Researching Motivational Factors Towards a Sustainable Electricity Consumption

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Abstract— **In relation to Smart Grid, which is currently in the making, this article presents findings from a qualitative study researching the motivational factors towards a sustainable electricity consumption. 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 more ecologically responsible behaviour. 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; electricity consumption.***

I. 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. As the current energy infrastructure is not constructed to handle these kinds of energy sources, it requires major changes in our existing energy infrastructure for these desired outcomes to be actualised [1]. Several initiatives have been taken to develop this new infrastructure, which is widely referred to as Smart Grid – a yet undefined concept with the purpose of creating a more flexible electricity grid through intelligent communication between the load of energy in the grid, the consumers, and their devices. Because renewable energy sources are uncontrollable, the electricity infrastructure must adapt and support flexible consumption in order to effectively make use of the renewable energy.

Right now, the consumption in Denmark is concentrated around electricity peak hours. This requires power stations to produce larger amounts of energy at certain hours of the day. It is not currently possible to store electricity extracted from renewable energy. Therefore, to utilise the renewable electricity it has to be used immediately in order for it not to be wasted. To eliminate the waste the aim is to move the current consumption in peak hours to periods when there is an overload of electricity available in the grid [1]. Due to the many aspects and the complexity of Smart Grid as a concept, we focus solely on private electricity consumption and the problems of peaks in electricity consumption.

Company stakeholders (GreenWave, HP, IBM, and DONG) in the field of Smart Grid have tested Smart Meters with the purpose of providing visualised information to inform individual users. The individual users' specific energy usage is visualised in an attempt to foster awareness of one's own energy consumption and as an incentive to change one's consumption practices [2]. Smart Meter is a development of the regular electricity meter that uses visual models and representations to display. In this regard, Tiffany Holmes, professor in art and technology, appropriately uses the term *eco-visualisations* to describe real time dynamic data visualisations of energy consumption as a method for inspiring environmental stewardship [3].

Steen Kramer Jensen, official energy consultant at Energinet.dk, points out that incentives for intelligent electricity consumption cannot only be economical [1]. Thus it is necessary to explore what other 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 having an influence on change in energy consumption behaviour [1, 4]. Therefore, we wish to explore and discuss how social interaction and eco-visualisation influence the user's practice around electricity consumption patterns. This study aims to advance the understanding of motivational factors behind

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behavioural change, and should be seen as an early exploration that provides inspiration and foundation for future research.

II. THEORY

Research has been undertaken in relation to Smart Grid, including the forementioned Smart Meters. Common to all this research is a focus on the technological aspects, or testing of new technologies. As professor of sociology, Elisabeth Shove argues: there is a tendency "... to pay greater attention to the invention and acquisition of the new things than to the way such novelties are subsequently deployed in practice" [5, p. 2]. Thus research within the field of Smart Grid seems to primarily focus on how to implement new technologies that will affect the everyday life but with limited understanding of the actual users. Hence, the research appears not to take into account how technologies and practices are mutually influenced because they are affected by the meso and macro level context in, which they are located or deployed [5].

Johan 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 experiences [6]. 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" [7, p. 270]. Furthermore, the chosen approach to this study, is based on the belief that individuals create meaning based on their own "lived experiences of a concept or a phenomenon" [8, p. 57].

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 [9]. Thus, our main approach is the presentation of the design for the user and the exploration of what and how the formation of meaning is created.

III. DESIGN ELEMENTS

To explore how social relations can have an influence on change in energy consumption behaviour we have designed what we call "The Social Electricity Meter" based on game and eco-visualisations theory. One of the purposes of the design is to inform users about their specific energy usage in an attempt to foster awareness of one's own energy consumption patterns through visualisation and thereby create an incentive to change consumption habits [3].

By integrating game elements in our design we aim to explore how social interaction can influence our behaviour in relation to private electricity consumption and understanding of electricity. Game designer Chris Swain argues how games can be designed to affect social change: "Games are well-suited to communicating a shared understanding of a problem because they allow users to experiment with potential solutions in a safe setting and generate their own mental frames for how it works" [10, p. 806]. The foundation for taking a playful approach to the design is that games set a frame, which people can relate to. Given that the implementation of Smart Grid is complex, and 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. By creating a design inspired by game theory we try to raise the energy usage issue without causing the user to get a bad conscience. By integrating social interaction, we aim to facilitate a *community of practice*, a term from the social anthropologist Etienne Wenge who has shown that by making it possible to share experiences and knowledge users build social capital and accumulate new knowledge and innovation [10].

Game theoreticians Zichermann & Cunningham emphasise that an important game mechanic, and one of the key corners of gamification, is feedback [11]. Based on this, the design contained a direct feedback in the form of points and comments triggered by the informants' performance, which indicate whether or not they were heading in the right direction.

IV. THE DESIGN

The design consists of a visual interface designed using HTML and PHP displayed on an iPad, which was placed in each of the informants' home. The visual interface consists of 5 elements; 3 "score-bars" presenting individual scores as well as the average score through lightning graphics, a windmill, and a button (Fig. 1). The informants' were asked to register every time they used certain products (washing machine, coffee machine etc.) by touching the button on the screen. The button was either green or red to symbolise whether it was a period with an abundance of electricity available in the grid or not. To further illustrate that there is an abundance of electricity in the grid (when the button is green) the windmill rotates as if moved by wind. Whenever the informants registered electricity used in the "green period" they gained a point and vice versa if it was registered in the "red period". The main function of the design was to show the two informants their individual point score as well as the average amount of points of both informants. This makes both of them able to compare their energy consumption continuously.

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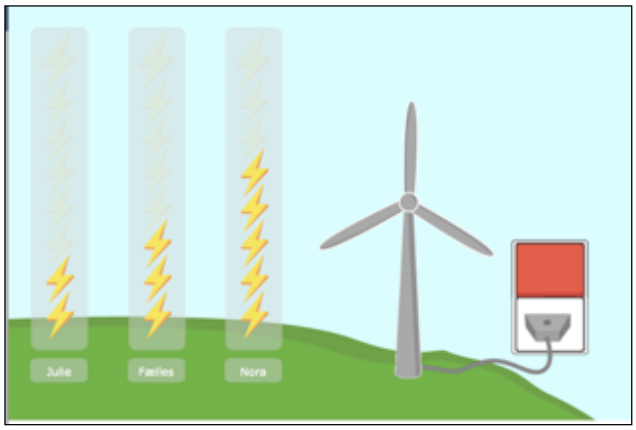

Figure 1. An example of the interface the user would see. In this case there is no abundance in the electricity grid, which is symbolized by the windmill not moving and the button turning red. If the user presses the button, which is now red, they will immediately get feedback in the sense of losing a "lightning-point"

Four informants, two pairs of friends, were using the design for seven days. The important selection criterion 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 [12].

As we are not trying to provide categorical "truths", but rather raise questions of what social practices are possible, more informants would not necessarily have created more representative findings. Thus this study can be seen as exploratory by examining the use and formation of meaning in relation to a specific design [13]. The empirical data was then analysed by reducing the information to significant statements, and then placing it into themes [8].

V. FINDINGS

In our data analysis, five particular themes were identified:

A. *Solidarity*

Contrary to expectations, it turned out that the informants could not relate to the part of the design, which showed their common score. We expected that they would contact one another to cheer, motivate and tell when the energy was green with the aim of increasing their shared score. However, they expressed that they could not influence their partners' performance, thus giving no incentive to contact their partner. Additionally, they described a feeling of the common goal as being too abstract, which might be caused by the design not being distinct enough and giving no clear incentive to reach a common goal. This resulted in a lower support of direct social interaction and sense of solidarity between the participants than expected. Therefore, reaching the common goal of gathering points together was not a substantial part of their experience.

B. *Discourse*

An important finding was the indication of a strong established societal discourse constituting that one has to act environmentally responsible. This was distinctively visible in several ways but most significantly in verbal statements from all of the informants who implied that energy responsibility is common sense. It is interesting that 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.

C. *Self presentation*

It seems that it was a motivational factor for the informants that others were able to monitor their performance. The study indicates two different motivational aspects of self presentation in relation to electricity consumption. The first aspect is explicit as it is focused on actively presenting one's own results to others, e.g., by posting it on social network sites, or having the device a central place in the home. The other aspect is implicit as it is grounded in an automatic presentation of results, which is triggered by the system e.g., posting the electricity consumption of last week on a social network site.

D. *Comprehension*

In spite of the common goal being too abstract, the informants were unanimous in their expression that electricity consumption was made tangible and easier to comprehend when it was visualised through the design within a certain continuum. It was also considered motivating to see one's own performance compared with the friend's performance because this made their own consumption tangible.

E. *Predictability*

The informants indicated that they only had a limited amount of time and willingness to wait for the "green" electricity in order to use it. In certain instances, some of the informants mentioned that they did wait for the "green" electricity before performing a specific task. There would, however, be a larger willingness to wait if they could get an indication of when this was going to happen as suggested by one of the informants.

VI. 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 behaviour seemed to be on an individual level.

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Research Through Design as an approach to explore future practices enabled us to zoom in on the detailed elements of electricity consumption and the behaviour around it. Thereby, we arrived at specific findings of the motivational factors in relation to electricity consumption.

Contrary to former research within the field of Smart Grid [1, 4] we have been able to explore the effect of social relations and also acquire information and an understanding of the underlying structures governing the motivational factors embedded in the social interaction. Because the design is put to actual use, existing practices are projected into the users' understanding of the design. Especially notable is how the aformentioned societal discourse on energy consumption has an influence on the use and understanding of the design. Most significant was how the elements of the design, which supports enrolment in the discourse, served as the motivational factors to change consumption behaviour.

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 behaviour. It seemed, though, that the comparison of the points in relation to the other informant was what made the concept of consumption tangible. This was because of the ability to assign a value to the points on the basis of comparison. The value assigned to the points was primarily due to the social interaction through the design. Not only did they 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.

Shove argues that the technology and the social discourses are coherently shaped by each other [5]. Thus, the understanding and the use of the design was very much assigned to this correlation. It also indicates that the design influences the discourse and the users' existing understandings of energy consumption. This seems evident in the way that the users, to some degree, have broadened their understanding of energy responsible behaviour from an understanding that energy responsible behaviour is only equivalent to reducing consumption, to a reformed understanding. A reformed understanding in, which it was not only about reducing consumption but also focused on what sources the energy derived from e.g., fossil fuels vs. renewable energy sources and how the production is distributed throughout the day.

VII. CONCLUSION

This study took 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 behaviours.

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, self representation played a part in the motivation for behavioural change. We have distinguished between whether the self presentation happens explicitly or implicitly through automated presentations.

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 behavioural change within the field of smart grid. Either as an inspirational point of departure, or a continuation of this research by redesigning "The Social Electricity meter" and going into depth with the elements, which were regarded as motivational.

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