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“Mama, It’s Peacetime!”: Planning, Shifting, and Designing Activities in the Smart Grid Scenario

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Abstract

In this paper, we describe a research-through-design (RtD) approach to investigate the potential of households’ electricity load balancing in the smart grid. Through the design probe “Peacetime”, householders explore peak hours as opportunities for serene and non-electricity consuming activities. During the 2 weeks, Peacetime was deployed in the homes of three households to explore an alternative framing of non-use of electricity to the commonly used framework for prompting people with feedback on their consumption. Households’ active load balancing included planning of, replacing, reorganizing, and skipping everyday domestic activities. Results indicate that focus could be shifted from restricting electricity use to creating alternatives – leading to a positive framing of load balancing. The scenarios reflected in this paper differ from those of rational energy managers basing decisions of domestic life on complex facts and figures. Scenarios from the study portray how planning, reorganization, and time shifting of activities may be obtained with soft means emphasizing values of well-being and respect of the variation of households’ social contexts.

Keywords: sustainable HCI, sustainable design, smart grid, load management interaction design, research through design

1. Introduction

Despite significant technological progress, domestic energy consumption is still increasing. During peak hours, a large amount of CO₂ emissions affects the atmosphere, since coal-burning power plants are activated to supply the extra energy. In residential buildings, this occurs mainly in the morning and in the evening, when people get ready for work and when they come home. Moving electricity-consuming activities to nonpeak hours is called peak shaving or load management and is generally considered one trend in the smart grid scenario,

which could decarbonize the electrical grid [1]. This approach is even more crucial when certain amounts of electricity are provided by renewable energy sources, which depend on weather conditions. Indeed, this introduces a variable in the calculation of the available amount of 'green' energy on the grid, making every day different from the other. On a windy day, for instance, the overall electricity consumption can be higher if energy is provided by wind power plants. 'Direct control' of load management requires customers to shift their domestic activities, which adapt to the available energy on the grid. This is challenging as it would require constant effort in re-planning even those domestic habits that are automatic, and therefore, usually demand little effort to execute (e.g., starting cooking right after coming home from work, or taking a shower after waking up). How to introduce, manage, and communicate peak hours and motivate users to perform peak shaving is challenging [2–7]. The vision about smart grids includes assumptions about households' active participation through the use of technology and the load balance of their electricity use. Some practices (e.g., preparing meals) have been perceived as "non-negotiable" [8]. However, there is a lack of knowledge regarding the design and implementation of smart grids in relation to people's everyday life [9]. Partly, this is due to the lack of approaches addressing the core questions of the social context of households. Considering this context, what factors may motivate them to be flexible about their electricity consuming activities in the future electric grid? Researchers need to focus on how households organize their everyday practices and to what extent and under which circumstances they are willing to shift and reorganize their practices. For instance, which everyday activities are static and which are more flexible in relation to the point in time when they are carried out during the day?

In a pre-study [10], we interviewed 10 households about their domestic activities, their motivations for change, and the flexibility of their domestic activities. Interview results showed that informants thought themselves to be quite flexible in their use of electricity. Some activities, however, were non-negotiable in respect of the hours during the day they would be performed. Cooking was one such activity. To be able to plan their activities differently, informants would need information about the periods of the day, during which they should avoid to use electricity and how long that period would be. They would need information in advance on when the non-electricity period would occur and also a reminder just before the onset of the period.

Our pre-study also indicated that households prefer to be actively in control of their electricity use, but in a soft way, without being told what to do and when. It also emerged that pleasant, sensory, and emotional experiences could support their engagement in a smart grid scenario. The informants react negatively to penalties as a feedback of their unsustainable behaviour. Thus, there was an emphasis on soft imperatives serving as advice rather than strict requests.

The purpose of the current paper is to describe a research-through-design (RtD) approach (see e.g., [11, 12]) to challenge the role of householders as mini-energy managers. This further explores the results from the pre-study. How can a future scenario use soft imperatives to support the non-use of electricity at certain times during the day? How can the non-use of electricity be framed in a positive manner rather than in a negative and prohibiting way? What is the nature of flexibility and innovation for householders in carrying out their everyday

activities? These questions will be explored through designing and placing a design prototype in real home contexts of households.

2. Related work

Within human-computer interaction (HCI), sustainability has been in focus for almost a decade. Blevis [13] outlines how HCI may mantle the endeavour of environmental sustainability. Different directions follow this field, many of which aim at providing users with detailed information about their consumption, typically through management systems based on displays, numbers, and graphs, sometimes referred to as eco-feedback [14]. The view of users in this type of research has been criticized for being too narrow [15, 16]. Strengers emphasizes the importance of designing systems reaching beyond models of users as rational decision makers – addressing what she calls the 'resource man' – towards more engaging solutions [17]. Especially in interaction design, research has focused on emotional and engaging ways to provide feedback with the aim to promote more sustainable behaviour. A number of ambient and tangible interfaces for eco-feedback have been developed in the field of sustainable interaction design. The ease of measurement of, for example, electricity use has been integrated into interaction design in different forms of feedback with the aim of visualizing to users what is otherwise hidden e.g. [18–22]. However, most of the solutions developed in this field communicate through vision and a few involve other senses. Research has explored how information can be conveyed by senses other than vision, and how this communication can potentially be both emotionally engaging and effective in motivating people to act [23]. In the field of eco-feedback technologies, the main strategies to encourage new habits are *information* and *awareness*. However, researchers argue that such strategies need to be accompanied by engaging and affective guidance for users on how to reimagine and adjust their practices [8, 24]. In order to investigate the possibility to integrate load management into daily routines, we applied RtD approach. In RtD, design becomes a tool for inquiry and its outputs can be used to explore future states of things [11]. In the following sections, we briefly present the development of the design concept and the prototype. Next, we describe the user study and the results. Finally, we discuss insights and potential of this approach in the smart grid scenario.

3. Design approach

In accordance with Strengers' [17] critique, we challenge the view of households as mini-energy managers and regard households' electricity use as embedded in social practices. Conscious of the complexity of a practice-oriented approach in the smart grid, we aim to offer alternatives to numerical data in the experience of the smart grid by designing a tangible and emotional interactive object, Peacetime. It focuses on an emotional and multimodal invitation to shift domestic activities according to the energy request peaks, while at the same time evoking emotions towards the environment.

The previously mentioned pre-study [10] informed the design of the probe. Through a participatory design process, designers, researchers, and end users were engaged in ideation sessions, conceptualization workshops, and focus groups to inform and enrich the development of the design. The process led to very different designs of information in relation to load management than suggested by [2, 3, 7]. For a full account of the design process, we followed a complete description of the final design of the Peacetime prototype [10, 25].

3.1. The Peacetime concept

The Peacetime concept connects the need to shift electrical activities in the smart grid scenario to the metaphor of being in balance with nature. Peak hours are converted from a space of prohibition to a positive space of opportunity, where people are invited to take a rest and to perform pleasant activities without the use of electricity.

The Peacetime concept is composed of two parts: (i) a physical product, consisting of a tree with a nest and pinecone, a scent-releasing flower, and three associated birds, (ii) a support interface, useful to plan non-electricity consuming activities (**Figure 1**).



Figure 1. Staged photography of the physical prototype, consisting of a tree, with nest and pinecone, a scent-releasing flower, and three associated birds. Photo credit to Juha Dahlbo.

When a load peak is approaching, the birds placed in different rooms (borrowing its aesthetics from the traditional cuckoo clock) start chirping 30 and 15 minutes before the Peacetime (**Figure 2**). The flower releases a scent in the house 15 minutes prior to the Peacetime period. When the Peacetime period begins, a pinecone drops from the tree. The length of the Peacetime period is displayed by the position of the pinecone, which slowly moves back while time passes, to show the remaining time.

The website interface proposes customized activities that can be undertaken during Peacetime (for example, alternative ways of cooking without using electricity, or ways to spend time together). It also displays the upcoming Peacetime periods (**Figure 3**). The Peacetime periods corresponding to the load peaks on the electrical grid alter from day to day during the week, as they follow the forecasts of peak hours.

3.2. The Peacetime prototype

A prototype of the Peacetime concept was built and 2-week forecasts of Peacetime periods were created. Peace hours could start in the morning, in the afternoon, or multiple times throughout the day. Forecasts were accessible 3 days in advance on the Peacetime website. A switch was programmed to activate the stepping motor of the pinecone in the nest, according



Figure 2. A chirping bird, in Household 2.

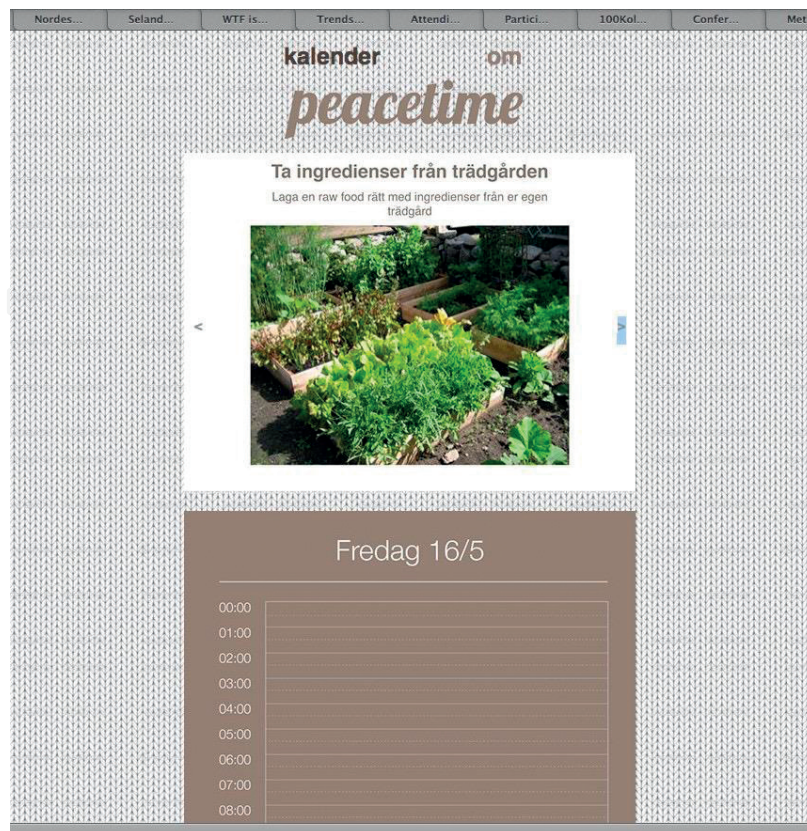


Figure 3. At the site Peacetime. The household members could see upcoming Peacetime period and get customized suggestion of alternative activities.

to the Peacetime forecasts. Birds were connected, via Bluetooth, to the tree and reproduced tweeting sounds through a speaker. The flower scent was made from an existing aroma scent diffuser.

4. Method contextual study

In order to explore households' experience of electricity load balancing, a contextual user study was conducted through the Peacetime prototype in three people homes. In accordance with RtD approach, the focus of these field studies was on qualitative data generated from the study to throw light on the issues explored – an alternative to prompt for refraining from electricity use. Thus, we did not aim for a quantitative comparison between the different households. The contextual studies were not designed as "tests", but rather as starting points for exploring basic issues regarding load balancing in the home.

Three households participated in the study, all recruited through a local business network in a Swedish town. Each household had the prototype in their homes for 2 weeks. As we aimed for different types of household constellations, we recruited one family with small children, one family with teenagers, and one family without children.

Household no. 1. The adults are in their late 40s and live with their three sons in a house with five rooms just outside the city. The twins are 11 years and the eldest child, 13 years old. The mother works as the assistant manager of a Science Park and the father as a caretaker for a cultural institution.

Household no. 2. The adults are in their mid-50s and live with their 19 year old daughter in a house with four rooms outside the city. The mother runs her own dental practice, the father works at a factory, and the daughter works as an assistant at her mother's clinic.

Household no. 3. This is a couple in their late 60s who live in a big house just outside the city. They previously ran their own business and are now both retired but active in various organizations and networks.

4.1. Preparation and implementation of contextual study

Prior to the study, we met the families to inform them about the setup of the study. To adjust the web interface to their preference, a Peacetime profile survey was filled out, consisting of five questions relating to what the families like to do in their spare time. The family members were asked to consider a place in their homes for installing the physical prototypes. When the prototype was installed (about 1 week later), the researcher presented the concept of load managing as a way to decarbonize the grid through Peacetimes (peak hours).

4.2. Procedure of contextual study

The three households participating in the contextual study lived in houses, thus, private houses constituted the site in which the study took place. Since there was only one set of physical prototypes, the three cases were studied one after the other, during 2 weeks at each site. Households were instructed in how to use Peacetime at the onset of the study.

The study had the same set up during both weeks at each site. The Peacetime periods, which lasted for 2 hours each, were distributed at different times during the days in order to highlight opportunities and challenges in relation to their domestic practices. Some days the Peacetime periods occurred in the morning, some days in the afternoon, some days in the evening, some days had two Peacetime periods, and 1 day had none.

4.3. Interviews

At the end of the 2-week test period, we conducted interviews in the participants' home. Two researchers were present and the interviews lasted approximately an hour. The entire household was encouraged to participate in the interview. The covered areas were: (1) motivation for load balancing, (2) their experience of shifting practices according to Peacetime, (3) their experience of the ambient and web interface, and (4) potential of the concept. The interviews were fully transcribed and transcripts and video material were analysed in order to identify major themes. Grounded theory analysis [8] was performed both on the interview transcripts and the households' activity books, to identify categories of concepts helpful to understand the users' reactions to the Peacetime concept, and more in general, to our approach to load balance.

5. Results

From the analysis of the interviews, five major themes emerged as the main findings of the user study: (1) General attitudes towards the Peacetime concept, (2) Planning for Peacetime, (3) Creation of new types of activities, (4) Reorganizing existing activities, (5) The Peacetime feeling and morality of leisure time.

5.1. Theme 1: Peacetime attitudes

A major finding was the participants' positive attitude towards shifting their activities according to Peacetime. The mother in Household 2 reasoned *"It doesn't take that much effort to be environmentally friendly [...]"*. She considered the overall concept of load managing a relevant way to decarbonize the grid. The twin boys in Household 1 were excited about the concept, shouting to the rest of the family *"It's Peacetime!"* when the Peacetime period started.

Both the tangible interface and the digital one were appreciated and were considered essential for the activity shift. The physical objects acted as reminders of the need to be more flexible and provided essential real time communication through different sensory modalities. This was considered especially pleasant. The digital interface was evaluated as valuable to plan activities in advance and to find inspiration for alternative tasks to perform during Peacetime.

5.2. Theme 2: planning for Peacetime

Informants used Peacetime for planning their activities in new ways. In both households with children, the mother took on the role of communicating peace hours to the rest of the household:

"I sent it [the schedule] to daddy and your big brother, because they have telephones" [mother in Household 1]

The following shows how another household planned and shifted cooking according to Peacetime:

"It's been an advantage to be able to go to the Internet and check when Peacetime occurs...it's been possible to prepare for it. It would have been harder if there only would have been [the Peacetime prototype] and you would have started something... and, then, the birds would have come out: 'damn it I just put a steak in the oven for two hours'... then you would have to switch off everything" (mother of Household 2).

5.3. Theme 3: creating new types of activities

The mother of Household 2 reported that, during Peacetime, they mostly did activities that they normally would do at other times. *"To remove dust or swab the floor"* or *"to sit and talk about everyday things in the kitchen"*. However, the parents of Household 2 did three activities that they considered out of the ordinary. One day they decided to bring out pen and paper and draw boats and roads. The daughter said: *"You made me draw [...]"* but it was actually fun". They took inspiration for the drawing session from the activities suggested by the Peacetime website, but would also like to add their own suggestions to the website.



Figure 4. Household 3 used the heat of the coffeemaker to defreeze the bun instead of using the microwave.

Household 3 did not do any activities out of the ordinary *“we are not going to build a sandbox”* (this was one of the suggested alternatives for them as they expressed great engagement in their 1 year old granddaughter in their peace profile). Household 2 did many of the suggested alternative activities such as day dream, read that dusty book on the shelf, and cuddle. *“We’ll keep the concept of Peacetime”* their mother said.

Household 3 planned new activities to cope with Peacetime. For instance, as Peacetime started, they finished to boil potatoes using waste heat – the final heat keeping the stove plate warm after the stove has been switched off. The household created new ways to thaw frozen bread, by using the waste heat from the coffee maker (see **Figure 4**): *“I took it out [from the freezer] before I went for my walk and I put it on top of the coffee maker, which was still hot...instead of heating it in the microwave...”*.

5.4. Theme 4: reorganizing existing activities

Households were flexible in at least three different ways when it came to reorganizing routinized behaviour. One strategy was to **shift routine activities** before or after Peacetime hours. For instance, individuals left for work earlier than usual due to the Peacetime hours. They also hurried from work earlier than usual in order to prepare dinner, so that electricity would not have been used during the Peacetime hours:

“I hurried home to cook before six o’clock. I fixed the minced meat-sauce .. then away.. Nobody was at home...I thought about what I had to do before the bell tolled... so to speak...Which electrical things have to be used and do I have time to take a shower before and stuff like that” (mother of Household 1).

Household 3 clearly stated that some activities had not changed, but the time during which they are carried out did:

"Those activities which we have done during Peacetime.... They have not been new so to speak... it's just that we have accommodated... we have done exactly what we usually do" (wife Household 3).

A second strategy to reorganize activities was to **replace electricity-consuming activities with activities generating similar results**, but excluding electricity use, e.g., preparing cold meals:

"During this period...we usually eat something light, so we don't fry... we don't cook, but we eat some salad" (mother of Household 2).

Another example using the strategy of replacing electricity consuming activities with other but with the same result is switching off the heat pump before showering, but still using hot water left in pipes:

"Well I realized it's Peacetime between eight and ten and I wanted to do a few things and then I wanted to take a shower... so then I go down and switch off the heat pump and then there's still hot water in the boiler... so you can use it and still shower during Peacetime" (Husband of Household 3).

A third type of strategy reorganizing activities to fit the Peacetime hours was to actually **skip activities using electricity without replacing them**:

"My husband switched on the coffee machine by mistake... but he switched it off and went outdoors to smoke instead" (mother of Household 2).

5.5. Theme 5: the Peacetime feeling and sense of morality of leisure time

The Peacetime hours seem to have upgraded the status of leisure activities, like reading and resting, to something good and the three households experienced a feeling of loss when the 2-week period with the Peacetime prototype came to an end.

Mother of Household 1: *"we...miss the Peacetime hours... or the feelings of them.. They contributed to... not to think TV and stuff like that.. I think we did good"*. The mother of household noticed that the twin boys extended the Peacetime period and did not immediately put on the TV as the Peacetime period was over.

The wife in Household 3 indicates that doing leisure things like reading was previously associated with a feeling of guilt. However, since Peacetime hours are intentionally combined with refraining from using electricity, and thus, contributing to something good (less environmental impact) the value of reading had been upgraded. She stated:

"Maybe I've done some more reading... yes with a pure conscience I was really allowed to sit down and read this book instead".

Her husband agreed: *"It almost felt better laying on the couch when it's Peacetime (laughs)"*.

The wife agreed and also said: *"Yesterday, which was the last day ... last Peacetime... so sad. I was on the couch and took in the scent and ah... it smelled so good"*.

6. Discussion

The Peacetime concept and the study reported in this paper has challenged the idea of households as rational mini-energy managers. Results from the study of the Peacetime probe in the context of households indicate that focus could be shifted from restricting electricity use to creating alternatives – leading to a positive framing of electricity load balancing. The RtD approach allowed us to critically examine the field of load balancing as envisioned in a smart grid scenario. The scenarios reflected in the Peacetime study differ from those of rational energy managers basing decisions of domestic life on complex facts and figures. The scenarios from the Peacetime study portray how planning, reorganization, and time shifting of activities may be obtained with soft means emphasizing values of well-being and respect of the variation of households' social contexts. Our study depicts scenarios where electricity use is a background priority of everyday life rather than a primary interest.

The themes presented in the results section point to several issues deserving attention when implementing smart grids in households. As general planning forms part of everyday practices in most households, the planning relating to load balancing adds on to or becomes integrated in other sorts of everyday planning. The results also show that households may be quite flexible and inventive both in creating new activities replacing the electricity-consuming ones and in reorganizing existing activities. This shows that it is possible for households to reorganize practices or creating new ones to accommodate to external conditions, such as the intermittence of renewable energy sources in the power grid. We found three strategies for households in reorganizing: they shifted times for when an activity usually was carried out to times either prior to or after Peacetime hours; they replaced electricity consuming activities with non-electricity activities generating similar results; and they altogether skipped activities using electricity without replacing them.

6.1. Peacetime practices

We challenged "resource man" [17] through the Peacetime concept communicating load management not only in a simplified manner, but also by allowing a mind shift for householders to consider actions associated with positive experiences rather than actions associated with constraints. The type of 'slow energy' uncovered by [26], when deployed and encouraged, was well received in our study. Theme 5 indicates how Peacetime not only allowed households to shift activities in time, but it also legitimized the leisure time activities. Peacetime might have substantiated the resolution of the requirements from electronically driven communication and information media. Actually, having something else proposing things to do other than routinely carried out activities appeared to be quite relieving. Introducing Peacetime might be compared to reintroducing the Sabbath – the day of rest.

The emotional ingredient elicited by Peacetime is worth noting. Surprisingly all households wanted to keep Peacetime periods. Alternative activities resulted in moments of human-to-human interaction, perceived as fun and meaningful. Alternative activities were mostly ordinary but with a twist from the participants. Especially one household considered suggested activities inspiring, and was open to new alternatives. One household could not relate to

the suggested activities, but they still considered the Peacetimes enjoyable and considerate moments to them.

Designing a concept that is respectfully integrated into everyday life is challenging. Understanding domestic practices in detail and providing pertinent support in those specific situations is complex. Social aspects, including piles of dirty laundry and a stressful schedule, are the reality of everyday life. As argued in Ref. [8], we aimed to introduce tailored alternative Peacetime activities to the users as inspiration of how to rethink their practices or “reimagine themselves” [27]. However, these were just fragments of what could be. Results indicate that this approach could become even deeper, richer, and more respectful to support users in their transition towards more sustainable practices. This points to a promising direction in sustainable HCI, which considers emphasizing the key role of interpretation in HCI [28]. Sustainable HCI can open up for approaches where design centres around other issues than electricity use, such as well-being, but still reaches the goals outlined for the electric grid. While energy companies tend to approach their customers with complex and numerical information to communicate, HCI, and design provide opportunities to align with motivations for enhancing the quality of life in a wider perspective than feedback on electricity consumption.

6.2. Limits and future developments

This explorative RtD study represents a first step towards the exploration of practice-based and emotional approach in the design of smart grid communication systems for households. We have not considered the effect of users’ habituation to the system over time and the system might be ignored as time passes. If habituation occurs, the system could be used as an invitation and introduction to load manage in a positive and emotionally engaging way, and it may be replaced by a different and less intrusive system after a limited period. Effects of the use of such a system over time should be carefully explored, in order to design systems that can have long-lasting effects on the development of sustainable practices. Although the study is explorative, it shows positive results that encourage further investigation in this field. This work can inspire others scholars and contribute to the discussion of an alternative and more emotional approach to support and engage users in the smart grid scenario.

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