Fraunhofer
ITWM

Energiemanagement für Mietwohnungen mit Open-Source Smart Metern (EMOS)

Short Report

FORSCHUNGSINITIATIVE
Zukunft BAU

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The project Ënergy management for appartments using open source smart meteringäims to evaluate the use of smart metering technology in rented appartments. In Germany, more than half of the population lives in rented appartments. The average age of a rented appartment is around 50 years — the potential for ecological modernization is huge. But tenants usually do not have any influence ofer modernization projects like heating upgrades or building insulation. In this project, our goal is to enable tenants to save energy by raising awareness about energy waste, enabling them to change their behavior.

During the project we did evaluate different smart meters, both for room climate and power consumption. We installed them in trial households and recorded the measurements via the internet. The smart meters are not suitable for billing purposes since they are not calibrated. Instead, they are suited for retrofitted and relatively cheap. Tenants can take them away when changing appartments.

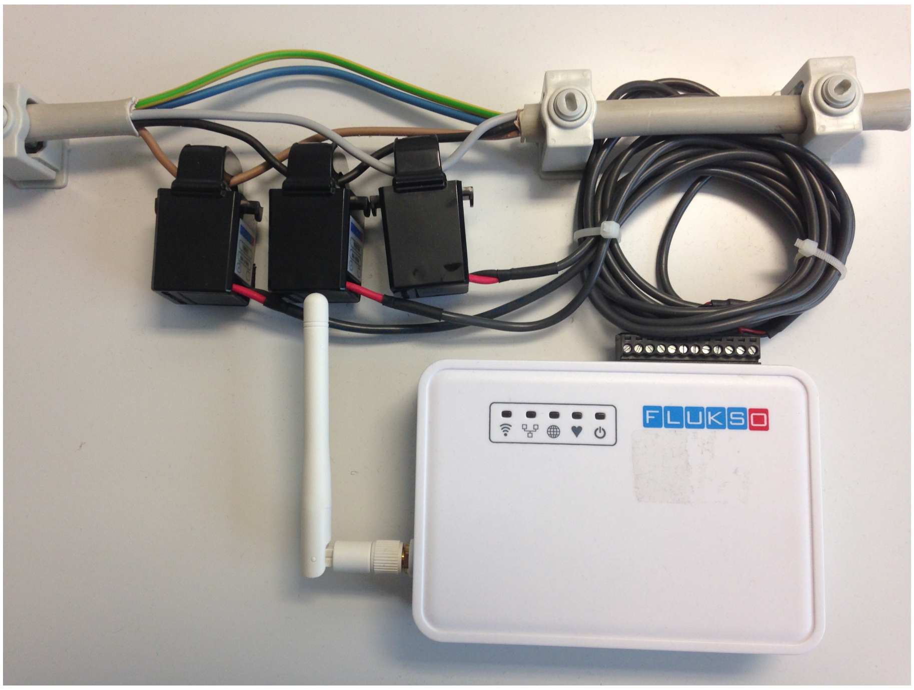

Abbildung 1 Installation of a Flukso. The device is similar to a wireless router. The black hall effect sensors are snapped around the phase conductor and connected to the Flukso.

The devices are licensed under open source terms and can be used freely. In the case of the smart meter Flukso we use existing hardware. We changed the software components massively in order to improve the installation procedure on-site. The Flukso is deployed into the existing wiring installation of the tenants and linked to the internet using the tenant's wireless.

Figure 1 shows a typical installation. The black hall effect sensors are snapped around the phase conductor and connected to the Flukso. Since no rewiring is necessary, the installation time is reduced significantly. The measurement itself is not as exact as using a calibrated meter. However, in the context of this project, this is not a real drawback — measurement data is quite accurate and sufficient.

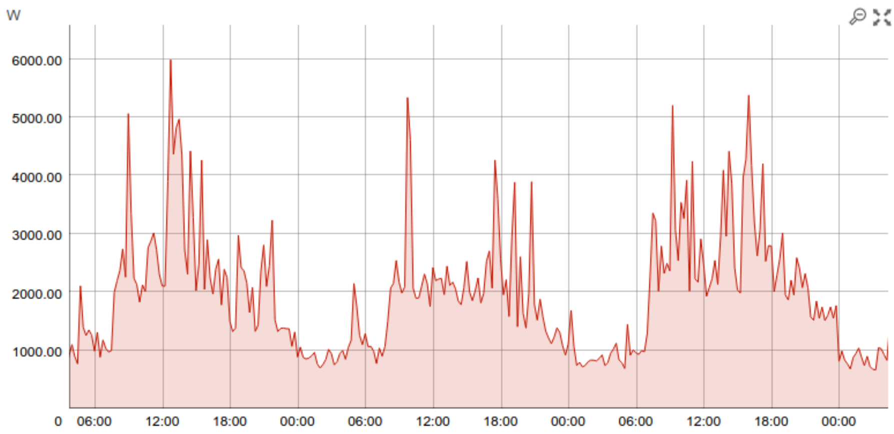

Abbildung 2 Three days of power consumption of one participating tenant. Other visualizations like daily consumption etc. are available as well.

The tenants can access all measurements using our website. They can select different visualizations for their power consumption. This helps them to identify energy wasting. The visualizations are engineering plots: We mostly display graphs and key numbers. Figure 2 shows an example. Other key figures are also accessible, for example a prediction of the yearly power bill, see figure 3.

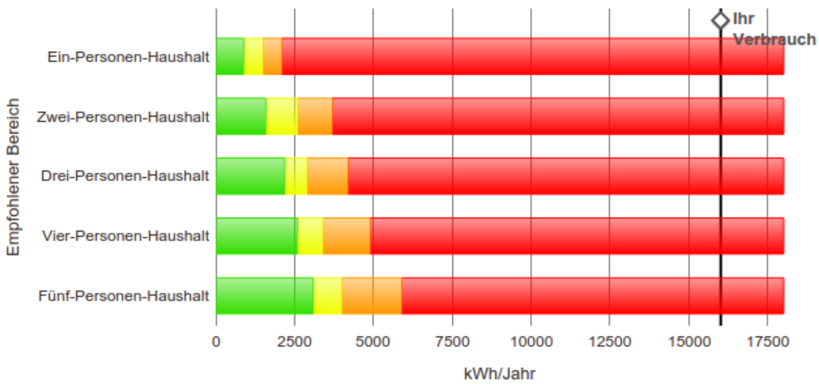

Abbildung 3 Visualization of a tenants power usage with an assessment based on household size.

Participants were also able to get notifications via email: for example, when the power consumption raises above a certain threshold, an email can be sent. We also provided a realtime view on the values on a local tablet, see figure 4.

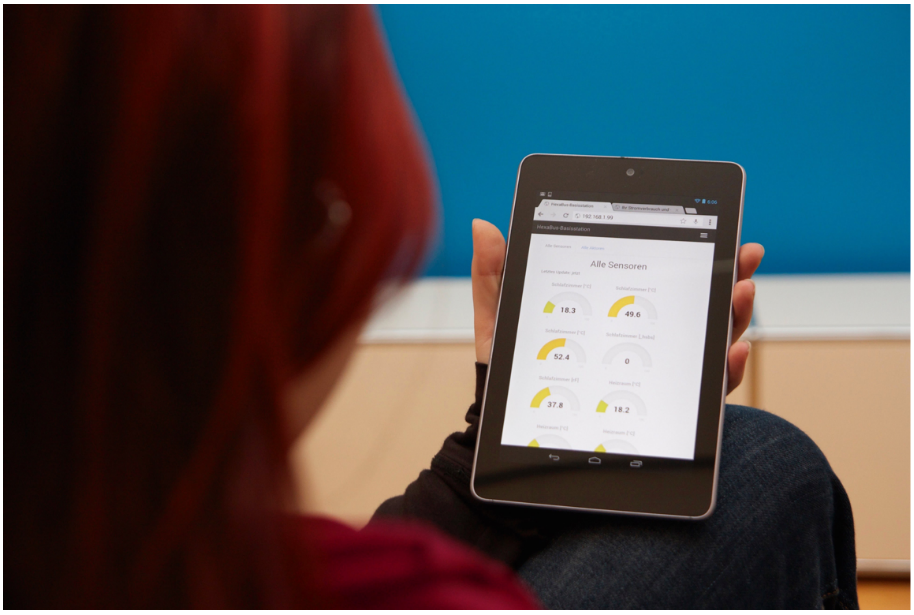

Abbildung 4 Sensor values being displayed on a tablet. Using their base station the participants had access to realtime sensor readings.

The realtime display has a time resolution of about 1s. This is very helpful when searching for energy wasting appliances: If one uses for example the water boiler, the energy consumption is updated very quickly. This fast feedback enables our participants to locate energy waste very effectively by using their smartphones or tablets.

We chose another approach for the room climate sensors. The visualization of the power consumption follows an engineering approach. For the room climate, we wanted to implement a more game-like approach. Can we define a game that helps you to improve the room climate? A basic requirement is a working game principle [1] and instant feedback. We chose to represent the room climate as a graph following Leusden and Freymarks RRaumbehaglichkeitsdiagramm-/citeleusden51raumbehaglichkeit, see figure 5.

Leusden and Freymark investigated at which combinations of temperature and humidity people feel comfortable. They differentiate three regions: *comfortable*, *acceptable* and *uncomfortable*. Our participants get practival advice on how to improve their room climate. For example, if the humidity is too high (21° C at 75% r.h.), they will be shown an öpen windowssign.

Originally, we intended to implement this display on a Chumby, an internet-enabled clock radio. But the manufacturer went bankrupt during the project, abandoning all support for their devices. This forced us to develop our

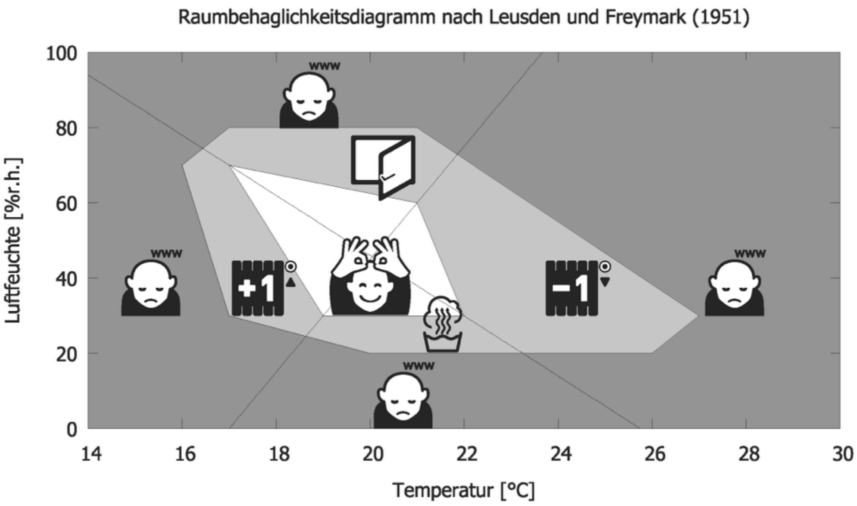

Abbildung 5 Room comfort level following Leusden and Freymark. They investigated how different temperature and humidity values affect the comfort of probands and derived a comfort zone from their observations.

own hardware, based on our Hexabus-System. The device we used is shown in figure 6.

The room climate sensor implements two functions: On one hand, it senses temperature and humidity. The measurements are sent to our project website using our home automation system Hexabus. On the other hand, it displays actions that the user can take to improve the room climate. If everything is fine an ok-icon is displayed, see figure 6. Participants have two ways of accessing their measurement values: on the room climate sensor itself and on our project website. On the latter the measurements are shown as a graph similar to the power graph, see figure 2.

During the project we were able to inspire 66 households to join the project. Households were permitted to join the project at any time — which is why we don't have continuous data from every household. Some people also moved away. We conducted three surveys during the project. The surveys aimed at quantifying attitude, motivations and expectations with regard to the project, see figure 7.

Abbildung 6 The room climate sensor in one of our participant's home. The device was developed for the project and displays advice icons on a well-readable epaper display.

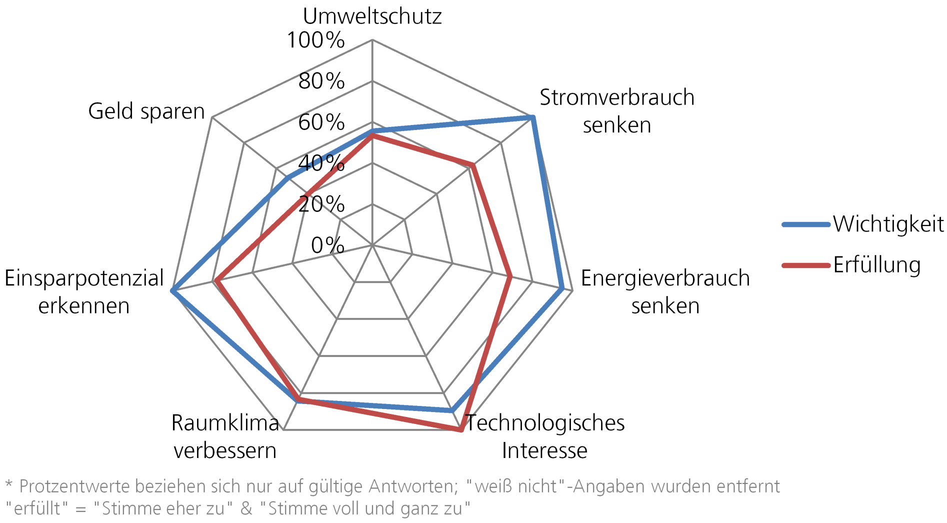

Abbildung 7 Classification of the interests of our participants. Which ones have we been adressing best?

Our participants did not put money saving or saving the environment highest on their priority list. Instead, the interest in technology and identifying energy waste was high on their list. We were able to meet their expectations in the fields of identifying energy waste, improving the room climate and interest in technology. We did not meet their expectations for the reduction of power usage. At the same time we have to point out that not many households even knew how high their power usage has been. Unfortunately, we were not able to collect enough data for comparisons. We therefore cannot deduct whether our participants really saved energy. Our participants would be willing to pay up to 150€for similar devices. We expect to meet this price for a production run of our devices.

During talks our participants made clear that they do not see the energy consumption graphs as helpful. This confirms our assumption that energy displays as such do not neccessarily lead to energy savings. Our room climate sensor gives hands-on advice on how to improve the room climate — which has been received very well.

For future projects we intend to work on gamification for energy consumption awareness [1]. The feedback of our participants lead us to believe that a simple representation of complex energy consumption patterns will have a very beneficial effect on domestic energy consumption. We were also able to identify two main groups of participants:

(1) The participant that is a technology enthusiast. They usually prefer to have uninterpreted measurement data and can derive actions from the data. Often, these people drive the adoption in our participating households.
(2) The second group of participants does not want to deal with the technology itself. They cannot derive actions from graphs. In order to create behavioural change, they need hands-on advice. Usually, they will follow the offered advice.

With respect to the introduction of smart metering in Germany it seems to be neccessary to adress both groups simultaneously. Currently, the smart metering industry adresses the needs of the technical users. For the second group, the technology needs to offer concrete advice so that these housholds can benefit from the energy saving potential.

Literatur

[1] Jane McGonigal. *Reality Is Broken: Why Games Make Us Better and How They Can Change the World*. Penguin Group , The, 2011.