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SIMULATION STUDY ON THE ENERGY SAVING POTENTIAL OF A HEATING CONTROL SYSTEM FEATURING PRESENCE DETECTION AND WEATHER FORECASTING

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Literature
[1] DIN V 18599-10:2007-02. Energy efficiency of buildings – Calculation of the energy needs, delivered energy and primary energy for heating, cooling, ventilation, domestic hot water and lighting – Part 10: Boundary conditions of use, climatic data.
[2] Christoffer, Jürgen; Deutschländer, Thomas; Webs, Monika: Testreferenzjahre von Deutschland für mittlere und extreme Witterungs-verhältnisse TRY. Offenbach a. Main: Selbstverlag des Deutschen Wetterdienstes, 2004.

BACKGROUND

Conventional heating control systems regulate the temperature based solely on local measurements – indoor or outdoor air temperature. Advanced systems allow users to programme schedules. During defined periods of absence, lower set temperatures in the rooms reduce the energy consumption for heating. However, these systems can neither react to periods of user presence or absence that have not been programmed, nor take the climatic conditions for the coming hours into account.

EVALUATED SYSTEM

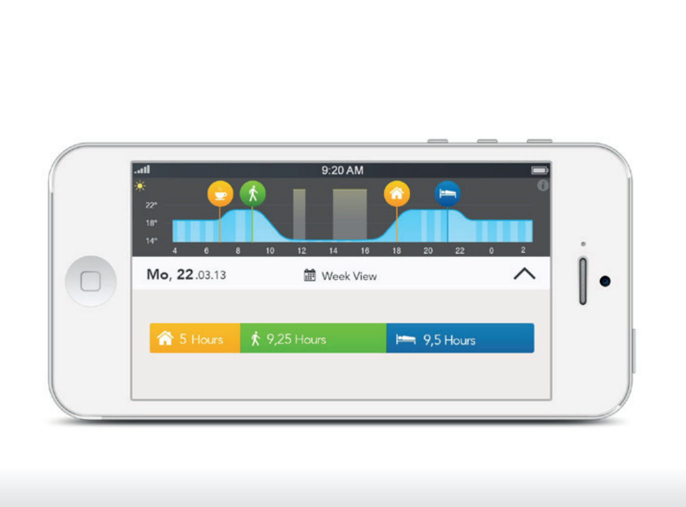
In addition to the features of conventional heating controls such as programmable periods of absence, the system evaluated here is able to detect the position of the residents' smartphones via GPS. Using this data, it statistically calculates each resident's estimated time of arrival at home. The intelligent system also learns how long it takes to heat the home so the heating can be activated early enough before the first user gets home. By choosing a comfort setting the users can specify how long before their arrival the heating is activated. That determines what level of comfort has already been reached by the time they arrive. Furthermore, the system has access to local weather forecasts and records data on how the forecasted solar radiation influences the room air temperatures. Based on these data, the system turns down the heating in advance when sufficient sun is expected within the next hour.

METHOD OF EVALUATION

The study described here is based on transient calculations (TRNSYS 17). The algorithm of the evaluated system is replicated in simplified form and linked with TRNSYS. This study is carried out on a typical single family house and a typical apartment with 5 rooms. In addition, it evaluates two different construction ages.

A single and a family household serve as scenarios to evaluate different kinds of usage. Realistic set temperature profiles are specified for each scenario.

In order to simulate the heating behaviour in conjunction with realistic supply tem-



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peratures, the simulation model includes a heating curve based on the outside temperature and detailed models of the radiators and their controls. This study uses one of the system's lower comfort settings.

THE REFERENCE BUILDING

The reference building is the baseline the results of the test building are compared to. It is the exact equivalent of the test building apart from one detail: the conventional radiator thermostats in all rooms are set so as to maintain a constant temperature of 20 °C during the day. To reduce the temperatures for the night the heating system's supply temperature is reduced by 10 K [1].

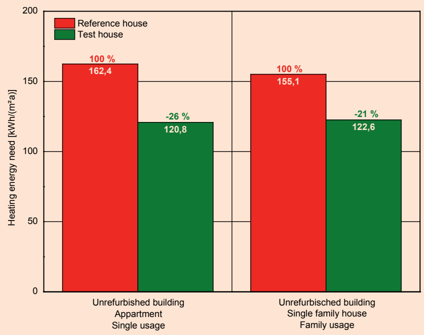
SIMULATING THE WEATHER FORECAST

The evaluated system uses a forecast of the solar global radiation. Naturally there is some deviation between this forecast and the actual level of radiation. The "real" radiation, like all the climate data, is represented in this study by the Test Reference Year (2004) for Munich [2]. To include the discrepancies between the forecast and actual values, this study uses the deviations between the forecast for the town of Holzkirchen and the measured data from the institute's own weather station. Based on this data, an appropriate mathematical deviation model is developed. The study uses the solar global radiation forecast from the TRY data set, adjusted according to this deviation model.

RESULTS

It can be shown that the evaluated system can reduce the heating energy requirements of the investigated homes by 14-26 % through intelligent control of the heat source (e.g. boiler or heat pump). Since a lower comfort setting is used in this study, the home is sometimes not fully heated when the first resident arrives. Therefore in some periods the actual temperature falls below the target temperature. Aside from the chosen comfort setting, the achievable energy savings primarily depend on the amount of time the users are at home each day, the chosen room air temperatures during absence, and the level of the internal heat sources (refrigerator, oven, etc.). The more frequently the users leave the home and the longer they are absent, the larger the system's potential energy savings are, as this increases the length and frequency of the periods with reduced room air temperatures. In the case of systems using preprogrammed usage periods, it is possible that the user will arrive to a cool home if he comes back at an unexpected time. Therefore, the periods of presence have to be set generously in order for the home to reliably be warm when the user is present. As such, the evaluated system, with its automatic presence detection, really shows its strengths when periods of presence are irregular. In this case, the temperature reduction times are adjusted to the actual user and there is no need to assume longer periods of use.

Fig. 1: Net heating energy savings for an unrefurbished appartment occupied by a single and for a single family house, occupied by a family.



It has been shown that the presence detection alone can bring about a heating energy saving of up to 24 %. Furthermore, by turning down the heating only based on the weather forecast, the system also can make additional savings of up to 7 %, based on the window sizes chosen here. If the window surfaces are relatively large, this effect will increase accordingly. The system evaluated here, called "tado°", has been available since November 2012.

1 *tado° mobile App report function on a smart phone.*

2 *illustration of the tado° presence detection.*