From Consumers to Owners: Using Meta-Design Environments to Motivate Changes in Energy Consumption

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Abstract. Unsustainable energy consumption is a systemic problem facing society that requires technical and social innovations and changes. We argue for understanding and using end-user developments as not just another design principle but as a socio-technical intervention to help people make better decisions as they work to solve such systemic problems. We further explore two established EUD frameworks, Meta-Design and Cultures of Participation, to design systems for one such systemic problem: the energy domain. We present the draft for a system that incorporates principles from these frameworks to inform, motivate, and involve end-users in reducing their energy consumption.
Keywords: meta-design, cultures of participation, energy sustainability, changing human behavior

1 Introduction

There is overwhelming evidence that our current lifestyle is not sustainable and human energy consumption causes global warming [1]. Governments, industry, and environmental groups are undertaking major efforts to reduce energy consumption, largely resulting in systems that, although technically innovative, are static and closed, viewing the end user as a passive consumer. To reduce energy consumption to sustainable levels, technological innovations and policy changes are not sufficient—changes in human behavior are necessary [2] and systems that involve users as active decision makers [3] are needed..

2 Efforts to Reduce Energy Consumption

Changes in behavior to reduce energy consumption can be fostered through both social and technological interventions. Providing feedback, goal setting, and tailored information are useful in motivating people to change their energy behavior [5]. Steg and Vlek [6] have shown that a *meta-design approach* [7] in which participants are

asked to become active in planning their energy environment increases the probability of participants changing their behaviors and saving more energy. Staats, Harland and Wilke [8] found in their longitudinal study that one of the most important contributing factors for changing behaviors and energy savings were supportive social environments. In addition, computer-based feedback mechanisms [9-11] are effective in reducing energy consumption [2, 5, 12] and have been implemented and analyzed in the HCI domain.

3 Motivating People with Socio-Technical Environments

To reach the goal of reducing energy consumption at a societal level, socio-technical interventions [13] that go beyond simple presentations of facts are necessary; they need to make use of new insights into social and behavioral psychology to *motivate* consumers. We have identified two mechanisms, *psychological ownership* and *motivating social environments* to involve consumers that could be facilitated by software systems but are currently being ignored in the energy domain.

Psychological ownership [14] describes a state in which a person feels closely connected to an object or idea, to the degree that it becomes part of an 'extended self'. As soon as people see something as their own, they value it higher and are more likely to invest time and effort in it.

In a meta-review of research on psychological ownership, Pierce and colleagues have found several requirements for psychological ownership: (1) *control*, (2) *investment of self*, (3) *intimate knowing*, and (4) *modifiable targets* [14]. If an object or an idea fulfills all of these requirements, people are more likely to feel ownership for this target.

While the technological foundations for these requirements are currently created with *smart grids (http://www.oe.energy.gov/smartgrid.htm)*, the software infrastructure available to end-users does not make use of them. In almost all developments of smart grids to date, consumers are given very limited *control*. The technical implementation and the utility companies do *not reward investment of self*. The grid is designed as a system for passive consumers in which consumers are given the same monthly bills that list overall consumption in the abstract unit kwH, *not supporting intimate knowing* of how energy is being used or how energy could be saved. Finally, the only thing that consumers can change in the current smart grid is which devices they use and how often they use them; the system does *not provide any means of modifiability* to end-users.

Motivating Social Environments. Although changes in the social environment have been shown to cause people to use less energy [15, 16], supportive social environments are not commonly used to reduce energy. Unfortunately, current energy infrastructures prevent consumers from creating social norms or peer pressure.

Social proof [17] describes the effect that people act a certain way because they observe others acting this way. In such situations, the fact that others chose something acts as *proof* that this choice is preferable. However, energy consumption is completely individualistic and invisible to the consumers themselves and to others [2]. Aside from choosing to drive a Toyota Prius as a symbol of energy-efficiency or installing solar cells to show support for renewable energies, people have few way to

share their energy attitudes or behaviors. Thus, for highly energy relevant behaviors like the temperature of the thermostat, the installation of house insulation, or the choice of appliances, no generally established social norms exist that could motivate and guide consumers to reduce energy consumption. Without awareness of other people's actions, no social proof can be created.

4 Conceptual Frameworks

To address and implement the two ways of motivating people mentioned above, we have found two conceptual frameworks to be particularly helpful, namely *meta-design* and *cultures of participation*. They are well suited for systems that motivate and involve end-users and thus offer themselves to the design of energy-relevant systems.

Meta-Design. Meta-design environments [7] are solution spaces [18] in which users are able to identify, explore, and reassess their needs during use time and act as designers that can change the environment accordingly when needed.

An important element of a meta-design environment is the *"Seed-Evolutionary Growth-Reseed"* model [7]. In this model, designers do not attempt to build a complete system; instead they create *seeds* for users that provide basic functionality and can be modified by end-users. All users can modify and expand the seed in the *evolutionary growth* phase before the designer *reseed* the system with the contributions made by the community.

Meta-design environments foster psychological ownership by giving users control and openness and rewarding investment of self in the ongoing development of the system. Being an owner of the system makes people more likely to prefer the system to others, invest more time in it, and develop extensions to it. Their own extensions, in return are something for which users are likely to feel responsible for, increasing their feeling of ownership and their motivation to contribute on an ongoing basis.

Cultures of Participation [19] offer a new platform for human connection, bringing together otherwise unconnected individuals and replacing common background or geographic proximity with a sense of well-defined purpose and the successful common pursuit of this purpose as the condensation point for human connection.

Cultures of participation and meta-design environments are tightly integrated [20]. To be a successful meta-design system, users have to be able to share their ideas and developments, to get help from other users, and to find extensions and developments that have already been implemented by others; they have to form a culture of participation. Cultures of participation require the underlying software system to be open and modifiable so that users can participate in meaningful problems. The software underlying a culture of participation has to be dynamic and has to allow users to adapt it to their needs, and to reseed their own developments with others in the community; meta-design environments are needed. Cultures of participation are well suited to foster and support motivating social environments in which people can create social proofs and social norms by providing tools for sharing and for creating awareness. Since people are not merely consumers of a system but active participants of a community, they are more likely to be influenced by the actions and opinions of others.

5 EMPIRE–A System to Reduce Energy Consumption

We are currently building EMPIRE (EMPIRE = Empower People in Reducing Energy Consumption), a meta-design environment in which users can measure, simulate, and visualize their energy consumption. We are following a design approach with the two conceptual frameworks providing the overall design and functionality of the system. In the design of the prototypes, we use personas that are based on a crowd-sourced survey using Amazon Mechanical Turk. This approach allows us to cover a wide variety of potential users, interest, and preferences; for the final versions, the personas will be based on the actual users of the system to more accurately fit their specific needs.

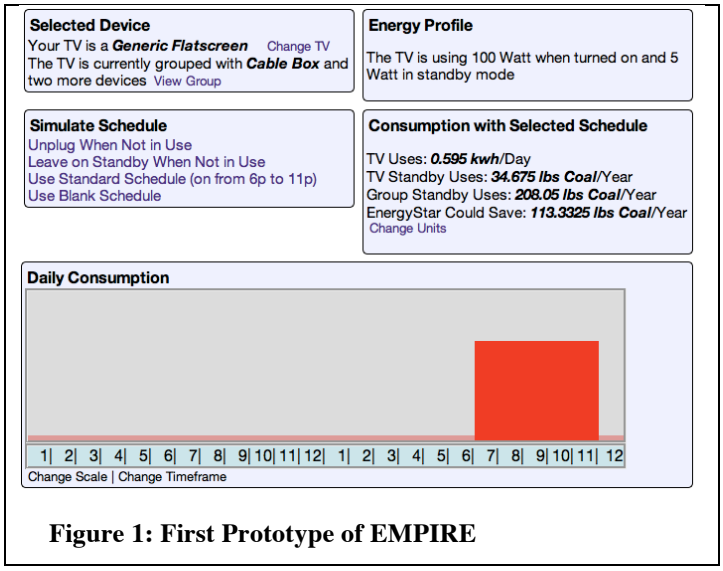

Figure 1: First Prototype of EMPIRE

The first iteration of EMPIRE aimed to address the problem of a missing psychological ownership. Using a meta-design approach, we created several prototypes that let users explore and visualize their own energy consumption by answering questions about their energy profile and integrating a simple energy simulator (see Figure 1). The goal of this approach was to foster *intimate knowing* by providing the ability to explore the causes and effects of consumption in detail. Initial informal tests with users showed that people were surprised by the results and expressed the opinion that prototypes gave them insights that had not occurred to them before. One participant found, to his surprise, that using a power-strip to turn off his cable box and DVD player at night would save him more energy than getting a new Energy Star certified TV–saving the money he would have spent on a new TV.

We are currently evaluating our early prototypes in crowd-sourced user studies, using Amazon Mechanical Turk [21] and CrowdFlower. In these studies, we measure how the different systems and different representations influence the users' decision-making processes and opinions about their energy consumption.

The next steps will be to further improve the meta-design aspects of the system and let all users *modify* and expand the system to their needs by creating simulations and visualizations that are meaningful to them. Currently, they can combine and select elements but not edit or create new ones. These steps should offer further reward for the *investment of self* and offer more *control*.

Finally, the individual's actions will be integrated with a culture of participation, so that users can share their creations and insights, help others, gain social recognition, and take on leadership roles within the community, thereby fostering and *rewarding the investment of self*. We will use our experiences and insights from our former work on supporting Cultures of Participation [22] and implement awareness tools [23], that will allow the community of EMPIRE participants to share and become aware of people's energy improvements, their insights, their behaviors, and their consumption. These tools build the foundation for a *supportive social environment* in which energy usage becomes social.

6 Conclusions

Meta-design and cultures of participation are promising frameworks for the development of more-involving and motivating energy systems. There is ample support in the literature that helping people to become psychological owners of their personal energy domain and to become part of a supportive social environment are effective and underused ways to reduce energy consumption. Our system building efforts are at an early stage and more user testing is needed to evaluate the effectiveness of our own implementation of the conceptual frameworks.

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