SUPPORTING DOMESTIC ENERGY REDUCTION VIA PERSUASIVE TECHNOLOGY

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ABSTRACT

Energy consumption is abstract and invisible for consumers within the household. Through the European rollout of smart meters, an attempt to develop information and communication technologies to reduce domestic energy consumption has been launched. There is the expectation that usage of these technologies will result in energy and cost savings. This paper describes an approach for integrating persuasive strategies within these technologies to increase savings. In this paper we discuss the success of some approaches by focussing on users' acceptance and usage. We then introduce our approach of applying persuasive strategies in information systems dealing with energy consumption.

INTRODUCTION

The reduction of power consumption has become a desired goal for many households due to economic and environmental considerations. Most end-users, however, are not aware of their domestic power consumption, which factors and appliances influence it, and what the consequences (i.e. in terms of cost) are. Put shortly, power consumption is abstract and invisible to residents. New approaches, such as increased frequency of energy bills (e.g. monthly instead of the traditional once per year) or dedicated metering devices have been introduced to overcome this invisibility regarding power consumption. Besides this interest in saving energy and costs on side of the consumers, there is also an interest in shifting loads in accordance with the needs of the energy provider, e.g. to minimize peak loads.

Research has shown that detailed feedback on domestic energy consumption can substantially contribute to achieving durable effects on energy savings in private households [4]. However, existing solutions such as regular energy bills or conventional home energy displays provide the feedback in an untimely and/or difficult-to-understand manner.

To improve the effectiveness and impact of such solutions we suggest the systematic application of a persuasive technology approach. Persuasive technology aims to influence users' attitudes and behaviour in a desired direction by integrating persuasive strategies within the system, and has been successfully applied in various contexts such as health [8] or mobility [12].

In this paper we first provide a short overview of existing energy monitoring solutions. We then discuss studies aiming to quantify achievable savings, and analyse advantages and limitations of the different approaches. Finally, we present our ideas on how to integrate persuasive strategies into energy monitoring technologies.

INFORMATION ON AND GUIDANCE FOR DOMESTIC ENERGY CONSUMPTION

In the last couple of years there have been great efforts made to increase the transparency of energy consumption in the domestic context. The aim is to increase awareness, followed by behavioural change, resulting in overall energy savings. Existing approaches to manage (i.e. reduce or temporarily shift) power consumption can be clustered into three main methodologies.

First, *paper-based* efforts try to make energy consumption more visible by increasing the frequency of the traditional bill. People achieve their paper-based energy bill more frequently, e.g. every month.

Second, *dedicated ambient devices* within the user's home are used to provide information for the consumer. Ambient devices are characterized by a high stimulative nature and therefore have the possibility to attract the users' attention and make consumption visible in real time. Examples are visualised in Figure 1.

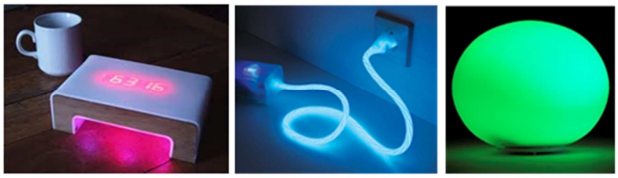

Figure 1: Wattson, Power aware cord, and Energy orb

Wattson[1] gives real-time information about the actual energy use in kWh as well as monetary values. Additionally it shines in different colours depending on the amount of energy used. This feature is also used by the Power aware cord [9]. This cord represents energy consumption through glowing pulses, color, and intensity of light. Finally, we want to mention the Energy orb[2], which guides energy consumption by giving visual feedback about the best time for consuming energy.

Third, *dedicated software programs for visualizing the energy consumption* are being developed that run on existing computing platforms (stationary and/or mobile). Present and previous consumption is visualised so that users can compare e.g. their monthly consumption. Example systems that provide data in this way are the PowerMeter by Google[3], hohm by Microsoft[4] or

1 http://www.diykyoto.com/uk
2 http://www.ambientdevices.com/cat/orb/PGE.html
3 http://www.google.com/powermeter/about/
4 http://www.microsoft-hohm.com/

GreenPocket[5]. Hohm and Power Meter are accessible through the web, whereas GreenPocket can also be bought as a smartphone app (see Figure 2).

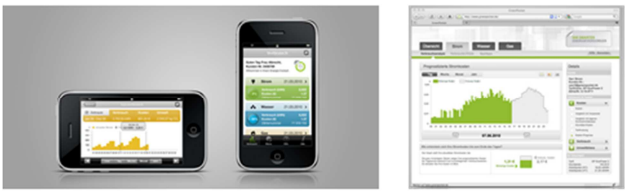

Figure 2: GreenPocket smartphone application and web page

Effectiveness of energy feedback/management methods

The general goal of the described methods is to make energy consumption more transparent to the individuals and thereby initiate behavioural change towards a more pro-environmental handling of energy. Consequently, there is high interest in evaluating and quantifying the achievable effects, to compare the effectiveness of different approaches, and to study which effects the introduction of different methods has on the everyday life of people.

Darby (2006) [3] provides a comprehensive meta-analysis of numerous empirical evaluations on the effectiveness of different types of energy feedback. According to Darby, feedback that is provided in real-time from a display monitor is labelled *direct feedback*. A typical example for this kind of feedback is the above mentioned Wattson systems. Achievable savings using this approach are between 5 and 15%. Besides this direct feedback effectiveness of *indirect feedback* was analysed. Information that is provided through indirect feedback has been processed before reaching the energy consumer and does not use real-time data. Typical examples are paper-based bills or the above mentioned Power Meter and Microsoft hohm. Found effects on savings for indirect feedback reach from 0-10% depending on the context as well as the quality of information that is given.

With regard to the effects on the everyday life recently Hargreave et al. (2010) [6] published first qualitative results of a one-year study with 275 participants in United Kingdom that gives insight on how users interact with smart energy monitors (direct feedback). Out of those 275 they interviewed 15 people asking them questions about motivations, usage and behavioural change. There are no quantitative results now, but based on first expressions of the qualitative interviews the authors stated that the amount of savings supposed by Darby [3] are hard to imagine for them. Analysing qualitative interviews with the respondents they identified three specific behavioural patterns while using the system over time. At the beginning there is a phase, labelled '*using it hot*' by the authors, in which people used the technology quite frequently. They start to monitor the device while switching devices on and off. After this initial phase people used the device less frequently but still regularly. A second pattern that had been identified was that the energy information was *integrated in the daily routines* to cut consumption. Users identified 'greedy' appliances and then changed their usage. Finally some users stated that they *changed their live style practices* based on this energy information like re-prioritize aspects of their live in order to reduce consumption.

ENHANCING EXISTING APPROACHES BY INTEGRATING PERSUASIVE STRATEGIES

To increase the effectiveness of existing approaches based on ICT we suggest the integration and application of persuasive strategies in the interaction and interface design. Persuasive technology is defined as…

"…any interactive computing system designed to change people's attitudes or behaviours"[6].

Persuasive technology has been applied for the improvement of health behaviour [8], promoting physical exercise [5] as well as for sustainable mobility [12]. The main question of persuasive technology is how behaviour and attitudes can be changed by use of technology.

To be able to successfully design persuasive system we think it is required to understand behaviour and how, why and when it changes in detail. Behaviour and its change is a complex construct which is a popular topic of research activities. Many behavioural change models have been developed in general [1], and have also focused on pro-environmental behaviour [2] to describe the process of a change. A summary of such models and frameworks can be found in [11]. These models typically are structured around two important key aspects:

a) *Influencing Variables*: There are several variables that encourage as well as inhibit a behavioural change. Examples are: problem awareness, social and moral norms, internal attribution, feelings of guilt, attitudes, perceived behavioural control and the intention to show a specific behaviour [2]. Those variables determine engagement possibilities as well as limitations for the individual.

b) *Attitude-action correspondence*: Attitudes influence the behaviour as mentioned before but do not directly result in a specific behaviour. Increasing problem awareness is not enough to change behaviour sustainable. Direct instructions of what to do can help, but nevertheless there can be variables that inhibit behaviour like perceived behavioural control.

Based on this understanding of behaviour we argue that persuasive strategies should systematically reflect and utilize the identified links between influencing variables like social norms, problem awareness and resulting behaviour. Within the next section we shortly characterize several relevant persuasive strategies suggested by different authors and provide suggestions on how to apply them in the context of domestic energy use.

5 http://www.greenpocket.de/

Persuasive Strategies

To guide persuasive system design, Fogg [6] suggested several targeted strategies. Derived from his postulated functional triad of tool, medium and social actor he identified seven persuasive strategies: Reduction, Tailoring, Tunneling, Suggestion, Self-monitoring, Surveillance and Conditioning. Similar strategies – however not within the technology context - for persuasion are proposed by Cialdini [3]: Liking, Reciprocity, Social Proof, Consistency, Authority and Scarcity. A comprehensive overview of 28 persuasive design principles and their usage is provided by [12] and [14]. Those authors state the most used persuasive principles in accepted papers of the international conference on persuasive technology. In Table 1 below we describe the nine most used persuasive principles and provide examples and suggestions on how they can be applied in energy monitoring technologies.

Persuasive Strategy	Description [5], [12]	Realization for energy issues
Tailoring	"Information provided by computing technology will be more persuasive if it is tailored to the individual's needs, interests, personality, usage context, or other factors relevant to the individual."	Benefits should be adapted to the needs of different user groups: monetary savings, social component, environmental aspects, knowledge.
Social comparison	"System users will have a greater motivation to perform the target behaviour if they can compare their performance with the performance of others."	Provide the possibility to compare energy consumption (actual, previous) with others (friends, similar strangers or whole world).
Normative Influence	"A system can leverage normative influence or peer pressure to increase the likelihood that a person will adopt a target behaviour."	Allow users to build a community and set collaborative goals, like a maximum of energy consumption.
Social Learning	"A person will be more motivated to perform a target behaviour if he or she can use a system to observe others performing the behaviour."	Provide the opportunity to observe other energy consumers and their habits (e.g. through a web-forum). Optimally those consumers should be more environmentally friendly than the person that observes, to orientate on their behavioural patterns.
Tunneling	"Using computing technology to guide users through a process or experience provides opportunities to persuade along the way."	Enrich feedback with instructions. Engage user during the process by providing continuous feedback.
Reduction	"Using computing technology to reduce complex behaviour to simple tasks increase the benefit/cost ratio of the behaviour and influences users to perform the behaviour."	Reduce the complexity to minimise cognitive effort. Good examples are the mentioned ambient devices (Wattson, Energy orb, Power aware cord).
Suggestion	"A computing technology will have greater persuasive power if it offers suggestions at opportune moments."	Besides feedback about power consumption, it is important to give instructions for reducing consumption (e.g. providing hints about energy efficiency of appliances). Instructions should be sensitive to the time and context (e.g. suggesting an energy-efficient light bulb when the consumer is in a usage situation).
Surface credibility	"People make initial assessments of the system credibility based on a firsthand inspection."	Attract the user's attention by addressing visual, acoustic or tactile aspects. Consider usability as well as user experience aspects in designing the interface.
Self-monitoring	"Applying computing technology to eliminate the tendium of tracking performance or status helps people to achieve predetermined goals or coutcomes."	Provide the possibility for users to monitor their actual consumption (real-time), as well as their previous consumption..

Table 1: Popular persuasive strategies and how they can be used to reduce energy consumption

Some of these strategies (especially self-monitoring, reduction, and social comparison) have already been applied in the above mentioned existing devices and applications for energy feedback and management.
All of these support self-monitoring functionalities. Social comparison is addressed by Wattson, which provides the possibility to compare individual consumption with others. Reduction strategies are applied in the Energy orb as well as the Power aware cord. Strategies that are neglected are Tailoring, Tunnelling and Suggestion. Efforts for user groups like older people or children are mainly ignored. Furthermore the strategies tunnelling and suggestion can help to overcome the attitude action gap.

DISCUSSION

Based on theoretical background and the practical applications of persuasive technology presented in the previous sections, we argue that this field has great potential for positively influencing domestic energy consumption. In particular, making the target behaviour as easy to achieve as possible, presenting a clear individual benefit to the user and maintaining the subjective comfort level are some of the most salient points to consider.
However, it still remains to be seen how such persuasive interventions play out in the long term, since the vast majority of studies have been rather short. Issues like the novelty effect and a loss of user interest and attention for the persuasive interface over time might prove to be some of the main challenges.

Acknowledgements

The work reported here is conducted as part of two ongoing projects (C2G - Consumer2Grid and PEEM - Persuasive End-User Energy Management) which deal with persuasive technologies for feedback on energy consumption. These projects aim at improving the communication of energy feedback by seamlessly integrating it in the environment of the user and providing it where and when it is most useful and efficient. C2G evaluates existing approaches for communicating energy related feedback for different user groups within a long-term study in Austria, Salzburg, focussing on comparing the timing of the feedback. Within the project PEEM, we aim to develop a new pervasive feedback method based on persuasive principles within the home context.

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