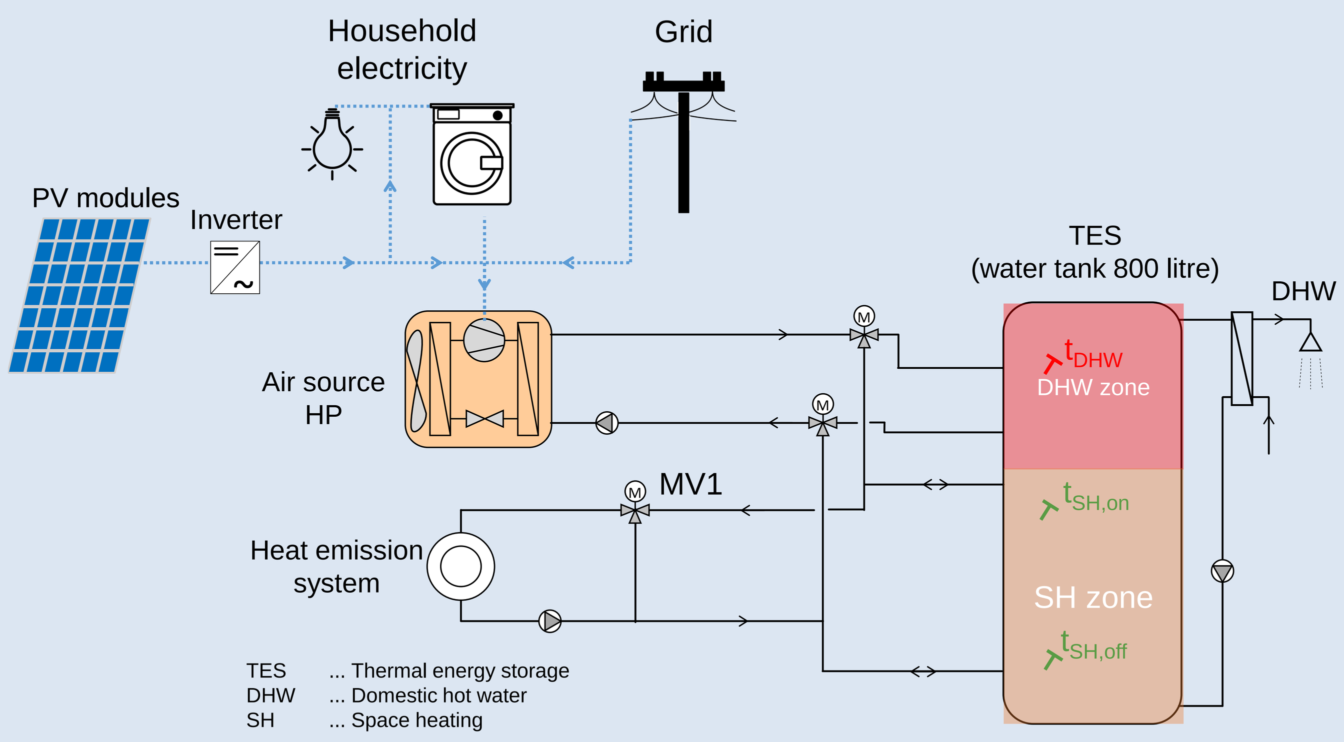
- **Goal:** Find optimal parameters for superheating control
- **Method:** Reinforcement learning





Optimal Heat Pump Control

- **Goal:** Minimize heating costs while still maintaining comfortable room temperatures
- **Method:**
  - Using forecasts for predicting heating demand
  - Consider variable electricity prices and electricity production from photovoltaic modules



Contact:
Birgit Hofer bhofer@ist.tugraz.at,
Franz Wotawa (Project lead) wotawa@ist.tugraz.at

Acknowledgments

The research described here is carried out within the FFG AI for Green program as part of the project FO999899931 GreenHeat – The next generation of AI-based services for heat pumps funded by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK).