Project: Combined Optimization of Heat Pumps and Heat Emitting Systems (OPSYS 2.0)

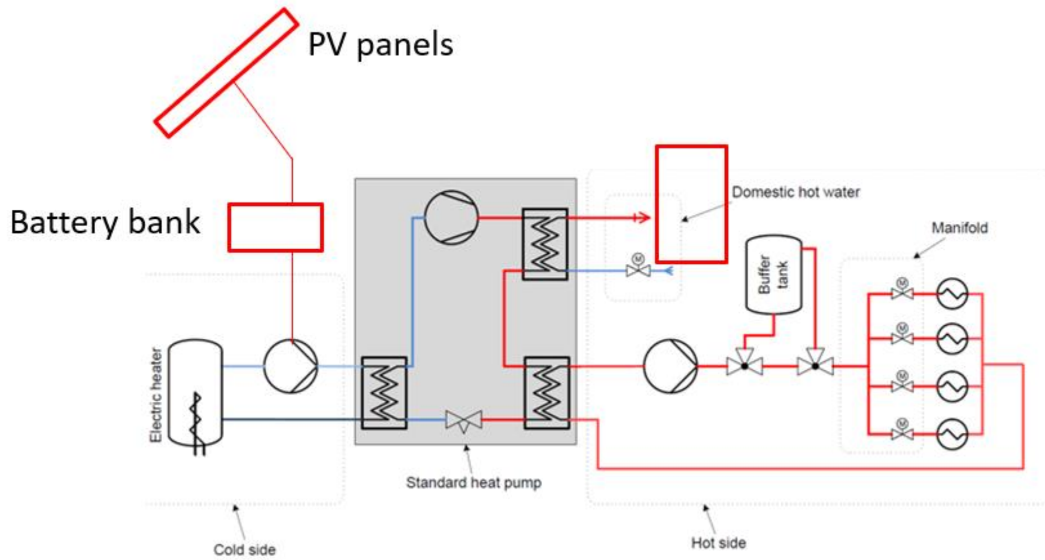

Figure 1: Principle sketch of experimental setup (on the test rig PV and battery are virtual).

Summary of project

The aim of the project is to increase the efficiency of both existing and new heat pump installations by developing a control kit that can optimize both the forward temperature from the heat pump and the flow rate through the heat emitting system, which is to be done by developing a control system capable of:

- Creating flexibility services for the stabilization of the electricity grid.
- Optimizing the self-consumption of PV generated electricity on private houses and/or avoid curtailment.

Heat pumps are intended to play a major role in the transition to renewable energy sources (RES) due to their high efficiency and ability to provide energy flexibility for stabilization of the future energy system with much RES. However, a survey has showed that only around 16 % of the heat pumps installations could be categorized as "good", as e.g. the regulation of the heat pump is not optimal as the forward temperature often is too high.

Although heat pumps in principle can be controlled according to the amount of RES in the system, only little energy flexibility can be provided, as the control of the heat pumps and the heating systems often is not coordinated. The Combined Optimization of Heat Pumps and Heat Emitting Systems concept (OPSYS) optimizes the performance of the heat pump installations via optimized control of the forward temperature and the flows in the system by controlling both parameters in accordance with the heat demand, the weather, and electrical grid needs.

Another important feature of the OPSYS concept is that it may increase self-consumption from on-site PV systems. The goals for the project include system-wide optimization of a house as energy

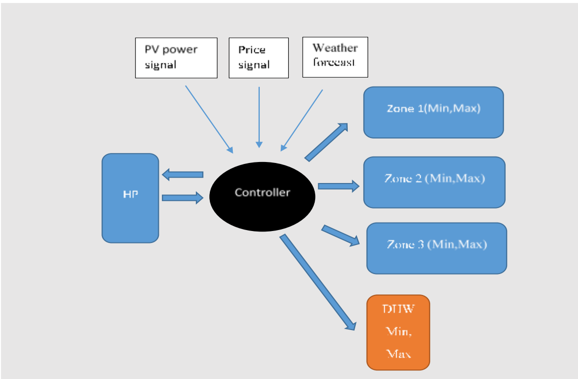

Figure 2: Simple representation of the controller.

consumer and producer by using control strategies for optimizing the self-consumption of PV electricity. The concept also includes utiliza-tion of storage in thermal mass and electric batteries.

The setup for the OPSYS test rig, can be seen in Figure 4. It can here be seen how the tempera-ture control is performed by inputs from floor and room models, with feedback from the physical system. The house model (see figure 3) is developed in Dymola (Modelica) and imbedded in a python script as a FMU (Functional Mock-up Unit). The house model includes all constructions of the house, the underfloor heating system of the four rooms, internal gains (people and appliances), external gains (solar radiation through windows), and the ambient tempe-rature.

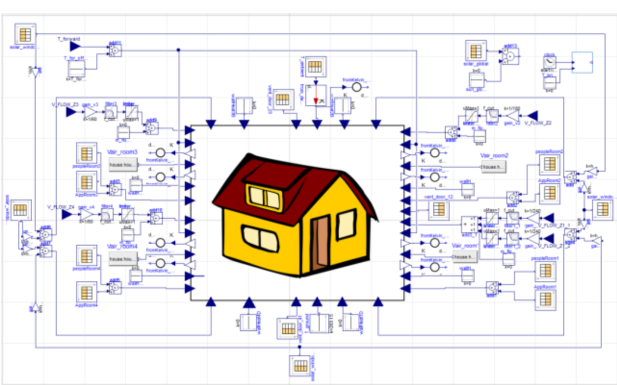

Figure 3: House model in Dymola.

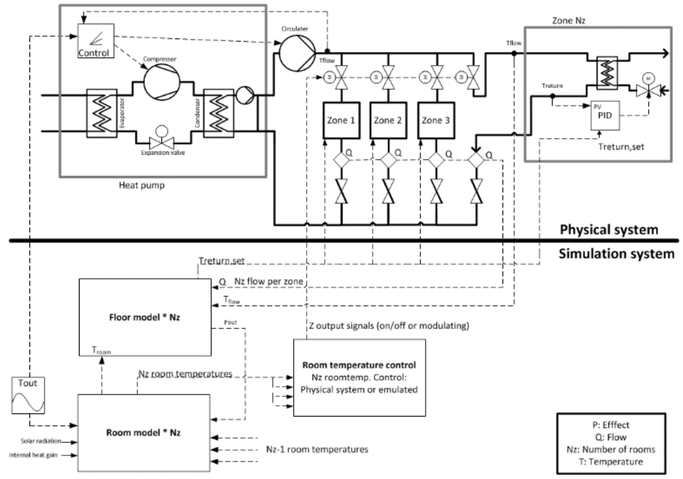

Figure 4: Physical and simulation system.

The control of the underfloor heating system will be a self-learning, dynamic and modulating type. This means that no complex manual fine-tuning is needed, and the flow is kept on the right level independently of the number of open circuits. The modulating approach secures the desired average valve setting by pulsing the power to the telestats (and later control thermostats on radiators) in order to obtain a desired opening degree of the valves.

Learnings and results

The experimental platform at DTI has been modified and adjusted to overcome some regulation instability issues. It was necessary to install a large brine buffer tank and after that the test rig is operational, however the PV system is yet to be simulated in detail.

The controller has also been installed in a real house with heat pump and a PV system. A number of practical problems related to communication with sensors has been observed. This house has been monitored for a while and results compared with the theoretical room temperatures calculated in the FMU house model. The project has been extended to allow measurements through a full heating season.

One part of the experiments is with pulsed operation of the regulation valves in the heating system which has been successfully carried out. The preliminary results showed a little advantage compared to on/off operation.

Contact information

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FACTS ABOUT THE PROJECT

IoT Catagory: Optimize heat pump operation
Goal: The goals for the project include system-wide optimization of a house as energy consumer and producer by using control strategies for optimizing the self-consumption of PV electricity.
Beneficiary: End-user.
Data required: Electricity prices, dynamic carbon intensity of power, grid tariff signals, weather data, operating data from heating system.
Analysis method: Model predictive control strategy
Modelling requirements: Dynamic self-learning models.
Quality-of-Service: Real-time.
Project participants: Danish Technological Institute, Neogrid, Aalborg University, Wavin, Bosch
Time schedule: 2019-2023.
Technology availability: TRL8 for control kit and TRL7 for the optimized control for grid interaction and increased self-consumption of PV electricity
Link to webpages:
https://www.teknologisk.dk/projekter/projekt-opsys-2-0/40581