Know Thyself: Monitoring and Reflecting Energy Consumption

Matthias Betz
Fraunhofer Institute for Applied Information Technology FIT
Schloss Birlinghoven
53754 Sankt Augustin
matthias.betz@fit.fraunhofer.de

Tobias Schwartz
Fraunhofer Institute for Applied Information Technology FIT
Schloss Birlinghoven
53754 Sankt Augustin
tobias.schwartz@fit.fraunhofer.de

Leonardo Ramirez
Fraunhofer Institute for Applied Information Technology FIT
Schloss Birlinghoven
53754 Sankt Augustin
leonardo.ramirez@fit.fraunhofer.de

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Abstract
In the last few years, a growing awareness has emerged on the impact that personal energy consumption have in the global levels of energy waste. Building on this trend, SmartMetering has focused on providing access to energy consumption data with increasing levels of granularity. In this position paper we show the results of a preliminary study of SmartMetering technology in different contexts of use. One repeating pattern observed in our studies was the relevance of the connection between metering data and usage habits. We argue that the efforts of SmartMetering are incomplete if they stop on data visualization without further supporting the change of habits in energy consumption. To illustrate our ideas, we provide a set of design sketches that move the focus from energy consumption displays towards supporting changes in personal and social behavior patterns which are ultimately the source of energy consumption.

Keywords
Life-logging, self-awareness, energy consume, energy efficiency

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Experimentation, Human Factors

Introduction

Energy usage has become a relevant issue in the last few years, and in modern life there is a growing awareness of our personal responsibility in prevent environmental pollution, minimize the waste of energy and reduce the carbon footprint.

Under the name of SmartMetering, a collection of new sensor technologies has emerged, that serves as enablers for the digital acquisition of energy consumption data well known. SmartMetering offers solutions for measuring, structuring, transferring, storing and visualizing consumption data, and is getting a promising new field of applications in HCI.

Besides its value for advanced network management and Smart Grids, the actual discourse in SmartMetering focuses on the acquisition and visualization of consumption data. SmartMetering promises more efficiency by offering adequate controlling interfaces and data visualizations of energy consumption over time for e.g. residents of private homes, in the hope of implicitly addressing personal behavior patterns.

The main problem of this perspective is that it fails to address the core problem. From our perspective, energy consumption values are only symptoms resulting from personal habits and behaviors, and energy efficiency is more about introducing changes in these habits. This is not to disregard the merits of SmartMetering technology, but to point out that visualization is just a part of fostering energy efficiency and that the interplay between energy consumption and personal behavior is what leads toward individual expertise which is the basis for more appropriate and efficient consumption behaviors.

One understandable reason for this incomplete perspective particularly lies in the difference of nature of these two elements: Energy consumption data is generated during the measurement of a running device, based on stable physical properties. They are easy to model and easy to capture and store. On the other side, personal behavior is hard to model, monitor and store [2]. Without appropriate models, there are very limited possibilities to reflect on behavior histories, let alone integrate behavior data and consumption data into coherent and valid models.

In this contribution we present the results of a preliminary study that supports this reflection, together with two complementary approaches for bringing personal behavior and energy consumption together to enable consumers to reach higher levels of energy efficiency. We illustrate these two approaches by means of a simple design sketch.

Approach

The corpus of data supporting this paper comes from a set of 3 empirical studies conducted both in domestic and office contexts over the course of eight months. We used a mixed-method approach [3,5] by doing a qualitative study complemented with online surveys in each field of application. The purpose was to research the use of SmartMetering technology in different environments.

Smart Metering in Work Context

We conducted a study in a large organization. Smart Metering infrastructure was installed in two offices to measure consumption both overall and at device level. The data was worked off with the participants of the study in a workshop and individual interviews. We fo-

cused on finding out if the provided SmartMetering data was enough to identify potentials for efficiency improvement and if the participants changed their behavior in relation to the new transparency of their energy consumption.

Online Questionnaire in an Organization
We conducted an online questionnaire to get a better insight of the phenomena observed on the Smart Metering in Work Context. We used an online questionnaire consisting of 27 statements related to the topics of energy consumption, personal behavior and the potential of SmartMetering infrastructure in the work environment of the participants. The questions were motivated by the experiences we made during the qualitative investigation. We provided the participants also with additional space to add their own comments and suggestions. The online-questionnaire was send to more than 950 people in the organization with a response rate of 17.5 %. 76% of the persons who participated at the survey added personal comments or suggestions. The gathered information provided a better understanding of the organizational context and the personal behavior of the employees.

Smart Metering in Domestic Context
In addition to the work context, we conducted an empirical study in private households. We equipped 13 voluntary households with simple smart metering technology to measure energy consumption at device level in four different categories. Prior to the installation of the metering technology, we conducted semi structured interviews focused on the individual energy consumption of each participant. After one week of measuring, a collaborative data interpretation session was conducted with each of the participants.

Common ethnographic methods like site visits, participatory observation, interviews and workshops were used to enrich the studies. The gained empirical material was analyzed with qualitative methods of social science [3,5,6].

Results

After analyzing the corpus of data collected, some common patterns emerged. The common ground for all of them is that in all cases, the interpretation of the energy consumption histories was accompanied by attempts of reconstructing the personal activities during the considered period. As stated in many interviews the participants needed as much information as possible about the situation and the situated behavior to estimate if any use of energy was a necessity or a waste. Most of the participants based their interpretation on speculative assumptions grounded on personal memories or group calendars, emails etc.

Overall in this early stage of the analysis we were able to see that smart metering data is only meaningful if integrated with information about personal activities, habits and behavior. People are able to optimize and rethink their energy consumption only if metering information goes along with the traceability of personal behavior.

Supporting Change of Habits

In design sessions hold after the studies, we discussed approaches for supporting the change of habits. The results emerging from our studies clearly showed that the interplay between energy consumption data and personal habits was the key for stimulating energy efficient behavior. We present here two contrasting design concepts that illustrate a change of focus in the con-

struction of energy efficiency fostering technology, from data visualization to habit change support.

Improving the capture of behavior
One option to include behavior is to capture and tracking the personal activities and integrates this information with the energy consumption data. Like stated in the introduction, personal behavior is very complex to model but weak structured approaches could support users reconstructing their behavior in the past for an ex post reflection and analysis of their energy consumption. One possible implementation could be the introduction of a tool like the sensecam [4] to capture and document situations. This photo streams could be then synchronized with SmartMetering information and may help users to recall certain situations and reflect their in-situ behavior. This approach would allow the construction of histories which form the basis for ex post analysis to stimulate learning and reflection and motivate change of behaviors in the future [1].

Provide energy consumption information in situ
Reconstructing context could prove very difficult. A supplemental approach could be to provide information of energy use in-situ, during use. The situation is then enriched by direct feedback of current consumption. Energy use produces a breakdown in the activities of the users which motivates a reflection and has the potential of triggering a learning process. A possible implementation of this approach is the use of haptic or acoustic feedback responding to current consumption, or to changes in patterns of consumption.

Future work

In the future we intend to build prototypes of the concepts presented and evaluate them in both contexts presented here. Then we want to compare both approaches regarding their effects on a more energy efficient behavior. The results will provide interesting insights in the field of IT support for energy-efficiency. Beyond that, the results will be discussed against existing paradigms in the field of context-awareness, behavior sciences and e-learning.

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