Researching Smart Grid through design:

How social interaction affects electricity consumption

Line Mulvad
IT University of Copenhagen
Denmark
limu@itu.dk

Sofie Hauge Katan
IT University of Copenhagen
Denmark
shka@itu.dk

Nicolaj Valberg Sundahl
IT University of Copenhagen
Denmark
nvsu@itu.dk

ABSTRACT

Smart Grid is currently in the making. While there is a tendency mainly to look at the technical aspects of the implementation, we wish to take a critical look at the current implementation issues from the users point of view. Previous empirical studies indicate that social interaction and visualisation of real time energy consumption patterns can trigger a more ecologically responsible behavior. This paper focuses on exploring this assertion through a qualitative study of a design called the "The Social Electricity Meter" by revealing an indication of motivational factors to change ones electricity use based on social stimuli. By reflecting theoretically on how this kind of empirical data is essential when designing future Smart Grid experiences, we also evaluate the capability of the approach *Research Through Design* to gather insights about future social practice.

Keywords

Smart Grid, Research Through Design, Eco Visualisation, Social Interaction, Gamification.

1. INTRODUCTION

By the year 2050 the Danish Government is striving to make Denmark almost independent of fossil fuels estimating that up to 80 percent of produced energy will come from renewable sources such as wind, wave, and solar production [1]. Several initiatives have been taken to develop a new infrastructure to handle these changes. Initiatives which is widely referred to as Smart Grid – a term that covers several different notions but all with the purpose of creating a more flexible electricity grid.

Right now the consumption in Denmark is concentrated around electricity peak hours, requiring the power stations to produce larger amounts of energy at certain hours of the day.

Because it is not currently possible to store electricity extracted from renewable sources, the amount of available electricity increases in the grid during production. Therefore, renewable electricity has to be used immediately in order for it not to be wasted. The aim is to move the current consumption in peak hours to periods when there is an overload of electricity available in the grid. Due to the many aspects and the complexity of Smart Grid as a concept, we focus solely on the problems of peaks in the private electricity consumption and practices.

This study explores what possible incentives might persuade users to modify their electricity consumption patterns. Research undertaken by different company stakeholders within the field of Smart Grid identifies social relations as possibly having an influence on change in energy consumption behavior [1, 2]. Therefore, we wish to explore and discuss how social interaction and eco-visualisation influence the user's practice around electricity consumption patterns. With the aim of advancing the understanding of motivational factors behind behavioral change, this study should be seen as an early exploration providing inspiration and foundation for future research.

2. THEORY

Company stakeholders[1] in the field of Smart Grid have tested *Smart Meters* which purpose is to provide visualised information to inform individual users about their specific energy usage in an attempt to foster awareness of their own energy consumption as an incentive to change their consumption practices [3].

Common to all this research is a focus on the technological aspects, primarily on how to implement new technologies that will affect the everyday life based on limited understanding of the actual users of this system in the future [4]. Hence, the research appears not to take into account how technologies and practices are mutually influenced because they are affected by the context in which they are located or deployed [4].

Additionally, Redström, docent in interaction design argues that design is defined by the user, in the situated use, and shaped by the context and practices of the user. By using the approach Research Through Design we want to make use of the process in which the user assigns meaning and function to the design in relation to their existing practices and experience [5].

Fallman and Stolterman note that bringing forth an artifact to explore alternative designs is "shaped by the ambition to explore new solutions, new directions, new technology and new usage, to broaden the overall design space or to rock the boat, without necessarily trying to solve existing and well-defined problems" [6, p. 270].

Smart Grid as a technology is still in the development stage. Research Through Design presents an opportunity to transform the world from a current state into a preferred state by introducing a design artifact. In this case providing a way to explore the users experience with elements of technology design not yet invented [7]. Thus our main approach is the presentation of the design for

[1] GreenWave, HP, IBM, and DONG.

the user and the exploration of what and how the formation of meaning is created.

3. DESIGN ELEMENTS

To explore how social relations can have an influence on change in energy consumption behavior we have designed what we call "The Social Electricity Meter" based on game and eco-visualisations theory.

Tiffany Holmes uses the term Eco-visualisations to describe real time dynamic data visualisations of energy consumption as a method for inspiring environmental stewardship [8]. One of the purposes of the design in this study is to foster awareness of one's own energy consumption patterns through visualisation and thereby create an incentive to change consumption habits [7].

Game designer Chris Swain argues how games can be designed to affect social change [8]. By integrating game elements in our design we aim to explore how social interaction can influence our behavior in relation to private electricity consumption and understanding of electricity. The foundation for taking a playful approach to the design is that games set a frame which people can relate to. Given that the understanding of electricity is abstract, it is beneficial to bring it into a game context where participants can draw upon previous experiences and thereby know how to play by the rules [8]. By integrating social interaction, we aim to facilitate a *community of practice* by making it possible to share experiences and knowledge. Thus the users build social capital and accumulate new knowledge [8, p. 807].

4. THE DESIGN

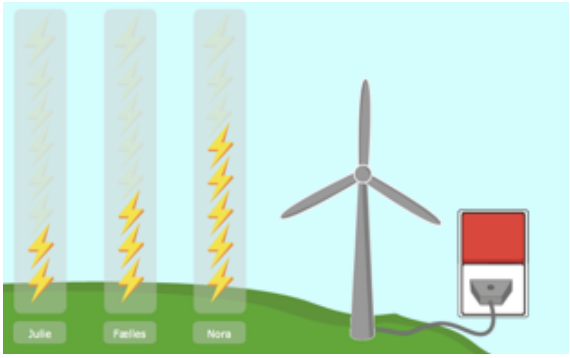

Figure 1

The design consists of a visual interface designed using HTML and PHP displayed on an iPad which was placed in the informants' home (figure 1). The informants' were asked to register every time they used certain products[2] by touching a button on the screen. The button is either green or red to symbolise whether it is a period with an abundance of electricity available in the grid or not. Whenever the informants registered electricity use in the "green period" they gained a point and vice versa if it was registered in the "red period". The design showed individual and common point scores simultaneously which made both of them able to compare their energy consumption continuously.

[2] Washing machine, coffee machine etc.

Four informants were using the design for seven days. The criteria for the selection was to find pairs of informants who already had a social connection thus creating the best conditions for studying the impact of the social interaction.

Two semi-structured qualitative interviews were afterwards conducted to follow up on their experience using the design, and how their electricity usage was influenced by the social aspect. The empirical data was then analysed by reducing the information to significant statements, and then placed into themes [10].

As we are not trying to provide categorical "truths", but rather raising questions of what social practices are possible, more informants would not necessarily have created more representative findings [11].

5. FINDINGS

Our research indicated five particular themes of motivational factors:

5.1 Solidarity

The informants described a feeling of the common goal as being too abstract which might be caused by the design not being distinct enough. This resulted in a lower support of direct social interaction and sense of solidarity between the participants than expected.

5.2 Discourse

An indication of an established societal discourse constituting that one has to act environmentally responsible was found. The discourse was a motivational factor in the sense that it was the decisive term behind the desire to create a representation of oneself as environmentally responsible both in relation to others and to one self. Thus, it was the major premise behind the following motivational factors.

5.3 Self presentation

Based on the fact that others were able to monitor one's performance, the study indicates both an explicit and implicit presentation of self in relation to electricity consumption. Some informants preferred actively presenting one's own results whereas others preferred self presentation triggered by the system

5.4 Comprehension

The electricity consumption was made tangible and easier to comprehend when it was visualised through the design. It was also considered motivating to see one's own performance compared with the friend's.

5.5 Predictability

In certain instances some of the informants mentioned that they did wait for the "green" electricity before performing a specific task. There would be a larger willingness to change behavior if they could get an indication of when there would be green electricity as suggested by one of the informants.

6. DISCUSSION

Initially we expected this study to show how social interaction would have an effect on energy consumption by creating a sense of community. On the contrary, what seemed to be a coherent tendency was the way social relations had an effect on the energy consumption in relation to the individual and self representation. This was due to either an implicit or explicit wish to represent one self as energy responsible. The sense of solidarity was not visible

but instead the primary motivational factors for changing behavior seemed to be on an individual level.

Research Through Design as an approach to explore future practices enabled us to zoom in on the detailed elements of electricity consumption and the behavior around it.

Contrary to former research within the field of Smart Grid [1, 4] we have been able to explore the effect of social relations but also acquired information and understanding of the underlying structures governing the motivational factors embedded in the social interaction. Thus, creating an understanding of how the specific findings were intercorrelated, mutually influenced by the context, the user practice, and the design.

Because the design is put to actual use, existing practices are projected into the users' understanding of the design. Especially notable is how the aforementioned societal discourse on energy consumption has an influence on the use and understanding of the design. Most significant was how certain elements of the design which enabled enrolment in the discourse served as the motivational factors to change consumption behavior.

The visualisation aspect of the design turned out to be a strong medium with the attribute of making the energy consumption tangible. Thus, it becomes a means for the user to create an understanding and a sense of self in relation to the above mentioned discourse on energy consumption.

The pivotal factor for the visualisation aspect seemed to be the allocation of points reflecting energy responsible behavior. It seemed, though, that the comparison of the points in relation to the other informant was what made the concept of consumption tangible.

The value assigned to the points did not only create a base for comparison with each other but also with one self over time. The comparison on different levels created a foundation for self representation. Thus the motivational factor was both a clearer conscience and also representing oneself as an environmentally responsible person on the basis of the shared discourse.

7. CONCLUSION

This study took a starting point from other research within the field of Smart Grid, but with the method Research Through Design we took it into a more defined context and thereby gathered more detailed and focused data. An underlying societal discourse was located as the premise behind other motivational factors to change electricity consumption behaviors.
The visualisation enabled the user to compare their performance with others thereby making it more tangible and concrete as to what their contribution to a renewable environment looks like. Hereby transforming abstract and "diffused" information into comparable and comprehensible data and altering the understanding of what constitutes sustainable electricity consumption. Also, either explicit or implicit self representation played a part in the motivation for behavioral change.

The study has opened up the design space by showing how social interaction, because of the societal discourse can be a motivational factor towards sustainable energy consumption. The specific findings could be used as guidelines when researching and designing for behavioral change within the field of Smart Grid. Either as an inspirational point of departure, or a continual of this research by redesigning "The Social Electricity meter" going into depth with the elements which were regarded as motivational.

8. REFERENCES

[1] Energinet.dk. Danmark satser på Smart Grid, Intelligent elsystem med mere vedvarende energi. Magazine, Energinet.dk, 2011.

[2] Valocchi, Michael, John Juliano, og Allan Schurr. *Lighting the way: Understanding the smart energy consumer.* IBM Institute for Business Value, 2009.

[3] Venables, M. »Smart meters make smart consumers.« *Engineering & Technology*, 2007: 23-23.

[4] Shove, Elizabeth. »Converging Conventions of Comfort, Cleanliness and Convenience.« 2002: 1-16.

[5] Redström, Johan. »RE:Definitions of use.« *Design Studies* (Elsevier Ltd) 29, nr. 4 (2008): 410-423.

[6] Fallman, Daniel, og Erik Stolterman. »Establishing criteria of rigour and relevance in interaction design research.« *Digital Creative* (Rouledge) 21, nr. 4 (2010): 265-272. pp. 270.

[7] Zimmerman, John, Jodi Forlizzi, og Shelley Evenson. »Research Through Desing as a Method for Interaction Design Research in HCI.« *SIGCHI Conference on Human Factors in Computer Systems.* San Jose, California: Carnegie Mellon University Research Showcase, 2007. 493-502.

[8] Holmes, Tiffany. »Eco-visualization: Combining Art and Technology .« *ACM*, 2007: 153-162.

[9] Swain, Chris. »Designing Games to Effect Social Change.« *DiGRA.* DiGRA, 2007. 805-809.

[10] Zichermann, Gabe, og Christopher Cunningham. Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps. California: O'Reilly, 2011. pp. 77.

[11] Kvale, Steinar. "Interview". Hans Reitels Forlag. Copenhagen, 1997. pp. 129-147.

[12] Silverman, David. *Doing Qualitative Research.* Sage, 2010.