Building simulation for identification and prediction of the water withdrawal

Algorithms for system identification and prediction of user behavior

1 Project goal

The progressive integration of renewable energies - especially solar energy - into current and future energy systems is becoming increasingly important for buildings and city infrastructure. It is possible to combine solar heat and solar radiation with additional heating in order to provide energy for space heating and water heating. These so-called solar combination systems are able to reduce the costs for heating and hot water. However, these are quite complex systems, especially to monitor proper functioning and to guarantee a certain level of performance. The effiency of such systems largely depends on the qualtiy of the state estimation and prediction of the future energy consumption of the user could help to ensure the level of performance and thus to increase user confidence in such systems.

The main goal of the project was to identify and create a mathematical model of a building that can be adapted to different buildings. This model had to take into account all available information like weather conditions such as solar radiation, indoor and outdoor temperature and the energy provided by a heating system. This model can be used to accurately and reliably predict the internal temperature at a specific heating level.

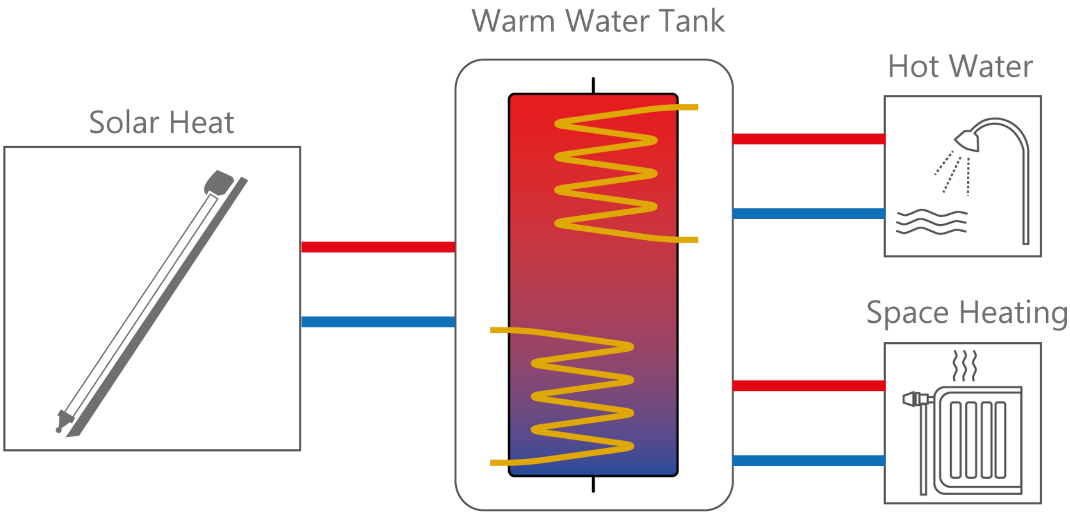
Another aim was to identify and predict the user's tapping behavior in order to always be able to guarantee the immediate availability of hot water, i.e., without long pre-heating times. This increases the user comfort and acceptance of such systems.

Knowtion GmbH
Experts in sensor fusion and automatic data analysis

An der RaumFabrik 33c
D-76227 Karlsruhe, Germany

Tel.: +49 721 486 995-10
www.knowtion.de

Knowtion
from data to knowledge



2 Development approach

In a first step, a data-driven model was trained on the basis of the recorded hot water tap events. The hot water time program including the required volume is then adjusted based on the profile learned. If enough training data is available, user behavior can be learned using the data-driven approach. In this way, the preheating time can be optimized to ensure that the user receives hot water immediately without having to wait long.

The energy costs of room heating can be further reduced using a mathematical model to predict room temperature. The model has various input signals such as the forecast of meteorological data (outside temperature and radiation) and the heating output of the space heater. A room temperature model can be trained based on these input signals and the measured room temperature. This model can then be used to design a model-based predictive controller (MPC). The MPC is designed to control all control values of the hot water storage tank in an optimized manner. This will allow it to provide energy at the right time, while the user comfort remains unchanged and the energy costs are reduced.

Predicting future energy demand and solar yield could help reduce costs and thereby increase user confidence in purchasing a solar combi system. As finally most customers don't select a system only based on their environmental finger print but rather on financial considerations as combination of the unit price and the overall livetime cost comparision. With such an MPC controller and a well adjusted model the efficency can be increased which allows a reduction in the overall livetime costs. Finally the solar yield can be simulated and compared with the actual values in order to automatically detect incorrect behavior, so-called anomalies, of the heating system to allow an early warning to the use or maintainance team.

Knowtion GmbH
Experts in sensor fusion and automatic data analysis

An der RaumFabrik 33c
D-76227 Karlsruhe, Germany

Tel.: +49 721 486 995-10
www.knowtion.de

3 Result and benefit

- Efficent and energy optimal combination of solar heat with additional heating
- State estimation and prediction of the future energy consumption of the consumer and the solar yield
- Mathematical model that describes the hot water tap profile
- Automatic identification of user behavior with regard to the water withdrawal profile
- Mathematical model for predicting room temperatures

Knowtion GmbH
Experts in sensor fusion and automatic data analysis

An der RaumFabrik 33c
D-76227 Karlsruhe, Germany

Tel.: +49 721 486 995-10
www.knowtion.de