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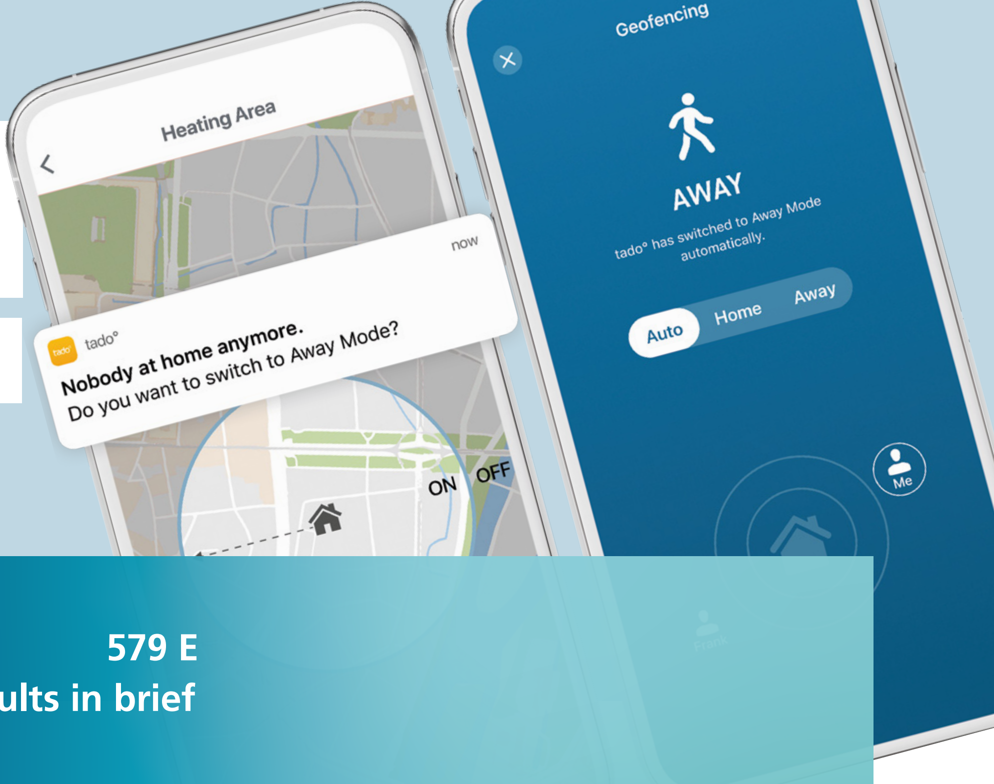

IBP-Report 579 E
49 (2022) New research results in brief

The energy saving potential of an intelligent heating control system

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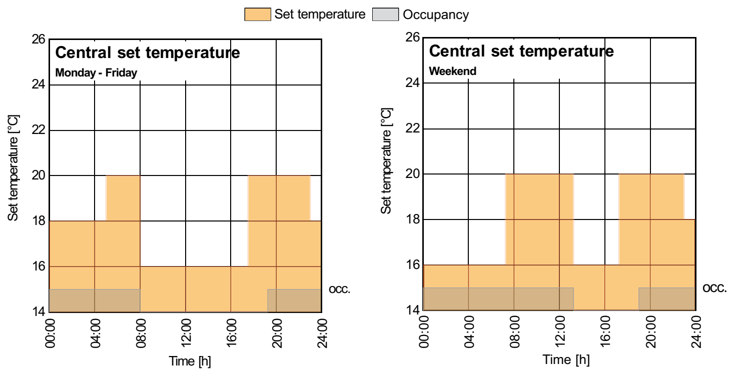
Background
Conventional heating control systems regulate the temperature based solely on local measurements – indoor or outdoor air temperature. Advanced systems allow users to program schedules. During defined periods of absence, lower set temperatures in the rooms reduce the energy consumption for heating. However, these systems can neither react to periods of user presence or absence that have not been programmed, nor take into account next hour's weather, nor can those turn off the heating when the window above a radiator is open.

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. This determines the level of comfort when the first occupant arrives. 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 this data, the system turns down the heating in advance when sufficient sun is expected within the next hour. Also the heating is turned off when an open window is detected by a sudden temperature drop, instead of the heater powering up because of the drop and the generated heat being vented out directly.

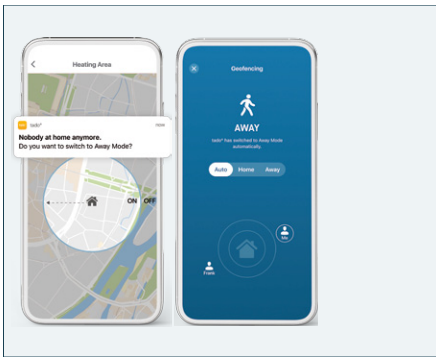
The study described here is based on transient calculations (TRNSYS 17). The algorithm of the evaluated system is replicated in simplified form and linked with TRNSYS. This study is carried out on a typical single family house and a typical five room apartment. In addition, it evaluates two different 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 behavior in conjunction with realistic supply temperatures, the simulation model includes a heat curve based on the outside temperature and detailed models of the radiators and their controls. This study uses the system's standard pre heat before arrival setting ("Balance").

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 to maintain a constant temperature of 20 °C during the day. To account for night setback 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 a Test Reference Year for Munich *[2]*. To include the discrepancies between a forecast and actual values, this study uses the deviations between a forecast and the measured data from the institute's own weather station. Based on this data, an appropriate mathematical deviation model is developed. The study



left:
Set temperature profile for occupancy by a single person.



right:
Screen shot of the tado° absence detection.

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 (without domestic hot water) of the investigated homes by 12–28 % through its intelligent control. When the 'Balance' pre-heat setting is used, there are times when the home is not fully heated to the desired temperature when the user arrives home. This leads to some periods where an occupied home has not yet reached the setpoint temperature.
Aside from the chosen comfort setting, the achievable energy savings primarily depends 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 fixed pre-programmed 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, has a potential strength when periods of presence are irregular. In this case, the temperature reduction times are automatically adjusted to the actual occupant(s) and there is no need to assume longer periods of use.
It has been shown that the presence detection alone can bring about a heating energy saving of up to 13–23 %. Furthermore, by turning down the heating only based on the weather forecast, the system also can make savings of 0.4–6 %, based on the window sizes chosen here. If the window surfaces are relatively large, this effect might increase. The open window detection by itself can save 1–12 % heating energy.
The system evaluated here, called "tado°", has been available since November 2012.
This IBP-Report summarizes the findings of a full report No. EER-021/2022/720 that can be requested from the client tado° GmbH.

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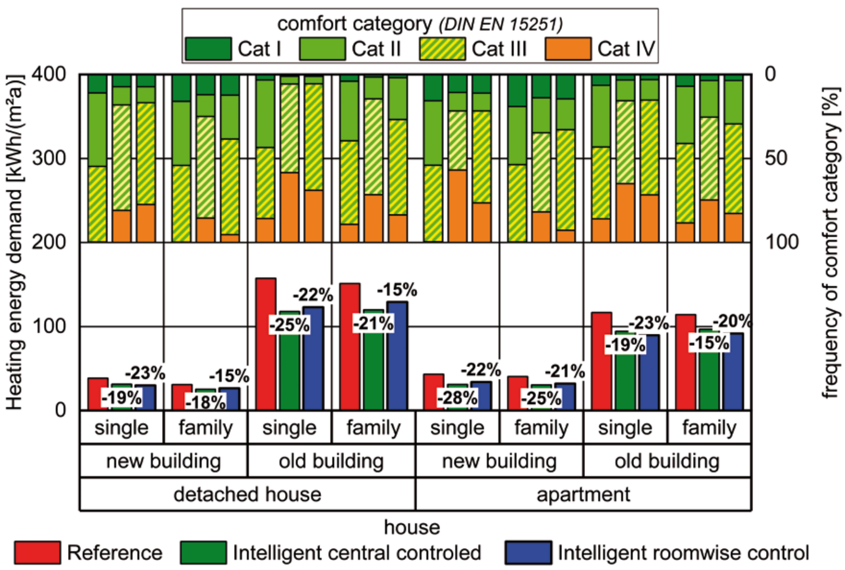
Literature
[1] DIN V 18599-10:2018-09. Energetische Bewertung von Gebäuden – Berechnung des Nutz-, End- und Primärenergiebedarfs für Heizung, Kühlung, Lüftung, Trinkwarmwasser und Beleuchtung – Teil 10: Nutzungsrandbedingungen, Klimadaten.
[2] Christoffer, Jürgen; Deutschländer, Thomas; Webs, Monika: Testreferenzjahre von Deutschland für mittlere und extreme Witterungsverhältnisse. TRY, Offenbach a. Main: Selbstverlag des Deutschen Wetterdienstes, 2004.



Specific heating energy demand (left Y) and relative savings [%]. The right Y axis shows a duration [%] where the temperatures are below the desired setpoint; the sum of negative set temperature deviations [K] and their duration [h] during heating period and user presence.