Collecting Factors for Motivating Energy-Saving Behavior

Marc Jentsch, Marco Jahn, René Reiners, Uwe Kirschenmann
Fraunhofer Institute for Applied Information Technology FIT
Schloss Birlinghoven
D-53754 Sankt Augustin, Germany
{*marc.jentsch, marco.jahn, rene.reiners, uwe.kirschenmann*}*@fit.fraunhofer.de*

***Abstract*—Ubiquitous computing systems are deployed for support in many different domains, one of them is energy efficiency. Existing ubiquitous computing systems, which aim at helping people to save energy, usually give feedback about their users' energy consumption. But these systems do not take into account age or gender of the users coming with different attitudes and motivation. Since we are considering user awareness as important factor for the success of pervasive energy saving support systems, we are going to develop a system on our own. In this paper, we investigate what requirements our system must meet and how it should be designed. We explore people's knowledge about energy efficiency and the motivation to save energy. Then, we investigate the impact of age on these aspects. The target groups are female, divided into two age groups ranging from 13 to 15 years and 23 to 30 years. Finally, we draw conclusions how to design our user-adaptive energy saving support system.**

***Keywords*-energy management, user interfaces, context adaptation, ubiquitous application;**

I. Introduction

Today's energy consumption behavior is characterized by a high amount of wasting. This causes unnecessary costs for companies or private households. In addition, global warming is being boosted, because more energy has to be produced which leads to higher CO_2 emissions. The reason for this behavior is often a lack of knowledge about the current energy consumption. In many cases, it is hard to identify energy-wasting devices. The only feedback about the own energy consumption is a yearly bill only allowing a retrospective, summarized view. This makes a change of behavior difficult due to the lack of a direct connection between cause and effect.

Current feedback-based ubiquitous systems are mainly based on the results from early studies in the field of environmental psychology that experiment with different interventions like feedback, goal-setting and rewards. Abrahamse et al. [1] provide a review of such studies, most of them resulting in energy savings up to 15%. But, Abrahamse et al. also note that most of these studies did not take into account determinants like knowledge, attitude, age etc. and that little is known about the long-term effects of the applied interventions. Other analyses come to similar results regarding the power of constant real-time feedback [2], [3] but also mention that environmental, social, and educational factors need to be considered when aiming at behavioral changes.

Since demographic aspects influence energy consumption behavior [4], we state that applications must be customized for different population groups. Our goal is to develop a pervasive system that supports people in saving energy. Unlike existing approaches, our system shall be context aware by taking the individual user into account. In this paper, we want to find ideas how to design our energy saving support system which adapts to different user groups. We have conducted a study that finds out about some differences in attitude and motivation towards the topic of saving energy with regard to different demographic aspects. This serves as basis for design decisions for our ubiquitous energy saving support system.

As starting point for investigation we take individual differences into consideration, as it is known from psychology. As this research topic is rather complex, the focus here is on age differences in prosocial behavior and will continue with gender differences in a following study. In this sense, Baldassare and Katz [5] show that women are significantly more likely to engage in environmental practices. That is the reason why we start investigating female behavior. Aging has a direct impact on energy consumption as the attitude tends to change over lifespan [6]. Therefore, we investigate possible differences between younger and older women with regard to energy saving and discuss how our energy saving support system should be individually designed.

The remainder of the paper is structured as follows. In Section II, we discuss related work which is occupying with the psychological background about motivational aspects to save energy. Additionally, we present existing feedback-based systems. In Section III, the setup of the study is described, its results follow in Section IV, the discussion in Section V. An outlook on future work is given in Section VI.

II. Related Work

Blocket et al. [7] analyzed the 1993 General Social Survey and found out that women show more environmental concern than men. On the other hand, they are not more likely to engage in environmental action. Steel [8] performed four waves of mail surveys and telephone follow-ups to

 ISBN: 978-1-61208-152-6

investigate the link between environmental attitude and behavior. As a result, women are more likely to participate in environmentally protective behavior. This is confirmed by Stern et al. [9] who found that women express stronger intentions to act than men. And later they found females having stronger biospheric-altruistic values [10]. Schahn et al. [11] again confirmed women having more environmental concerns. At the same time, men showed higher knowledge about environmental problems in their study.

A survey [12] of 801 women at 18 years or older addressing attitudes and awareness about energy emphasizes the importance of the role of women when it comes to energy awareness. For example, 77% of the women take primary or equal responsibility for paying their electricity bills. 97% try to save energy, e.g., by turning off lights, using energy saving lamps etc.

Almost all industrial and scientific efforts to increase energy awareness of users are based on the concept of providing constant real-time energy consumption information. Several products focussing on feedback are currently entering the market, e.g. Google PowerMeter [13], Microsoft Hohm [14], Greenbox [15] or The Power Tab [16]. As an example from the scientific community, Mattern et al. [17] present the eMeter system, which connects a smart meter with a mobile phone to provide the user with real-time feedback on device level. The user interface visualizes consumption data as well as historical data and costs per device. The power-aware cord [18] is a classical example for a ubiquitous computing system that aims at enhancing energy awareness: It is an electrical power strip that visualizes the amount of energy passing through it by animating the wire with lights. Jacucci et al. [19] present the EnergyLife system, which combines real-time feedback information with goal setting and awareness tips.

All systems miss to take into account the individual social and educational background. They show consumption data, costs and CO_2 emission and assume that the same visualization works equally well for different gender or age, associated with different attitude and motivation of users. In this paper, we will show that different user groups come up with different attitude and motivation towards energy saving. Additionally, we will draw conclusions how our own user adaptive energy saving support system can be designed.

III. Study

In order to find out how the age of participants influences motivation and knowledge about energy consumption, we created a questionnaire that we gave to two groups at different ages. We expected to find ideas how to design our user-adaptive energy saving support system. As related work promises women to be higher motivated to save energy, we started comparing girls and women.

The survey was conducted in two sessions, each lasted 30 minutes. In the first session, we engaged eight girls in the age of 13 to 15 representing teenagers. The second session contained eight women at the age of 23 to 30 representing grown-ups. All participants had never used any energy saving support system. At the beginning, both groups were briefed that we are investigating knowledge and motivation regarding energy saving. We explained that the questionnaire was anonymous and they will not be judged in order to decrease potential inhibitions. Each participant got one questionnaire. A moderator read aloud every question which the participants should answer. This procedure had the advantage of clarifying arising issues together with the participants.

The first three questions investigated the background knowledge regarding energy savings in order to find out what kind of information needs to be provided by our assisting system. First, we wanted to know if there is awareness of energy consumption behavior at all. Then, we asked for methods for energy saving without predefined options. Next, we gave predefined options and a free text field for finding out the source of this knowledge.

The latter two questions asked for the motivation for saving energy. From the gathered results, we expected to draw conclusions on how we can increase peoples' motivation. The first question "*What can be reasons for you or others to save energy?*" targeted to find every possible motivation in general. The whole group should name possible motivations for energy saving aloud. The second question asked each participant individually to rank the collected aspects by personal priority. Reasons that were personally not relevant should be listed unranked in a special area of the questionnaire. By this, we expected to get an overall ranking of the importance of motivational aspects.

IV. Results

In this section we present and arrange the results of the questionnaire which will then be discussed in Section V.

Awareness: All participants answered that they have reflected how energy can be saved. At the same time, everyone stated to try to save energy at least once in a while.

Knowledge: With respect to the question how energy can be saved we identified two classes of answers. On the one hand the participants proposed to change equipment. On the other hand, a change of behavior was proposed. Each class could be divided into four subclasses.

The equipment class consisted of using *Energy Saving Lamps*, buying *Efficient Devices*, *Thermal Insulation* and *Solar Plants*. For the *Efficient Devices* subclass the women suggested to pay attention to energy efficiency when buying new devices in general or gave examples like new washing machines or new refrigerators.

In the behavior class, the participants argued to completely remove unused devices from the power line instead of using the stand-by mode. They also stated to switch off lights when not being in the room. We summarized further answers as

 ISBN: 978-1-61208-152-6

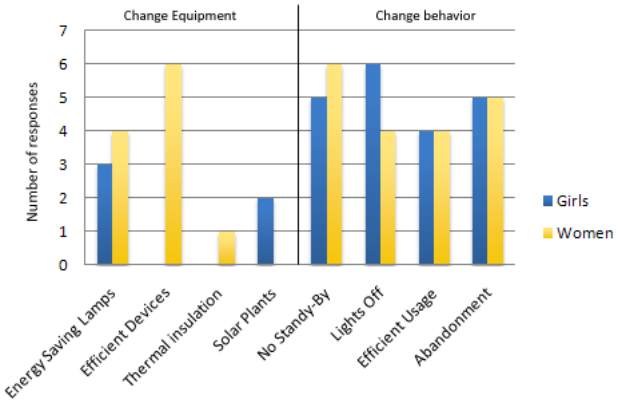

Figure 1. Grouped answers to the question: "*How can energy be saved?*"

deliberate *Efficient Usage*. Examples are "*Close the window when heating*" and "*Don't start the dish washer before it's full*". For the last subclass the participants proposed to abandon e.g. a dryer, the elevator or to live vegan. Figure 1 illustrates the distribution of answers to the question about ways to save energy.

Knowledge Sources: Figure 2 shows the distribution of the answers to the question "*How do you know about energy saving?*" All four girls who filled in the *Misc* field wrote: "*I have found out myself*". One of the women who filled in the *Misc* field wrote: "*By usage*", the other one answered "*Radio, Friends*".

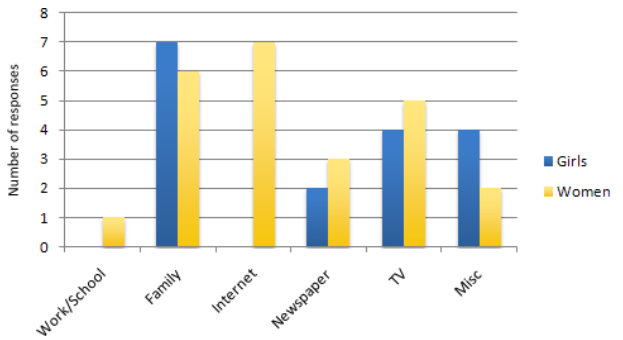

Figure 2. Answers to the question: "*How do you know about energy saving?*"

Motivation: During the group discussion, the girls identified six motivational factors for saving energy: *Environment Protection*, saving *Costs*, parental *Bringing-Up*, *Side Effects*, *Personal Visualization* and *Games*. *Side Effects* was explained using the example of vegetarian lifestyle which has a lower energy need than non-vegetarian lifestyle. In this example, the motivation to live vegetarian was to save animals while saving energy is just a side effect. *Personal Visualization* means that if the girls just see how much energy they consume, this would be a reason to try to save energy.

Figure 3 shows how often the reasons for saving energy were put on which rank by the girls. For example, *Environment Protection* was classified by six of the girls on the first rank, placed by one girl on the third and another one on the fourth. The diameter of each circle is proportional to its value. The idea to come up with *Games* where the goal is to save energy was seen as promising during the group discussion but in the end none of the girls ranked it as relevant.

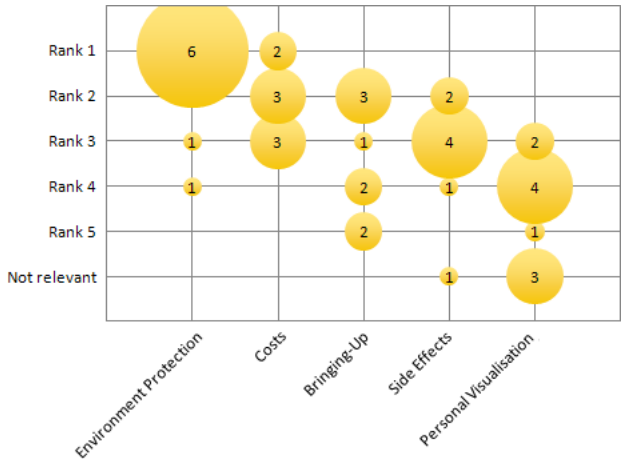

Figure 3. Overview of girls' motivation rankings

The women came up with eight motivational factors: Saving *Costs*, *Environment Protection*, *Social Pressure*, *Laws*, *Less Attrition*, *Raising Awareness*, being *Trendy* and being *Opposed to Energy Companies*. *Laws* refer to the assumption that if more laws like the prohibition of traditional light bulbs had been adopted, less energy would be wasted. *Less Attrition* means that devices are better preserved when being less used. The women also argued that starting to save energy would raise the self-awareness which is a good motivation. Figure 4 shows the women's ranking distribution. Being *Trendy* and being *Opposed to Energy Companies* was not ranked as relevant by any of the women.

V. Discussion

In this section we discuss the results of Section IV and conclude how to design our energy saving support system.

Awareness: The fact that everyone in our study states to have reflected about how energy can be saved shows that there is a general awareness of energy consumption. Also everyone answered that she tried to save energy. So, in general the motivation to save energy exists and does not need to be arisen by our system. This result may be biased by the fact that being motivated to save energy is socially requested.

Knowledge: When comparing the answers how energy can be saved, the most obvious difference between the groups is that six of the women mentioned to pay attention to energy efficiency when buying new devices while none

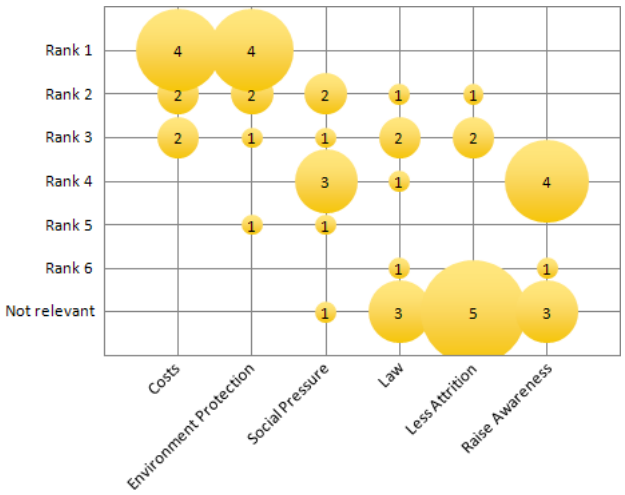

Figure 4. Overview of women's motivation rankings

of the girls had this idea. This is probably because girls do not have to buy new devices. As a conclusion, our energy saving support system will not suggest any hints to younger users because this would be a useless tip for them. It only might lower the acceptance of the system. For grown-up users, these kind of hints will be included in the system.

Two of the girls mentioned *Solar Plants*. Although, solar plants do not help to save energy, our system could show how the energy is produced.

As for the other answers the difference between the groups is two at maximum, we do not consider any distinction for different aged users of our system on these topics.

Since the answers *No Stand-By* and *Lights Off* were named very often, we interpret that the knowledge about these energy saving options is omnipresent. So, our system will not introduce them, small reminders will suffice. In contrast, information on rarely mentioned alternatives, like *Thermal Insulation*, needs to be introduced.

Knowledge Sources: With respect to the probands' knowledge about energy saving, there are again only two categories with a difference between the groups. The fact that nearly all of the women but none of the girls know about energy saving from the *Internet* may be biased by the fact that some of the women work as computer scientists. That is why we don't make conclusions for our system in this case.

The second difference is that much more girls think they worked out energy saving methods by themselves. This may indicate missing awareness of the amount of external information they are exposed to on a daily basis.

Regarding the sources *Work*, *School*, *Family* and *Friends* the information is rather pushed to the user. Coming to the sources *Internet*, *Newspaper*, *TV* and *Radio* users rather select which information to get, so these are pull services. Summarized, women named eight push and 16 pull sources while girls wrote eight push and seven pull sources. Since people have complete freedom to choose pull services, we conclude that pull services are prefered by women. In contrast, as the younger participants of our study do not use pull services regularly, information rather needs to be pushed. Hence, our energy saving support system will rather push information to younger users but provide information to be actively requested for older ones.

As interesting overall result, the family is a knowledge source for nearly everybody while work resp. school is not. While being prominent at home, saving energy does not seem to be covered at work and at school. So, we will deploy our energy saving support system in work and school environments.

Motivation: The main motivational aspects were named by both groups. Besides *Environment Protection* and *Costs*, *Bringing-Up* is similar to *Social Pressure* and *Personal Visualization* denotes the same factor as *Raise Awareness*. *Law* and *Less Attrition* were only mentioned by the women, while *Side Effects* was stated solely by the girls.

The motivational aspects' ranking differs more. While the women ranked *Environment Protection* and *Costs* almost equal, the girls gave a much higher priority to *Environment Protection*. We conclude this is again because girls do not have to pay the energy bill by themselves. Our energy saving support system will keep in mind what motivates the user group and provide the appropriate incentives.

In general, *Environment Protection* and *Costs* are the most important motivational aspects since everyone ranked one of them first. On the other hand, the approach to use *Games* to get people to save energy does not seem to be promising since nobody felt attracted. The same applies to the attempt to make energy saving trendy and ways to incite against energy companies.

VI. Future Work

With the conclusions drawn from this survey we derived features that we will implement in our adaptive energy saving support system. Next, we will set up the same study with appropriately aged groups of men to investigate gender as other influencing factor. After that, we will implement adapted systems for each group and evaluate them in user tests.

Acknowledgements

This research was supported by the European Commission within the SEEMPubS project (project No. 260139).

References

[1] W. Abrahamse, L. Steg, C. Vlek, and T. Rothengatter, "A Review of intervention studies aimed at household energy conservation," *Journal of Environmental Psychology*, vol. 25, pp. 273–291, 2005.

 ISBN: 978-1-61208-152-6

[2] G. Wood and M. Newborough, "Dynamic energy-consumption indicators for domestic appliances: environment, behaviour and design," *Energy and Buildings*, vol. 35, no. 8, pp. 821–841, 2003.

[3] S. Darby, "The effectiveness of feedback on energy consumption," *A Review for DEFRA of the Literature on Metering, Billing and direct Displays*, no. April, 2006.

[4] D. Newman and D. Day, *The American energy consumer*. Ballinger, 1975.

[5] M. Baldassare and C. Katz, "The personal threat of environmental problems as predictor of environmental practices," *Environment and Behavior*, vol. 24, no. 5, p. 602, 1992.

[6] E. Yamasaki and N. Tominaga, "Evolution of an aging society and effect on residential energy demand," *Energy Policy*, vol. 25, pp. 903–912, 1997.

[7] T. Blocker and D. Eckberg, "Gender and environmentalism: Results from the 1993 general social survey," *Social Science Quarterly*, vol. 78, pp. 841–858, 1997.

[8] B. Steel, "Thinking globally and acting locally?: environmental attitudes, behaviour and activism," *Journal of Environmental Management*, vol. 47, no. 1, pp. 27–36, 1996.

[9] P. Stern, T. Dietz, and L. Kalof, "Value orientations, gender, and environmental concern," *Environment and behavior*, vol. 25, no. 5, p. 322, 1993.

[10] P. Stern, L. Kalof, T. Dietz, and G. Guagnano, "Values, Beliefs, and Proenvironmental Action: Attitude Formation Toward Emergent Attitude Objects1," *Journal of Applied Social Psychology*, vol. 25, no. 18, pp. 1611–1636, 2006.

[11] J. Schahn and E. Holzer, "Studies of individual environmental concern: The role of knowledge, gender, and background variables," *Environment and Behavior*, vol. 22, no. 6, p. 767, 1990.

[12] G. Q. R. Research, "Women's Survey on Energy & the Environment," 2009.

[13] Google, "Google PowerMeter," 2011, available online at http://www.google.org/powermeter; visited on June 30th 2011.

[14] Microsoft, "Microsoft Hohm," 2011, available online at http://www.microsoft-hohm.com; visited on June 30th 2011.

[15] SilverSpring Networks, "greenbox - Empowering energy customers to better manage their usage," 2011, available online at http://getgreenbox.com; visited on June 30th 2011.

[16] energyaware, "The PowerTab In-Home Display," 2011, available online at http://www.energy-aware.com/our-products/ihd; visited on June 30th 2011.

[17] F. Mattern, T. Staake, and M. Weiss, "ICT for green," in *Proceedings of the 1st International Conference on Energy-Efficient Computing and Networking - e-Energy '10*. Passau, Germany: ACM Press, 2010. [Online]. Available: http://portal.acm.org/citation.cfm?doid=1791314.1791316

[18] A. Gustafsson and M. Gyllensward, "The power-aware cord: energy awareness through ambient information display," in *Computer Human Interaction*, 2005, pp. 1423–1426.

[19] G. Jacucci, A. Spagnolli, L. Gamberini, and P. Monti, "Designing Effective Feedback of Electricity Consumption for Mobile User Interfaces," *PsychNology*, vol. 7, no. 3, pp. 265 – 289, 2009.

 ISBN: 978-1-61208-152-6