Smart grid, smart users: The user experience and impact of a persuasive mobile electricity managing assistant

Master's Thesis in Computer Science

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Abstract

Keywords: Mobile Applications, Persuasive Technology, Electricity Consumption, Behaviour Change, User Experience

By 2017 smart meters are to be installed in all Norwegian households, opening the door for different billing models with regards to electricity consumption. One such model is *effect-based billing*, where customers subscribe to a maximum watt consumption, and pay a fee if their consumption rises above that maximum threshold. In this paper I introduce an application for mobile phones - anchored in persuasive technology theory - that helps users stay below their threshold. A lab experiment was conducted with two groups of three participants - one group that used the persuasive application, and one that did not - to research the user experience of such an application, as well as the impact it had on the consumption. Results show that the application combined with the prospect of paying fees successfully persuades its users to turn off appliances to stay below their threshold. It was also found that users who received no feedback during the test felt uncertain about their consumption and whether they were above their threshold, something those who used the application did not. The application was well received by its users, and all participants were positive to use a mobile assistant to help manage their electricity consumption. The experiment was not able to demonstrate any significant impact on the consumption caused by the application. This was likely due to the nature of the experiment, and further research should be conducted to find if there is any significant difference in the long run.

Acknowledgements

I would like to thank my thesis advisor Harald Holone for sound advice and invaluable help throughout the whole project.

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Chapter 1

Introduction

The consumption of electricity is different from household to household. Consumption varies based on the number of inhabitants, the weather, the seasons, and other properties. However, certain trends can be found when analysing consumption data, as Jukka V. Paatero and Peter D. Lund did for a set of measurements of electricity consumption from Finnish households in 2006 [27]. On workdays the consumption for households rises in the evening when compared to the consumption during the day when inhabitants are away from home. In Finland, and other Nordic countries, more electricity is used during winter than during the summer, due to electric heating and less need for electrically powered cooling in homes during summer than in other parts of the world [27].

This fluctuation in electricity consumption creates challenges for electricity grid maintainers and power suppliers. For instance, a grid may have capacity problems during a brief window of peak demand, but be over capacity for the majority of the time. The demand for power has to be met, but suppliers do not want to over-produce electricity. As such, short-term generators must be available to come online when demand is higher than a long-term baseline production is available to meet [23]. This short-term power is expensive to generate, and so it is in the interest of both these stakeholders to reduce this peak in consumption [23].

Sarah Darby conducted a survey in 2006 of energy consumption studies from the past thirty years and found that the energy consumption of comparable homes and households could differ by a factor of two or more, depending on the behaviour of the inhabitants of the home [3]. She found that *feedback* on the consumption in the household had a significant, measurable impact on the energy consumption of that household. Darby notes:

> Most domestic energy use, most of the time, is invisible to the user. Most people have only a vague idea of how much energy they are using [...] and what sort of difference they could make by changing day-to-day behaviour or investing in efficiency measures [3].

The literature Darby surveyed demonstrates that clear feedback is not only important, but necessary to learn to control consumption. Instant and direct feedback in combination with frequent billing, which Darby notes is a kind of indirect feedback, is needed in order to achieve a sustained reduction of energy consumption in households [3].

In the case of instant feedback, Darby found that electricity savings ranged from 5% to 15% [3]. For indirect feedback, such as individual information alongside billing, savings ranged from 0% to 10% depending on the quality and detail of the feedback. Indirect

feedback seemed to be more suitable to demonstrate effects of energy efficiency measures, as the effects may seem small on an immediate-feedback display, but over time will have a significant impact [3].

Darby notes that, while online billing – detailed feedback on a website – can be a useful and interactive feedback service, it is unlikely to be a good substitute for a more direct display or device [3]. Given that a user will have to turn on a computer and access the feedback mechanism online it becomes less effective since it requires effort and motivation from the user to be given feedback.

Opportunities arise with modern, touch-based, context-aware, and Internet-connected smart-phones for providing feedback on electricity consumption when coupled with a smart meter. Smart-phones phones have had a significant rise in penetration rate over the past few years, and are with their owner for large parts of the day. The user can receive immediate notifications upon an increase in consumption, and get suggestions for reducing the consumption. In this way it may be possible to encourage people to reduce their peak consumption and adopt a more balanced consumption pattern.

This potential with smart-phones and feedback on energy consumption comes with some uncertainty. Will the feedback be welcomed by the user, or will the notifications only add noise to the user experience on the phone? I wish to shed some light on this question with this thesis project, as well as see if there is a positive trend towards balancing and being aware of the electricity consumption with such an application of technology.

1.1 Motivation

My personal motivation for this thesis is that of an interest in mobile technology, and how it affects people. I have been developing applications for mobile devices for several years, and I am still fascinated by the capabilities of such devices and the applications for them. During the early stages of finding a thesis project the concept of *persuasive technology* was brought up, and I was immediately interested. Learning how technology in general, and mobile technology in particular, can affect people's behaviour is very interesting. Applying that knowledge to the problem of energy conservation is an exciting prospect.

For electricity consumers the motivation may be to be more aware of their own electricity consumption and so reduce it, either for financial reasons or from an eco-friendly conviction.

Legislation has been passed in Norway that all households must have installed smart electricity meters by 2017[1], which opens up the possibility of billing models where the customer can be charged additionally if a watt threshold is passed. This category of billing model will throughout this thesis be referred to as *effect-based billing*. Fredrikstad Energi – who have cooperated with me through parts of this thesis project – have a pilot project in Hvaler, Norway where customers have such a billing plan after having installed smart meters[2]. Should such a model become wide-spread in Norway an assistant tool that helps consumers could become valuable. Fredrikstad Energi and their partner currently ship a display to homes partaking in the project (shown in figure 1.1) to allow for such self-monitoring.

Also mentioned in the introduction, grid maintainers and electricity suppliers may be interested in having customers be more aware of the load they are putting on the grid

[1] http://www.sintef.no/home/SINTEF-Energy-Research/Xergi/Xergi-2012/Artikkel11/

[2] http://www.tu.no/kraft/2013/12/06/slik-vil-nettselskapene-holde-nettleia-oppe-i-fremtiden

in order to reduce the gap between a normal and peak load. Combined with a billing model such as the one Fredrikstad Energi are trying, a mobile application designed to help people stay below a load threshold may help towards this goal, and so be of interest to those stakeholders.

Figure 1.1: The eWave display being offered to Fredrikstad Energi's customers. The display is 7 inches across, and is based on the Android platform. Photo by Odin Media.

1.2 Towards a Research Question

If an application on a mobile phone is to have any effect on someone's electricity consumption it needs to be able to change that someone's behaviour in some way.

There are numerous ways of inspiring a change in behaviour in people. In his 2013 thesis, Tordbjørn Wang Eriksen researched how *gamification* could inspire adolescent diabetics to measure their glucose values more often [9]. Gamification is the application of game elements in non-game contexts. In its most basic of forms, gamification can be the application points and levels in a website, or frequent-flier programs where points are gained from flying, used for free flights. Gamification is described in more detail in section 2.3.

Eriksen created an Android application where users would enter their measured glucose levels in order to earn points that went towards feeding a personal avatar, and purchasing things for that avatar. His results showed an increase in the number of measurements in the short-term, but "it [was] likely relatively short-lived" [9]. However, without a long-term study the long-term effects remain uncertain.

Another avenue for inspiring change in users is persuasive technology. Persuasive technology is a field of research that focuses on using technology as a means to persuade users to behave in a certain way or perform certain actions. For instance, a persuasive application can make use of a person's calendar to make suggestions at opportune moments. Google Now[3] does this, suggesting that a user should leave soon in order to reach

[3]http://www.google.com/landing/now/

an appointment due to traffic between the user's current location and the location for that appointment. Amazon[4] makes use of a customer's browsing and purchasing history to tailor a list of suggestions for items that customer may be interested in. Persuasive technology is described in more detail in section 2.2.

Persuasive technology can be, and has been, applied in the effort to reduce energy consumption in households. The device Wattson and companion software Holmes is an example of a persuasive application. Yi describes the device in *Persuasive Technology in Motivating Household Energy Conservation*[24]. The device will glow with an ambient light, changing color as the consumption goes up or down. Holmes gives the user graphs and more detailed historical data. Through self-monitoring, awareness of consumption is created, and consumption reduced [24].

Gamification and persuasive technology seek to encourage a specific kind of behaviour in users. In the case of Eriksen's thesis, the goal was to encourage users to measure glucose values more often. In the case of Wattson, the goal is to create awareness of and reduce electricity consumption. The ways in which a gamified application and a persuasive application go about making this behaviour change is different.

A gamified application seeks to create enjoyment, engagement, and loyalty. If a certain behaviour or task is made fun and engaging, the notion is that the task/behaviour will be repeated and maintained by the user. A persuasive application uses different techniques to achieve behaviour change, such as self-monitoring, a reduction of a task's complexity, tailoring to specific users (such as Amazon's suggested items), or suggestions at opportune moments (such as Google Now).

1.3 Research Questions

As mentioned, opportunities arise with smart-phones for providing feedback on electricity consumption when coupled with a smart meter. A display such as the eWave, shown in figure 1.1, requires that a user take it upon themselves to check their consumption regularly. An application that notifies the user when consumption is high on a device that, for most parts of they day, is within reach of its owner does not require this initiation. However, it is not certain how such notifications will affect or be perceived by users. Further on in the report I attempt to shed some light on this.

My research question consists of two parts. First, I wish to shed some light on the user experience:

> **RQ1:** Given immediate feedback on changes in the electricity consumption through their mobile phone, how do users respond?

Secondly, I wish to see if there is a trend towards a lowering of the electricity consumption peak:

> **RQ2:** What impact does a mobile phone assistant have on electricity consumption patterns in an effect-based billing situation?

[4] http://www.amazon.com/

1.4 Report Outline

In chapter 2 I present work from the main research fields that I apply in this thesis, and related fields. I also present related work that has been done in energy conservation and persuasive technology, and energy conservation and gamification.

Chapter 3 describes the methods used to design and perform the test that gives data to discuss the research questions, and methods used to analyse the results from that test.

The report then goes into presenting the results from the testing described in chapter 4, before I discuss the results in light of previous research in chapter 5.

Finally, I present my conclusion before suggesting paths for future work in chapter 6.

Chapter 2

Background

This chapter presents the main research topics that form the background for the research in this thesis.

Persuasive technology is the field of research that is the main focus of this thesis. I present the field in section 2.2. In section 2.1 I present some background on persuasion (sans technology) and behaviour change.

I also present the field of gamification in section 2.3. Gamification was the focus of a thesis written at Østfold University College in 2013 which attempted to answer how gamification could be applied to achieve behaviour change in young diabetics [9]. While the case in this thesis is quite different from that of Eriksen, since gamification was used to attempt to change behaviour it warrants further scrutiny in this thesis as well.

After presenting gamification I present related work that has been done with applying persuasive technology and gamification to reduce electricity consumption in section 2.4.

2.1 Behaviour Change

In this section I present cognitive dissonance, the transtheoretical model for behaviour change, and techniques for achieving behaviour change. I summarize these topics in section 2.1.6.

2.1.1 Cognitive Dissonance

In this section I briefly describe the *cognitive dissonance* theory by Festinger. The original paper on cognitive dissonance was written by Festinger in 1957, and has since been revised a number of times [15].

Cognitive dissonance arises when there are inconsistencies between elements of knowledge a person has about himself, his behaviour, or his environment. This inconsistency leads to discomfort that motivates people to reduce it, for instance, by changing their beliefs, attitudes, or behaviour [34].

For instance, a person can be fully aware of the speed limit for a stretch of road, but argue with himself that he is late for an appointment, or that "everyone else does it", so driving faster than the speed limit is not an issue. In this case, rather than changing his behaviour – slowing down so as to stay within the speed limit – the person changes his attitude to where it does not matter keeping within the set limits.

In *Using Cognitive Dissonance to Encourage Water Conservation*, Chris Ann Dickerson and colleagues applied cognitive dissonance with the aim to change behaviour in patrons of a campus recreation facility with regards to water consumption [8]. They made the patrons feel hypocritical about their showering habits, by making them aware of their own wastefulness after having asked them to commit to get others to consume less water.

Results showed that subjects who felt a sense of hypocrisy took shorter showers than the control group [8]. Dickerson et al write that:

> "the findings have implications for using cognitive dissonance as means of changing behaviour in applied settings, especially those in which people already support the desired goal, but their behaviour is not consistent with those beliefs." [8]

Cognitive dissonance can be applied as a means towards behaviour change in electricity consumers, for instance with regards to conservation. Electricity customers who see themselves as environmentally conscious can be encouraged to reduce their consumption by being made aware that the electricity they use is, partly or completely, generated by coal or fossil fuels.

2.1.2 Behaviour Model for Persuasive Design

What exactly makes someone change their behaviour? To understand that, in *A Behaviour Model for Persuasive Design*, BJ Fogg presents the *Fogg Behavioral Model (FBM)* [13].

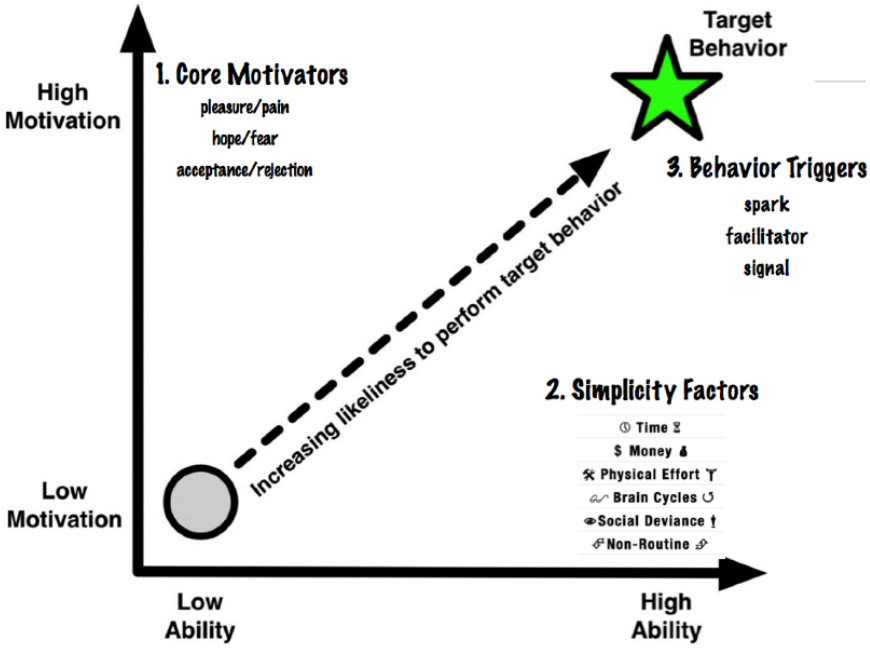


Figure 2.1: The Fogg behaviour model, as illustrated in *A behavior model for persuasive design* [13]

Fogg writes that in order to achieve a desired target behaviour three things must be true:

1. The person must be motivated
2. The person must have the ability
3. The person must be triggered

Fogg presents three groups of motivators: pleasure/pain, fear/hope, and social acceptance/rejection [13].

Pleasure and pain is perhaps difficult to invoke, and ethically it should perhaps not be invoked even if it could be - especially pain. Nevertheless, pleasure and pain are two core motivating factors in humans [13]. Pleasurable experiences are gladly repeated, and painful ones are avoided.

Hope and fear are two sides of the same coin: the anticipation of an outcome [13]. You hope for the best, but perhaps fear the worst. Both hope and fear have been used in behaviour change for a long time, for instance invoking hope to get people to join dating websites, or fear to purchase and update anti-virus software or home security.

Social acceptance and rejection are powerful motivators. People spend large sums of money on brand merchandise to "fit in", and go to great lengths to please their peers to avoid rejection [13]. With social media, this social game is extended to the online arena, and advertisers and businesses exploit this.

People can be motivated, but without the ability to perform it there will be no target behaviour. Ability (or lack of it) comes in many forms. Fogg presents six: time, money, physical effort, brain cycles, social deviance, and non-routine [13]. Time and money are in short supply for many, and if something takes a long time, or costs money, there will be many who give up. The amount of physical effort and time to think required will have an impact on the number of people successfully persuaded as well. Routine tasks are easy to perform, so if something becomes routine, people usually have the ability. With social deviance Fogg means that people will be less inclined to do something that is outside of the social norm.

Finally Fogg describes three types of triggers: sparks, facilitators, and signals [13]. Sparks create motivation through the use of language, visualizations, or other means (examples include campaign videos, or news headlines). Facilitators create ability. For instance, customers can be inclined to visit the store if given discount coupons. Lastly, signals are triggers for people who are motivated and have the ability. This is simply a well-timed reminder.

Triggers are especially interesting with regards to smart-phones. Some training companion applications for smart-phones, for instance Nike+[1], allow you to share your exercise on Facebook, where friends can hit "Like" while you are out exercising (see figure 2.2). The app will play a sound of people cheering when this happens, creating motivation through social acceptance. Such apps can create hope or anticipation by letting you see your progression and where you will be if you keep exercising.

Persuasive technology and mobile devices are discussed further in section 2.2.2.

2.1.3 The Transtheoretical Model and Stages of Change

In this section I present the Transtheoretical Model (TTM), by Prochaska et al [28]. It is a popular model, having been applied in many studies regarding behaviour change, particularly in studies focused on turning people away from unhealthy behaviour.

[1] http://nikeplus.nike.com/plus/products/gps_app/

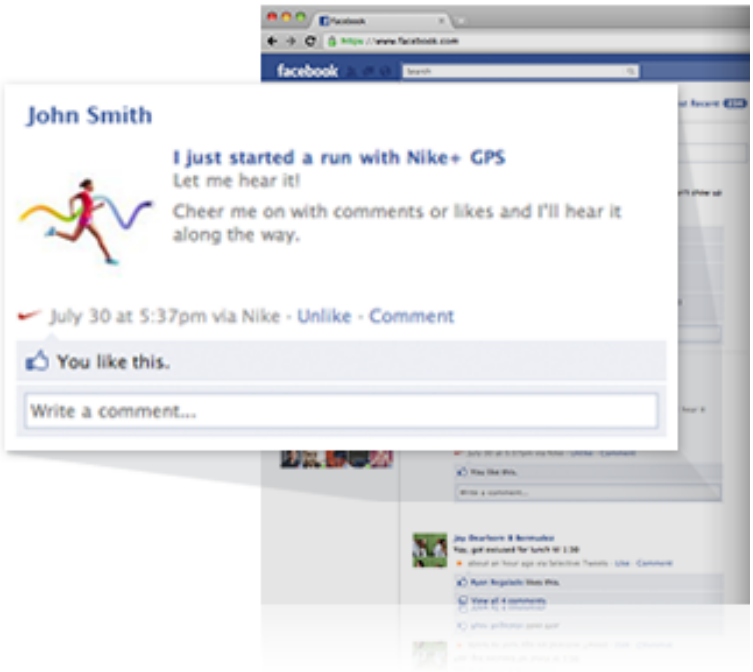


Figure 2.2: A screenshot from the Nike+ GPS app website showing how friends can cheer for you as you exercise

The TTM attempts to model behaviour change as a set of discrete stages, called the *Stages of Change* (seen in table 2.1.3). The notion is that a person finds himself in these separate stages – from precontemplation to change the behaviour, to termination of the behaviour – when changing his behaviour. The way in which a person moves from stage to stage is modelled under the *Process of Change*, also shown in table 2.1.3.

The TTM "emerged from a comparative analysis of leading theories of psychotherapy and behaviour change", for instance Freudian consciousness raising, Skinnerian contingency management, and Rogerian helping relationships [28].

Studies Applying the TTM

The model has been applied in many studies and programs aimed at changing unhealthy behaviour to healthy behaviour, among them substance abuse [33][25], obesity [2][31][17], and smoking [35][10]. The results from these studies have been mixed.

Criticism

A vocal opponent of the TTM is Stephen Sutton. In his review titled *Back to the Drawing Board?* Sutton criticizes the methods applied in studies using the TTM [33]. Sutton notes that he is not an opponent of a behaviour change model that involves stages of change, like in the TTM. However, he finds that the TTM is a poor implementation:

> There are serious problems with the existing methods used to measure the central construct of stages of change. [33]

Stages of Change	
Precontemplation	No intention to take action within the next 6 months
Contemplation	Intends to take action within the next 6 months
Preparation	Intends to take action within the next 30 days and has taken some behavioural steps in this direction
Action	Changed overt behaviour for less than 6 months
Maintenance	Changed overt behaviour for more than 6 months
Termination	No temptation to relapse and 100% confidence

Process of Change	
Consciousness raising	Finding and learning new facts, ideas, and tips that support the healthy behaviour change
Dramatic relief	Experiencing the negative emotions (fear, anxiety, worry) that go along with unhealthy behavioural risks
Self-reevaluation	Realizing that the behaviour change is an important part of one's identity as a person
Environmental reevaluation	Realizing the negative impact of the unhealthy behaviour or the positive impact of the healthy behaviour on one's proximal social and/or physical environment
Self-liberation	Making a firm commitment to change
Helping relationships	Seeking and using social support for the healthy behaviour change
Counterconditioning	Substitution of healthier alternative behaviours and cognitions for the unhealthy behaviour
Reinforcement management	Increasing the rewards for the positive behaviour change and decreasing the rewards of the unhealthy behaviour
Stimulus control	Removing reminders or cues to engage in the unhealthy behaviour and adding cues or reminders to engage in the healthy behaviour
Social liberation	Realizing that the social norms are changing in the direction of supporting the healthy behaviour change

Decisional balance	
Pros	Benefits of changing
Cons	Costs of changing

Self-efficacy	
Confidence	Confidence that one can engage in the healthy behaviour across different challenging situations
Temptation	Temptation to engage in the unhealthy behaviour across different challenging situations

Table 2.1: The stages and processes of change, decisional balance and self-efficacy making up the transtheoretical model presented in *Transtheoretical model of behavior change* [28]

Sutton presents two such methods for measuring stages of change that have been used: staging algorithms, and multi-dimensional questionnaires.

A staging algorithm is a set of criteria that have to be fulfilled before a person is said to be on the next stage in the process. Sutton has criticized studies for having "arbitrary" definitions of the time-span in their algorithms [33]. Changing the time periods in the algorithm would greatly affect the distribution of subjects, giving time alone a disproportional significance.

Sutton brings up three questionnaires that have been applied in several studies:

1. University of Rhode Island Change Assessment (URICA)
2. Stages Of Change Readiness and Treatment Eagerness Scale (SOCRATES)
3. Readiness to Change Questionnaire (RCQ)

Common for all these studies, Sutton found, is that the measurements show people as being in several stages at once [33].

> Whatever it is that these multi-dimensional questionnaires are measuring, they are clearly not measuring discrete stages of change. [33]

Sutton urges researchers to develop new stage models, and not give more attention to the TTM [33].

2.1.4 Achieving Behaviour Change

Long-term Behaviour Change

Behaviour change is a complex and long-term process, and the relapse rates are high [19]. For instance, Prochaska et al cite studies indicating that for quitting smoking, relapse rates only go down to about 7% after five years [29]. After a year of abstinence from smoking the relapse rate remains at 47% [29].

Klasnja et al present another project where less than half of the patients undertaking a cardiac rehabilitation program keep exercising regularly after six months [19]. Dietary programs following cardiac rehabilitation show similar results, with adherence rates after one and three years are at 49% and 42% respectively [19].

Prochaska et. al. have found – based on empirical research and a review of literature – that for behaviour change to stick, a person has to maintain that behaviour for several years [29].

Techniques

In his survey *Changing Behaviour and Making it Stick*, Raymond De Young presents a categorization of different behaviour change techniques aimed at conservation — reducing not only electricity consumption, but water usage and waste generation. De Young bases his categorizations on existing work on behaviour change techniques, and his categorizations are "evolved from these earlier frameworks" [4].

Information interventions have the goal of getting people to understand the issues their behaviour raises [4]. If a person is unaware of what consequences their actions have it will be difficult to make them understand that a different behaviour should be adopted.

In the situation that people want to change their behaviour, but are uncertain as to how they should proceed, giving the person information on how to behave in a more positive way may make that person change their behaviour [4].

Examples of specific information techniques are education, training, and prompts – such as signs, notifications, and PA messages. For achieving sustained behaviour change, prompts are not effective, as the behaviour change achieved when using prompts vanish when the prompt is removed [4]. However, for short-term behaviour change prompts can be an effective technique, for instance prompting people to turn off the light before they leave a room.

According to the Fogg Behavioral Model, presented in section 2.1.2, a person without motivation will not be triggered to perform the desired behaviour [13]. De Young presents the category called *positive motivation*, where the purpose is to create motivation in people through positive enforcement [4]. De Young lists two techniques for such motivation:

- Monetary reinforcement
- Social reinforcement

Monetary reinforcement can come as reduced taxation or other beneficial programs minted to encourage the desired behaviour. For instance, electric vehicles can be exempt from many of the taxes that are put on petrol-driven vehicles, healthy foods can be exempt from or have a reduced value-added tax, or government-funded programs to insulate homes and bring them over to less energy-consuming heating can be put in place. Sustained change is an issue with material and monetary incentives. If the incentives are stopped, the desired behaviour is stopped quickly after [4].

The social aspect of motivation is also significant. Social status and recognition is a driving force for people's behaviour, and using this to encourage specific behaviour is useful [4]. For instance, a publicly announced commitment to reduce consumption can help to make people keep their commitment - both from a status perspective, but also from a fear of social rejection were they to fail.

As with positive motivation, *coercive motivation* can be applied when motivation to change is lacking. When in an undesirable situation, people are known to change their behaviour rapidly in order to better their situation [4]. This can be used in order to encourage a desired behaviour in people. While punishing people for specific behaviour is argued against, De Young writes that there are techniques that coerce without directly punishing [4].

Monetary disincentives is brought up as a type of coercive motivation by De Young [4]. Just as reducing the cost for desired behaviour can be used to encourage it, increasing the cost of undesirable behaviour can be used as a disincentive — for instance through taxation of unhealthy foods, petrol driven cars, or an increase in electricity prices.

Again utilizing the need for social recognition, coercing people into adopting desirable behaviour through peer pressure can be a powerful technique [4]. As with all coercive motivation, the ethical issues with this techniques will have to be considered.

Physical barriers is another coercive motivator that can be utilized. While the name might imply it, the barriers need not have physical properties in and of themselves. For instance, litigation can be passed that make certain chemicals illegal to use in consumer products. In traffic, actual physical barriers can be designed to only allow public transportation through a busy thoroughfare.

Finally, De Young writes that fear can be used to motivate [4]. Highlighting negative consequences if behaviour is not changed, for instance by showing a map where the sea level has been raised according to projections, can instil a sense of fear in people and coerce them to change their behaviour to one that has a lower negative impact on the environment.

A major issue with coercive motivation is the negative impact they have on the individual. While the goal of coercion is to instil motivation, a *decrease* in motivation may be the result [4].

Energy Conservation: The Importance of Feedback

Sarah Darby conducted a survey in 2006 of energy consumption studies from the past thirty years and found that the energy consumption of identical homes and households could differ by a factor of two or more, depending on the behaviour of the inhabitants of the home [3]. She found that *feedback* on the consumption in the household had a significant, measurable impact on the energy consumption of that household. Darby notes:

> Most domestic energy use, most of the time, is invisible to the user. Most people have only a vague idea of how much energy they are using [...] and what sort of difference they could make by changing day-to-day behaviour or investing in efficiency measures [3].

The literature Darby surveyed demonstrates that clear feedback is not only important, but necessary to learn to control consumption [3]. In *Consumer Feedback: a Helpful Tool for Stimulating Electricity Conservation?* Corinna Fischer performs a similar survey to that of Darby [11]. Fischer notes that the effects of feedback with regards to energy conservation in the surveyed projects varies depending on a number of factors [11]:

- Frequency
- Breakdown (appliance level vs total)
- Presentation
- Comparison with previous consumption, similar households

Instant and direct feedback in combination with frequent billing, which Darby notes is a kind of indirect feedback, is needed in order to achieve a sustained reduction of energy consumption in households [3]. Fischer writes:

> It can be expected that feedback is the more effective, the more directly after an action it is given because it would allow the consumer to make an easy connection between his actions and their consequences [11].

In the case of instant feedback, Darby found that savings ranged from 5% to 15% [3]. For indirect feedback, such as individual information alongside billing, savings ranged from 0% to 10% depending on the quality of the feedback. Indirect feedback seemed to be more suitable to demonstrate effects of energy efficiency measures, as the effects may seem small on an immediate-feedback display, but over time will have a significant impact [3].

Darby notes that, while online billing can be a useful and interactive feedback service, it is unlikely to be a good substitute for a more direct display or device [3]. Given that a user will have to turn on a computer and access the feedback mechanism online it becomes less effective since it requires effort and motivation from the user to be given feedback.

The presentation of feedback affects its effectiveness. Feedback can be given on electricity consumption (kilowatt-hours), on cost, or on environmental impact. Lucid's BuildingDashboard, presented in section 2.4, presents consumption in these ways, and also in the number of laptops the current consumption could power. Some people are highly motivated to protecting the environment, and so giving feedback on the environmental impact of the consumption can have great effect. On the other hand, some people are more motivated by cost, and so an application only giving feedback on the environmental impact may fail to engage as effectively as one presenting cost. In the projects Fischer reviewed, both kilowatt-hours, cost, and environmental impact were presented through feedback, though with a focus on consumption and cost [11]. The appeal of the user interface also has an impact on the effectiveness of an application – an unappealing or unfriendly application interface is less likely to be used frequently [11].

Fischer writes that feedback may become more informative if it is broken down, for example on a per-appliance level, and on a minute-to-minute basis [11]. She notes that such a breakdown of feedback is "almost the only way of establishing consciousness of the relevance of *individual* actions" [11].

Comparisons drawn between a person's consumption and that of others can incite competition and create ambition in people [11]. Also, if feedback is given rapidly when consumption is outside the norm it can encourage the user to make corrections and reduce consumption.

2.1.5 Evaluating Behaviour Change Applications

With a behaviour change application in place, the question becomes how you should conduct your evaluation of the application.

As described in section 2.1.4, behaviour change is a long and complex process with a high probability for relapse. With such high probability of relapse, and the complex nature of behaviour change, long-term studies are required to get conclusive results about the effectiveness of an application designed towards changing behaviour [19].

Certain aspects of the behaviour change can be observed over a shorter period in cases where long-term studies are unfeasible. Klasnja et al bring up the following example for evaluating an application of the self-monitoring type (as described by Fogg [12]):

> [...] an evaluation should assess whether during the period when participants are actively using the system, the rates of the target behaviour increase from their baseline levels prior to the intervention. In addition, it should test whether after the intervention is stopped, the rates of behaviour begin to go down again. Such a pattern could be seen in even a few weeks, obviating the need for a long-term study. [19]

Klasnja et al also note that a follow-up study, even if conducted as quickly after the initial study as one month, can be an important part of the evaluation process [19].

2.1.6 In Summary

As noted in section 2.1.5, long-term studies are needed to see if long-term change has been achieved. As such, this thesis will not be able to give conclusive results to whether such a long-term change in behaviour has taken place. However, signs of a possible trend can be found with short-term tests, indicating if the area warrants further research.

Coercive reinforcement, presented in section 2.1.4, is applied in Fredrikstad Energi's pilot project, where customers with smart meters can have effect-based billing (discussed in section 1.1). In this case the customer is punished financially for going above the effect threshold agreed upon with Fredrikstad Energi by having to pay a significantly higher rate for the consumption above the threshold. I have chosen to use this model as a premise for my research question, since a model such as Fredrikstad Energi's may become widely adopted.

According to the Fogg Behaviour Model a person must be motivated, have the ability to change, and receive a trigger in order to achieve the target behaviour. Using a monetary disincentive to motivate, and using a notification on a smart-phone as a trigger at a time when a user has the ability to act on that trigger can prove to be effective in changing behaviour.

2.2 Persuasive Technology

Persuasive Technology is a relatively new research field. The first conference on persuasive technology was held in 2006, and has been held seven times since then as of 2013.

The pioneer work in the field was that of B.J. Fogg in his 2003 book *Persuasive Technology: Using Computers to Change What We Think and Do* [12]. Fogg presents the term and field *captology* as the study of computers as persuasive technology.

Fogg places captology near the field of human-computer interaction (HCI) [12]. Specifically, Fogg writes, captology investigates how people are motivated when interacting *with* computers rather than *through* them. As opposed to computer-mediated communication (CMC), in captology and HCI "the computing product is a participant in the interaction, and can be seen as a source of persuasion" [12].

Johan Redström, in his paper from the 2006 Persuasive Technology conference, notes that all technology can be seen as inherently persuasive [30]. Objects are designed to be used in a specific way, and through deliberate design the target behaviour is invoked in the user. In this way you can argue that technology and technology design is always, in some way, about persuasion. Redström notes that:

> If this argument is right, it means that 'persuasive technology' as a concept defining a new area is somewhat problematic [30].

Fogg's definition of captology has also been criticized. Bernadine M.C. Atkinson criticizes that Fogg throughout his book is anthropomorphizing computers, giving them human traits [1]. Fogg writes that "the computing product is a participant in the interaction" [12]. Atkinson disagrees [1], writing that:

> the relationship [between human and computer] is not one of equals, it is a utilitarian association [...] [The computer] is not capable of independently instigating a genuine relationship, nor any relationship, without other human beings providing it with that simulated capacity. [1]

As such, the notion of computers themselves being social actors is dismissed by Atkinson. However, she notes the ways in which the computer system can mimic social interaction to create more likeable systems still have merit [1].

While Fogg's definition from 2003 has come under fire, many of his findings still have value and can be applied to applications to encourage specific behaviour - persuade.

I will leave it to others to argue over whether persuasive technology should be accepted as a field of its own, and instead focus on findings of Fogg and others relevant to my research question.

2.2.1 Computers as Persuasive Technology

Fogg writes that persuasion techniques are most effective when interactive, or adapting to the situation based on user input and needs.

Using computers to persuade rather than using traditional media such as magazine advertisement, radio, and television has the advantage of being just that - interactive [12]. Over time a computer system can also learn much about a user, and that knowledge can be applied in persuading him, something online advertisers and shops know to use.

Fogg proposes that a computer plays, from the user's perspective, three basic roles - the role of tool, medium, and social actor - with most applications being a mix of the three [12]. A tool is something that is used directly, a medium acts as a channel or vessel for what persuades the user, while a social actor speaks with and interacts with the user [12]. As mentioned in the introduction to this section, Fogg has been criticised in particular for treating computers as social actors [1].

A list of seven categories of persuasive tools is presented by Fogg, with two categories being of particular interest in this thesis project: suggestion tools, and self-monitoring tools. A suggestion tool is a tool that "interven[es] at opportune moments", while a self-monitoring tool "eliminat[es] manual tracking of performance or status" [12].

The first research question in this thesis focuses on the user experience of an application that notifies its user when electricity consumption nears or passes a threshold. This could be seen as a persuasive suggestion tool, intervening at an opportune moment - close to the time when an action takes the user close to or past the threshold.

Self-monitoring is also of interest since, as mentioned in the introduction, electricity consumption is mostly invisible to the consumer. An application that allows for monitoring of the consumption can have a great impact, as demonstrated by the findings in Darby's survey - a 5% to 15% reduction in consumption with direct feedback [3].

2.2.2 Mobile Persuasion

Fogg notes that timing and context is important when trying to influence someone [12]. As such, mobile devices that are with a person for greater parts of the day are very interesting channels for persuasion. Add to the fact that modern smart-phones usually are connected to the Internet and the potential applications become greater. Mobile applications will be able to utilize what Fogg calls the *kairos factor* [12], illustrated in figure 2.3, to make suggestions at the most opportune moment.

Defining the kairos factor, Fogg writes that:

> Kairos is the principle of presenting your message at the opportune moment [12].

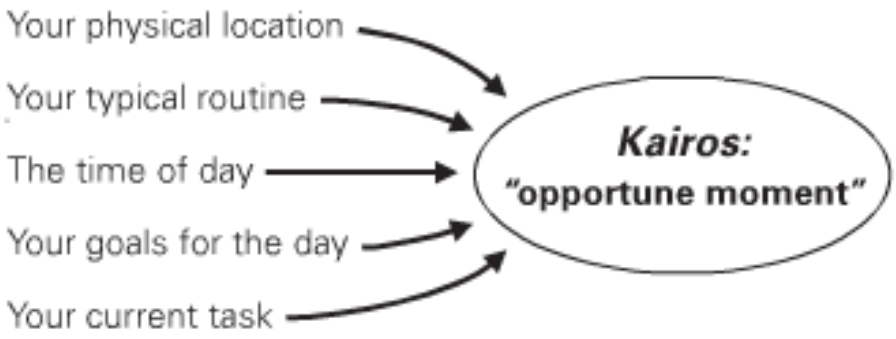


Figure 2.3: A figure illustrating the elements that make up the *kairos* factor, as defined by Fogg in *Persuasive Technology : Using Computers to Change What We Think and Do* [12]

With smart-phones so ever-present, and the phones becoming increasingly aware of context and their surroundings, the kairos factor becomes easier to exploit. Since the smart-phone is an interactive platform the user will also be able to react immediately, increasing the potential for persuasion [12].

Fogg presents an extreme example:

> Imagine how eBay.com might develop its recommendation engine to such a degree that you as you lingered in a museum to admire sculptures by Auguste Rodin, the site could identify your interest in this artist and send you a special offer to buy prints of Rodin's work, if you have opted to receive such information.

Users of the Google Now[2] application may see the beginning of just such a type of mobile application. Leveraging your location, traffic data, and your calendar, Google Now is able to remind you ahead of your manually scheduled reminder that you need to go to make it to your appointment, due to traffic (see figure 2.4). Google Now also uses your location to make recommendations on places to visit near you.

2.2.3 In summary

In this section I have presented Fogg's work on persuasive technology, and some critics of his work and the notion of persuasive technology as a research field.

I have presented how computers can be used as persuasive tools, mediums, and social actors. I have also presented how mobile phones can be an important and effective channel for persuasion, due to its variety of sensors making it context aware.

2.3 Gamification

In this section I present *gamification*. Elements of gamification can be applied to increase user engagement and encourage specific behaviour in users.

Gamification is, like persuasive technology, a relatively young research field.

[2] http://www.google.com/landing/now/

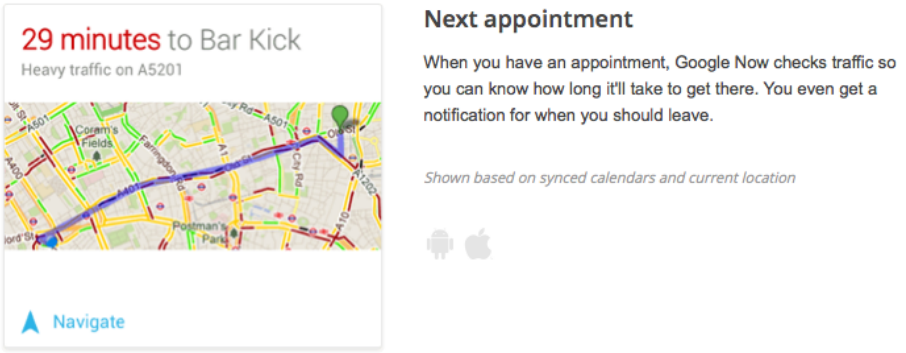


Figure 2.4: A snippet from the Google Now website, showing the traffic-based appointment reminder

2.3.1 Defining Gamification

Gamification is distinguished from *traditional/whole games*, *serious games* (simulations), and "toys from applications which utilize game-design elements in a non-game context" [9], and is defined by Deterding et. al. as:

> the use of game design elements in non-game contexts [7].

In his 2013 thesis, Tordbjørn Wang Eriksen gives an overview of gamification [9]. Eriksen explains that there are two main schools of though in the field of gamification; that of Deterding et. al., and that of Zichermann and Cunningham.

Zichermann and Cunningham define gamification as

> the process of game-thinking and game mechanics to engage users and solve problems [36].

Deterding's school of though is described by Wang Eriksen as being more academically based, focusing on the elements that make up games (such as rules and mechanics) to build new gamified applications rather than adapting existing products to engage users and create loyalty [9].

2.3.2 Using Gamification to Increase Loyalty and Engagement

Zichermann and Cunninghams's book, *Gamification by Design*, focuses on bringing gamification elements to web- and mobile applications. The end goal is to create loyalty in the users of the application, "a form of loyalty that gets users to make incremental choices in your favor when all things are mostly equal" (compared to competitors) [36]. The way in which the authors suggest doing this is through what they call *SAPS*, which is an acronym for *status, access, power, and stuff* [36]. These four things are given to the user of the application to encourage the sought-after loyalty:

Status can come in many different shapes. The top position on a leaderboard, badges to showcase achievements, karma points, levels, or titles [36].

Access would mean getting features or opportunities other users of the application do not have, for instance early access to a new product or version of a product [36].

Level	Description	Examples
Game interface design patterns	Common, successful interaction design components and design solutions for a known problem in a context, including prototypical implementations	Badge, leader board, level
Game design patterns and mechanics	Commonly reoccurring parts of the design of a game that concern gameplay	Time constraint, limited resources, turns
Game design principles and heuristics	Evaluative guidelines to approach a design problem or analyse a given design solution	Enduring play, clear goals, variety of game styles
Game models	Conceptual models of the components of games or game experience	Challenge, fantasy, curiosity, game design atoms
Game design methods	Game design-specific practices and processes	Play-testing, play-centric design, value concious game design

Table 2.2: Deterding et. al. five levels in designing gamified applications, from least to most abstract, as presented in *Gamification: State of the art definition and utilization* [14]

Power can be granted to loyal users in the form of moderator responsibilities, a role in which the user exerts power over other users [36].

Stuff is simply real-world prizes, for instance free flights for frequent fliers [36].

Deterding criticizes Zichermann and Cunningham's SAPS-thinking, claiming SAPS "do not by themselves make gamified spaces fun and engaging" [6]. Especially stuff can in fact be detrimental to user motivation, as it shifts the motivation from being intrinsic to being extrinsic [14]. It is also important to balance the usage of any awards. If a user gets accustomed to receive an award every time he performs an action the enjoyment from performing that task will decrease. If the reward from performing the task is removed, the enjoyment from performing that action will be lower than it was before the award was introduced in the first place. This effect is known as *overjustification* [14].

2.3.3 Applying Gamification

Looking at previous research on game design, Deterding et. al. define five levels in designing gamified applications, listed in table 2.2.

All levels should be considered during the design of a gamified application.

Schell and Deterding introduce three important principles when applying gamification [14]. The three principles come from Deci and Ryan's *self-determination theory* [5]:

- Relatedness: The universal need to interact and be connected with others.

- Competence: The universal need to be effective and master a problem in a given environment.
- Autonomy: The universal need to control one's one life.

Relatedness: In order for achievements and reputation points to mean anything to a user, and so become desirable, the user will have to be connected to a community that is meaningful to the user [14]. For instance, in the case of the website Stack Overflow users connect to fellow software developers and earn points for providing good answers to questions[3]. Users may feel that, through these points, they can show that they are knowledgeable within their field and that their help is appreciated by their peers. Since the audience of Stack Overflow is mainly software developers these points equal status. If there was a wider and less meaningful audience, or if there was no community at all, the points would mean less and so be less desirable. As Groh put it: "If there is nobody whom you can show it to, your achievement will be nothing special" [14]. It is also important to connect to a user's personal goals, for instance for a training app running further than his friends. No one kind of goal will be one that all users would want to achieve, so having customizable goals can be a good thing.

An alternative or supplement to a community can be an engaging story. For instance, rather than focusing on creating a community of runners, the makers of the gamified running app *Zombies, Run!* have created a story where you as a user will have to run for your life from digital zombies[4]. The game is divided into exercises that each tell part of the story, and players will have to keep running to go through it all.

Competence: Game designer Raph Koster said: "Fun from games arises out of mastery. It arises out of comprehension. It is the act of solving puzzles that makes games fun. With games, learning is the drug" [21]. It comes from this that dishing out achievements and badges for trivial task will devalue them, rendering them obsolete. Facing users with interesting challenges is therefore important. However, there is a balance. Too hard, and users will quit out of frustration. It is important to divide up the challenges into manageable chunks with a clear progression and increase in difficulty. "Even failures are desired", Groh notes, "because it improves the experience of mastering the challenge thereafter" [14].

Autonomy: Playing games is a voluntary activity - the motivation for doing so is intrinsic. If extrinsic rewards are offered, such as rebates or other real-world cash prizes, the motivation can quickly cease to be intrinsic. There is a danger that, since money is involved, the activity ceases to be fun and engaging, and instead becomes a chore [14].

In his 2013 project, presented in the next section, Tordbjørn Wang Eriksen applies these principles to affect behaviour.

2.3.4 Gamification to Affect Behaviour

In his thesis project Tordbjørn Wang Eriksen researched the possibilities of applying gamification to get adolescent diabetics to measure their blood glucose values more often [9]. Eriksen designed and created an Android application where users would enter their measured glucose levels. Each time the user entered their glucose value they would be given

[3] http://stackoverflow.com
[4] https://www.zombiesrungame.com

points, which would be used to feed and care for a personal avatar, to keep it happy. The avatar portion of the application can be seen in figure 2.5.

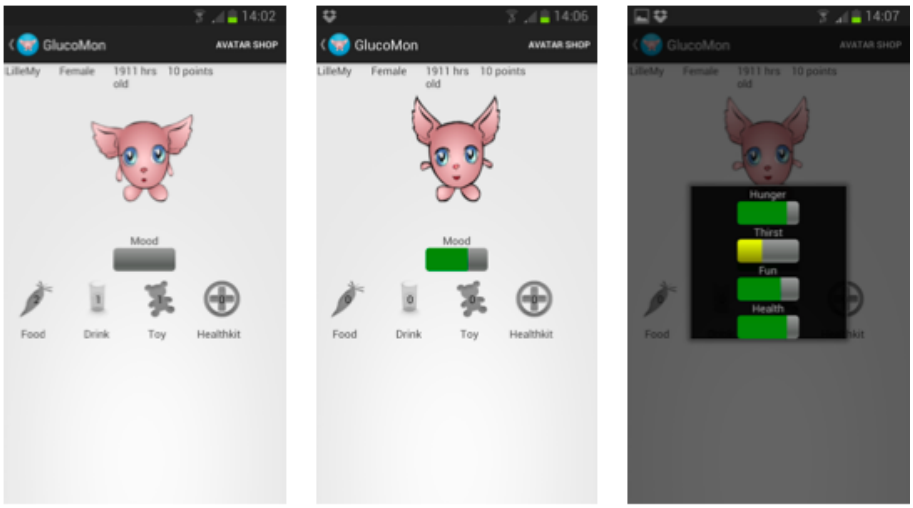


Figure 2.5: Screenshots of different parts of the application Eriksen developed as part of his thesis project, *Getting adolescent diabetics to measure more often using mobile technology and gamification* [9]

If users did not enter measurements regularly, there would not be enough points to sustain the avatar's happiness. This, Eriksen hypothesized, could lead to users altering their measurement habits to measure more often to get enough points to keep the avatar happy.

Respondents were positive and showed an increase in their number of measurements after introducing the application, one respondent claiming his number of measurements doubled [9]. However, Eriksen notes "it [was] likely relatively short-lived" [9]. Without a long-term study the long-term effects remain uncertain.

2.3.5 In Summary

In this section I gave an introduction to the field of gamification and its uses: increasing loyalty and engagement. I also presented things to consider when applying gamification: interaction with other users, the sense of mastery and control, and game design.

I briefly presented a thesis project where gamification has been applied to change behaviour - with some success. However, I choose not to apply gamification in this thesis project, instead focusing on achieving behaviour change through timely notifications and motivation through cost.

2.4 Related Work

In this section I present related work that has been done in applying gamification and/or persuasive technology to the problem of household or building energy conservation.

2.4.1 Wattson

In 2009 Yi Bing Tan presented his paper titled *Persuasive Technology in Motivating Household Energy Conservation* at the seminar Business Aspects of the Internet of Things [24]. In his paper Yi focuses on on using persuasive technology to bridge the *action-attitude gap* with regards to current household electricity consumption and its impact on environmental issues [20]. Members of a household may be aware of the environmental impact of excessive consumption, but because of the action-attitude gap do not act. The author focuses on the role of feedback as a strategy to bridge this gap, by using machine-to-machine technology and web technology.

Yi presents Wattson[5], a home electricity consumption monitoring device, shown in figure 2.6. Wattson is installed in a home and will change the color of its ambient light depending on current consumption. Wattson also has a computer interface where users can keep track of consumption patterns over time. Wattson fits in Fogg's functional triad as a persuasive tool, while the bundled computer application Holmes uses the computer as a persuasive medium. Holmes takes usage data from Wattson and builds a historical graph of usage data that the user can learn from.

Figure 2.6: The Wattson device and Holmes companion software, as shown in a promotional image on the Wattson product page

Yi notes that Wattson is an example of a "self-monitoring persuasive strategy mentioned by Fogg" [24]. Yi also notes that the Wattson technology provides timely intervention, giving an immediate indication to the user when electricity consumption is increased.

One downside to Wattson from an adoption point-of-view is having to invest in a device up-front. Unless the household is already intrinsically motivated - the household wants to change their behaviour - they will not purchase the device. Yi also notes that studies show that the sustained motivation from Wattson-like intervention is not maintained [24].

Yi suggests using a social web application for sustained behavioural change. He presents the results from EcoTeams: that "group participation in effecting sustainable behavioural change has been demonstrated" [24][32].

In section 2.4.4 I present a few gamified web applications attempting to have users reduce consumption.

Figure 2.7: The BeSmart prototype application developed by Sunniva Johansen and Kristin Tønnesen, showing the consumption for the current day [16]

2.4.2 BeSmart

BeSmart is an application prototype developed by Kristin Tønnesen and Sunniva Johansen in collaboration with eSmart Systems. The prototype was developed to research the possibility of using the cross-platform application development framework Xamarin[6] for developing a smart-phone application for household users [16].

The prototype that was developed during the project gave the user access to current, historical, and predicted electricity consumption. The user was given a choice of presentation between single-day, week, and month. The user could also choose whether the consumption should be measured in kW/h, NOK, or CO^2. Each presentation gave the user an indication as to whether consumption was below, above, or in accord with the expected consumption by using the colors green, red, and yellow respectively. A light-bulb avatar would scold or praise the users given their consumption. The application also came with a library of tips for reducing consumption that the user could browse.

The application was not tested by users during the project, since it focused on the developer side of things with regards to Xamarins cross-platform capabilities. The authors found that the benefits of using Xamarin were outweighed by the disadvantages for their application, due to the advanced nature of their interface – few standard widgets were

[5] http://www.diykyoto.com/uk/aboutus/wattson-classic
[6] http://xamarin.com/

available and up to par with their needs [16].

2.4.3 eWave

eWave is a seven-inch tablet that is dedicated as a monitoring tool for smart meters[7]. The display was offered for a time as part of a pilot project Fredrikstad Energi were running in Hvaler, Norway. The display is shown in figure 2.8. It is capable of showing consumption history, and users can also set a target consumption and compete with themselves to stay below or as close to the target consumption as possible.

Figure 2.8: The eWave display being offered to Fredrikstad Energi's customers. The display is 7 inches across, and is based on the Android platform. Photo by Odin Media.

The display is able to calculate a prediction for the consumption of the customer that day, and the user can make it his goal to stay below that consumption.

The main screen of the display shows the current consumption, as well as the accumulated consumption for the current day and the day before.

The display communicates wirelessly and runs on battery power, and so can be placed anywhere within wireless range.

2.4.4 Gamified Web Applications for Reducing Energy Consumption

BuildingDashboard is a product by Lucid that brings tenants of a building, or several buildings under the same ownership, together in a gamified social platform [8].

Figure 2.9 shows Brown University's BuildingDashboard home page[9]. The home page gives visitors quick access to find their own building, either by browsing a carousel in alphabetical order, or by searching. When a building has been selected, the home page content is replaced by content specific to that building, such as a calendar showing a calendar view of consumption, a building-wide "White Board" for short messages, and how the building fares compared to other university buildings.

[7] http://e20smartstrom.no/wp-content/uploads/2014/02/eWave-Brukerveiledning.pdf
[8] http://luciddesigngroup.com/buildingdashboard/index.html
[9] http://buildingdashboard.net/brown/

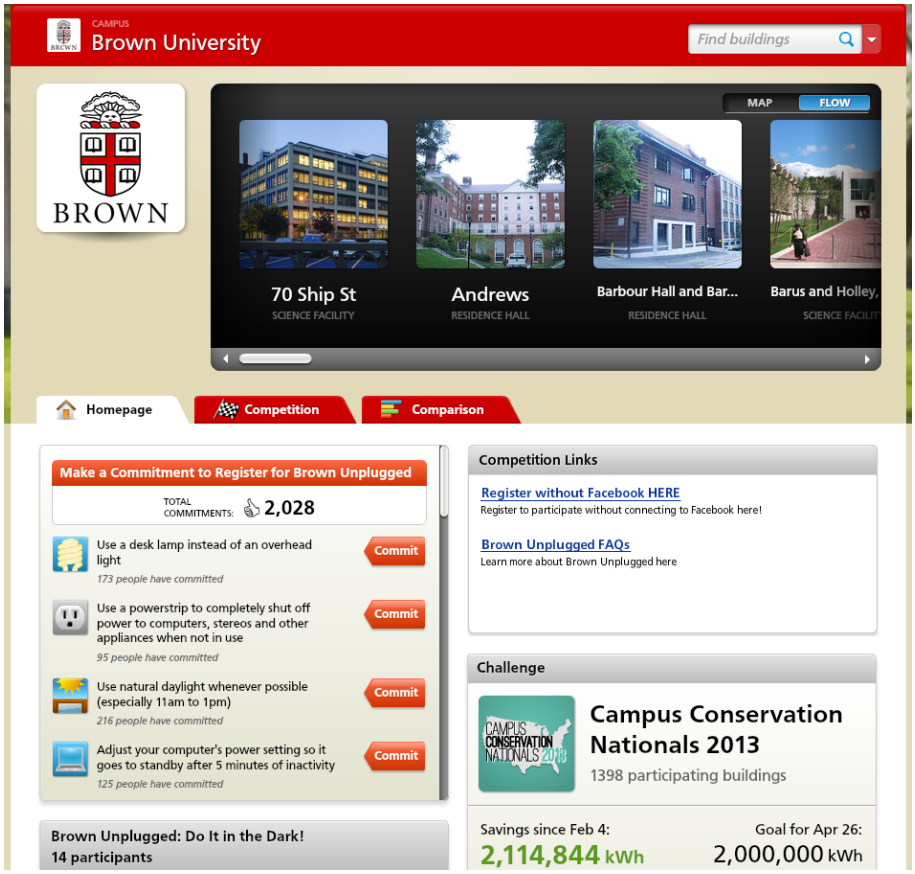


Figure 2.9: Screenshot of the BuildingDashboard for Brown University

Competitions are run from time to time where tenants of a building make commitments in order to reduce consumption. Commitments can for instance be "use a desk lamp instead of an overhead light", or "use a powerstrip to completely shut off power to computers, stereos, and other appliances when not in use". Commitments are easily made with a single click. A leader board is displayed, and the buildings that do well are awarded with a trophy indicating their rank in the competition.

BuildingDashboard is built for institutions like universities and larger office buildings where competition between buildings or departments is possible. For the household BuildingDashboard is a bad fit. However, there are vendors with products meant for households.

Opower[10], Quinzee[11], and Simple Energy[12] are three vendors that provide a product that, through engaging and informing home owners, attempt to reduce energy consumption. The products store consumption history so the user can see the development from month to month, and year to year. The products also give tips on how to reduce consumption. Quinzee also makes use of neighbourhood- and friend leader boards to spur on competition between users.

[10] http://www.opower.com
[11] http://quinzee.ca
[12] http://utilities.simpleenergy.com

2.4.5 In Summary

In this section I have presented some existing applications demonstrating the use of gamification and persuasive technology in energy conservation and awareness raising. These applications serve as inspiration during the design phase of this project.

Chapter 3

Method

My research question in this thesis consists of two parts. First, I wish to shed some light on the user experience of a mobile application designed to help users manage their electricity consumption patterns, more specifically staying below a set watt threshold. Second, I wish to see if there is an indication towards a lowering of the electricity consumption peak with such a mobile application

My first research question – focused on the user experience – is:

> **RQ1:** Given immediate feedback on changes in the electricity consumption through their mobile phone, how do users respond?

The second research question focuses on the measurable impact of the application:

> **RQ2:** What impact does a mobile phone assistant have on electricity consumption patterns in an effect-based billing situation?

To be able to discuss these research questions I conduct a test, described in section 3.3, where I gather data on consumption patterns, as well as conduct interviews to shed light on the user experience of such a mobile phone assistant.

3.1 Changes in the Project Scope

In the beginning of this thesis project I collaborated with the Halden company eSmart Systems. eSmart Systems were interested in running a thesis project around mobile technology and the concept of gamification. Through brainstorming sessions we came up with the concept of a mobile assistant that would take an active role, messaging the user at moments of high consumption.

Through eSmart Systems I was put in contact with Fredrikstad Energi, who had a pilot project running where customers had installed smart meters and were willing to take part in projects Fredrikstad Energi were running. We tried getting a project going where customers would be using the application in a real every-day situation for a few weeks. However, due to delays with external providers and issues with communication we could not get the project off the ground to complete within reasonable time.

The scope and focus of the project was then changed, and collaboration with Fredrikstad Energi and eSmart Systems was put on hold.

In the next sections I describe the design and development process from the beginning. As such, some of the elements that are designed, tested, and discussed are not part of the prototype that ended up being tested. The design, testing, and discussion is included in the interest of documenting the process.

3.2 The Mobile Assistant

In this section I describe the design and implementation process of the mobile assistant that is used to shed light on the research questions RQ1 and RQ2. As mentioned in section 3.1, the scope of the project and feature-set of the application changed after the initial design process. As such, some of the elements described in the design section were not implemented in the application used during testing.

3.2.1 Collaboration with eSmart Systems and Fredrikstad Energi

In the early stages of the project I had several meetings with eSmart Systems. We had a clear and exciting case in Fredrikstad Energi's pilot project in Hvaler (Smart Energi Hvaler[1]), where customers had installed smart meters that could make consumption data available to a third party application. What we wanted to do was make a mobile application that would act as the consumer's window to their power consumption.

eSmart Systems is a re-seller of Lucid's BuildingDashboard, presented in section 2.4.4. They had also collaborated with two students for a summer project where the students implemented a mobile application - BeSmart - inspired by BuildingDashboard, presented in section 2.4.2. BuildingDashboard and BeSmart served as inspiration in the early phase of the project.

eSmart Systems had access to historical consumption data for electricity customers in Hvaler through their involvement in Smart Energi Hvaler, and we wanted to utilize this data in the application to show the user a history of his or her consumption. We also discussed the possibilities of implementing a prediction algorithm to show the user possible future consumption. This would be in combination with the app making current consumption available to the user, to act as a near-real-time monitor.

eSmart Systems put me in touch with Fredrikstad Energi, who I met with directly on a few occasions. With Fredrikstad Energi I discussed the practical issues surrounding the test I wished to conduct. There was the issue of getting participants, getting access to the participant's data, and getting the necessary hardware to the participants - contrary to previous belief, this was not in place. I was put in touch with the supplier for the hardware that would be used, to get access to a testing API and documentation for said API. There were delays in getting test participants, delivering hardware, and in getting the testing API up and running.

After a while I was no longer comfortable with being able to implement the application and conduct the test in a reasonable amount of time. After discussing it with my advisor, I decided to call off the project and collaboration, and rethink the experiment. This new experiment is described in section 3.3.

[1] http://www.smartenergihvaler.no/

3.2.2 Designing the Mobile Assistant

In this section I describe the design process behind the mobile application used during the test described in section 3.3 to shed light on the research questions for this thesis project.

The main task for the mobile assistant is to give feedback on the electricity consumption of the household. Initially there were a few ways I intended to do this:

- By the user being able to check the current consumption at any time within the app
- By the user being able to see consumption history and compare it to what was predicted with a prediction algorithm
- By sending push-messages to the user whenever consumption rose above a certain threshold

The two first methods fall in the self-monitoring category of persuasive technology, as defined by Fogg and described in section 2.2.1. Through measuring and history-keeping the user learns about his or her consumption, which can lead to the user making changes to get the consumption to a comfortable level.

While self-monitoring methods require the user to initiate interaction, having the feedback monitor on the phone can potentially be an improvement from having it on a website or a dedicated device, such as BuildingDashboard and Wattson, described in sections 2.4.4 and 2.4.1 respectively.

The third method, and the one that is given focus in this thesis, falls in the suggestion category of persuasive technology. The application notifies the user at an opportune moment in order to attempt persuasion - getting the user to reduce consumption. An opportune moment is defined as a moment when the user is able and motivated to take action - in this case not long after electricity consumption has risen above a certain threshold. The threshold will vary from household to household, depending on the contract with their electricity provider, but for the sake of the experiment described in section 3.3 the threshold is set to 5000W.

With the three methods above in mind the user interface design process began. In order to get external feedback I conducted a test using mockups of the design on paper.

User Tests With Mockups

The mockups were made using the application Pencil[2]. Using Pencil I mocked each screen in the application using high-quality images of typical Android components. Each screen was then printed on separate pieces of paper, for use in testing.

The mockups can be found in appendix B. An example is shown in figure 3.1.

The initial design was inspired by the functionality and presentation in the BeSmart application, presented in section 2.4.2. Features such as allowing to choose between seeing consumption measured in kWh, NOK, or CO^2, choosing between showing today's, this week's, or this month's consumption, and browsing tips were inspired by the BeSmart application.

Two students from Østfold University College were recruited to perform an initial test of the design. The test candidates were both female, 24 and 25 years old. The test candidates had experience in prototype testing, and were both familiar with technology

[2]http://pencil.evolus.vn/

Figure 3.1: Mockups of the different screens of the setup process. These mockups were presented to the test candidates during the test.

and smart-phones. As such, they may be considered experienced, if not expert users. Given the previous experience of the test candidates, the results from this initial test may not reflect the experience end-user have. Still, the test gave several valuable insights and highlighted some flaws with the design suggestion.

They assumed the roles of users during the test, thinking aloud while they navigated the application. The candidates were both new to the application and project.

The goals of the test were:

- See if the initial configuration of the application is easy to understand
- See if the design is simple to navigate
- See their reaction to receiving a notification

Audio was recorded during the tests, with the participants' consent. I acted as the computer, laying out the correct piece of paper for the action the test participant made.

Initial Configuration The test candidates were first asked to complete the setup of the application.

The first step in the configuration – shown to the left in figure 3.1 – was to enter the identification number for the household measuring device, in order to pair device with household. The first test candidate said that she was unsure what number was needed, and would like a short description of where to find it.

The second step in the configuration process was a questionnaire consisting of three questions where the candidate was asked to answer with "Agree", "Disagree", and "Neutral". Both candidates remarked that the questions came unexpectedly, and they wondered why they were answering these questions. One of the test candidates felt that an "Answer later" option should be available, in case the user would like to not answer the questions. The questionnaire consisted of three questions, and an indicator on screen showed progress to the candidates. This was appreciated by the candidates.

The Consumption View Once the initial configuration was completed, the test candidates were presented with the consumption overview screen, shown in figure 3.2. The candidates explored the interface with relative ease, finding the controls self-explanatory.

Two different scenarios were posed to the candidate at this point:

- "From the home screen, start the application to check your consumption for this week"
- "You receive this notification. What do you do?"

Both candidates found the presentation of the consumption was somewhat unclear. The meaning of the coloured bars was not immediately apparent, neither was the meaning of the dotted bars. The coloured bars indicate whether the consumption for that day was below (green), around (yellow), or above (red) the predicted consumption. The dotted bars show the predicted consumption for that day.

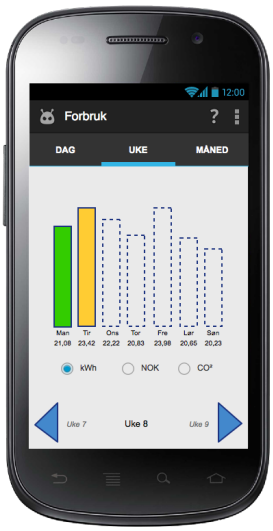


Figure 3.2: The consumption view mockup shown to the test candidates

After having the meaning of the colours and dotted bars explained one of the candidates noted that it would be interesting to see the predicted consumption for the current as well

Figure 3.3: Mockups of the notification flow shown to the test candidates

as previous days, not just future days. This in order to compare ones performance to what was predicted. Also requested was an indication of how different the consumption was from what was predicted.

Notifications The test candidates were given a scenario where they received a notification as shown to the left in figure 3.3 and were asked what they would do. One of the candidates noted that the wording of the notification ("Your power consumption is high") produced a feeling of anxiety. When discussing this the test candidate said that a notification that was worded more positively would make her feel better, for instance having a notification when power consumption was low.

Both candidates chose to open the notification tray to see the notification details, but only one candidate chose to press the notification. The other candidate explained that the notification seemed to show her everything, so she would likely not have clicked it.

> "I'd press it if I didn't get the whole message, like – if I get the start of a sentence on Facebook I click it"

When the notification was clicked, the candidates were shown a screen containing a more detailed description of a recommended action in order to reduce consumption, shown to the right in figure 3.3. The navigation between tips and actions was simple to understand, but the navigation from the tips screen to the consumption screen and vice versa was not as clear. Having the navigation options hidden away in the "overflow" menu to the top-right was seen as unclear and confusing by both candidates, who requested the navigation option to be clearly visible as an action bar button.

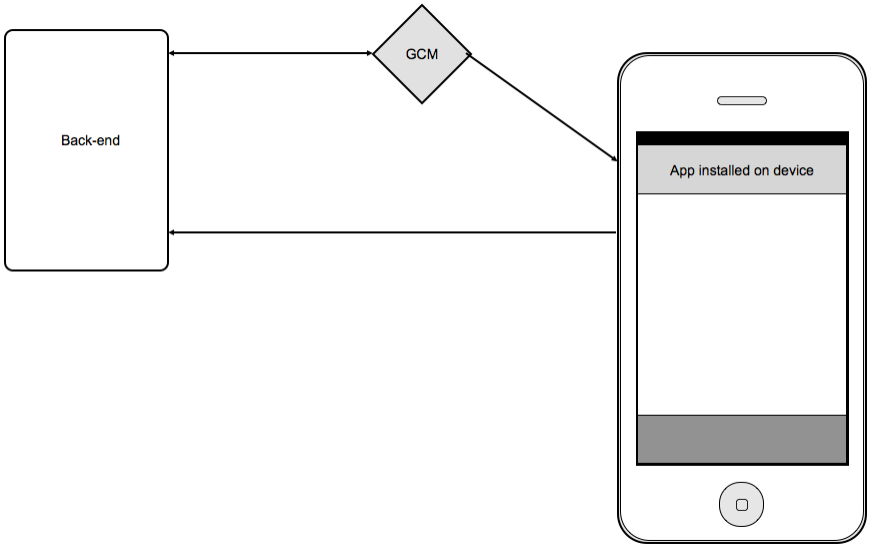


Figure 3.4: Illustration of the data flow for a system using Google Cloud Messaging for sending push messages

3.2.3 Implementing the Mobile Assistant

With the feedback from the mockup test taken into consideration development started on the mobile application. The assistant was implemented as an application for the Android platform. Android was chosen due to my previous experience developing for the platform, as well as knowledge of Google's Gloud Messaging[3] framework for sending *push notifications*, messages sent to the recipient with no action taken by the user.

Push messages stand in contrast to the user's client performing scheduled synchronization. For a mobile assistant meant to give immediate feedback on changes in the electricity consumption, utilizing push messaging is highly desirable.

To use Google Cloud Messaging (GCM) an Android app goes online and registers with GCM, and gets a unique GCM identifier in return. This identifier is then sent by the app to the service that sends messages to the app. Messages are then sent by the service to GCM, along with the GCM identifier. GCM then sends the message on to the application who owns that identifier. The flow is illustrated in figure 3.4.

As mentioned earlier, the scope of the project and application changed significantly after the first design iteration. As such, only a small part of the designed application was actually implemented, namely the push notification functionality. If the user opens the application he is greeted with a nearly blank screen, seen in figure 3.5. When a notification arrives the user can press it to open the application, which will then display the full message text.

The code for the implementation can be found in appendix E.

[3]https://developer.android.com/google/gcm/index.html

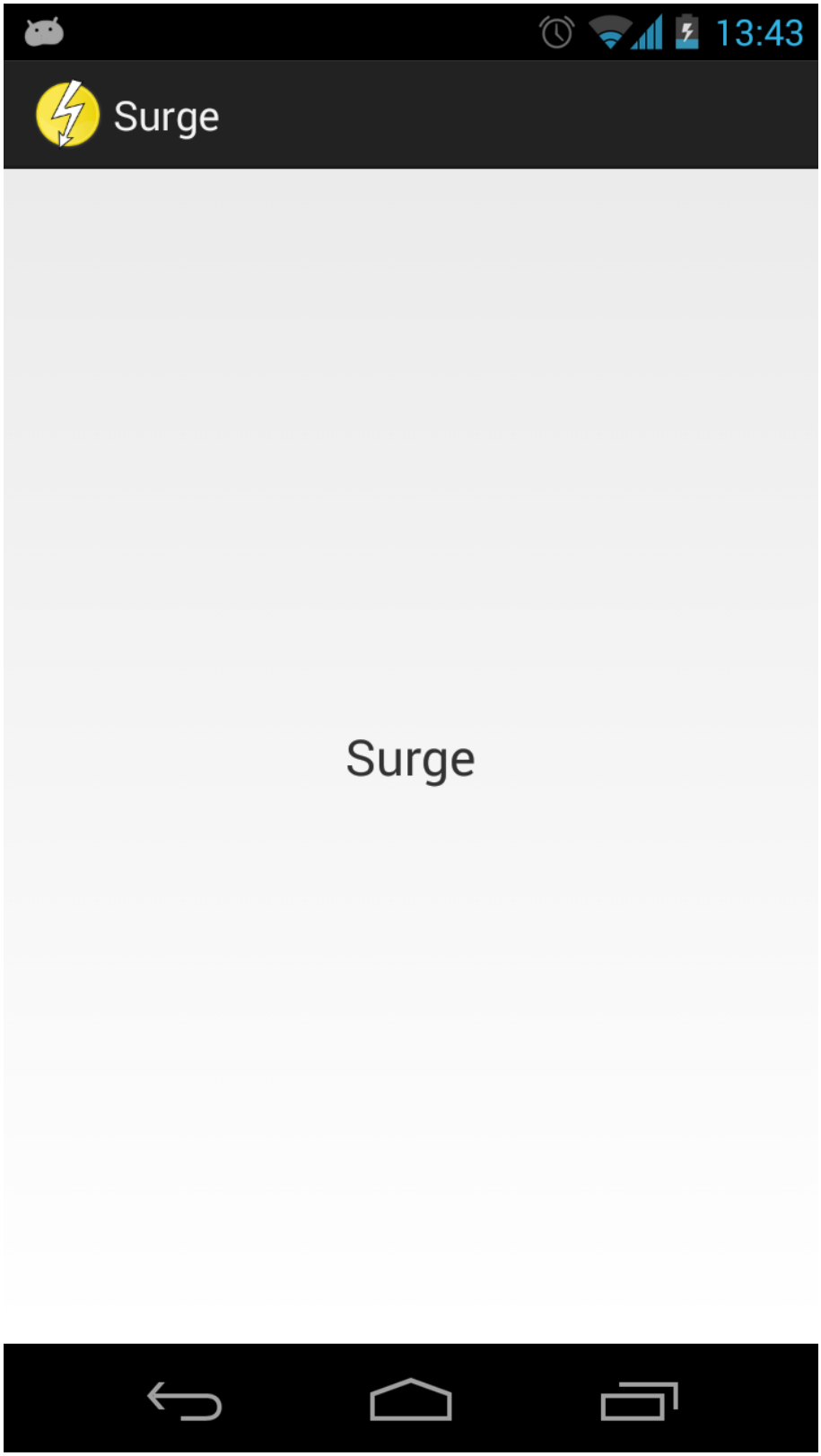


Figure 3.5: A screenshot of the finished application. When the user receives a notification and clicks it, the full message text will be displayed here.

The Back-end Service

As illustrated in figure 3.4, a client application communicates with GCM and a back-end, which in turn communicates with the client application through GCM.

Google present an example implementation of such a back-end[4] in their documentation. Their example implementation is a Java servlet, which needs to be hosted by a container server such as Tomcat[5] or Glassfish[6].

I chose to extend Google's example implementation, by adding logging with the Log4j framework, as well as persistent storage for the GCM IDs using SQLite. I also chose to cut unneeded functionality from the demo project. My servlet ended up responding at three URLs:

- /register
- /unregister
- /send

The *register* and *unregister* end-points receive a GCM device ID through a POST HTTP request. The register end-point stores the ID in persistent storage, while unregister removes it.

The *send* end-point takes a message text through a POST HTTP request, and sends it to the GCM ID that is stored in persistent storage. Only a single phone ended up being needed for the test, otherwise a GCM ID would also be needed.

Listing C.1 shows the code that runs when a message is posted to the send end-point. The full code for the implementation can be found in appendix E.

3.3 The Test

An everyday situation that is played out in many homes in Norway:

> When you come home you put on the washing machine to have some clean clothes. You then watch TV for an hour before starting the stove to make dinner. The washing machine is done, and you throw the clothes in the dryer and start it up. After that, while the oven is pre-heating you decide to quickly vacuum the kitchen and living room floors, the TV still on. This happens during winter, and four wall-mounted electric heaters – one in the bedroom, one in the living room, one in the kitchen, and one in the bathroom – are all on providing heat.

A situation like the one described above, when taking place in multiple homes, is a problem for the electrical grid. The test is designed to somewhat mimic such an everyday-life situation. Compared to the low consumption during mid-day a peak such as this puts a considerable stress on the grid. Reducing this peak, as described in section 1.1, is of interest to grid owners and could in the not-too-distant-future be of interest to electricity consumers as well, if effect-based billing becomes widespread.

[4] http://code.google.com/p/gcm/source/browse/
[5] http://tomcat.apache.org/
[6] https://glassfish.java.net/

Figure 3.6: The home model constructed in a lab at Østfold University College. This model serves as the location for the main test in this thesis project.

3.3.1 The Test Lab

In order to have a controlled environment for testing the user experience a lab test was designed.

At Østfold University College a lab is available to students where a home model has been constructed. This home model, shown in figure 3.6, consists of two rooms: a washing room/bathroom, and a kitchen/living room. A few appliances are placed in each room.

The washing room has the following appliances:

- Washing Machine
- Tumble Drier
- Water Heater
- Vacuum cleaner
- Spot Lighting

The kitchen/living room has the following appliances:

- Stove
- Coffee Maker
- Television

Appliance	Watt value
Spot Lighting	25W per spot
Washing Machine	2300W[7]
Vacuum cleaner	1600W[8]
Stove Heating Element	2900W
Wall-mounted heater	600W[9]
Coffee Maker	1000W[10]
Television	275W[11]

Table 3.1: The different appliances that were part of the test, and example watt consumption values used during the test

- Spot Lighting
- Wall-mounted Electric Heater

In table 3.1 I list the different appliances and a watt value the appliance is likely to demand. The water heater and tumble drier is not taken into account in the test. The values are taken from product pages in Norwegian electronics stores Komplett and Elkjøp, as well as Enova.

3.3.2 Test Participants

Six test participants were recruited from the pool of students at Østfold University College, as well as extended family.

The test participants were between the age of 22 and 45 – four male and two female. Five were students at varying stages of their education – from their first year to their fifth – and the sixth participant was unemployed due to health issues.

The participants had different living situations, ranging from living alone in an apartment, to living in a collective, to being a family in a villa. All participants paid their own or contributed to their common electricity bills.

The participants were divided evenly into two groups: the first group getting feedback on their choices through a smart-phone application, and the second not getting any feedback during the test at all.

Instant Feedback

Participants in the group that was given feedback during the test were given a smartphone running the Android operating system version 2.3. The application described in section 3.2 was installed on the phone. The phone did not have a SIM-card, and no other non-system applications were installed, so as to not interfere with the test. The phone connected to the Internet over WiFi.

[7] https://www.komplett.no/whirlpool-awod-7216-vaskemaskin/776477

[8] http://www.elkjop.no/product/hjem-og-husholdning/stovsuger-og-rengjoring/S2111MANGO/miele-stovsuger-s-2111-mango

[9] http://www.elkjop.no/product/hjem-og-husholdning/oppvarming/VP1006KT/adax-panelovn-vp-1006-kt-hvit

[10] http://www.elkjop.no/product/hjem-og-husholdning/kaffetrakter/TKA1411V/bosch-kaffetrakter-tka1411v

[11] http://www.enova.no/about-enova/about-enova/259/0/

A notification was sent to the phone whenever the accumulated consumption rose to or above 4000W, with a message notifying the participant of the fact. Translated, the message read:

> You are getting close to your consumption threshold (nW of 5000W). If you can, turn off appliances to avoid the overconsumption fee.

The value of n was calculated by a test administration tool developed for the test, described in section 3.4.1.

If the participant went over the 5000W threshold a different notification was sent. Translated:

> You have gone past your 5000W threshold (nW of 5000W) and are being billed the overconsumption fee. If you can, turn off appliances you don't need.

If the participant has neared the threshold and gotten the 4000W notification, and then dips down below 4000W, a notification is sent to inform the participant of such. Translated:

> Your consumption has fallen some (nW of 5000W). Good job!

A notification was also sent if the consumption dipped below 1000W. Translated, that message read:

> Your electricity consumption is quite low (nW of 5000W). If you have something that needs to be done that takes a lot of electricity now is the time!

It was up to the participant what to do after these notifications were received.

No Feedback

To act as a control group, half of the test participants were not given any feedback during the test, only seeing their results after the test was completed.

3.3.3 Test Setting and Content

I met test participants at Østfold University College and guided them to the lab. There I started by introducing the test environment – the home model – and some background as to why the test is conducted:

- That legislation was passed that by 2017 all households must have smart meters
- That smart meters give more accurate and detailed measurements to the electricity provider, which opens the possibility of effect-based billing
- What effect-based billing is and means to the consumer

I established with the test participants that with effect-based billing they as a consumer would be interested in staying below their effect threshold to avoid paying extra fees.

The participants were then explained specifically what the test entailed. They were told that they would imagine the model home being their house, where they had a smart meter and effect-based billing. They had a few appliances running:

- Wall-mounted heater
- Spot lighting in both rooms
- TV

They were then given a set of tasks they had to complete as part of the test:

- Brew a kettle of coffee with the coffee maker
- Leaving the stove heater on for fifteen minutes to cook dinner (frozen pizza)
- Complete a quick-wash program with the washer
- Vacuum the floors

All test participant were shown the list of appliances and their watt consumption before the test, but the list was not available to the during the test. This can be compared to checking the consumption of an appliance when purchasing or installing it.

The accumulated consumption of the appliances running at the start of the test is 950W, when using the values from table 3.1. The accumulated consumption for all the appliances the participant will have to use to complete the test is 7800W, and the worst-case – all appliances running at the same time – is 8750W (disregarding the stove's ceramic heaters).

Given the numbers above, the threshold for sending a warning notification was set to 4000W, and the threshold for applying additional fees to 5000W. A lower threshold of 1000W was set, where the participant would be notified that there was much room to use appliances.

Before the test was started the participant signed a form giving their consent to use data from the test and interviews in this thesis project, and that they accepted the tests being recorded on video. The participants were also asked to announce when they turned an appliance on or off.

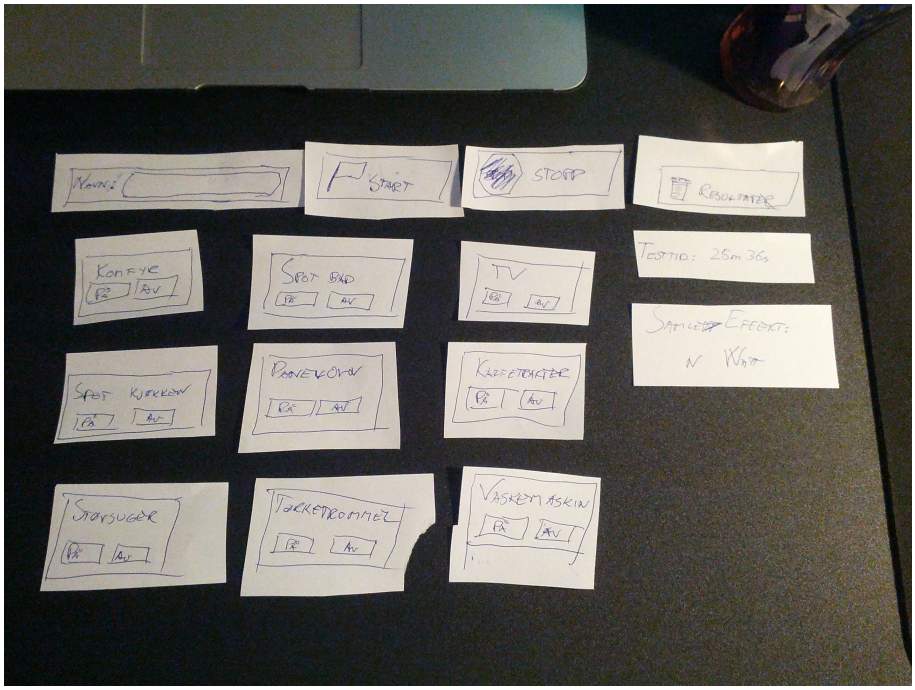


Figure 3.7: Image of the paper mockup of the test administration dashboard

3.4 Conducting the Test

During the test each time a participant turned an appliance on or off it would need to be logged to calculate the accumulated consumption for the participant at any given point in time. To facilitate logging of this data, and sending notifications during the test, an administrator tool was developed. This tool would only be used by the test administrator, in this case me, so no others were involved in the design process. The design, development, and finished tool is described in section 3.4.1.

3.4.1 Administrator Tool

The design of the administrator application was done step-wise. A paper prototype was made by making interface elements on pieces of paper and arranging them in a way that felt functional and clear. The paper prototype can be seen in figure 3.7. Two main activities had to be supported: logging during the test with automated message sending at certain thresholds, and processing the results.

For the logging a dashboard interface was prototyped that had each of the nine appliances involved in their own *cards*. Each card contained the name of the appliance it represents, as well as buttons for logging that the appliance has been turned on or off. In addition to the nine cards is an input field to enter the name of the test participant, and buttons for starting and stopping the test. A button to get to the results is in the top-right of the prototype. Below the results button is a timer, showing the time that has passed since the start of the test, as well as an indicator of the current consumption. An image of the prototype can be seen in figure 3.7.

Development started after the paper prototyping stage. The popular web front-end

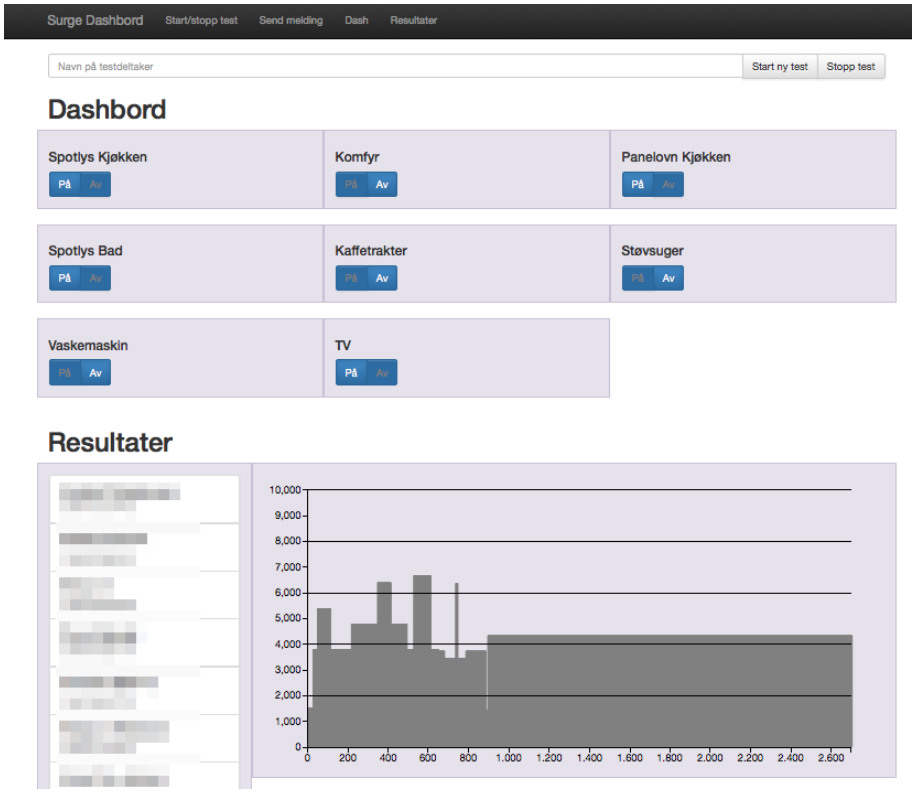


Figure 3.8: The test administration application. The graph shown below visualizes the logged data for the chosen test participant. The participant is selected from the list to the left of the graph (list items blurred).

framework Bootstrap was used[12] for the front-end. The web interface was hosted on a local Apache installation. A screenshot of the finished application can be seen in figure 3.8. The rest of the application was coded in JavaScript using the popular jQuery[13] framework. The code for the implementation can be found in appendix E.

As can be seen in figure 3.8 the cards holding on and off buttons for each appliance was implemented, as was the input field for the test participant name, and the start and stop buttons. The test timer has been moved to the black navigation bar - inactive and invisible in figure 3.8 - along with the button to get to the results. The results are shown below the appliance cards in the finished application, with a list for the different test participants to the left and the result graph to the right of that list. The code behind the graphing is described in more detail in section 3.4.2.

3.4.2 Plotting the Graphs using D3

As described in section 3.4, data of when the participants turned on and off appliances was logged. This data was used to calculate accumulated consumption at those times and plotted as a graph for each participant. These graphs are presented in section 4.2.

[12] http://getbootstrap.com/
[13] http://jquery.com/

The log data was stored in the web browser's localStorage. When the test was concluded, the administrator application allowed for generating a graph from the logged data. This graph was generated using the JavaScript framework D3[14].

From the product description on D3s website:

> D3 allows you to bind arbitrary data to a Document Object Model (DOM), and then apply data-driven transformations to the document. For example, you can use D3 to generate an HTML table from an array of numbers. Or, use the same data to create an interactive SVG bar chart with smooth transitions and interaction.

Each participant was given a key used for looking up their log data in localStorage. The key consisted of two parts: the participant's name, and the UNIX time-stamp for when the test was started, separated by a number sign (#). Each time an appliance was turned on or off the application fetched the existing data at that key and appended the UNIX time-stamp, the appliance name, and the state in which the appliance was in after the participant's interaction with it (on/off) - the values separated by a comma. At the beginning of the test, the appliances that were considered running at the start of the test (spot lighting, electric heater, TV) were immediately logged as being turned on.

In the application there is a Measurement class that is used to hold the measurement data in memory. The Measurement class is shown in listing C.2. When the graph was being generated, one Measurement object was created for each second of the test.

After the measurement objects were generated the application read the data for the participant from localStorage. The data was at this point a single large string, so it was split in different parts.

Every third bit was a timestamp. This timestamp, along with the timestamp for the start of the test, was used to find what second of the test the appliance was turned on or off. The proper Measurement object was then altered by adding or subtracting the watt value for the appliance to reflect the change that had been made by the test participant.

After all actions by the test participant were reflected in the list of measurement objects, in order to "fill the blanks", the application iterated over the measurement object carrying over values from the previous measurement and added them to the current one. Of course, a negative value would mean the value was subtracted.

See listing C.3 for the code. Once the measurement array had been properly generated, it was iterated over yet again, this time to convert it to a format that D3 could understand.

Once D3 had the data it needed in a format it could understand it was a matter of defining the properties of the graph, such as axis and the scales for those axis, as well as the size for the generated graph. The code in listing C.4 shows how this was done.

The end result - the graphs - are shown in section 4.2.

[14] http://d3js.org/

3.5 Data Analysis

3.5.1 Qualitative Data Analysis

To discuss RQ1 I conducted semi-structured interviews after each test. These interviews were recorded on video with the participants' consent. Each interview was conducted in the same room as the model home. Both the test participant and I sat down by a table, and held a relaxed and informal tone during the interview.

The interviews were semi-structured, with a set of main topics I wished to discuss, with sub-topics at hand to drive the conversation if it was needed. If the test participant brought up something we would discuss that to the point where the line of conversation ended before I moved us on to the next main topic. The topics and sub-topics are listed in appendix A, and are described below.

Interview Guide

The first two topics discussed were the participants' experience with technology and electricity. Someone with much experience using advanced electronics may be biased towards a positive attitude towards new electronics or electronics applied to something new. Someone with much experience and awareness of electricity may already be concious about the choices they make with their consumption, and so the effect of an assistant may be smaller. To attempt to glean this information I opened the interview with the two first topics.

I discussed how participants felt the test went to have the user tell me about their experience doing household chores in a setting such as the test - having a maximum threshold they should stay below while still doing their tasks within a window of time. It is interesting comparing the answers for the two groups - feedback and no feedback.

The consumption graph was shown to the participant and discussed with them to get their thoughts and comments on their choices during the test.

The group that got feedback was asked how their experience getting messages was. Getting the user perspective on the notifications is important to discuss RQ1.

With both groups I discussed whether they would be interested in using an electronic assistant to help monitor their power consumption if effect-based billing were to become the norm. I encouraged the interviewee to not only think about the phone assistant if they had one during the test, but also consider more simple displays, and other devices such as smart sockets - inspired by the products Fredrikstad Energi offered to their customers in their pilot project.

Transcribing

The interviews were transcribed using a denaturalized style, where speech elements such as stutters and pauses are ignored [26]. Denaturalized transcription stands in contrast to natural transcription, which attempts to represent all aspects of a conversation, including but not limited to pauses, stutters, and emphasis. Naturalized transcription is used extensively in language studies, where such elements are important to answer the research question [26]. Such is not the case in this project, where the content of the conversation is of more import than the way in which the speech was delivered.

The transcripts are presented as a dramatic script, where each turn in the conversation has its own line. It is noted when speech is overlapping, but besides that no other notation

is used. The full transcripts are available in appendix D, with excerpts presented in chapter 4 and 5.

All real names were removed from the transcripts, replaced with a fake name. This is no full anonymizing, but the data contained in the interviews are non-sensitive, and so full anonymity is not critical. The participants were notified of this before giving their consent.

Open Coding

Once the test had been transcribed I started the process of *open coding*. Open coding is the process of going through data and "to examine closely, compare for relations, similarities, and dissimilarities" [18]. Important information is labelled, or *coded*, and information that can be classified in the same category has the same code. The code for any piece of information can change, as this is an iterative process. Codes that are related can be grouped together under one common code in the next iteration. For instance, the codes email, telephone conversation, and text message are all a form of *communication* [18].

There is more than one way to do an open coding process. A common method is line-by-line coding, where - like the name might suggest - you code the contents of each line, one after another [18]. However, Khandkar explains in *Open Coding* that:

> ... based on the research requirement, we can also look into a bit broader scale and code against a sentence, paragraph, chapter etc. There can be situation where we may just need to define concepts for an entire document [18].

In the transcripts in appendix D I code by paragraph. Since the transcripts are presented as dramatic scripts, one paragraph is often no longer than two-three lines.

Code names started out mainly *in vivo*, meaning the codes are the words used in the interview [18]. As the process went on, some codes were dropped, others added, and yet others changed to *constructed codes* - code names chosen by myself [18]. The final codes are included in the transcripts. Once the coding was complete I copied the coded information into separate documents - one for each code, to get a better overview of the data for each code.

3.5.2 Quantitative Data Analysis

As described in sections 3.4 and 3.4.1, an administrator application was used to collect consumption data based on the watt values in table 3.1. Each time an appliance was turned on or off it was stored alongside a timestamp. At the end of the test the application calculated the total consumption per second based on whether appliances were on or off. The consumption was then plotted on a graph where the Y axis represented accumulated watt consumption, and the X axis represented time.

The graphs for the participants who did not get feedback and the ones that did were studied side-by-side to see if there were any patterns to discern. An average of the watt value each second for the two groups was calculated and compared in the same fashion.

To calculate the average for each group the data was split into two lists, one with data for participants receiving feedback and one for those without. The lists were then given to the method getAverageData, shown in listing C.5.

The getAverageData method generates a D3-compatible format containing the average consumption at each second for that group. The method works in much the same way as

listing C.3, but altered to do the same for multiple tests, calculating the average between them.

The D3 data was sent to the same method for generating a graph as the regular data, shown in listing C.4. The resulting graphs are shown in figure 4.7 and 4.8.

The graphs are presented in chapter 4.

3.6 Limitations and Possible Problems

As mentioned in section 2.1.6, long-term studies are needed to see long-term effects. As such, this test can only show indications that a mobile application notifying its user could have an effect. A long-term study must be conducted to establish this with certainty.

The test participants are not fully representative, being mostly students of Østfold University College. The participants were mostly relatively young, with an affinity for technology. As such, their experiences may be biased towards an accept towards new technology and be overly positive.

The number of test participants is low. This means that there is too little material for a quantitative analysis to give any definitive answers with regards to RQ2.

All test participants were aware during the test that their goal was to keep under a consumption threshold. Even with an effect-based billing it is not certain that consumers would be as aware of their consumption as the test participants that did not get feedback through a smart-phone were. This could lead to less of a visible effect from using the smart-phone application versus not using it.

Chapter 4

Results

In this chapter I present the results from the test described in chapter 3, as well as how they were found.

As explained in chapter 3, a test was conducted to gather data. Six participants were recruited and partook, and I begin by introducing the participants in section 4.1.

In section 4.2 I present the different graphs that were generated from the log data for each test participant, as well as the average consumption for the two groups of participants.

In section 4.3 I present the topics that were discussed during the semi-structured interviews conducted after the test. I also describe the process of analysing the transcripts of the tests and interviews, and the findings from that analysis.

4.1 Test Participants

Six test participants were recruited from the pool of students at Østfold University College, as well as friends outside the college.

The test participants were between the age of 22 and 45 – four male and two female. Five were students at varying stages of their education – from their first year to their fifth – and the sixth participant was unemployed due to health issues.

The participants had different living situations, ranging from living alone in an apartment, to living in a collective, to being a family in a villa. All participants paid their own or contributed to their common electricity bills.

Each of the participants have been given a fake name, which will be used to refer to them for the rest of this report. Their key information is listed in table 4.1.

John, Susan, and Fiona performed the test with feedback from the phone. Greg, Harold, and Kevin had no feedback during the test.

Name	**Age**	**Gender**	**Occupation**	**Living arrangement**
John	29	Male	Student	Single apartment
Greg	22	Male	Student	Single apartment
Harold	23	Male	Student	Collective
Kevin	24	Male	Student	Single apartment
Susan	45	Female	Unemployed	Villa
Fiona	25	Female	Student	Single apartment

Table 4.1: Key information about the test participants. The names for the participants are fake.

4.2 Result Graphs

This section is divided in two sections - one for the participants that received feedback and one for the participants that did not - that again are divided in individual subsections, each with the graph for the participant, as well as a brief description.

4.2.1 Feedback

In this section I present the graphs for the participants that received feedback through the mobile phone application developed for this thesis project.

John

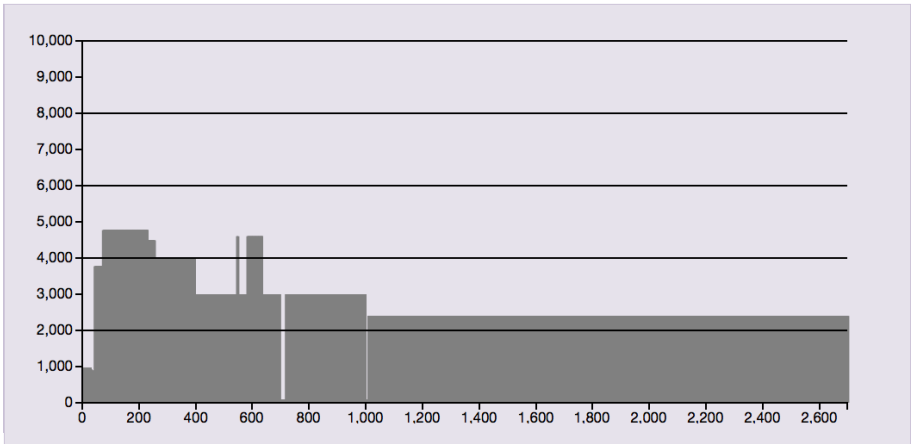


Figure 4.1: Graph of John's consumption. John received feedback via notifications on a phone.

John never went above the threshold, as the graph seen in figure 4.1 shows. At two points Johns consumption went below 1000W, closing in on zero consumption. He also passed the warning threshold of 4000W at two points.

Susan

Susan was the first participant who got feedback during the test who went above the threshold. She chose to turn on more appliances after getting an initial warning after going above 4000W, but chose to turn them off again when she received the 5000W notification telling her she was now accumulating fees. However, she did not get back below the 5000W threshold before well over ten minutes later. After the initial trespass, Susan stayed below the thresholds for both warning and fee.

Fiona

Fiona was the third and final participant who got feedback during the test. At several points during the test she tried turning on appliances only to turn them off again after getting a warning. This can be seen in the early portion of the graph - the number of

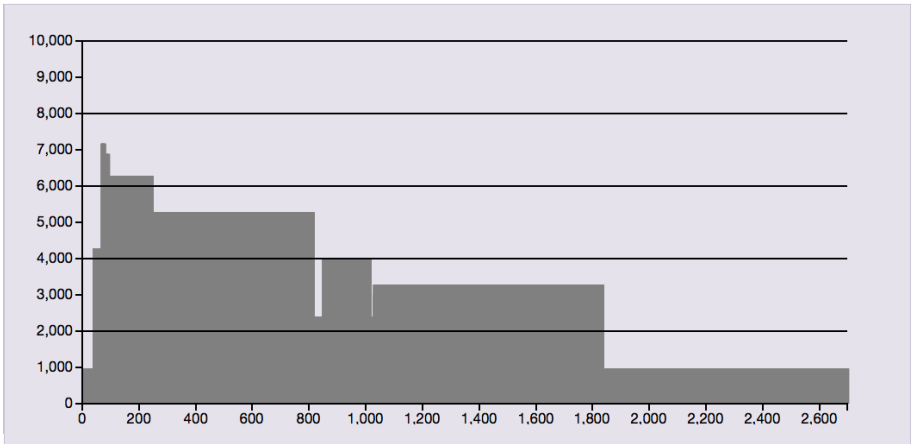


Figure 4.2: Graph of Susan's consumption. Susan received feedback via notifications on a phone.

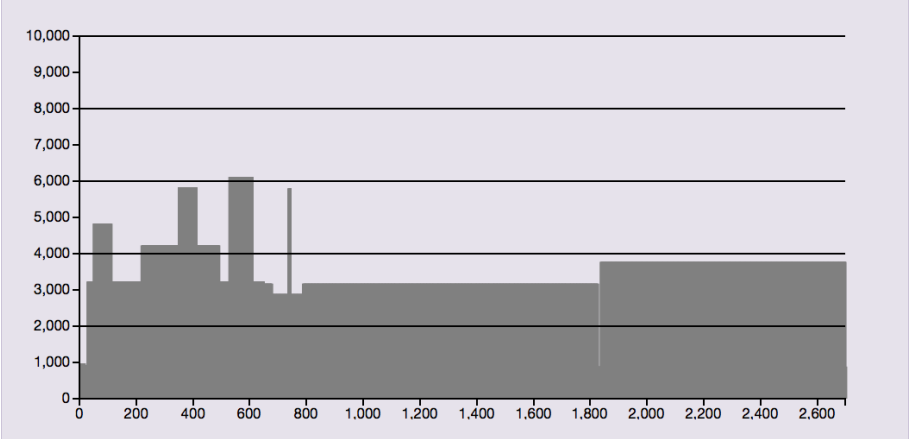


Figure 4.3: Graph of Fiona's consumption. Fiona received feedback via notifications on a phone.

relatively short spikes in consumption is Fiona testing and responding to feedback from the phone.

4.2.2 No Feedback

In this section I present the graphs of the participants that did not receive feedback during the test.

Greg

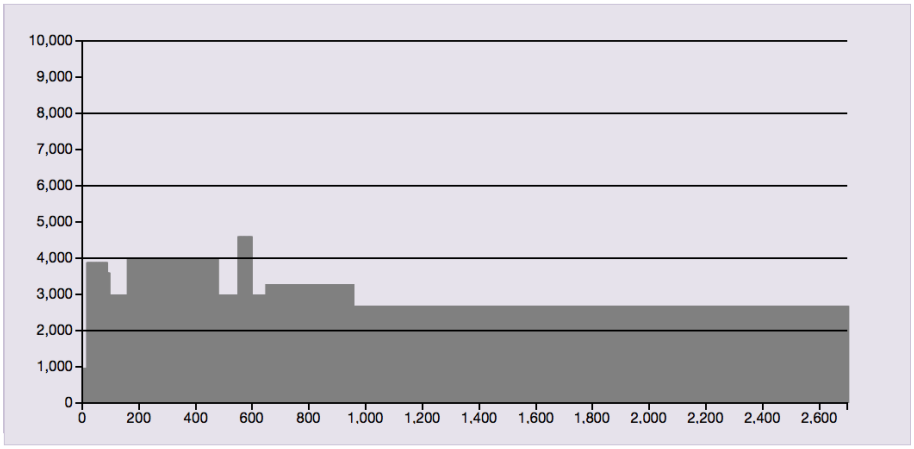


Figure 4.4: Graph of Greg's consumption. Greg received no feedback during the test.

Greg never went above the threshold, as figure 4.4 shows. If Greg had a phone during the test he would be notified when going above 4000W, as he did once, but no other notifications would have been triggered.

Harold

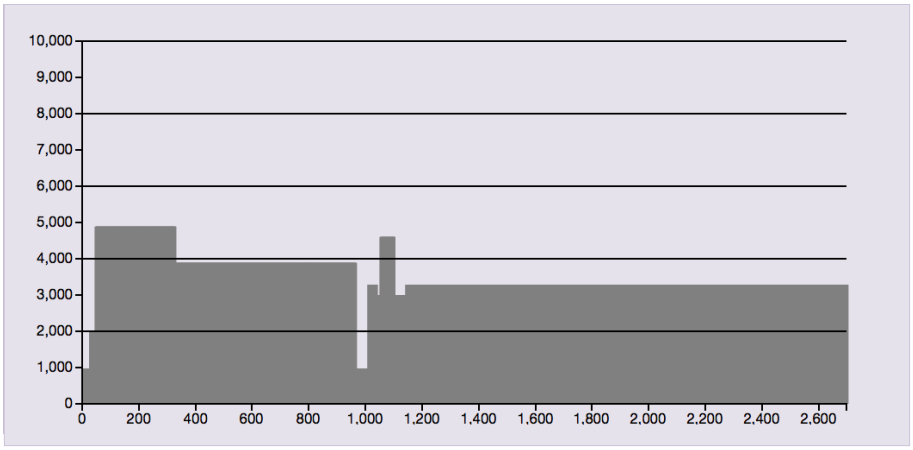


Figure 4.5: Graph of Harold's consumption. Harold received no feedback during the test.

Harold too would never go above the threshold, but would have gotten warnings at two points, as well as a notification that his consumption was low at one point during the test, as can be seen in graph 4.5. Harold received no feedback during the test.

Kevin

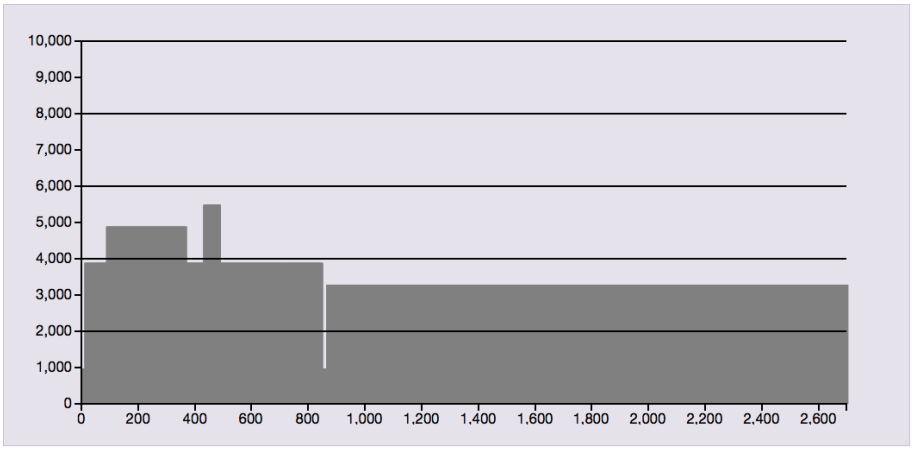


Figure 4.6: Graph of Kevin's consumption. Kevin received no feedback during the test.

Kevin was the first participant to go above the threshold, going above the 5000W threshold at one point. He also went above the 4000W warning threshold at one point, but stayed below for the rest of the test. Kevin received no feedback during the test.

4.2.3 The Two Groups' Average

There were two groups of participants: three participants who got feedback through a smart-phone application, and three who received no feedback at all.

An average of the two groups' consumption was calculated and a graph was plotted from the result for each group. The graphs are shown in figures 4.7 and 4.8.

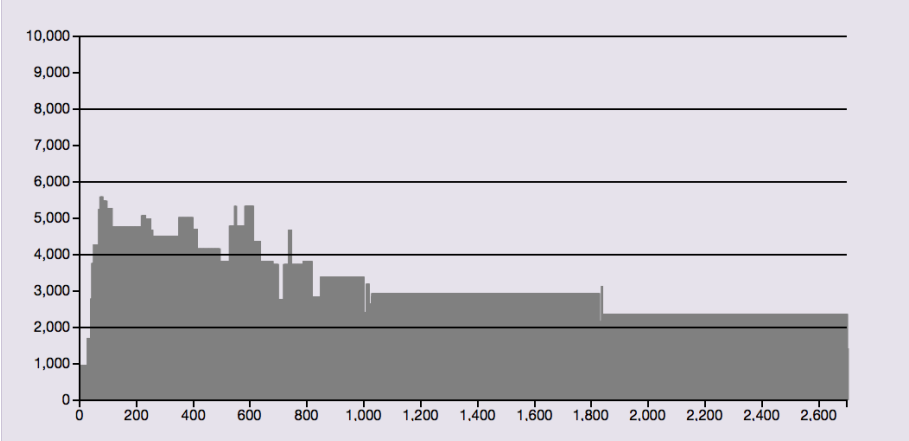


Figure 4.7: Graph showing the average consumption for the group that got feedback through a mobile application

From the graph of the average consumption for the group that got feedback through the mobile application we see a peak in load in the beginning of the test. We also see that the load rises and falls repeatedly in the beginning, before stabilizing as time goes on.

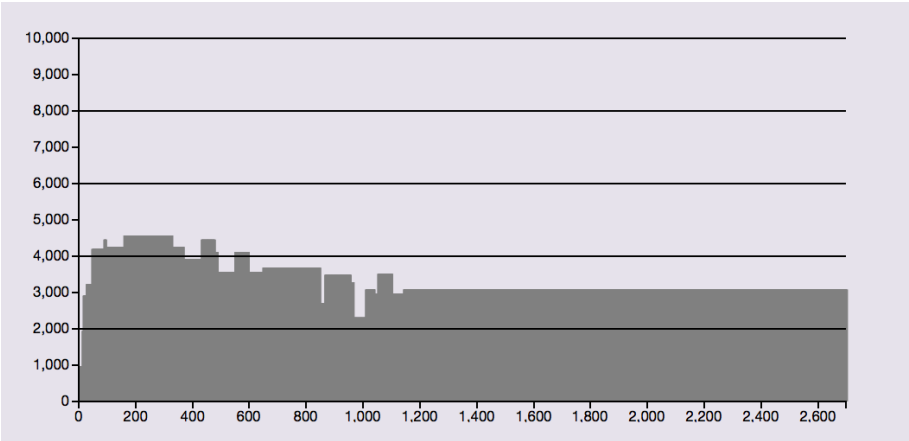


Figure 4.8: Graph showing the average consumption for the group that did not get feedback through a mobile application

Compared to the group that got feedback, the feedbackless group has a lower peak load. As with the group that got feedback, the feedbackless group has a higher load in the beginning, with more changes in the earlier portions, before the consumption falls and stabilizes as time goes on.

4.3 Semi-structured Interviews

In order to shed some light on RQ1 the user experience would have to be discussed with the test participants, so a semi-structured interview was conducted immediately after the test. For convenience the interviews took place in the same room as the home model, with the interviews as well as the test recorded on video. The video was transcribed in English, and the transcripts can be found in appendix D.

The following sections will describe the topics discussed, the process of transcribing, the open coding process that followed, and observations made from the data.

4.3.1 Interview Guide

The interview guide was presented in section 3.5.1. A summary is presented here for convenience.

Each interview was conducted in the same room as the model home. Both the test participant and I sat down by a table, and held a relaxed and informal tone during the interview.

The interview was semi-structured, with a set of main topics I wished to discuss, with sub-topics at hand to drive the conversation if it was needed. If the test participant brought up something we would discuss that to the point where the line of conversation ended before I moved us on to the next main topic. The topics and sub-topics are listed in appendix A.

The first two topics discussed were the participants' experience with technology and electricity. I then discussed how participants felt the test went, to have the user tell me about their experience doing household chores in a setting such as the test. After this the consumption graph was shown to the participant, and we discussed it so I could get their thoughts and comments on their choices during the test.

The group that got feedback was asked how their experience getting messages was. Getting the user perspective on the notifications is important to discuss RQ1. With both groups I discussed whether they would be interested in using an electronic assistant to help monitor their power consumption if effect-based billing were to become the norm.

4.3.2 Transcribing and Coding

Transcripts were made of the interviews to be able to more easily work with the information. The interviews were made in Norwegian, and I translated the interviews to English during the transcribing. The transcripts are presented in a dramatic script form, where each turn in the conversation has its own line.

On the translated transcripts I performed an open coding process, where paragraphs of note are given a code that classifies the information in that paragraph. The coding process is iterative, so codes that are given in the first iteration are not final.

The full transcripts, including the final coding, are available in appendix D.

For each iteration I performed I took note of the coding that had been used, and that coding is presented in this section. The codes for the first iteration are listed in table 4.2.

Codes for the second iteration are listed in table 4.3. In the second iteration I removed the positive prefix from some codes to better be able to discuss positive and negative aspects of the same category (for instance pro-electronics), combined two or more codes

Planning	Reduction	Consumption
Conservation	Load	Notification
Feature request	Student	Industry experience
Gadget	Smart meter	Monitoring
Experimentation	Awareness	Stressless
External influence	Cost	Relevance
Persuasion	Timing	Would use
Household	Family	Control
At-home situation	Programmer	Tinkerer
Expert user	Aware	Clean energy
Uncertain[ty]	Stressed	Anxiety
History	Ability	Not gadget person
Safety	Pro-electronic assistant	Mobile assistant
Better on phone	Interested in electronics	Learning
Behaviour change	Surprise	Experienced user
Saving	Subconscious	Surprise
Inability	Pro-mobile assistant	App-person
Timing	Routine	Pro-electronics
Concentrated consumption	Lack feedback	Feedback

Table 4.2: The codes for the first iteration of the open coding process

under one where there were similarities (for instance expert and experienced user), or removed codes entirely where they felt unneeded (for instance student).

After the coding I extracted the coded material and collected it in separate documents, one for each code. In each document I also made the distinction between the two groups of participants.

John		
Planning	Aware	Current behaviour
Mobile assistant	Feature request	Industry experience
Electronics	Electronic assistant	Confident
External influence	Cost	Relevance
Persuasion		
Greg		
Planning	Current behaviour	Uncertainty
Cost	Electronics	Experienced user
Aware	Stressed	Electronic assistant
Mobile assistant	Feature request	Persuasion
Ability		
Harold		
Current behaviour	Planning	Aware
Safety	Consumption	Cost
Uncertainty	Mobile assistant	
Kevin		
Expert user	Aware	Conservation
Uncertainty	Surprising	Cost
Electronic assistant	Persuasion	Mobile assistant
Learning	Planning	
Susan		
Surprise	Persuasion	Planning
Current behaviour	Aware	Experienced user
Electronics	Mobile assistant	Learning
Electronic assistant		
Fiona		
Planning	Persuasion	Electronics
Aware	Cost	Ability
Learning	Electronic assistant	Mobile assistant
Feature request		
All codes		
Planning	Aware	Uncertainty
Current behaviour	Surprise	Feature request
Experienced user	Industry experience	Electronics
Electronic assistant	Confident	External influence
Cost	Relevance	Persuasion
Mobile assistant	Conservation	Learning
Ability	Safety	Consumption

Table 4.3: The codes for the second iteration of the open coding process

4.4 Findings

In this section I present my findings from the transcripts, using the coding from table 4.3 as a tool for classifying what participants said of the different subjects. In the sections that follow I present what participants said of different topics.

4.4.1 Planning

It became clear that participants in both groups were planning their moves ahead of time in order to try to stay below the threshold. They tried performing rough calculations of their current consumption before deciding what would be their next move.

John explains during the interview:

> Of course you go into the test with a mindset that you should keep the effect down, so you think a bit about how you should do things ahead of time.

Other participants were thinking out loud about their planning during the test. Greg thought during the test:

> The TV I think I can live without for now, so I'll turn it off. And the heater, I mean I can plug that out. It's plugged out already I see. I turn off the heater, because the stove is hot! So yeah, the plan now is that I turn on the coffee maker at the same time as the stove, and I'll vacuum when I'm washing clothes afterwards.
>
> By the way, I assume that the stove uses more power than the washer. Might be I recall that wrong, but yeah. That's what I'm thinking, if you want to know. So that's why – I mean the coffee maker probably uses less electricity than that (vacuum), but I'm not quite sure. I mean that (coffee maker) gets hot, while that (vacuum) just sucks. Don't know. Coffee maker is usually at 1000W though. And here (on the vacuum) it says 1500.

Harold showed some signs of planning his moves. He began by turning on the coffee maker before asking himself:

> The question is what do I do first? Do I make food, or do I? I'm turning on the stove.
>
> Lights I have on anyway, nobody turns off the lights when they vacuum. So, then I vacuum while the washer is on, because multitasking is my friend. Even if I go above the threshold I assume it doesn't cost all that much.

In the second quote Harold mentions going above the threshold, and that the cost will probably low. Cost, it turned out, was the main motivating factor for the test participants. More on that in section 4.4.4.

Kevin was decisive, but did not share much during the test. At one point he said:

> Some coffee before cleaning or vacuuming is a good idea I guess.

Susan started off by turning on both the washer and the stove, which resulted in her shooting past the threshold. She attempted to get back below the threshold by turning off appliances again, and started thinking about how best to proceed:

> The way I did things now I went above right away. Jumped over in one second (laughs). What I would do now is to wait with the vacuum until the coffee maker is done. And the stove was done. That's what I'd do.

Susan started by doing what she usually does at home. She describes a usual situation at home, and what she would probably do if she had effect-based billing:

> Well, if I had an app like this on my phone, then I'd maybe have the heater off, and wait with vacuuming until I was done with eating, then turn the heater back on after that. That's what I'd have done.

Fiona was less vocal about her planning during the test. However, after turning on the washer she had a moments pause:

> Right. While that is on I guess I'll vacuum a bit. (Fiona vacuums the washing room floor, then proceeds to turn off the lights in the washing room. She then moves to the kitchen and turns on the lights there. She seems to be contemplating her next move, before going for the coffee maker).

While participants showed signs of planning, not everyone were too sure of their plans during the test.

4.4.2 Uncertainty and Surprise

Participants who did not get feedback expressed varying degrees of uncertainty, both during the test and when talking about the test in the interviews that followed.

Greg thinks aloud during the test:

> Now I think I'm just below the threshold, or I have a decent margin I think. Like, I think I might have been able to turn on the heater, but then I'd be pushing it I think.
>
> I'm thinking - because this thing uses, if these numbers are watts, which I find likely, this uses 0.5 kW more than the coffee maker – I'm still below the threshold, or I should be.

When planing his next move in the second quote, Greg tries to calculate his consumption based on the information that is available to him. However, he is not 100% sure of his calculations, as he explains in the interview:

> I don't think I got any fees. Can't say for sure though, but I don't think so.

I asked him if he felt stressed during the test, to which he replied yes. As a follow-up question I asked if it was the time limit that was stressful, to which he answered:

> Yes. But also that "fear" to go above the threshold. Less relaxing, to put it that way. Not like I was very stressed.
>
> If I were to go though a whole day with that feeling, I don't know.

Harold was a bit uncertain with what order he should do things in to keep the consumption low. As he explains:

> It's not like there's a label or something that I can see the consumption, so I just had to imagine a bit. That's what I was most unsure of.

Kevin felt similarly:

> I did feel a bit uncertain. Like, I had the calculation sort of right in my head I think, and then I heard that the heater and such was on, so – but I don't think I was over by a lot. Just around the threshold.
>
> I don't know if I went above, I might have with the vacuum.

Susan, when the first notifications ticked in at the start of the test, was surprised:

> (message arrives on the phone, Susan checks it right away). Already? Dear lord.

During the interview after the test Susan elaborates on her surprise:

> I thought it was surprising, like I hadn't thought I'd jump so high up so quickly. I'd thought that, if I put all the big things on at once – vacuum, washer. The coffee maker I didn't think about, like with the load. So that surprised me, how high it jumped up in a few seconds.

Participants were different in how aware they were of their consumption, both during the test and at home.

4.4.3 Experience, Awareness, and Conservation

During the test John felt confident in his own calculations, without the phone having sent a notification, saying "I still shouldn't be over 5000". At one point during the test John tells me:

> This is, I have worked a lot with this before, with effect conservation and things like that, and I've had a watt meter in my home to play a bit with it and keep the load down. And that is a big thing where you know appliances - like, if you want to do more things at once then - yeah - spread it out a bit rather than getting it all done in fifteen minutes.

I asked John during the interview to elaborate on having used a smart meter with a display in his home. I asked him if he saw any changes in his consumption based on the feedback he got from that display. He answers:

> No, a bit because I know my consumption so well already. I, before I worked for the grid company, had summer internships at a different company measuring electricity consumption. So I've worked in the industry for fifteen years, in one form or another.

Greg also had previous experience with working with electricity:

> I went to high-school as an aspiring electrician, or electronics guy. So I've had quite a bit of theory about electricity. Then there's the Raspberry Pi stuff I dabble with on my own. So I know what a kW is, to put it that way.
>
> So I have a relationship to it. Maybe more so than most.

Harold explains that he thinks about his electricity consumption, turning off lights and heating when he leaves the house his apartment is in. Kevin is also aware of his consumption in his daily life:

> Well, I always try to think about it, and not use more than I need.
>
> Me: So you try saving?
>
> Yes, but my consumption has never been very high. It's my computer that uses the most, like apart from what everybody does. Heating does take a bit of power, but I try keeping it around 20 (degrees Celsius), 18. Between 18 and 20 at least. It varies a lot, I live in kind of a funky house. But I turn off lights and try to run thinks like as quickly as possible.
>
> It's not like it should degrade stuff, but you can always save a bit.
>
> You know, there's no point in throwing money away, having lights on in a room I'm not in.

Susan explains the situation at home, with an older electrical system that forces the household to be aware of how much load they put on the fuse box. A common scenario in their home:

> Because to use the microwave and the vacuum down in the ground floor at the same time, we can't do that. So to vacuum I usually turn off the heater in the living room. I know that, if the heater turns on while I'm vacuuming then the fuse will go out. That's just because I don't want to go upstairs all the time and flip the fuse, and I'm thinking it may not be good for the appliances or the system that it keeps dropping out all the time. So we may have become very conscious about it because we've lived in old homes all the time. Because we don't have the same capacity in our house like there is in a new one.
>
> So of course, if you have that problem you may be more aware even if you don't actively think about it. [...] But not any conscious decisions to save, no.

At home, Fiona is conscious about her choices with regards to electricity. She tries to not run heavy appliances during "rush hour". She mentions cost as being a motivating factor for doing so:

> I do try to turn on heavy appliances in the morning or late at night though. I think that when people get home from work it's probably more expensive, so I stay away from that.

As mentioned earlier, cost turned out to be the main motivating factor for the participants.

4.4.4 Cost and External Influence

Cost was a recurring factor when participants consider their electricity consumption at home. However, John felt a different external influence would be needed. I asked him whether the fact that something is nagging him about having passed a threshold affects him, to which he answered:

> That won't really have an effect until they implement some kind of throttling.
>
> There's been talk of setting the maximum effect to 2 kW. [...] If you go above that the main fuse trips. That's an idea that floats around the industry. 2 kW or 3, depending on the season and so on. It's varying, but yeah.

John also felt that giving notifications would not be effective unless users immediately saw costs related to them:

> Well, of course if you see it in relation to price in that app, and show it immediately how much this costs or how much you can save by turning off the stove for instance. Until that comes I feel it becomes too abstract. Like, 5 kW, what does that entail? But until the price for that effect-based billing, until it becomes known and visualized, I think... It will be a nice reminder for some, but most will just keep using power like they have.

Greg considers the cost of electricity, but "prioritize[s] being warm, rather than being home freezing and not getting up."

Harold talked about his efforts in saving energy by turning off lights and heaters when he left his house. I asked him whether it was the bill that made him do it, or if there was an environmental factor at play. He simply answered "money".

For Kevin, cost was not as important. "I've never had problems paying the power bill, to put it that way", he says. For him saving electricity was more of a principle:

> No sense letting it go to waste. Doesn't hurt anybody. In fact, good for everyone, perhaps except the power company. Or I mean, even for them maybe, what with the grid and all.

When asked after the test if she would have liked to use a mobile application such as the one in the test if she had effect-based billing Susan said she would have used it, especially if it helped save money:

> I'm a bit like that, I think it's interesting. And if you on top of that could save some money (laughs). Some advantages there and I'd definitely use it.

Fiona explained that she chooses to run heavy appliances late in the evening or early in the morning - to save money.

> I think that when people get home from work it's probably more expensive, so I stay away from that.

On the prospect of paying fees if her consumption rose above a threshold, Fiona said:

> Of course you turn things off, since you don't want the worlds largest electricity bill. And it's no problem, so you know.

During the test, Fiona did turn things off based on feedback from the mobile application. More on that in section 4.4.7.

4.4.5 Technology and Electronics

All participants were what can be considered experienced users when it comes to using advanced electronics such as smart-phones or computers. Five were at varying stages of an education in IT, while the sixth had a personal above-average interest, liking to keep up to date on the smart-phone front. However, she did not have much interest in other technologies or gadgets.

Greg spoke jokingly, saying that "it might be that I use more time with technology than people". Greg used his private phone during the test to keep the time by setting an alarm.

Kevin says that he "use[s] technology pretty much all the time", John says "gadgets are always fun", and Fiona says "we love that". She elaborates, saying:

> You usually - at least as an IT student - you sit with something in your hands all the time.

Kevin, when asked if he saw himself as a gadget person answered:

> I think it's interesting and all that, but I kind of feel it gets to be a lot of gadgets, so I kind of distance myself to it.
>
> It's good to get away from it for a while. Like, if you put the phone away then that's enough. [...] With all other small gadgets it becomes like, you never get away. [...] Like, you're always online.

Harold did not see himself as a gadget person, although he usually kept his phone close by, "it's like my relationship with it. I bring it to bed when I sleep, and have it by me by the PC".

4.4.6 On an Electronic and/or Mobile Assistant

With both groups I discussed whether they would be interested in using an electronic assistant to help monitor their power consumption if effect-based billing were to become the norm. I encouraged the interviewee to not only think about the phone assistant if they had one during the test, but also consider more simple displays, and other devices such as smart sockets - inspired by the products Fredrikstad Energi offered to their customers in their pilot project.

All participants were positive to having an electronic assistant. Harold was interested, saying "if it was a reasonable offer when staying under, or if the price for going over was high, I'd be very careful. So yes, I'd take that offer.".

Kevin thought his consumption graph would have looked differently had he had a display that showed his consumption. "Then I'd see that, no I can't use the coffee maker now". Kevin was positive to using an electronic assistant.

John had already installed a smart meter with a display in his home and used it over a period of time, and was positive to having one in the future. Of his previous experience with the smart meter John says:

> I thought it was fun to play with it and play with numbers, and with the display, to see what I could get from the fuse box (laughs).

Susan was positive to an assistant application on her phone:

> Because I am not so knowledgeable about these different appliances that I know how much they use, even if I know how many watts each thing takes I can't do that calculation on my own when I'm using it. I'd have to sit down and work out that calculation. So I think this would work as a good reminder

She would like a tablet display that behaved similarly to the app she used during the test, saying that it was "very nice, that it notified you". She would like an assistant application on her phone more than on a tablet though, saying:

> The advantage of having it on the phone is that I can actually control a bit those who are home (smiles). I mean I wouldn't bring a tablet when I left the house. This (phone) I could bring with me and have an idea of – I mean if my daughter was at home [...] I could actually give her a call.

Fiona expressed similar thoughts:

> I imagine they would be good to have if you have children though, and they are at home, and you see that suddenly it becomes really high - (mimics phone-call) hey!

Fiona would also like the information on just more than one device, saying "you don't always have the phone with you everywhere".

John would use an assistant app that sent messages on his phone if one was available, as would Greg. Harold also felt that an assistant app on his phone would be helpful:

> It would be simpler for me. Since you have the phone all the time.

Kevin and Fiona both felt that notifications may be useful in a learning period, but that there should be an option to turn them off. Kevin says:

> I think it would be practical in the beginning. But I – and like when you introduce new appliances – but apart from that I think you learn pretty quickly what you can do and can not do. So it would mostly be when you introduce new appliances, like have it on in the beginning.

Susan said during her interview that "over time I think I'd change my routine, yes, with such an app". She did not mention wanting the option to turn off notifications.

Of using the notifications in a learning period Fiona says:

> It's just about changing your routine I think. You get help, I mean it (the app) will help you, you learn that you can't use everything at once.

Once that learning period is over, Fiona would like to disable notifications:

> If I'm aware I don't want a message (laughs). I don't know how to solve that, or what I'd prefer.
>
> [It] would be good, to be able to turn off the messages. [...] perhaps just have it so you check yourself.

As a possible solution to the "no messages when I'm aware"-problem Fiona suggested only sending notifications if the consumption had been above the threshold for some time, for example two hours.

4.4.7 Persuasion

During the test, Susan and Fiona altered their original plan when they received notifications on their phone, choosing to turn off appliances that were turned on.

Early in the test, Susan turned on the washer and coffee machine, which triggered a notification:

> (message arrives on the phone, Susan checks it right away). Already? Dear lord. (Susan looks around at the stove and TV, looking like she contemplates the next move). I'm still turning it on (stove). (new message arrives, Susan checks the phone right away). Where do I turn off the TV? [...] Turn the heater off as well maybe?

Fiona experienced a similar situation:

> You have gone past your effect threshold, turn off appliances if you can. Aaw, I wanted pizza. (Turns off the stove). (New message arrives on time, Fiona checks it right away). Yay! (laughs). I can't make pizza then.
>
> I can make pizza in the dark (laughs).
>
> *Me: You turn off the lights in the kitchen?*
>
> Yes. I'm in the living room anyway, so. The TV. (jokingly) I'll take in the view from the window.

After turning off the heater, lights, and TV Fiona then tried to turn on the stove again:

> (Fiona turns on the stove again, which triggers a message on the phone. She checks it, and turns off the stove again, which triggers another message which she checks right away). (laughs) Can I turn on a lower temperature?

She chose to turn off the stove shortly after. When describing the experience of getting messages in the interview, Fiona says:

> Getting a message helps [...], like now you're using a bit much. Of course you turn things off, since you don't want the worlds largest electricity bill. And it's no problem, so you know.

Susan said in the interview that getting the current consumption sent as part of the notification was "very nice".

John expressed earlier that notifications probably would have little effect on him unless there were some external influence, like throttling of his power supply. When asked if a message saying he was now paying fees, and saying how much it was costing him, would have any effect he said:

> I probably would have made some changes to get back below. I assume then that the moment I got below the threshold I would get a new message that would have told me I had gotten below.

During the test, John kept the phone on the counter. On one occasion the phone vibrated and made a noise, but John did not notice and missed the notification completely.

When asked if they would have done something if a message was sent to their phone when going above their threshold, Greg and Kevin were positive. Greg said it "[would be] efficient, probably. I'd go and turn things off". Kevin said "it would have been like, I'd only to one thing at a time really". Greg and Kevin did not have access to the application during their test, as they were part of the group that received no feedback.

4.5 In Summary

In this chapter I have presented my findings from the test described in chapter 3.

All participants, both with and without feedback through the mobile application, planned their next move ahead of time when faced with the prospect of paying a fee if they went above a load threshold. Those who did not get feedback through the mobile application attempted to calculate their consumption and what they could and could not do.

Participants in the group that did not receive feedback from a phone during the test showed varying signs of uncertainty that was not seen in the participants that did get feedback.

Two of the participants had some professional relationship to electricity, while the rest were consumers who paid or contributed to their electricity bill. All were somewhat aware of their consumption in their everyday lives.

Cost was the main motivating factor in the choices that participants made regarding electricity. One participant tried to use only what he needed as a matter of principle.

All participants were experienced in using electronics such as smart-phones and computers. All participants were also positive to have an electronic assistant to help them monitor their consumption if they were to have effect-based billing.

Participants were also positive to have a mobile assistant that sent them notifications. Two participants would only want notifications in a learning period, with the option to turn them off.

Those participants that received feedback through a mobile application responded to that feedback and make changes in their original plan during the test. Notably Susan and Fiona made several changes based on the feedback they got from the phone.

Chapter 5

Discussion

In this chapter I discuss my research questions in light of the findings presented in chapter 4, as well as relevant theory and related work. I discuss each research question in its own section.

5.1 User Response to Immediate Feedback

My first research question is:

> Given immediate feedback on changes in the electricity consumption through their mobile phone, how do users respond?

Before I go into how the users responded to the notifications it is natural to discuss the mobile phone itself.

5.1.1 The Mobile Phone as an Assistant

In the introduction I make the claim that the smart phone "for most parts of the day is within reach of its owner". However, even with a small number of participants, the test has shown that people have different habits when it comes to their phone.

During his test John kept the phone on the counter, and not on him. At one occasion the phone vibrated and made a noise as a message was received. However, John did not notice the message, and as such was unaffected by it.

The two other participants who had access to the phone during the test kept it on them. However, during the interview after the test Fiona said "you don't always have the phone with you", and said she would like an assistant not only on her phone but on other platforms as well. In contrast, Harold says "you always have the phone with you". Harold usually keeps his phone within arms reach, having it by his computer and his bed, and with him when he goes outside the house.

Fiona and Susan brought up the point that with a mobile application it is possible to have some degree of control over the consumption of the household when out and about. This can potentially be valuable to families with children that stay home. As Susan puts it:

> The advantage of having it on the phone is that I can actually control a bit those who are home (smiles). I mean I wouldn't bring a tablet when I left the

> house. This (phone) I could bring with me and have an idea of – I mean if my daughter was at home [...] I could actually give her a call.

Fionas example is similar:

> I imagine they would be good to have if you have children though, and they are at home, and you see that suddenly it becomes really high - (mimics phone-call) hey!

While there may be more of a difference in people's habits at home (leaving your phone alone in a public place is perhaps not as common), it is when the user is at home the assistant application will be most impactful - it is then the user has the ability to do something about it, a key element in the Fogg behaviour model presented in chapter 2.1.2.

It may be an issue that notifications go unnoticed if the mobile phone is outside of earshot of its owner. However, missing a notification in this way can be compared to not looking at a monitor such as the eWave presented in section 2.4.3, or not being in the same room as the Wattson presented in section 2.4.1. While it is unfortunate, it is not an issue with the mobile phone alone. The mobile phone also has advantages that dedicated devices do not have, as both Fiona and Susan bring up with regards to control when out and about, but also for instance the penetration rate and mobility compared to other solutions. This makes the mobile phone a promising platform for a consumer electricity management application.

5.1.2 Persuasion Through Notifications

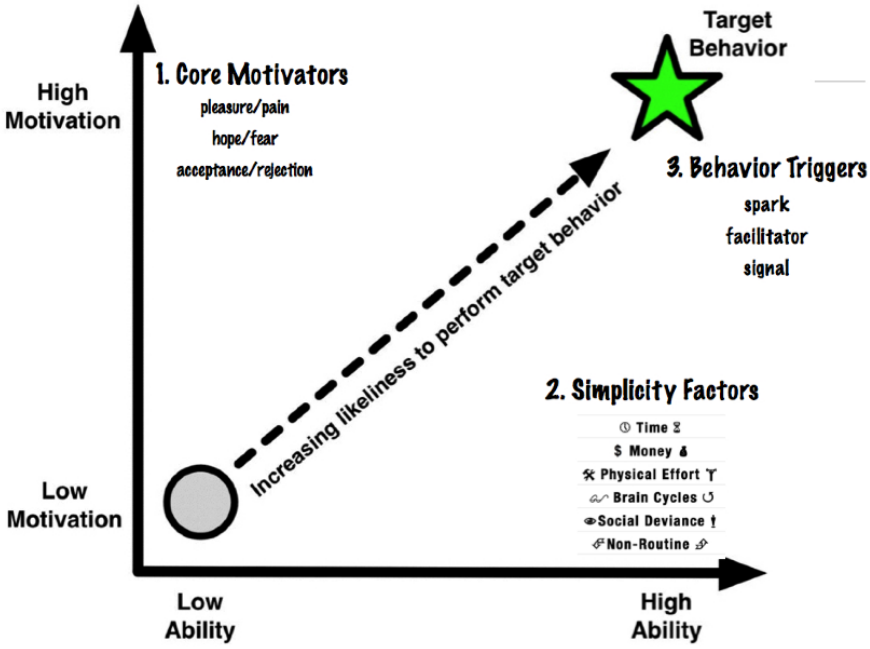


Figure 5.1: The Fogg behaviour model, as illustrated in *A behavior model for persuasive design* [13]

In the Fogg Behaviour Model (FBM, illustrated in figure 5.1), Fogg illustrates the three main components that are needed to achieve a target behavior in people:

1. Motivation
2. Ability
3. Trigger

A notification alone will never fill all three roles. However, a notification can be the *trigger* that makes the target behaviour happen. A motivator and the ability to do something must be in place before a trigger will have any effect.

Cost was the main motivation in the participants. The prospect of paying fees made participants concerned with staying under the threshold. The participants who received feedback when they went above the threshold chose to turn off appliances to get back below the threshold. There was the ability do so something - turn off appliances - and the motivation to do so - cost - with the notification acting as a signal to trigger the target behaviour.

Successful persuasion was achieved on several occasions. Susan and Fiona chose to respond to the notifications by turning appliances off to get back below their threshold - the target behaviour and reason for sending the notification.

As mentioned in section 5.1.1, John received a notification at one point which he did not notice, and as such there was no trigger that reached him and the target behaviour was not achieved.

John also felt that a notification alone would have no effect. Indeed, John felt that without a significant cost being communicated clearly through the notification throttling of his power supply would be needed to create a motivation for him, since electricity was so cheap.

Cost will have to be clearly communicated to the customer, preferably through the application itself, if the application is to persuade its users.

5.1.3 Long-term Behaviour Change

Behaviour change is a long process with a high probability for relapse into previous behaviour. Long-term studies are required to get conclusive results about the effectiveness of an application designed towards changing behaviour for the long-term [19]. However, a shorter study such as this can give an indication as to whether something will be effective in the long-term and warrants such a study.

From section 5.1.2 we see that short-term behaviour change was achieved with a combination of cost, ability, and a mobile application sending notifications triggering the behaviour change. Notifications were effective in triggering the desired behaviour, and users expressed that the notifications were helpful and welcome.

Kevin and Fiona both felt that notifications may be useful in a learning period, but that there should be an option to turn them off when they wanted to. Kevin says:

> I think it would be practical in the beginning. But I – and like when you introduce new appliances – but apart from that I think you learn pretty quickly what you can do and can not do. So it would mostly be when you introduce new appliances, like have it on in the beginning.

Similarly, Fiona says:

> It's just about changing your routine I think. You get help, I mean it (the app) will help you, you learn that you can't use everything at once.
>
> If I'm aware I don't want a message (laughs). I don't know how to solve that, or what I'd prefer.
>
> [It] would be good, to be able to turn off the messages. [...] perhaps just have it so you check yourself.

Given the successful persuasion described in section 5.1.2 it is not unlikely that after a while users change their routine behaviour. However, a long-term study is needed to give any conclusive answers with regards to that question. Such a long-term study should include the option of opting out of notifications, and perhaps also allow users to configure their personal thresholds.

5.1.4 The User Experience

Participants in the group that did not receive feedback from a phone during the test showed varying signs of uncertainty that was not seen in the participants that did get feedback. The feedback-less participants were trying to calculate their consumption as the test progressed, but were unsure of their calculations and current situation. One participant said that while during the test the uncertainty he felt was not much of a problem, if he were to go like that for a whole day the story would be different. This shows the need for immediate feedback in an effect-based billing situation to reduce uncertainty for consumers.

During the interviews participants were positive to have a mobile assistant that sent them notifications. The notifications were received well, and user responded by making changes in what appliances were running in order to get back down below the threshold set for the test. During the interviews the fact that the current consumption was shown in the notifications was highlighted as positive. Participants requested the possibility to see the current consumption on-demand instead of just when the application sent them a notification. This option of self-monitoring should be implemented in any feedback solution.

Susan expressed surprise at the speed that she received the notification, and John would want a warning sooner to have more room between the warning and going above the threshold. This illustrates a need for customization options where users set their own thresholds for notifications.

When discussing the notifications two participants felt they would only want notifications in a learning period, with the option to turn them off, thinking they would become less useful over time as they would learn what appliances could and could not run at the same time. While the option to turn off notifications should probably be in place in a final product, there is the possibility that routines can be undone. We know from section 5.1.3 that rates are high when it comes to relapsing into old behaviour. Users may feel overconfident and turn off notifications when given the option, only to relapse into old habits.

5.2 The Impact of a Mobile Phone Assistant

In her 2006 survey of literature Darby found that instant feedback on electricity consumption created a reduction in consumption everything from 5% to 15% [3]. The survey does not mention peak load however. Nevertheless, an at-worst 5% reduction of consumption is a significant impact.

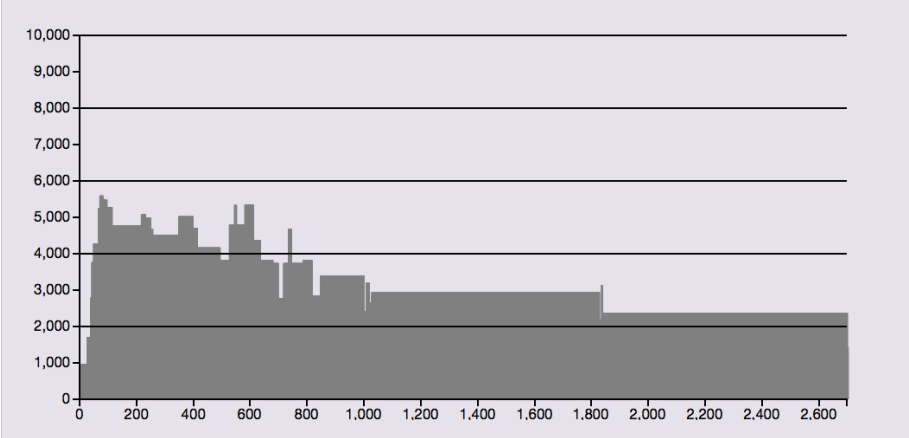


Figure 5.2: Graph showing the average consumption for the group that got feedback through a mobile application

From the plots of the average consumption for the two groups seen in section 4.2.3, also shown in figures 5.2 and 5.3, we see that there is indeed a difference - around 1kW - at several points early in the test. However, there is no trend towards a lowering of the peak consumption for the group that received feedback. On the contrary, we see that the group that received feedback through the mobile application has a higher peak load.

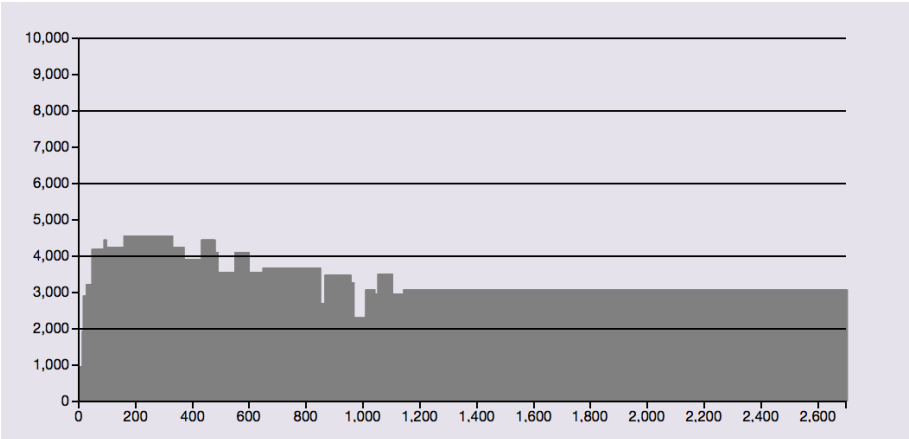


Figure 5.3: Graph showing the average consumption for the group that did not get feedback through a mobile application

Participants in both groups were to some degree aware of and focused on keeping their consumption below the threshold, which likely had an effect on the results. As shown in

section 4.4.1, all participants showed signs of planning their next move based on where they thought their consumption was at the time compared to the threshold. Given the short timespan of the test, this awareness likely did not recede.

The households in the papers surveyed by Darby were households where the billing model is the traditional *cost per kWh*. As such, homes that did not receive feedback had no significant penalty for not controlling their consumption as the feedbackless group in this thesis project did. The papers surveyed were also conducted over a longer period of time, ranging from a few weeks to several months. It may be that if the billing model for the control group was more traditional, or if the experiment was run over a longer period of time, that a larger difference in the consumption and load could be found.

When looking at the graphs of the average consumption for the two groups we see that the peak load is higher for the group that received feedback through a mobile application. That higher peak can come from a sense of trust in the technology. This trust has been observed with users of GPS systems, for example in *In-car GPS navigation* by Leshed et al [22]:

> Some participants listened to the vocal instructions and followed them, without knowing where they are or questioning whether the instructions are correct.

All participants in the test were experienced users, so this sense of trust may very well be present. If users trust the application to tell them when their consumption is high they may pay less attention to it themselves, with a higher peak load as a result.

We see from the graph in figure 5.2 that participants with the mobile application made several changes during the test, indicated by the number of smaller spikes in the beginning of the test. This technology-triggered change in behaviour could indicate a similar trust in the technology as shown with the GPS users presented by Leshed et al in *In-car GPS navigation* [22].

An experiment with more participants and over a longer period of time is needed to give a conclusive answer to this research question. Over time, without feedback, participants may become less aware of their consumption, and a greater difference between the two groups could be observed.

Over time it may also become clear if those who get feedback from an electronic assistant indeed do place trust in the application, with a higher peak consumption as a result.

Chapter 6

Conclusion

In this thesis project I have researched the user experience of a mobile application using persuasive technology theory to affect electricity consumption. I also wanted to see if there were any trends towards a lowering of the peak consumption using such an application.

A lab experiment was conducted with two groups of three participants - one group that used the persuasive application, and one that did not - to research the user experience of the application, as well as the impact it had on the consumption. All participants were given a set of tasks they were to complete while trying to stay below an effect threshold, lest they pay penalty fees.

Results show that the application together with the prospect of paying fees successfully persuades users to turn off appliances to stay below their threshold. It was also found that users who did not receive feedback through the application felt uncertain about their consumption and whether they were above their threshold during the test, something the participants that received feedback did not. This shows the need for immediate feedback in an effect-based billing situation.

The mobile assistant was received well by the test users, who were all positive to using a tool like it in the future. Some participants pointed out that the application with its notifications would be helpful in a learning period, but that after a while a new routine would probably be established making the notifications less useful. On one occasion a participant did not notice a notification, and so did not respond to the attempted persuasion. Nevertheless, the mobile phone is a promising platform for a consumer electricity management application.

The experiment was not able to demonstrate any trend towards the lowering of the peak load in the users of the application. There was on average a somewhat higher peak consumption for the participants that received feedback compared to those who did not. However, this is likely due to the nature of the experiment. All participants were to some degree aware of their own consumption for the duration of the test, and were planning their moves ahead of time. As such, the participants that received no feedback may have been more careful than their phone-using counterparts.

6.1 Future Work

As described in section 3.1, the project underwent some significant changes after the initial design. Initially the plan was to recruit test participants from the pool of Fredrikstad Energi's customers at Hvaler, and run the test over the course of several weeks. The

application was to use actual consumption data from the individual customer's smart meter.

An experiment such as the one that was planned initially should be conducted to research the user experience and effect of a persuasive mobile application over a longer time period, no shorter than two weeks.

The number of participants in the experiment that was conducted in this thesis was too low to say something conclusive about the effect of the mobile application. A project that focuses on this research question should conduct an experiment with a larger number of participants.

The persuasive application implemented and tested in this thesis project can be classified as a suggestion application when looking at the seven types of persuasive technology presented by Fogg in *Persuasive Technology : Using Computers to Change What We Think and Do* [12]. During the test and interviews users requested the option of checking current consumption manually. This self-monitoring should be compared to a suggestion application to research differences between the two approaches.

Bibliography

[1] Bernadine M.C. Atkinson. Captology: A critical review. *Lecture Notes in Computer Science*, (3962), 2006.

[2] Cindy Byfield Dallow and Jennifer Anderson. Using self-efficacy and a transtheoretical model to develop a physical activity intervention for obese women. *American Journal of Health Promotion*, 17(6):373–381, 2003.

[3] Sarah Darby. The effectiveness of feedback on energy consumption. *A Review for DEFRA of the Literature on Metering, Billing and direct Displays*, 486:2006, 2006.

[4] Raymond De Young. Changing behavior and making it stick the conceptualization and management of conservation behavior. *Environment and Behavior*, 25(3):485–505, 1993.

[5] Edward L Deci and Richard M Ryan. *Self-Determination*. Wiley Online Library, 1985.

[6] Sebastian Deterding. Pawned. Gamification and Its Discontents. In *Playful 2010*, London, 2010.

[7] Sebastian Deterding, Dan Dixon, Rilla Khaled, and Lennart Nacke. From game design elements to gamefulness: defining "gamification". In *Proceedings of the 15th*, volume Tampere, F of *MindTrek '11*, pages 9–15. ACM, 2011.

[8] Chris Ann Dickerson, Ruth Thibodeau, Elliot Aronson, and Dayna Miller. Using cognitive dissonance to encourage water conservation1. *Journal of Applied Social Psychology*, 22(11):841–854, 1992.

[9] Tordbjørn Wang Eriksen. Getting adolescent diabetics to measure more often using mobile technology and gamification. Master's thesis, Østfold University College, 2013.

[10] Joseph L Fava, Wayne F Velicer, and James O Prochaska. Applying the transtheoretical model to a representative sample of smokers. *Addictive behaviors*, 20(2):189–203, 1995.

[11] Corinna Fischer. Consumer feedback: a helpful tool for stimulating electricity conservation? *SCP cases in the field of Food, Mobility and Housing*, page 503, 2007.

[12] B. J. Fogg. *Persuasive Technology : Using Computers to Change What We Think and Do*. Morgan Kaufmann, 2003.

[13] Bj Fogg. A behavior model for persuasive design. *Proceedings of the 4th International Conference on Persuasive Technology - Persuasive '09*, page 1, 2009.

[14] Fabian Groh. Gamification: State of the art definition and utilization. *Institute of Media Informatics Ulm University*, pages 39–47, 2012.

[15] Eddie Harmon-Jones. A cognitive dissonance theory perspective on persuasion. *The persuasion handbook: Developments in theory and practice*, pages 99–116, 2002.

[16] Sunniva Johansen and Kristin Tønnesen. Besmart app presentation. http://prezi.com/soqmnwmvvqew/app/, 2013.

[17] Sara S Johnson, Andrea L Paiva, Carol O Cummins, Janet L Johnson, Sharon J Dyment, Julie A Wright, James O Prochaska, Janice M Prochaska, and Karen Sherman. Transtheoretical model-based multiple behavior intervention for weight management: effectiveness on a population basis. *Preventive medicine*, 46(3):238–246, 2008.

[18] Shahedul Huq Khandkar. *Open Coding*. University of Calgary, 2009.

[19] Predrag Klasnja, Sunny Consolvo, and Wanda Pratt. How to evaluate technologies for health behavior change in hci research. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 3063–3072. ACM, 2011.

[20] Anja Kollmuss and Julian Agyeman. Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental education research*, 8(3):239–260, 2002.

[21] Raph Koster. *Theory of fun for game design*. " O'Reilly Media, Inc.", 2013.

[22] Gilly Leshed, Theresa Velden, Oya Rieger, Blazej Kot, and Phoebe Sengers. In-car gps navigation: engagement with and disengagement from the environment. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1675–1684. ACM, 2008.

[23] Gilbert M Masters. *Renewable and efficient electric power systems*. John Wiley & Sons, 2013.

[24] Florian Michahelles, Yi Bing Tan, and Michael Steiner. Business Aspects of the Internet of Things Persuasive Technology in Motivating Household Energy Conservation Promising Business Applications of Vehicular Communication Systems. 2009.

[25] Jeffery P Migneault, Jeffery P Migneault, Troy B Adams, Jeffery P Migneault, Troy B Adams, Jennifer P Read, Jeffery P Migneault, Troy B Adams, and Jennifer P Read. Application of the transtheoretical model to substance abuse: historical development and future directions. *Drug and alcohol review*, 24(5):437–448, 2005.

[26] Daniel G Oliver, Julianne M Serovich, and Tina L Mason. Constraints and opportunities with interview transcription: Towards reflection in qualitative research. *Social Forces*, 84(2):1273–1289, 2005.

[27] Jukka V. Paatero and Peter D. Lund. A model for generating household electricity load profiles. *International Journal of Energy Research*, 30(5):273–290, April 2006.

[28] James O Prochaska. Transtheoretical model of behavior change. In *Encyclopedia of Behavioral Medicine*, pages 1997–2000. Springer, 2013.

[29] James O Prochaska, Sara Johnson, and Patricia Lee. The transtheoretical model of behavior change. 1998.

[30] Johan Redström. Persuasive design: Fringes and foundations. In *Persuasive Technology*, pages 112–122. Springer, 2006.

[31] Julie A Sarkin, Sara S Johnson, James O Prochaska, and Janice M Prochaska. Applying the transtheoretical model to regular moderate exercise in an overweight population: validation of a stages of change measure. *Preventive medicine*, 33(5):462–469, 2001.

[32] Henk Staats, Paul Harland, and Henk AM Wilke. Effecting durable change a team approach to improve environmental behavior in the household. *Environment and Behavior*, 36(3):341–367, 2004.

[33] Stephen Sutton. Back to the drawing board? a review of applications of the transtheoretical model to substance use. *Addiction*, 96(1):175–186, 2001.

[34] Frank Van Overwalle and Karen Jordens. An adaptive connectionist model of cognitive dissonance. *Personality and Social Psychology Review*, 6(3):204–231, 2002.

[35] Wayne F Velicer, James O Prochaska, Joseph L Fava, Gregory J Norman, and Colleen A Redding. Smoking cessation and stress management: applications of the transtheoretical model of behavior change. *Homeostasis in health and disease*, 1998.

[36] G Zichermann and C Cunningham. Gamification by Design. *Oreilly & Associates Inc*, 2011.

Appendix A

Interview Guide

There were six main topics that were discussed with each participant, with sub-topics available to drive the conversation should it be needed. The topics and sub-topics are listed below.

- Their view on and experience with technology and electronics
  - Are they familiar with it?
  - Do they consider themselves "gadget people"?
- Their association with electricity
  - Do they ever think about the power bill?
  - Do they consider environmental aspects with their consumption?
- How they felt the test went
  - Did they feel stressed?
  - Did they feel uncertain?
- Their consumption graph
  - What did they think of their performance?
- For those who got feedback from the phone: how their experience was getting the messages
  - How was it to get a message saying they used too much?
  - Likewise for having a very low consumption
  - Did they react to the wording of the messages?
  - What did they feel about the number of messages?
- If they could see themselves using an electronic tool for helping with keeping their consumption under the threshold
  - Why? Why not?
  - Any changes you would like to make?
  - Other areas where a phone and smart meters could mix?

Appendix B

Design Mockups


12:00
Forbruk
DAG
UKE
MÅNED
Man 21,08
Tir 23,42
Ons 22,22
Tor 20,83
Fre 23,98
Lør 20,65
Søn 20,23
kWh
NOK
CO²
Uke 7
Uke 8
Uke 9


12:00
Forbruk
DAG
UKE
Sparetips
Innstillinger
Man
21,08
Tir
23,42
Ons
22,22
Tor
20,83
Fre
23,98
Lør
20,65
Søn
20,23
kWh
NOK
CO²
Uke 7
Uke 8
Uke 9


12:00
Hjelp
Forbruk
Jolt viser deg forventet forbruk (stiplede linjer) og faktisk forbruk. Om forbruket er høyere enn forventet vises dagen som rød. Er forbruket noe høyt vises dagen som gul. Er forbruket lavt vises dagen som grønn.
Velg om du vil se kroner, gram CO2, eller kW per time
Velg om du vil se dag, uke eller måned
Trykk på pilene for å bytte dag og uke
Tips
Du kan bla i generelle sparetips, og tips for å flytte forbruket til andre tider på døgnet. Trykk på pilene for å bla i tipsene.
Jeg trenger fortsatt hjelp
Send en epost til William


12:00
16:15
Strømforbruket ditt er høyt
Kan du skru noe av eller ned?
Du står i fare for å bruke 5 kW i timen.

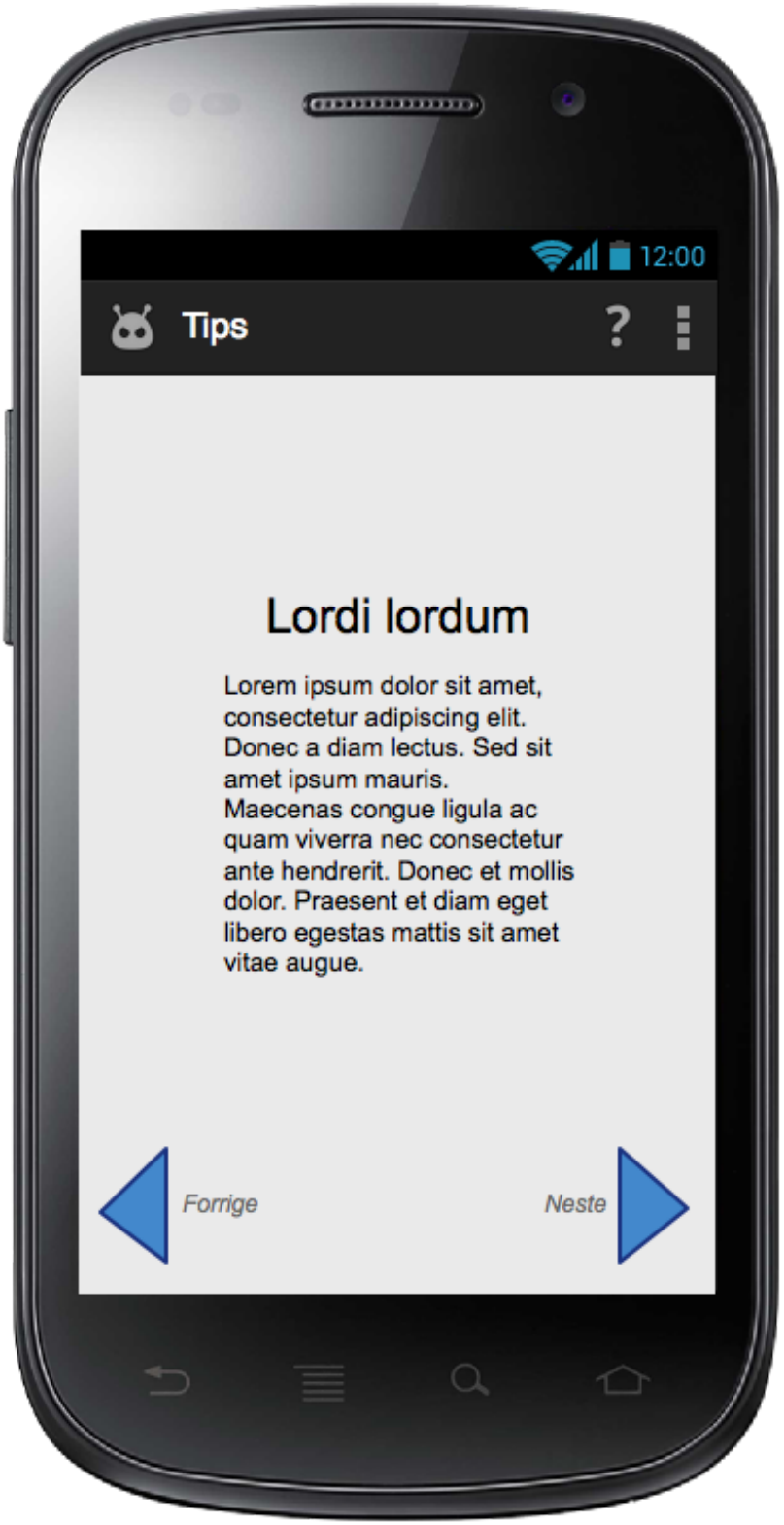

Strømforbruket ditt er høyt
12:00
Google


12:00
Jolt
?
Spørsmål 1/3
Alle må bidra til å redusere klimautslipp
Uenig
Nøytral
Enig
Svar


12:00
Jolt
?
Spørsmål 2/3
Jeg tenker på kostnadene når jeg varmer opp huset med panelovner
Uenig
Nøytral
Enig
Svar


12:00
Jolt
?
Spørsmål 3/3
Jeg tenker på andres strømforbruk
Uenig
Nøytral
Enig
Svar


12:00
Jolt
?
Målernummer
Registrer


12:00
Tips
Lordi lordum
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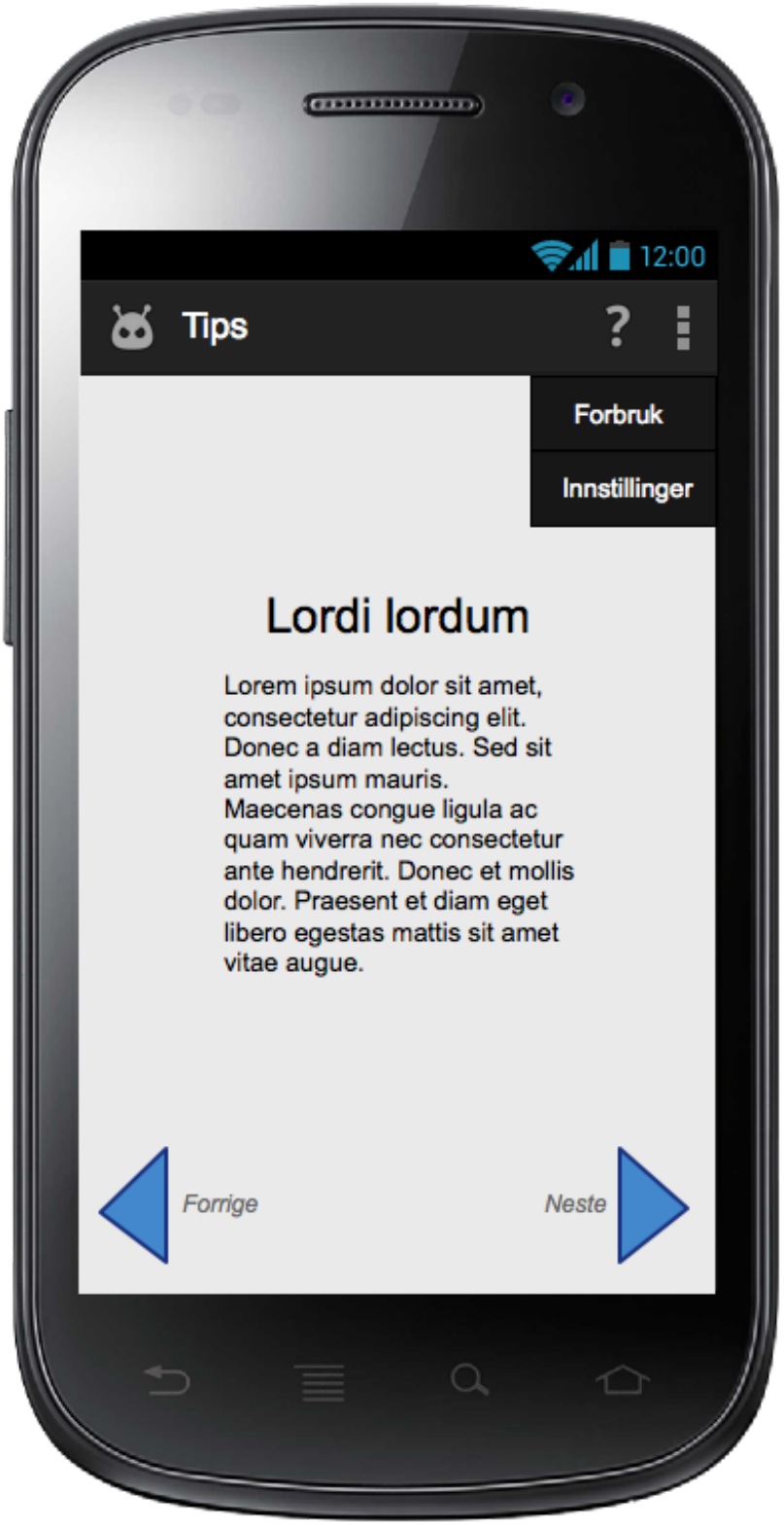
12:00
Tips
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Lorem ipsum dolor sit amet, consectetur adipiscing elit. Donec a diam lectus. Sed sit amet ipsum mauris. Maecenas congue ligula ac quam viverra nec consectetur ante hendrerit. Donec et mollis dolor. Praesent et diam eget libero egestas mattis sit amet vitae augue.
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Appendix C

Highlighted Code

This chapter contains the code listings referred to throughout the thesis project.

Listing C.1: The code for sending a message request to GCM

```
            //Gets the message content from the HTTP request
            textMessage = getParameter(req, BaseServlet.ATTRIBUTE_MESSAGE);
            // For the experiment, only a single client is ever active.
            // Get the GCM ID for the active client from Datastore
            registrationId = Datastore.getDeviceId();

            // Send a single message using plain post
            Message message = new Message.Builder().delayWhileIdle(true)
                    .addData("message", textMessage).build();
            Result result = sender.send(message, registrationId, 5);
            logger.info("Sent message to one device: " + result);

            // Respond with an OK
            resp.setContentType("text/plain");
            resp.addHeader("Access-Control-Allow-Origin", "*");
            PrintWriter response = resp.getWriter();
            response.append("Message sent");
            resp.setStatus(HttpServletResponse.SC_OK);
```

Listing C.2: The Measurement class

```
1  function Measurement(){
2    this.spotKitchen = 0;
3    this.spotBathroom = 0;
4    this.heaterKitchen = 0;
5    this.television = 0;
6    this.washer = 0;
7    this.stove = 0;
8    this.coffeeMaker = 0;
9    this.vacuum = 0;
10
11   Measurement.prototype.isNotSet = function()
12   {
13     if(this.spotKitchen == 0 &&
14     this.spotBathroom == 0 &&
15     this.heaterKitchen == 0 &&
16     this.television == 0 &&
17     this.washer == 0 &&
```

```
18      this.stove == 0 &&
19      this.coffeeMaker == 0 &&
20      this.vacuum == 0)
21      {
22        return true;
23      }else{
24        return false;
25      }
26    };
27
28    Measurement.prototype.totalConsumption = function()
29    {
30      return this.spotKitchen + this.spotBathroom + this.heaterKitchen +
            this.television + this.washer + this.stove + this.coffeeMaker +
             this.vacuum;
31    };
32  };
```

Listing C.3: Generating D3 data

```
1       var measurements = [];
2       var rawTestData = localStorage.getItem(testKey);
3       if(rawTestData == null)
4       {
5         return [{x:0,y:0}];
6       }
7
8             // To have less datapoints to plot I increase i by 1000 (
                  one second)
9       var testDurationSeconds = Surge.getTestDurationSeconds();
10      for(var i = 0; i < testDurationSeconds; i++)
11      {
12        measurements.push(new Measurement());
13      }
14
15      var splitTestData = rawTestData.split(",");
16      var startTimeInt = parseInt(splitTestData[0]);
17      for(var i = 0; i < splitTestData.length; i+=3)
18      {
19        console.log("Going through test data. i = " + i);
20        var eventTime = parseInt(splitTestData[i]);
21        var device = splitTestData[i+1];
22        var deviceStateString = splitTestData[i+2];
23        var deviceTurnedOn = false;
24        if(deviceStateString === "on")
25        {
26          deviceTurnedOn = true;
27        }
28
29        // Finds the index in the measurements array where this
              measurement belongs by calculating which second from test
              start the measurement was made
30        var measurementIndex = Math.floor((eventTime - startTimeInt)
              /1000);
31
32        // In order to "fill the blanks" later consumption values are
              carried over from the previous measurement and added to the
               current one. Therefore, when a device is turned off, the
              value is set as a negative to subtract the value later on.
```

```
33          if(device === "Spotlys Kjokken")
34          {
35            measurements[measurementIndex].spotKitchen = (deviceTurnedOn
                  ? 50 : -50);
36          }else if(device === "Spotlys Bad")
37          {
38            measurements[measurementIndex].spotBathroom = (deviceTurnedOn
                   ? 50 : -50);
39          }else if(device === "Panelovn Kjokken")
40          {
41            measurements[measurementIndex].heaterKitchen = (
                  deviceTurnedOn ? 600 : -600);
42          }else if(device === "Komfyr")
43          {
44            measurements[measurementIndex].stove = (deviceTurnedOn ? 2900
                   : -2900);
45          }else if(device === "Kaffetrakter")
46          {
47            measurements[measurementIndex].coffeeMaker = (deviceTurnedOn
                  ? 1000 : -1000);
48          }else if(device === "Stovsuger")
49          {
50            measurements[measurementIndex].vacuum = (deviceTurnedOn ?
                  1600 : -1600);
51          }else if(device === "Vaskemaskin")
52          {
53            measurements[measurementIndex].washer = (deviceTurnedOn ?
                  2300 : -2300);
54          }else if(device === "TV")
55          {
56            measurements[measurementIndex].television = (deviceTurnedOn ?
                   275 : -275);
57          }
58
59        }
60
61        // Fills in the blanks in the measurement data by adding the
              previous consumption data to the current measurement object
62        for(var i = 1; i < measurements.length; i++)
63        {
64          measurements[i].spotBathroom += measurements[i-1].spotBathroom;
65                  measurements[i].spotKitchen += measurements[i-1].
                        spotKitchen;
66                  measurements[i].heaterKitchen += measurements[i-1].
                        heaterKitchen;
67                  measurements[i].television += measurements[i-1].
                        television;
68                  measurements[i].washer += measurements[i-1].washer;
69                  measurements[i].stove += measurements[i-1].stove;
70                  measurements[i].coffeeMaker += measurements[i-1].
                        coffeeMaker;
71                  measurements[i].vacuum += measurements[i-1].vacuum;
72        }
73
74        // Generates a data format that D3 understands from the
              measurement array
75        var d3Data = [];
76        for(var i = 0; i < measurements.length; i++)
```

```
77      {
78        d3Data.push({x: i, y: measurements[i].totalConsumption()});
79      }
```

Listing C.4: Generating the graph with D3

```
1       var barWidth = 2;
2       var margin = {top: 20, right: 10, bottom: 20, left: 60};
3       var width = 880 - margin.left - margin.right,
4           height = 430 - margin.top - margin.bottom;
5
6
7       var x = d3.scale.linear().domain([0, data.length]).rangeRound([
            margin.left, width-margin.right]);
8       var y = d3.scale.linear().domain([10000, 0]).rangeRound([
            margin.top, height-margin.bottom]);
9       var yAxisScale = d3.scale.linear().domain([10000,0]).rangeRound([
            margin.top, height-margin.bottom]);
10
11      var xAxis = d3.svg.axis().orient("bottom").scale(x);
12      var yAxis = d3.svg.axis().orient("left").scale(yAxisScale);
13
14      $("#chart-container").empty(); //Remove existing chart
15      var chart = d3.select("#chart-container")
16        .append("svg:svg")
17        .attr("width", width)
18        .attr("height", height)
19
20      console.log(typeof(y));
21
22      chart.selectAll("rect")
23        .data(data)
24        .enter()
25        .append("svg:rect")
26        .attr("x", function(d, i) { return x(d.x); })
27        .attr("y", function(d) { return y(d.y)-margin.bottom; })
28        .attr("height", function(d) { return (height)-y(d.y); })
29        .attr("width", barWidth)
30        .attr("fill", "gray");
31
32
33      chart.append("g")
34        .attr("class", "axis")
35        .attr("transform", "translate(0," + (height-margin.bottom) + ")
              ")
36        .call(xAxis);
37      chart.append("g")
38          .attr("class", "axis")
39          .attr("transform", "translate(" + margin.left + ",0)")
40          .call(yAxis);
41
42      chart.selectAll("line.horizontalGrid").data(y.ticks(4)).enter()
43          .append("line")
44            .attr(
45            {
46          "class":"horizontalGrid",
47          "x1" : margin.left,
48          "x2" : width - margin.right,
49          "y1" : function(d){ return y(d);},
```

```
50          "y2" : function(d){ return y(d);},
51          "fill" : "none",
52          "shape-rendering" : "crispEdges",
53          "stroke" : "black",
54          "stroke-width" : "1px"
55            });
```

Listing C.5: Code for calculating the average consumption for the two groups

```
1       getAverageData: function(groupData)
2   {
3     var measurements = [];
4     var testDurationSeconds = Surge.getTestDurationSeconds();
5     for(var i = 0; i < testDurationSeconds; i++)
6     {
7       measurements.push(new Measurement());
8     }
9
10    for(var line in groupData)
11    {
12      var startTimeInt = parseInt(groupData[line][1]);
13      for(var i = 1; i < groupData[line].length; i+=3)
14      {
15        console.log("Going through test data. i = " + i);
16        var eventTime = parseInt(groupData[line][i]);
17        var device = groupData[line][i+1];
18        var deviceStateString = groupData[line][i+2];
19        var deviceTurnedOn = false;
20        if(deviceStateString === "on")
21        {
22          deviceTurnedOn = true;
23        }
24
25        var measurementIndex = Math.floor((eventTime - startTimeInt)
              /1000);
26        if(measurementIndex>2700)
27        {
28          console.log("MSIndex out of bounds: " + measurementIndex);
29          console.log(eventTime + device + deviceStateString);
30        }
31        console.log("startTime " + startTimeInt + ", eventTime " +
              eventTime);
32        console.log("measurementIndex " + measurementIndex);
33
34        if(device === "Spotlys Kjokken")
35        {
36          measurements[measurementIndex].spotKitchen += (
                deviceTurnedOn ? 50 : -50);
37        }else if(device === "Spotlys Bad")
38        {
39          measurements[measurementIndex].spotBathroom += (
                deviceTurnedOn ? 50 : -50);
40        }else if(device === "Panelovn Kjokken")
41        {
42          measurements[measurementIndex].heaterKitchen += (
                deviceTurnedOn ? 600 : -600);
43        }else if(device === "Komfyr")
44        {
```

```
45            measurements[measurementIndex].stove += (deviceTurnedOn ?
                  2900 : -2900);
46          }else if(device === "Kaffetrakter")
47          {
48            measurements[measurementIndex].coffeeMaker += (
                  deviceTurnedOn ? 1000 : -1000);
49          }else if(device === "Stovsuger")
50          {
51            measurements[measurementIndex].vacuum += (deviceTurnedOn ?
                  1600 : -1600);
52          }else if(device === "Vaskemaskin")
53          {
54            measurements[measurementIndex].washer += (deviceTurnedOn ?
                  2300 : -2300);
55          }else if(device === "TV")
56          {
57            measurements[measurementIndex].television += (
                  deviceTurnedOn ? 275 : -275);
58          }
59        }
60      }
61
62      for(var i = 1; i < measurements.length; i++)
63      {
64        measurements[i].spotBathroom += measurements[i-1].spotBathroom;
65                measurements[i].spotKitchen += measurements[i-1].
                      spotKitchen;
66                measurements[i].heaterKitchen += measurements[i-1].
                      heaterKitchen;
67                measurements[i].television += measurements[i-1].
                      television;
68                measurements[i].washer += measurements[i-1].washer;
69                measurements[i].stove += measurements[i-1].stove;
70                measurements[i].coffeeMaker += measurements[i-1].
                      coffeeMaker;
71                measurements[i].vacuum += measurements[i-1].vacuum;
72      }
73
74      var d3Data = [];
75      for(var i = 0; i < measurements.length; i++)
76      {
77        d3Data.push({x: i, y: (measurements[i].totalConsumption()/3)});
78      }
79      return d3Data;
80    }
```

Appendix D

Test and Interview Transcripts

All transcripts use a dramatic script form, where one line is one person's turn in the conversation. Overlapping speech is indicated with an equals-sign (=). The test conductor's speech is in italic type, while the test participant is in normal type.

The transcripts are written in a denaturalized style, although (longer)s and cues in intonation that do not translate to writing are indicated, such as (jokingly) and (ironically).

An Open Coding process was employed to categorize information. The final codes are written inside [brackets].

The transcripts are rendered in English, but the conversation took place in Norwegian. Translation was done by the project author.

For the tests with John and Greg there were two test conductors, while the remaining four tests were conducted by one.

D.1 John

"John" was a participant who got the phone for feedback. He put it on the counter, as that was natural to him - not carrying it in his pocket when he is home.

1. Heater and spots and...
2. *TV*
3. The TV is on?
4. *Yes*
5. Right. So, the spots can stay on, but the other things I can really just turn off right away. That's the first thing that comes to mind. [planning]
6. *Yes*
7. At least when I have to reduce the load. [planning]
8. *Turn of everything but the lights?*
9. Yes
10. *Yes. So you do that now then?*

11. Yes
12. *Yes*
13. Then I begin with the stove. Do I turn it on, or? It works, right?
14. *It works, yes, you can turn it on.*
15. I have a certain ballpark idea of when it is done. 250 degrees Celsius was it? Or was it 225? [planning]
16. *25*
17. Oh right, it says so here. Then I guess I can make some coffee as well. (jokingly) Exciting moments! Watching TV?
18. *Are you?*
19. No, I turned it off when we started.
20. *(jokingly) But you're watching the TV. Watching a turned-off TV.*
21. Yeah. There aren't even any buttons on this panel thing. What's up with that?
22. *I think they're under there. Have you gotten a look at these (sheet with the effect for the appliances) then? I should have taken this away before we started, you don't really have access to this =*
23. Ah, ok!
24. *= during the test.*
25. I get why it smells like burning in here, the stove bottom is filled with crumbs and food.
26. *People have eaten a lot of pizza here. I swear, I heard it from people sitting in the Bachelor student's room last year and this year. Now they're thrown out I think. I know I'm not supposed to affect the test, but none of us are watching TV. For god's sake, it is inconclusive. (TV is plugged in at this point, but as far as the test is concerned it is off)*
27. *Should I turn it off?*
28. *I mean, I reckon it's a factor. He doesn't know himself if the TV is on. Not that I think it has such an impact when it comes to electricity consumption.*
29. TVs actually consume quite a lot if you let them stay on. Just imagine, at least with slightly older TVs, if you touch the back of them after a while, they get quite hot. Pretty high heat coming from TVs. [aware]
30. *You have to say that you turned off the TV*
31. *He turned off everything but the lights at the start*
32. *Oh*

33. Yes. I did say that at the start.
34. *Oh. I caught that you said lights.*
35. That's fine I guess, I still shouldn't be over 5000, so. [aware]
36. *Wait a minute, so he turned off everything except*
37. The spots
38. *(sighs) Oh Jesus.*
39. (jokingly) Did you fuck up?
40. *That's fine, I have it in my notes, so I can just adjust the timestamps in the data afterwards. That's OK. This is also why we record video.*
41. This is, I have worked a lot with this before, with effect conservation and things like that, and I've had a watt meter in my home to play a bit with it and keep the load down. And that is a big thing where you know appliances - like, if you want to do more things at once then - yeah - spread it out a bit rather than getting it all done in fifteen minutes. At the same time, reducing effect is, at least in companies, it usually entails an increase in consumption. [aware]
42. *Oh?*
43. Yup
44. *How does that work?*
45. Take for example the University College, the building here. They have - what is it, three? - three electric boilers each at around - let's say 10 kW. I don't quite recall.
46. *Mhm*
47. And they have three boilers, and they start them simultaneously. That's 30 kW in starting load. If you want to reduce that load (message arrives on phone) hm? (Goes to check the phone) (Gives thumbs up). Now the coffee maker is done. The point with controlling the load is to start the boilers - since the starting load is high before falling somewhat - the University College had a load peak over the course of a year - 10 kW is way too little by the way - had a load peak over a year of about 4000 kW! Or something like that, ridiculously high. That was because of three electric boilers, I think they were 900 kW each or something.
48. *Mhm*
49. The point is, they started them each simultaneously once, and ran them one hour in - what - February I think it was, with a ridiculous peak, and they paid to be able to reach that peak the whole year round. What you can do instead is, okay, boiler number one starts three hours earlier. Boiler number two one hour after the first, and the third boiler an hour after that. That peak is then reduced by a third - or not a third, down a third perhaps? [aware]
50. *Mhm*

51. So you save a great deal through the year, but on the other hand you run those boilers for longer, so the consumption is higher.
52. *Aha*
53. You increase consumption over time, but reduce the load. The only reason to do that is to not have to upgrade the grid so it can carry a large load, because that's where the problem is, but if you talk to environmentalists - they hate that solution, because it increases energy consumption and that's not good. There you have two opposing views.
54. *Hm. .*
55. (Is thinking for a while)
56. *(jokingly) Should have spoken with you a long time ago!*
57. Hehe. Yeah, let's vacuum a bit, that's something we can do.
58. *That's something we can do, yes*
59. (Puts towels in the washer. At the same time, a notification arrives on the phone, which is not heard by John.) Just putting these in here, I'm not turning on the washer now.
60. *The cleaning ladies will probably be happy if you actually vacuum, but you don't need to plug it in if you don't want.*
61. Well, if you're going to vacuum there has to be sound! There is power on isn't there?
62. *Yes*
63. All right (Proceeds to vacuum). I don't know how long you vacuum
64. *No, it's like =*
65. The point is to up the effect isn't it?
66. *= yeah*
67. *(jokingly) We can do the test at my place next time*
68. Well, if you'd be satisfied with that job, then!
69. *Looking at the time now, the stove's been on for ten minutes, so five minutes ish until the stove is done*
70. The plan now is that I won't start that (washer) until this (stove) is done. [planning]
71. *The coffee maker was also done quite a while ago. Did you get that?*
72. *Coffee maker off, yes? I did.*
73. Whoo! This (stove) is heated at least.
74. *OK, so. Just now? Just now it's done?*

75. Yes
76. *OK*
77. Or, just now it's heated.
78. *Yeah*
79. Took a bit longer than expected
80. *Happy with the pizza then?*
81. *No, now the pizza is put in the oven*
82. Yes
83. *So then we'll be at 23 by the time that is done*
84. Then you have a problem with 45 minutes
85. *Then we'll say that you're faced with a choice*
86. (laughs) Wet clothes or =
87. *Either you are somewhat delayed...*
88. = Wait a bit now (points at the washer)
89. *That runs for half an hour. So it may be that we misjudged the time it takes for the stove.*
90. No, that (washer) was 2300, wasn't it?
91. *Mhm. Or yeah, ballpark.*
92. I don't know what you planned, with regards to time
93. *I planned 15 minutes-ish*
94. OK. I use the grill setting at least.
95. *Well, you turned on the stove at 44:30-something*
96. (John frowns)
97. *Or, pretty much right away*
98. Yeah. 44?
99. *44:30 remaining*
100. Ah, OK
101. *Yeah, I count down, so. If we say the stove runs for 15 minutes, from start to finish*
102. Yeah

103. *So it's the same for everyone*

104. (John checks his phone. It erupts in messages.) Hey! (John picks up the phone and unlocks it)

105. *What's up with that thing?*

106. Don't know. It was a lot (looks puzzled at the phone). I wonder if this is an old message, cause now it says 75W of 5000W. But that wasn't a message that came now, it came when I pressed "Back".

107. *OK. . Those might be messages from testing during development that just lagged behind =*

108. Yeah

109. *= and decided to show up.*

110. Something you made?

111. *Yeah*

112. Cool

113. *Could just as much be the network as a queue*

114. *Mm. Google keep messages that I send to the phone, and then push them when the phone is available. So if the phone has been disconnected for a while, and I have sent messages, then, well.*

115. So, the idea behind this test, is it to see planning of time, or planning of load?

116. *Uhm, like =*

117. Like, in an ordinary scenario you'd have those extra fifteen minutes, if load was what you planned for. At least that's what I think. [current behaviour]

118. *No, uhm =*

119. No, doesn't really matter, the washer can just keep running after I have left, no problem. [current behaviour]

120. *What I'm after is your thoughts on how it is to get feedback, the user experience, not how "well" you do.*

121. No, no. Well, then I can trigger, uhm, trigger that it gives me a message, we can do that. Because now I just try to stay clear of those messages. I mean, the one I got was like, your consumption is 3800W of 5000W, you're staying clear. But, I mean, I can trigger the threshold if...

122. *No, just do things like you would have done, to get it a bit realistic in a way, so. But now the stove has been on for slightly above fifteen minutes, so we can =*

123. Yeah

124. *= say that the pizza is done, so you can turn it off if you want.*

125. Then I'll do that, so (notification on the phone) I can start the washer, for example. (checks the phone). Yeah. I just got a message about having low consumption, 75W of 5000W, which is a bit odd since the spots were 50W each. [planning]

126. *Yes, that is a bit odd. Bugs!*

127. Heh. At the same time, when I had the app open and it ticked in it didn't show in the app. I had to close the app and open the notification.

128. *That is an on-off bug, I'm not sure what it is.*

129. Yeah, just - feedback

130. *Mm, (jokingly) it's a feature*

131. Haha

132. *But now you turned on the washer?*

133. Yup

134. *OK*

135. Uhm, can you, like, add a feature here where I can push a button and get the current consumption? [feature request]

136. *I'd love to discuss that with you later*

137. OK

138. *Now you turned on the washer*

139. Yes

140. *Will you make any changes until it is done? Because that is the final task, or what-have-you.*

141. No

142. *No? Then we'll cheat, and push the fast-forward button. Instead of waiting for half an hour we simply say that this situation repeats itself until the test is done, so press stop test.*

143. *OK*

144. *OK, great. Now, it would be great if you could sit down here, and I'll - if it's OK with you - move this camera to capture the =*

145. That's OK

146. *= conversation on tape.*

147. Just include the face if you feel like it, doesn't matter to me

148. *Yeah, OK. Let's see, I just need this, my notes. Yeah. If you would please say a few words about yourself, how old are you, I know you are now studying, and that you have worked =*

149. In the industry

150. *= in the industry and have some inside knowledge in that way.*

151. Yes. Don't need the name?

152. *Hm?*

153. You don't need the name?

154. *Well, you can say that as well.*

155. (laughs) Well, my name is John, I am 29 years old. Currently studying, I used to work for an electrical grid maintainer, and in a software company specializing in software for the power industry. The former company were grid owners and maintainers, as I said, and we worked - among other things - with measuring consumption. [industry experience]

156. *Yes. So, you are pretty familiar with the whole concept here, so we may not have to go into too much detail on that. You have an education in IT.*

157. Yes

158. *So, the next question or subject is perhaps a bit given - how do you feel about technology? How does it affect your everyday life? Phones, gadgets, PCs - something you use a lot?*

159. Yes. Gadgets are always fun. [electronics]

160. *Would you call yourself a gadget person?*

161. Medium, perhaps? I get, if I find something I like I get stuck in that. I don't get the newest after three months. [electronics]

162. *No?*

163. I don't

164. *No. New things like wearables - Jawbone or what it's called, workout bracelet.*

165. No, don't know of it [electronics]

166. *But you're at least accustomed to technology, you use phones and PCs every day*

167. Yes [electronics]

168. *The next topic, which you also are very familiar with, is electricity. Something you know inside out I'd presume. You mentioned that you had a watt meter in your home and played a bit with that.*

169. Yes

170. *How was that?*

171. The device itself was really pretty simple, not that accurate. What it measured was - it started with a stable current, at 230V, and - yeah. What it measured was resistance at the main. You had three magnet clamps that you put on and around, what really were transformers , that the company I worked at offered for a time. [electronic assistant]

172. *To all customers, or?*

173. Yeah, to all customers who had, well, for a price

174. *OK*

175. And that was, you put this thing on in your fuse box, and it sent values to a display you had inside that showed the current watt value [electronic assistant]

176. *So this was shown on a small screen?*

177. Yes

178. *Where was that screen? Was it attached inside the fuse box, or?*

179. No, no. It - the kitchen maybe? - it was wireless, so I could have it anywhere. [electronic assistant]

180. *Ah, OK*

181. So Yeah, I could have it anywhere. Kitchen counter, wherever I wanted. In addition, the screen had a USB-port, so I could connect it to a laptop with some software stuff, so I could download data, and upload stuff like the price for electricity to calculate what things would cost. This is, what, four years ago? [electronic assistant]

182. *Oh, that much?*

183. Yeah. So I played a bit with that one time when I borrowed it from work. [electronic assistant]

184. *Did you notice any effect by using that?*

185. (laughs)

186. *Or did you sense any effect?*

187. Consumption rose maybe? (laughs) I thought it was fun to play with it and play with numbers, and with the display, to see what I could get from the fuse box (laughs). [electronic assistant]

188. *So your goal was to max out the fuse box? (laughs)*

189. Well, at least to see what I could get from it

190. *So, after this measuring thing, to call it that, would you say you became more conscious about your consumption?*

191. No

192. *Not?*

193. No, a bit because I know my consumption so well already. I, before I worked for the grid company, had summer internships at a different company measuring electricity consumption. So I've worked in the industry for fifteen years, in one form or another. [aware]

194. *Yeah*

195. So

196. *So it's something you're conscious about*

197. Yes

198. *Let's move to what we've been doing today. How did you feel the test went?*

199. It worked well. I think so. It gives a... Of course you go into the test with a mindset that you should keep the effect down, so you think a bit about how you should do things ahead of time. If you had given me those tasks without the sheet with the effect of the different appliances, and just told me that within 45 minutes all this has to be done, and said these tasks take so and so much time, you'd get completely different results. [planning]

200. *Mm. That much is clear, and the reasoning behind giving you that sheet is that, I imagine that in the beginning when you have an agreement with you electricity provider where you have effect-based billing, at least in the beginning you are going to be more conscious about it.*

201. That's true

202. *So that's why I hand out that sheet and say that is the goal for the test. . Did you feel stressed at some point during the test?*

203. No [confident]

204. *Not even when like five messages ticked in?*

205. No. It might have something to do with the fact that I - I don't really like saying this on tape, but - I'm a "miljøsvin" (literal translation: environment swine, describing someone who is not particularly concerned with the environment) (laughs).

206. *(laughs) OK?*

207. I give heat to the birds, I use power, I know that Norway has the world's cheapest power, and I know Norwegians whine about it, but no other country comes close. So I use power, and I feel comfortable. [confident]

208. *So the fact that something is nagging you about having passed a threshold that doesn't affect you?*

209. That won't really have an effect until they implement some kind of throttling, if you are familiar with that concept [external influence]

210. *That, I haven't =*

211. Effect throttling

212. *= really seen that as an option anywhere. It's rather been - at least in Fredrikstad Energi there's been talk of having a fee for what you consume over the threshold*

213. Yeah. It's been talk of throttling as well, but. Especially, or perhaps mainly against those who don't pay.

214. *Yeah*

215. For them there's been talk of setting the maximum effect to 2 kW

216. *That's not a lot*

217. If you go above that the main fuse trips. That's an idea that floats around the industry. 2 kW or 3, depending on the season and so on. It's varying, but yeah. [external influence]

218. *So you feel that some external influence, be it a display, or a phone that sends messages - it won't really have an effect on you until you really feel it?*

219. Well, of course if you see it in relation to price in that app, and show it immediately how much this costs or how much you can save by turning off the stove for instance. Until that comes I feel it becomes too abstract. Like, 5 kW, what does that entail? But until the price for that effect-based billing, until it becomes known and visualized, I think... It will be a nice reminder for some, but most will just keep using power like they have. [cost]

220. *Speaking of visualizations, here we have your graph, your consumption graph, as it has been logged. Here you have at least a visualization of how the consumption developed during the test. At the end here it gets lower. Here we probably see the gap between the stove and the washer. If you had something like this, a report such as this, available each day where you see - here you're above, and it costs you this much.*

221. Weekly would be better

222. *Yeah, or weekly*

223. Daily would be spam

224. *Mm. But anyway, say you get a report like this. You get a visualization of where you've been above the threshold, and what it has cost you. What effect would that have on you?*

225. A larger effect, at least in terms of communicating the effect - that's what this is about, what the peaks would have cost me - so getting a report on what it actually costs me, what the bill actually will be, that's probably what would make most of an impact on me. [cost]

226. *Money talks?*

227. Yes

228. *You had the phone on the counter. And at least once that I noticed, when you were vacuuming, where the phone received a notification - it vibrated and made a sound - and you didn't notice. The phone remained on the bench.*

229. Oh. I didn't even hear it.

230. *No. And it demonstrates a problem. The idea with having the app on a phone is that the phone is a device that, most of the time if not all the time, is close to you.*

231. Yeah

232. *But then you get home, and you throw things off you, and now this bloody phone isn't going to bug me any more, so I put it somewhere away.*

233. Right

234. *So in that case, the premise for this will be somewhat uncertain. People are different. I, personally, always have the phone within reach. But these notifications that you did notice, how did you experience getting that feedback? You mentioned earlier that there was a "miljøsvin"-attitude.*

235. Well, I mean, it was fun to see. I expected maybe a... Well, it was fun to get. Of course in a, say - I had maybe though that I should get a message when I reached 50% of the threshold. Could be more relevant than at 80%. Then you actually have some wiggle-room. 1 kW is a bit, you can do a few small things, but on 2.5 kW you can actually do quite a bit. And that I'm down to almost no consumption? I kind of know that when the house is dark and there's nothing on. It's a given. [relevance]

236. *So that's not as interesting?*

237. No, not quite as interesting. Say you're going to bed. You know the washer is off, stove is off, everything is off, lights are off and all that. And you go to bed =

238. *(mimics vibrator)*

239. = you know, exactly, you know your consumption is low. But of course, when you get close to the threshold, 80% is of course valid. The one where you've reached the threshold I didn't get. [relevance]

240. *No. Likely lost in translation. There were two cases I think where you got more than one message at a time.*

241. Yeah, I don't know. Let's see, that vibration you may have heard was me pressing these buttons here (home, back, menu buttons). The messages I have seen were three. One for low, one for getting close to the threshold, and one for being low again.

242. *OK*

243. So if more have been sent, it lacks sort of a log or some thing like that [feature request]

244. *OK. Well, if you received a message that said you were using too much, now you pay a fee until you go back below.*

245. I probably would have made some changes to get back below. I assume then that the moment I got below the threshold I would get a new message that would have told me I had gotten below. [persuasion]

246. *Yes. You mentioned that the low consumption message was a bit given. What do you think about the number of messages like this? This was obviously a relatively short period of time.*

247. Well, looking at it like that, if over time you get a lot of messages, at least it's contained to one app. So it doesn't really matter. Then again, the message at 50%, not all that important. As long as you get a warning when you are getting close to and above the threshold, and when you go below again. That is probably the most important, because it's there people start caring, when the fees start. Only then do you spring to action. So maybe do some adjustments to the thresholds near the top, for messages, is more important than the ones further down. [cost]

248. *If your electricity provider offered a tool like this, would you see yourself using it?*

249. Yes. I'd use it. [mobile assistant]

250. *Anything you'd like to have in such an app? You mentioned a button so the current consumption would be sent whenever you wanted to.*

251. Yeah, some form of refresh button, or get consumption now, would be interesting. [feature request]

252. *That, and a message log for those of us who put our phones down*

253. Yes

254. *I had another participant here two days ago, where we did sort of a dress rehearsal. He lives in a house with three other people, friends, not close relatives. We spoke about how it would be for him if he got a message when someone else did something to put the house over the threshold. Say you lived like that, in a family home, or lived with someone as a family unit.*

255. Families I don't see a problem with. There you at least are one unit. If someone in the family uses a lot, it's more the principle that he/she shouldn't be doing that in the first place, than that I get a message. Of course that depends on the effect-based billing, how that works, with price and threshold.

D.2 Greg

Greg performed the test without the application.

1. *And we're rolling*

2. OK. Let's see here. I guess I'll turn on the stove. Do I do it for real, or?
3. *Do it for reals*
4. OK. Let's see, that was five minutes for pre-heating and...
5. *Yes, the time is?*
6. *44 minutes remaining. 14:30.*
7. I guess just set it (alarm on private phone) to fifteen then
8. *Yeah. It's now 14:28. So, about a quarter past is when the stove is done.*
9. Yup. Oh, and let's see - everything is on. Hmm, everything is on. Right. Not the washer I presume, but still.
10. *TV, spots, and heater is on.*
11. Right. The TV I think I can live without for now, so I'll turn it off. And the heater, I mean I can plug that out. It's plugged out already I see. I turn off the heater, (jokingly) because the stove is hot. . So yeah, the plan now is that I turn on the coffee maker at the same time as the stove, and I'll vacuum when I'm washing clothes afterwards. (puts on the coffee maker). Are you getting log data for this stuff? [planning]
12. *Yes. Not automatically though. That's why I get help from my assistant here.*
13. *(jokingly) I'm the key-logger*
14. By the way, I assume that the stove uses more power than the washer. Might be I recall that wrong, but yeah. That's what I'm thinking, if you want to know. So that's why - I mean the coffee maker probably uses less electricity than that (vacuum), but I'm not quite sure. I mean that (coffee maker) gets hot, while that (vacuum) just sucks. Don't know. Coffee maker is usually at 1000W though. And here (on the vacuum) it says 1500. [planning]
15. *What do you think your consumption is right now?*
16. Now? Now I think I'm just below the threshold, or I have a decent margin I think. Like, I think I might have been able to turn on the heater, but then I'd be pushing it I think. Kind of a bad deal this. I guess you get that peak down at least, on the grid. [uncertainty]
17. *We'll see if it has any effect, we can discuss that later*
18. I have to start the washer pretty quickly after the stove is done [planning]
19. *Should have had some kind of TV show on, that we could watch, so that it would be more of a desire to watch TV.*
20. *Yeah?*
21. Yeah, if I had been home and not with that threshold I'd be watching TV right now and just relaxing until the food was done. [current behaviour]

22. *If you didn't have that threshold? If you did have a threshold, what then?*
23. I'd still have it on I think. I mean, when I don't have that threshold, I turn on the TV.
24. *Right. But if the TV had cost you twenty NOK extra per minute =*
25. Then I'd not have it on [cost]
26. *= then you'd not have it on.*
27. (jokingly) Depends on how good the show is
28. *(jokingly) If it's Game of Thrones or something?*
29. (jokingly) Ancient Aliens! . Or just skip the coffee
30. *(jokingly) What?!*
31. But since I have to have coffee here
32. *(jokingly)Yes, coffee is a must*
33. (jokingly) Coffee and "noe attåt", something else
34. *(jokingly) Would you like a pizza Grandiosa?*
35. You could see an increase in board-game sales though, with a threshold like this
36. *Yeah. (jokingly) Conspiracy! To get people away from video games and on to board games. (coffee maker starts to make noises). That (coffee maker) seems to be done.*
37. Actually, I wouldn't turn it off right away. If it's just me, and I make this much coffee I'd leave it on to keep warm probably. [current behaviour]
38. *Did you turn it off now, or do you leave it on?*
39. I turned it off now
40. *We'll say you have a Thermos*
41. *Did you turn it on again?*
42. I turned it off now. (checks his watch). That leaves seven minutes. I think I can vacuum before the stove is done. Do I vacuum for real, or? [planning]
43. *You can choose to just move the vacuum around, or you can plug it in.*
44. OK, then I'll do that. I'm thinking - because this thing uses, if these numbers are watts, which I find likely, this uses 0.5 kW more than the coffee maker - I'm still below the threshold, or I should be. [planning][uncertainty]
45. *So now it's on?*
46. I turned it on now, yes. (jokingly) This is how it looks when I vacuum! Rarely do I vacuum behind the stove.

47. *(jokingly) You don't do that every time?*
48. (jokingly) Should perhaps do it more often
49. *That was you done with vacuuming?*
50. Yes, short work made of that
51. *Small house, little dust*
52. There. Now, let's see. There's five minutes until the pizza is done. That just leaves the washer. That will have to wait. So, five more minutes. [planning]
53. *What's the time showing now?*
54. *Thirty four*
55. *Thirty four minutes left*
56. I can turn on the TV though
57. *Right, turned on the TV*
58. Should have had a Raspberry Pi with media center
59. *Should have had that, yes*
60. *Is it possible to fail this test, I wonder?*
61. *No. Nothing is considered wrong here, really.*
62. You mean the test? If it's possible, or likely that people go over?
63. *Yeah, well if. I mean, if there's an overlap between the stove and washer for instance.*
64. Speaking of, I doubt the washer uses constant power
65. *It doesn't. Or, in this test world it does. Very simplified world.*
66. (alarm rings on Greg's phone). Now there's pizza for everyone! [electronics]
67. *Yay*
68. And then I turn this (washer) on. It's not hooked up I presume?
69. *No*
70. All right, then I turn that on
71. *It's on now?*
72. Yes
73. *It runs then for a half-hour*
74. Half-hour yes. Then I've done everything I guess.

75. *You're done with all the tasks, yes. Would you like to do some changes for the rest of the test? Or does that (washer) run it's course and then you're done?*

76. I think I'll sit and watch TV while it's (washer) on, yes.

77. *Then we'll say that the test is over, and we'll have a chat, so I don't know if you'll want to sit in that chair over there, and if it's OK if I move the camera to get you in frame*

78. That's fine

79. *I'll be off then, just call if you need me*

80. *Do that, we're done now with what I need help for, so, thank you very much for the help! (assistant leaves). Right, then I'll just need my notes.*

81. Do you need room on the desk?

82. *No, that's fine. Right, if you'll say a few quick words about yourself that would be great. How old are you, what do you do, what your name is.*

83. My name is Greg, I'm 22 years old, I'm a student and I work part-time at the College library.

84. *You study IT*

85. Yes. And I have IT as a hobby. Programming. [experienced user]

86. *Right. The first topic is just as fun to ask IT students every time, but how is you relationship to technology?*

87. Well it's very practical in many ways. At least when we can gain benefit from it rather than be exploited by it.

88. *You say practical, any examples of that, for your part?*

89. Well, an alarm clock is technology. Very few deny that. Or, I mean people like their alarm clock, to put it that way.

90. *(jokingly) Or, love/hate perhaps?*

91. True. Then you have writing, PC, so you don't have to edit things by hand. Would be hell to write a thesis then I suppose.

92. *Yes!*

93. Or just write anything really.

94. *Any gadgets in particular you like?*

95. Well, there's the gaming PC. My laptop, I have a few Raspberry Pis that I have set up as, well, I use them quite a lot. [electronics]

96. *Set up as what?*

97. As a media center and network storage, and one that I think like - it doesn't really matter if I ruin it by trying to add a sensor or something. I've tried a bit of that. Not a lot, but still. [electronics]

98. *OK. So you could say you are pretty familiar with technology, in different forms, shapes and sizes*

99. Yes. (jokingly) It might be that I use more time with technology than people. [experienced user]

100. *(jokingly) Might be that I find myself in that situation as well. When I say electricity, it's not a given that everyone is as experienced with that as John that was here. He's worked in the industry for fifteen years. But is that something you have a relationship to?*

101. Yes. I went to high-school as an aspiring electrician, or electronics guy. So I've had quite a bit of theory about electricity. Then there's the Raspberry Pi stuff I dabble with on my own. So I know what a kW is, to put it that way.[aware]

102. *Right. This has been on like a household level, right?*

103. Mostly micro electronics, but also like how much an appliance needs to run, like from the grid. I ordered a PSU for my PC, it's like 1000W. So I have a relationship to it. Maybe more so than most. [aware]

104. *You mentioned your PSU, and that it took 1000W. Do you think about the cost of it?*

105. I tried calculating it, but it doesn't need 1000W unless I play or push the PC to the max.

106. *Yeah, it's like a theoretical maximum*

107. Yes. And I think it's like that with a lot of things. For instance if you have a heater it won't use as much all the time

108. *No. Or the washer, like you mentioned.*

109. Yes, exactly. The centrifuge will probably require more.

110. *And the heating of water and such. So there's not a constant, really, with anything. Maybe with the exception of a heater when it's on, but then there's the thermostat and all. But you do consider the cost then?*

111. Yes [cost]

112. *Do you pay your own power bill?*

113. I do. I got a bill here now actually, 1600 NOK for two months, and I've hardly ever been home. I do think about it, but I prioritize being warm, rather than being home freezing and not getting up. [cost]

114. *Yes. Do you consider - because now there's this whole green wave - do you consider the environmental aspect when you use electricity?*

115. Not all that much. I do that more when I use my car. I mean, in Norway we have very much hydro-electric power. And even though we buy foreign power I mean - we have hydro-electric power and then you settle with that thought, and are happy and with a clear consciousness.

116. *I recognize myself with that statement. Right, how did you feel the test went?*

117. Good. I don't think I got any fees. Can't say for sure though, but I don't think so. [uncertainty]

118. *No? Here we have a graph of the logged data.*

119. Oh, there we have a peak

120. *Now, unfortunately we can't see exactly what was on at that time, =*

121. No. Relatively early though.

122. *= a small peak where you go above 5000, but that is minimal.*

123. It might have been before I turned off the TV. When I turned on the coffee maker but didn't turn off the TV

124. *Well, here I see that, before and after, it says that there's a difference of almost 1000W, so it might be . What can that be? You know, I'm not sure. But anyway, you kept under the threshold very well. At least to not have any aid during the test. You had an idea of how much you were consuming, and you planned ahead. Speaking of having a plan, did you ever feel stressed?*

125. Yes, somewhat, when the pizza was done. I was a bit stressed to stay within the 45 minutes, so I had to turn on the washer immediately instead of sitting down to enjoy my pizza.

126. *So it was the fact that you had limited time that was stressful?*

127. Yes. But also that "fear" to go above the threshold. Less relaxing, to put it that way. Not like I was very stressed. [uncertainty]

128. *More like an uncertainty, perhaps?*

129. If I were to go though a whole day with that feeling, I don't know. [uncertainty]

130. *So if you were to have this kind of deal, effect-based billing, you'd want some form of feedback, be it a display, =*

131. Yeah, it could just be a simple message =

132. *= or an app on a phone*

133. = on a display or something [electronic assistant]

134. *Right. OK. Could you see yourself having something like that on your phone?*

135. Yes. That would be cool. [mobile assistant]

136. *What would you want from such an app?*
137. Just monitoring would be fine
138. *Just like a, you are now using so and so?*
139. Yes. Maybe a view of past data, like a graph. I hadn't really needed anything else. [feature request]
140. *If you had such an app on your phone, and you received a message - you are now above the threshold, now you pay a fee until you go back down again.*
141. Efficient, probably. I'd go and turn things off. [persuasion]
142. *You would?*
143. Well, if I knew what it was. If it was the water heater that decided it was time to run I wouldn't be able to do much, but otherwise. [ability]
144. *Right. That's it for my part. Thank you very much for your time!*

D.3 Harold

1. *I'm pressing Start Test now*
2. (turns on the coffee maker) The question is what do I do first? Do I make food, or do I? I'm turning on the stove. [planning]
3. *You're turning on the stove?*
4. What did I have to put it on again? (checks the task sheet) . That had to be on for fifteen minutes?
5. *Yes*
6. Yes
7. *I counted now 44 minutes left when you turned on the stove, so when that is at 29 the pizza is done. Du you have a watch?*
8. No, sorry, I left my phone.
9. *All-right, mine is seven now (gives the phone to Harold), so when it is 19:15 it's done*
10. So, if in my head I'm thinking that I'm saving power I sit and watch TV in the mean time. Since the TV is on.
11. *Yes, if you want to watch TV while waiting for the food to be done you're doing that now.*
12. For I have no option to - I could turn off the TV, right?
13. *You can turn off the TV, yes*

14. Yes, but then again I want to do something, so I'll be watching TV. So I just wait then, until 19:15?
15. *We can at least wait until the coffee maker is done, it's done in a few minutes.*
16. Yes
17. *Then we can fast-forward a bit in time, if you don't want to wait*
18. No, I'm just thinking what's best for you
19. *No, no, don't mind me at all*
20. Well, what I would have done, I would have waited - it's normal for me to watch TV while I'm waiting for the food. I wonder what the others did. [current behaviour]
21. *Yeah, we can discuss that afterwards maybe. You can sit down if you want.*
22. I suppose I could turn off - yeah, I'll just wait until this is done and then. That coffee maker was a bit awkward, it began pouring down the side.
23. *Yeah, that's OK.*
24. Sounds like it's done. I just turn it off then?
25. *That you may*
26. That is done then. Was there any time I was supposed to spend on that?
27. *No, no specific time, I just let it finish, I haven't timed it*
28. Well, that's done at least. Still waiting for the food though. (jokingly) My favourite show is on. You should have had a dishwasher as well.
29. *(jokingly) We wash by hand here*
30. Right, right. Saving power.
31. *We're so eco-friendly here. That's why there's a tumble-drier there.*
32. Right! I had to think there for a second.

At this point Harold and I discussed current events to pass the time.

33. *We need to watch the time here.*
34. Two minutes to go
35. *I see that it's 19:14-something*
36. Yes. So I can turn off =
37. *We'll say that =*
38. the stove then.
39. *= the stove is done then. You turn that off then?*

40. Yes. Do I just leave it closed?
41. *Yes*
42. Then I eat! I need the lights still, for that.
43. *(laughing) Yes!*
44. What would I do then? I had of course done the dishes, but that's done by hand here.
45. *We'll do that some other time*
46. I spilled something on my clothes.
47. *Stains on your clothes, yes?*
48. Yes. So I throw =
49. *Needs to be washed*
50. = them in here
51. *Yes. You turn on the washer then? That runs for half an hour, or the rest of the test period. So then it's just a matter of =*
52. Just =
53. *= yes?*
54. = what is natural to me is, now I've spilled on myself and the floor, so I'll do the dishes while the washer runs, I wouldn't - right, I'll turn off the TV.
55. *You turn off the TV?*
56. I turn off the TV. I'm cleaning.
57. *Then we'll turn off the TV. That leaves the vacuum.*
58. Lights I have on anyway, nobody turns off the lights when they vacuum. So, then I vacuum while the washer is on, because multitasking is my friend. Even if I go above the threshold I assume it doesn't cost all that much. [planning]
59. *Right, you accept that fee*
60. Yes. Then I vacuum until it's clean, I don't know how long that takes.
61. *Well, a minute or two perhaps?*
62. Yeah, there's like these corners and such, so five minutes perhaps?
63. *A minute should do it*
64. Right. I'm done vacuuming.
65. *Yes*

66. That leaves some minutes for that (washer). How long? Five?
67. *For the washer?*
68. No, for the vacuum
69. *No, we say that's done, now that you could have gone over the floors here in a reasonable manner*
70. Right. There's no big stuff, just crumbs from the pizza.
71. *Yeah, just a quick thing*
72. Well, now that (washer) is on, so I'll wait for that to be done while watching TV.
73. *While watching TV? Then we'll turn on the TV. And that runs until the washer's done? Then we are pretty much done with the test.*
74. Yes
75. *You have made dinner, made coffee, washed clothes - or is washing, and vacuumed. So, then I'll press Stop Test here, and then I'll just turn this (camera) a bit, so you'll be in frame if that's OK with you?*
76. That's fine, just show my good side
77. *While I find my notes, can you say a few words about yourself? Your name, age, and what you do?*
78. Harold, 23 years old, studying IT
79. *You study IT*
80. Yes
81. *That probably means that the first topic is a bit given. I assume you're no stranger to electronics.*
82. Mhm [electronics]
83. *Would you consider yourself a gadget person?*
84. Not really [electronics]
85. *Not really. But, phone?*
86. I have that, yes
87. *Of the touch-type*
88. Touch, yes [electronics]
89. *What do you usually have of apps and such on your phone? Like category, I don't need to know the exact names.*
90. Well, Facebook. That, and Google Chrome. That's really what I use the most.

91. *OK. So social apps, browser. Do you play any games on your phone?*
92. No, not really.
93. *No Flappy Bird?*
94. I have it, but I don't play it. I can't, I keep failing.
95. *Me too. I think my record is three or something. When I say electricity =*
96. Yes
97. *= do you have any relationship to it? Do you think about it in your day-to-day life?*
98. Well, I do think about how much I use, mostly with regards to electric heating. Turning off the lights and such. [aware]
99. *You turn off lights in rooms you're not in*
100. When I leave the apartment, I always turn off the lights. Mostly for safety. [safety]
101. *Like wall mounted heaters?*
102. Yes
103. *Thinking of fire safety then?*
104. Yes, mostly fire and of course consumption. [consumption]
105. *When you say you think about consumption, is it the bill you're thinking of? Or is there an environmental factor here?*
106. Money [cost]
107. *This test, how do you feel it went, like for your part?*
108. If there is a correct way to do this I don't know, but personally I'd say that this is the way I would do it at least.
109. *There is no correct or wrong way to do this. What I'm after is a somewhat realistic result, just like you would have done it, so your way is the right way.*
110. I know with some certainty that that (vacuum) and the washer on at the same time probably takes me over the threshold.
111. *OK. We can actually check that in the log data. It does not look bad at all. 5000, in the middle here, that's the threshold. We see you're above that two times. And that is - this here is seconds - so from around 100 to almost 400. 300 seconds, that's =*
112. Around when I watched TV perhaps?
113. *= two-three minutes? Anyway, a few minutes where you're above the threshold. And a small period here where you're over as well. But not bad at all, not bad. But yeah, what do you think when you see that result, considering how you felt that the test went?*

114. Like what I expected?

115. *Yeah*

116. Well, I pretty much knew, or I expected that that (washer) and that (vacuum) would bring me over, but I guess it doesn't cost all that much? [cost]

117. *Well, when above it would likely be a fee for each kW, and you weren't over by much, so it wouldn't have cost you all that much. During the test, did you feel uncertain?*

118. Like with what I did?

119. *Like, if you were kind of - what do I do now? I seem to recall once you said something like that, that you didn't know what you should do?*

120. Yeah, like what order I should do things in to keep the consumption. It's not like there's a label or something that I can see the consumption, so I just had to imagine a bit. That's what I was most unsure of. I did think that, I mean I could have turned off the lights in the room I wasn't in, but I thought that was just so little.Not really much else. The heater would be on. I like being warm. And I'd turn it all off if I left, so. [uncertainty]

121. *So it wasn't like - whaa, what do I do now?! - it was more like*

122. Like what is the most practical here now

123. *Yeah*

124. You go into it with the mindset that it's a test, so you think about what you would have done. But if - looking back - if it's me I would have forgotten to turn off the TV. So that would be on all the time. [current behaviour]

125. *Would you - if you had it like this, you pay a fee if you go above a certain threshold - would you have liked to have a tool of some sort, like a display to show - like, in the olden days they used to have this needle, this dial in the kitchen that showed the current consumption - would something like that be of use?*

126. Yeah. On the phone. [mobile assistant]

127. *Well, you know some of the background here, so that might be coloured by that.*

128. Yeah. But still, it's really dumb to go to the fuse box to check, so.

129. *Fredrikstad Energi have a pilot project in Hvaler. Instead of using a phone they have a display, a small tablet - 7 inch - that is dedicated to show electricity consumption.*

130. Where does that sit?

131. *It's wireless, so wherever. On the kitchen counter, the living room, yeah. If you had one of those, would you use a similar tool on your phone at all?*

132. If it was a reasonable offer when staying under, or if the price for going over was high, I'd be very careful. So yes, I'd take that offer. [electronic assistant]

133. *So you'd have it on your phone*
134. It would be simpler for me. Since you have the phone all the time, say if it beeps if you're getting close. [mobile assistant]
135. *Right. When you get home, where do you usually put your phone?*
136. Pocket. Oh, when I get home? I put it on the table.
137. *By the PC?*
138. That's where I sit (laughs)
139. *Me too*
140. It's like my relationship with it. I bring it to bed when I sleep, and have it by me by the PC. [electronics]
141. *So it is close to you when you're home, and out and about.*
142. Yes. I've become better at taking care of it when I'm out, so.
143. *Right. That's it for my part. Thank you for taking the time to help me with this.*
144. No problem

D.4 Kevin

1. *So, if you're ready we can go ahead and start*
2. Right. (walks to the stove)
3. *So you turn on the stove?*
4. Yes. (goes to the coffee maker). (jokingly) You want actual coffee?
5. *No thanks*
6. I'll just let it run through then
7. *Yes. One thing I forgot to mention is that there are a few things that are turned on as the test starts, that counts. The lights, electric heater, and the TV.*
8. And the TV. Yes.
9. *So, you can choose to turn things off or on as you please*
10. (checks the TV). Oh it's on, just no image.
11. *Right. Let's pretend it's the news or something. And not everything is as obvious to me when you turn it off and on, so if you could say it out loud that would be great.*
12. Right. You got these (points to coffee maker, stove) right?
13. *Yes*

14. Some coffee before cleaning or vacuuming is a good idea I guess. Can we like talk during the test? [planning]

15. *Sure, we just have to make sure to keep the time*

At this point Kevin and I chatted to pass the time

16. (The coffee maker starts making noises, Kevin turns it off before heading for the vacuum. He proceeds to vacuum the floors.) Do I just leave it there, or?

17. *Yeah, that's fine*

18. (Kevin then checks how warm the stove is). Jeez, this thing doesn't get enough power it seems. Doesn't get warm

19. *That's fine. You started by turning it on, so we count fifteen minutes from then. Seven and a half minutes left.*

20. OK. (jokingly) Dinner's going to be nice!

At this point Kevin and I continued to chat while waiting for the stove

21. *And there the pizza is done*

22. Right. (Kevin turns off the stove and walks to the washer). Hm.

23. *That one's not hooked up*

24. Ah, OK. Click. It's fast.

25. *Not something else you were wondering?*

26. No, just that. Was thinking where the quick wash program was. Probably a bit weird to have water here just for that.

27. *Are you feeling done? Like, apart from the wash that's on.*

28. Yes

29. *So it's OK if we say that the test is done now, and that the current situation is duplicated for the remainder of the test period.*

30. Sure

31. *There's 29 minutes left now, so this would run then for the rest of the test, so.*

32. Yes

33. *Right, then I'll press Stop Test. So, if you could take a seat here or there, doesn't really matter as long as I can get you on camera, if that's OK with you.*

34. OK

35. *I just need my notes. Well Kevin, you're 24 years old*

36. Yes. I had to calculate that the other day myself, so yes.

37. *Right. And you are studying IT at Østfold University College, a Master's degree*
38. Yes
39. *So, it might be that the first topic is somewhat given, but how do you feel about electronics and technology? Do you have a lot of it at home? Something you use a lot?*
40. Yes, I use technology pretty much all the time. [experienced user]
41. *What kinds of devices are we talking here?*
42. PCs and phones mostly. Of course I use every typical appliance as well.
43. *Microwave, stuff like that?*
44. Yes
45. *But somewhat advanced electronics, it's phones and PCs*
46. Yes
47. *And you're pretty experienced using those (laughs)*
48. (laughs) Yes [experienced user]
49. *Would you consider yourself a gadget person? Say, like wearables like Jawbone, Arduino, Raspberry Pi and stuff like that?*
50. Well, I think it's interesting and all that, but I kind of feel it gets to be a lot of gadgets, so I kind of distance myself to it. [electronics]
51. *OK. So it becomes too much, you think?*
52. Yeah, and - you know - it's good to get away from it for a while. Like, if you put the phone away then that's enough. [electronics]
53. *Right*
54. So, with all other small gadgets it becomes like, you never get away [electronics]
55. *Right. Gets a bit tiresome after a while?*
56. Yes. I mean it has already. Like, you're always online.
57. *Right. So when you get home, you put the phone away, or?*
58. No, it's more when I feel I need a break. I feel that would happen more often if I had like wearables and stuff. [electronics]
59. *Something not everyone have the same relationship to is electricity. What do you think about when I say electricity? Do you think about that in your everyday life? Is it something you're conscious about?*
60. Well, I always try to think about it, and not use more than I need. [aware]

61. *So you try saving?*

62. Yes, but my consumption has never been very high. It's my computer that uses the most, like apart from what everybody does. Heating does take a bit of power, but I try keeping it around 20 (degrees Celsius), 18. Between 18 and 20 at least. It varies a lot, I live in kind of a funky house. But I turn off lights and try to run thinks like as quickly as possible. [aware]

63. *So you try saving power, like within reason.*

64. Yes, it's not like it should degrade stuff, but you can always save a bit. [conservation]

65. *When you do want to save a bit, is it for financial reasons?*

66. I've never had problems paying the power bill, to put it that way. [cost]

67. *No, but*

68. It's like, yeah a bit like

69. *Penny saved*

70. Yeah, a penny saved, and - you know, there's no point in throwing money away, having lights on in a room I'm not in. [conservation]

71. *Any environmental aspect with this saving?*

72. No

73. *Money rules?*

74. Well, it's sort of like a combination, looking at it as a whole, if I'm honest. Again, no sense letting it go to waste. Doesn't hurt anybody. In fact, good for everyone, perhaps except the power company. Or I mean, even for them maybe, what with the grid and all. [conversation]

75. *So a whole, then. Not just money, not just the environment.*

76. Right.

77. *Sort of a principle*

78. Yeah

79. *How did you feel about having to go around here keeping your consumption below 5000?*

80. A bit difficult to stay under 5000, because everything took a lot.

81. *Oh?*

82. I don't know if I went above, I might have with the vacuum. [uncertainty]

83. *So you felt the vacuum may have taken you over?*

84. Because the stove was on at the same time, plus the heater, lights, and the vacuum, so I felt like it peaked a bit there maybe. And it was a very unfamiliar way to think. Usually it's like, doesn't matter how high the effect is, as long as it gets done and can be turned off again afterwards.

85. *Yeah, like kWh is what we know, not just kW*

86. Right

87. *Yeah, it is different, different way to think. Did you feel uncertain? You did talk a bit about that you thought you went above the threshold with the vacuum.*

88. Yes, I did feel a bit uncertain. Like, I had the calculation sort of right in my head I think, and then I heard that the heater and such was on, so - but I don't think I was over by a lot. Just around the threshold. [uncertainty]

89. *Well, we can take a look actually. This is you (shows graph). And we have the threshold here at 5000.*

90. Yes

91. *So we see that you were slightly above here, and here.*

92. Coffee maker and vacuum then

93. *Probably, yeah*

94. Well, it was harder than I though then, looking at it

95. *You weren't over by much. Like, if there was no gap here, if these were overlapping, then we'd be talking. So the fees should be low I think, but you were over by a bit.*

96. Right. Surprising that I went over twice. I guess the coffee maker maybe took more than I though. [surprising]

97. *Well, it does take 1 kW, so that may be. But yeah, the result seems OK?*

98. Yes

99. *It went better than you thought, was that what you said?*

100. Well, I was pretty sure that it would be up there for a bit, but yeah, this shows that it pays to be patient, if this system becomes a thing.

101. *So if you weren't in a scenario like this, then you'd do things differently?*

102. Well, if I lived at home I don't think I'd choose a system - at least not with 5000, that's =

103. *No, 5000 is just an example*

104. = example, yes but it's a bit like - if I knew the threshold and didn't have limited time I'd rather have taken my time with this. Maybe just separated it all, just have some speakers on and listen to music while I waited. Because then - how to put it? - time becomes money in a different way. [cost]

105. *At Hvaler, Fredrikstad Energi are having a pilot project where they have this stuff running for a few customers, and the people out at Hvaler have the choice between a few product packages to help them manage their consumption and stay, hopefully, under this threshold. One is like a home automation deal, smart sockets that turn off at certain times of day. The simplest package is a display, a small 7-inch tablet, wireless, that they can bring with them around the house, that is only for showing the consumption as it is, it's dedicated. Do you think this test would have gone differently if you had something like that?*

106. Well, yes. Then I'd see that, no I can't use the coffee maker now. [electronic assistant][persuasion]

107. *So you'd postpone that, if you'd seen that if you used that you'd go over?*

108. Yes. It would have been like, I'd only to one thing at a time really. [persuasion]

109. *So, something that gives you feedback*

110. It would have helped if you had a threshold like that [electronic assistant]

111. *If you had such a monitoring thing on your phone that, in addition to that you could check yourself, had given you a message, for instance when you turned on that coffee maker and got above, =*

112. Like a warning

113. *= now you're above the threshold*

114. I think it would be practical in the beginning. But I - and like when you introduce new appliances - but apart from that I think you learn pretty quickly what you can do and not do. So it would mostly be when you introduce new appliances, like have it on in the beginning. [mobile assistant][learning]

115. *So like a tool for learning more than something you have on all the time*

116. Yes. I think so. Like, the notification bit. [learning]

117. *OK. That's what I had. So thank you very much for your time!*

118. No problem

D.5 Susan

Susan had the phone on her for the duration of the test.

1. *So, as I was saying - if you have any questions during the test don't hesitate to ask.*

2. Right

3. *Then I'll press Start here, and the stage is yours.*

4. Oh my (goes for the coffee maker, phone in hand). Then I'd turn on the washer.

5. *OK*
6. (message arrives on the phone, Susan checks it right away). Already? Dear lord. (Susan looks around at the stove and TV, looking like she contemplates the next move). I'm still turning it on (stove). (new message arrives, Susan checks the phone right away). Where do I turn off the TV? [persuasion][surprise]
7. *We'll just say that it's off now*
8. OK. That doesn't help does it, it's not the TV that takes much.
9. *It all adds up*
10. Turn the heater off as well maybe? [persuasion]
11. *Turn off the electric heater?*
12. Yes. The way I did things now I went above right away. Jumped over in one second (laughs). What I would do now is to wait with the vacuum until the coffee maker is done. And the stove was done. That's what I'd do. [persuasion][planning]
13. *Right. A bit of food and coffee before cleaning?*
14. Yes. Then there's the issue of remembering to turn things off.
15. *Right. You started the stove pretty quickly*
16. Yes, that's done at about 11:30.
17. *It's on then to about 11:30, yes. The coffee is done in a minuter or two it seems.*
18. Yes, it's done soon. I don't know how much (power) such a thing needs. Maybe I get a new message when it's done. (Susan checks the phone). Is this set up so that what these things use is what they actually use in a home?
19. *I got the values from Elkjøp, so it's roughly what it is , but here it's pretty simplified. For instance a heater won't use as much electricity all the time, just when it actually is heating. And a washer doesn't use its max all the time, there are pauses in the program.*
20. So this measures what it takes when you turn it on, its full effect in a way?
21. *Yes. It wouldn't be quite this bad in real life.*
22. Yeah, because that was incredibly fast. A bit scary, really. (coffee maker is making noises, Susan is by it and turns it off).
23. *That is done then. No, it is to make it a bit simpler to test, really.*
24. No, because that washer you can't really do anything about. It usually runs for an hour and a half after you turned it on. Well, if I had an app like this on my phone, then I'd maybe have the heater off, and wait with vacuuming until I was done with eating, then turn the heater back on after that. That's what I'd have done. [planning]

25. *But if you didn't have it, then*

26. I don't think about this [current behaviour]

27. *It's not how we pay for electricity*

28. No. But in Denmark it is a bit like this, isn't it?

29. *I don't know*

30. At least they have meters that make it cheaper to do laundry at night

31. *I know that in Britain they have different prices during the day and during the night. They still pay for kWh like we do now, just different prices at different times of day.*

32. Yes. That's how it is in Denmark as well, it's cheaper at night. But they ran into trouble with that, that people put on their washers at night, what with water damage and fires and the like. But I have to admit, I never consider this at home. Then again, we have an old house, so sometimes the power goes out, the fuse, if we put on too many things at once. So we may be a bit conscious about it after all, like subconsciously conscious. [aware][current behaviour]

33. *Yeah, like trying to not have the fuse go out*

34. Exactly, because to use the microwave and the vacuum down in the ground floor at the same time, we can't do that. So to vacuum I usually turn off the heater in the living room. I know that, if the heater turns on while I'm vacuuming then the fuse will go out. That's just because I don't want to go upstairs all the time and flip the fuse, and I'm thinking it may not be good for the appliances or the system that it keeps dropping out all the time. So we may have become very conscious about it because we've lived in old homes all the time. Because we don't have the same capacity in our house like there is in a new one. [aware][current behaviour]

35. *Food for thought, that modern homes may have too high a capacity*

36. Well, yes, you don't think about it I'd imagine. I noticed that when we lived in the apartment where we used to, because it wasn't like that there. Today that is a bit old, but at that time it was pretty new. So there you could use anything and everything and not think about the fuses going out. So of course, if you have that problem you may be more aware even if you don't actively think about it. So there are some advantages there (laughs).. But I have to say, it surprised me that it was so quick to rise in kWh (sic) [aware]

37. *Well, this wasn't kWh, but yeah*

38. Right, but when you turn on, it's a load that as well. It's not just what you use, but what load you put on the grid. I mean, I'd also but on the drier, you know? (laughs) I always do that. I always have a wash that I put in the drier, and then I put on a new wash. The drier probably uses loads. [current behaviour]

39. *Yes, that one's also a bit consumer. Probably around the same as the washer, but it's more constant I guess, since it heats until the clothes are dry*

40. Yes, it uses a lot all the time. So I'd probably be close to 10 kW then.
41. *Yes, if you'd have the stove, washer, and drier on at the same time. The dries isn't a part of this test though.*
42. No, but I'm thinking about home, I'd do that. That means you use more than you're aware of.

At this point Susan and I chatted for a while

43. *We have to mind the time here, the stove is done soon, and the washer has around fifteen minutes to go.*
44. Fifteen minutes to go?
45. *We can =*
46. Turn off the stove?
47. *= turn off the stove*
48. Fifteen minutes have passed?
49. *Yes, or close to it. (Susan moves to the stove, and gets a message before turning it off. She checks the phone immediately.). Now you got a message a bit early.*
50. Right. (Susan goes to the vacuum). And then I actively vacuum?
51. *You don't have to do that, but you'd do that now?*
52. Yes, I would do that now. Still with the TV and heater off, put on the vacuum.
53. *Right. Then we say that is on for around two minutes.*
54. Quick vacuum
55. *Small rooms*
56. Yeah

We continued chatting for the duration of the imagined vacuuming

57. That's two minutes, then I'd again put on the heater and TV, and sit down and watch TV while I was eating
58. *Right, then we'll turn on the heater and watch TV*
59. Yes
60. *Let's see, that leaves 12-ish minutes left on that clothes washer, so let's put that down. So, when that wash is done, what would you do then?*
61. Then I'd - well that depends on what's on the TV (laughs). Well, what I do at home is I turn the TV on to a radio channel. So the TV is on really all day, using power. I don't know how that is compared to our radio actually. [current behaviour]

62. *Probably it uses more than a radio. So then, when the wash is done it remains on?*
63. TV and heater remains on, yes.
64. *And lights remain on?*
65. Yes
66. *Then we're done, actually. I'll make a note here, that when this timer would have been around 15 minutes we turn off the washer, and the TV and heater remains on.*
67. (jokingly) And then we turn on the drier (laughs)
68. *Yes, exactly (laughs)*
69. I never turn off the lights
70. *Well, there's not too much to gain there either*
71. No, but when I saw how quickly that message popped up - it may be time to start thinking about it. Like the lights in the windowsill, they don't need to be on now in the day. [current behaviour]
72. *Then we'll say that the practical part of this test is over. We'll make some changes to the future and fast-forward a bit.*
73. Yes
74. *Then, if it's fine with you, I'll move the camera to get us in frame. Then there's a few questions and subjects that I'd like to talk about. Firstly, if you could have said how old you are, and your living situation.*
75. My name is Susan, I'm 45 years old, I live in a house with my family.
76. *How many live there?*
77. Three who live there, sometimes three more, and lots of visitors (laughs).
78. *I know you Susan, and I know that you like keeping up to date on the phone front, like following the news in that department.*
79. Yes [experienced user]
80. *Are there any other electronics that you have a similar interest in?*
81. Tablets, William! (laughs) [electronics]
82. *Tablets, right*
83. Tablets, PC, and phone, those I want [electronics]
84. *Nothing else, like TVs - not so important?*
85. No, that's not as interesting. I kind of want a Smart-TV the next time we buy one, but that's it. Not because I know what it can be used for, but I'm thinking it sounds smart (jokingly). [electronics]

86. *Well, nowadays you can't really get any non-smart TVs it seems, so*

87. Yeah

88. *But yeah, you're used to using phones and electronics, so it's not unfamiliar and difficult to you.*

89. (Susan shakes her head) No it's not [experienced user]

90. *So, when I say electricity, we've talked a bit about it now during this test, and how you do it at home*

91. Right

92. *And you say that, because of the fuse situation at home, you're conscious - or at least subconscious - about keeping the load down. Do you think about saving electricity?*

93. No, it's more so that the fuses don't trip. On the other hand, now these energy efficient light bulbs are used more and more, because the others have vanished. We don't have a shower-head that saves water I think. Then again, it's pretty new, so It might be more efficient than those old ones. I'd think so. But not any conscious decisions to save, no. [conservation]

94. *Right. How did you feel about the test? How was it to walk about here and get messages.*

95. Like I said I thought it was surprising, like I hadn't thought I'd jump so high up so quickly. I'd thought that, if I put all the big things on at once - vacuum, washer. The coffee maker I didn't think about, like with the load. So that surprised me, how high it jumped up in a few seconds. [surprise]

96. *What did you think when you got that message? I mean you were surprised, but anything else?*

97. I though, damn I should have turned things off (laughs). But the stove had to be on for fifteen minutes, and I had already started the coffee maker. But I thought, damn if I had thought about it for a bit I had (trails off)

98. *So you regretted your decisions a bit?*

99. Well, no, I'd maybe done one thing at a time, not all together. Maybe wait with the washer until I was done with the stove and coffee maker.

100. *Right*

101. And maybe turn off the heater before I started, so I had only used the things where I actually was. And not have that washer be on in a different room. I might have done that. But again, that might only have been if I had lost power, if the fuse flipped.

102. *Right*

103. I mean, I do this at home, I use the stove and coffee maker at the same time without thinking about it. But when you're reminded of it, then wow. [current behaviour]

104. *Yes. Then there's the whole - I mean now you don't pay for electricity in that way, so there's not any reason to do so, other than the fuse of course. But say you have it like that in, say, five years. The only thing the power company offers is a deal like this.*

105. Then you'd have to do things very differently, and then this (points at phone) would be very nice to have, to know. Because I am not so knowledgeable about these different appliances that I know how much they use, even if I know how many watts each thing takes I can't do that calculation on my own when I'm using it. I'd have to sit down and work out that calculation. So I think this would work as a good reminder, and that if the threshold is 5000 = [mobile assistant]

106. *That will vary*

107. = right, of course, but that's something we put in ourselves. But that you are made aware of it, because then you learn what you can do at the same time below the threshold. [learning]

108. *So a tool that helps you get a feel for what you can do*

109. Yes, and probably I'd do things differently, if that becomes the deal. And I'm like an app person, I like trying out new things, so I'd probably use this. I'd probably hook that up to the fuse box, and see. [mobile assistant]

110. *Right, that's one of the questions I was going to ask, but you imagine you would use this on your phone?*

111. I'd want it on my phone, yes, don't you think? (laughs). I am a bit that way (laughs). I have to try everything new, and yeah. If I had seen that this, in a way, helped me change how I did things, and that I saved money on that, I'd use it, no doubt about it. I'm a bit like that, I think it's interesting. And if you on top of that could save some money (laughs). Some advantages there and I'd definitely use it. [mobile assistant]

112. *Let's look a bit at your results. Here we have a graph. It'll be a bit off at the end here, since you turned off the washer at about fifteen minutes left. Here we have the threshold at 5000.*

113. Looking at it I'd probably want a message a bit sooner.

114. *Sooner?*

115. Yes. I mean, since it was that quick to go over, that it was that much that quickly, I'd want a message at - say, 3000?

116. *At about the half-way mark?*

117. Yeah, 3000 maybe. It was at 4000 that you got a message?

118. *4000 yes*

119. I'd like a message at 3000.

120. *So some form of warning earlier.*

121. Yes, I'd like that. But then, that is - as I'm saying - because I do things the way I do them, I turn everything on at the same time to be able to do other things. I mean at home I maybe would have vacuumed at the same time as everything, so that I could have eaten and relaxed when I was done. [current behaviour]

122. *Yeah, exactly*

123. So I'd want the message a bit sooner. Yeah, then you'd have a way to plan things differently. Like with something like this (points to phone) I'd learn pretty quickly, like when you turn on these things it's a good idea to turn off the TV, wait with - like do one thing first. Over time I think I'd change my routine, yes, with such an app. [learning][planning][persuasion]

124. *At Hvaler, Fredrikstad Energi are running a project where customers have this kind of deal. They have smart meters in their homes, and they have a subscription where they pay a sum each month and can use as many kWh that they want, as long as they stay below a certain kW threshold. If they go above it they pay an extra fee. And to help them stay below that threshold they have a small tablet. (jokingly) Unfortunately they can't install any apps or anything on it, it's dedicated to showing the current consumption, just like a digital version of those old dials you had in kitchens.*

125. Yes, that old dial

126. *Yeah, with some graphs and history and stuff like that. Do you think that would help you as well?*

127. Well, if the app was the same as that, because those messages were very nice, that it notified you. I liked that. The advantage of having it on the phone is that I can actually control a bit those who are home (smiles). I mean I wouldn't bring a tablet when I left the house. This (phone) I could bring with me and have an idea of - I mean if my daughter was at home with the heater on, used the microwave, vacuumed, did all these things at the same time, I could actually give her a call and say do one thing at a time, or at least limit yourself a bit. So I think I'd want to have it on my phone. I mean, I remember those old dials. I remember that we used to check it before we did things like turn on the stove, and it makes you more conscious, more than we are now. We don't have that now. If we didn't have that problem with the fuses tripping we'd not even considered it, and our consumption would be much higher, I'm sure of it. So for us it's become habit because of those fuses. Maybe I'd want both (laughs). [mobile assistant][electronic assistant]

128. *That would be possible (laughs). I didn't keep count of how many messages you got, but did you react in any way to the number of messages you got? You mentioned you'd like it earlier, but.*

129. No, what I reacted to was that it came so quickly, but of course since it's a new thing I did feel a bit stressed and wondered how to use this thing, but I was most surprised that it came so quickly. [surprised]

130. *Did you read any of the messages?*

131. Well I did notice that I was above, and that it was 7000-something, but I didn't see like if there were any suggestions to what you could do.

132. *No*

133. So I just read that I was above the threshold

134. *Did the wording make you react in any way?*

135. No. I liked that you saw in parentheses how much you were using.

136. *OK. That was what I had, so we can call it a day. Great that you could come, extremely helpful!*

137. (laughs) No problem!

D.6 Fiona

1. *We're rolling*

2. (Fiona goes to turn off the lights in the kitchen. This triggers a message, which she doesn't notice.)

3. *You turn off the lights in the kitchen?*

4. Yes. I'm going to wash clothes, so I'm not in the kitchen. So then I turn this (washer) on

5. *OK*

6. Right. While that is on I guess I'll vacuum a bit. (Fiona vacuums the washing room floor, then proceeds to turn off the lights in the washing room. She then moves to the kitchen and turns on the lights there. She seems to be contemplating her next move, before going for the coffee maker). [planning]

7. *(jokingly) If you want to actually make coffee you can do that*

8. Should I do that? (smiles) Or do I just turn it on and let it be perhaps?

9. *The water has been through that machine six times now, so you may want to change that water if you want coffee.*

10. (Fiona turns on the coffee maker, sans coffee) I'll sit down in the living room then.

11. *Watch some TV?*

12. Just sit down and collect my thoughts (laughs). Maybe watch some TV. It's on now right?

13. *Yes*

14. I like having some background noise while I do stuff

15. *Nice to have something to watch*

16. Yes
17. *(jokingly) Control signal cable is my favourite show*
18. (jokingly) It is pretty exciting. It's been better lately. It was a bit slow to begin with.
19. *(jokingly) Better towards the end of the season*
20. (Fiona decides to vacuum the Kitchen). Nice and clean. (the coffee maker starts making noises). Does that turn itself of?
21. *No*
22. (Fiona turns off the coffee maker). Maybe make some pizza for this coffee? (Fiona turns on the stove). I'm turning this on then.
23. *You turn on the stove?*
24. (Fiona nods)

At this point a message should have arrived, but it has not

25. *Does the phone have Internet?*
26. Huh?
27. *Is the phone connected to the Internet?*
28. (Fiona checks the phone) What, it's not? (Fiona unlocks the phone, and a torrent of messages arrive) Oh crap! (laughs) (Fiona checks the phone and the app)
29. *What does the last message say?*
30. You have gone past your effect threshold, turn off appliances if you can. Aaw, I wanted pizza. (Turns off the stove). (New message arrives on time, Fiona checks it right away). Yay! (laughs). I can't make pizza then. [persuasion]
31. *Well, that's your decision to make.*
32. I can make pizza in the dark (laughs)
33. *You turn off the lights in the kitchen?*
34. Yes. I'm in the living room anyway, so. The TV. (jokingly) I'll take in the view from the window. [persuasion]
35. *You turn off the TV?*
36. Yes
37. *Play some cards or something?*
38. Yes. (Fiona is fiddling with the phone). It won't notify me unless it's running?
39. *Well, yes, it's supposed to. I don't know if it turned itself off.*

40. I thought it was going to notify me, like vibrate or something.

41. *Yes, that was the idea.*

42. (Fiona turns on the stove again, which triggers a message on the phone. She checks it, and turns off the stove again, which triggers another message which she checks right away). (laughs) Can I turn on a lower temperature? [persuasion]

43. *I'm afraid not*

44. (laughs) OK

45. *The washer is just over fifteen minutes off from being done. You've vacuumed and made coffee.*

46. Yes

47. *And you're waiting with the stove?*

48. I'm waiting with the stove until I'm done with the washer yes. I can be so bold that I watch some TV while I wait.

49. *So the TV is turned on?*

50. Yes

51. *Need something to do for fifteen minutes, right?*

52. Yeah

53. *So until the washer is done, you'll just watch TV?*

54. Yes

55. *Right, so then we'll fast-forward a bit. We'll say that what's on now will stay on until the washer is done. That leaves around fifteen minutes of the test.*

56. Right

57. *So, then we are now fifteen minutes in the future, there's fifteen minutes left, I turn off the washer now, and everything else that was on is still on.*

58. OK (Message arrives on the phone, Fiona checks it right away. She turns on the stove after that). Pizza! And I still watch TV.

59. *Still watch TV, yes. Then we count fifteen minutes from now until the pizza is done. Then I guess I can ask again if you want to do some changes for the next fifteen minutes?*

60. No, not in the kitchen and not in the bathroom, so. I'll be in the living room watching TV, and the heater stays on at home so.

61. *All right. Then you are done with all the other tasks, and if you keep watching TV until the pizza is done then we can press the stop-button here.*

62. So I stay under?

63. *You haven't gotten any messages now?*

64. No

65. *Well, then you stay under*

66. OK

67. *(jokingly) So, congratulations! You got through the obstacle course. We can take a look at - now this time-line is a bit off, but we can see the parts where you've gone over the threshold here. This is when you tried to have the stove and washer on at the same time, which you received a message for.*

68. Right

69. *These are relatively short spikes, so we see that you did respond to the feedback you were given.*

70. Yeah

71. *If you could sit down over there, there's a small part with some questions. I'll just adjust the camera here a bit. And, yeah. First just a little bit about yourself. We know each other Fiona, you study the same as I do, so a Master's in IT, so then you're probably not the greatest opponent of electronics and technology and stuff like that.*

72. No, we love that [electronics]

73. *Yes. Could you say a bit about how you use electronics in your day-to-day life?*

74. Well, a lot is running most of the time. I have a bad habit of having chargers plugged in all the time, which uses power. Would be nice to see exactly how much it uses. I have a tune app that is left on, pretty much 24/7. I like doing things at the same time. When I do things I do all the things. So I'll make food while the dish-washer is running, and think I might as well put on a clothes was too. So yeah, I like doing things right away. Kind of a here-and-now person. The PC is on, tablet is on - but that's battery powered. But the charges is plugged in so. So I'm not a power saving person. I do try to turn on heavy appliances in the morning or late at night though. I think that when people get home from work it's probably more expensive, so I stay away from that. [aware][cost][electronics]

75. *So you do consider that?*

76. Yes, I do think about that

77. *You are actually the first of the ones I've spoken to*

78. Oh (laughs). Well, I do. Plus I'm often not home at those times, so I get some help with that I suppose (smiles). But I am conscious about it, I am. So on a Sunday, turning on the washer at 12-13 may not be the best idea. So I try turning it on very late at night. [aware]

79. *So definitely conscious about it.*

80. (Fiona nods). I am conscious about it, but I don't always do what I should (smiles). I may be more motivated to do that if I knew exactly. Now I don't know exactly, I just know that it's probably more expensive at certain parts of the day. But if I don't have anything I need to do before, I might just turn on the washer or something anyway. [cost]

81. *Right. Still, being conscious about it is the first step.*

82. Yeah

83. *So, here you got to play around with perhaps knowing a bit more exactly what the status was. How did you feel the test went?*

84. It went OK. To try and save electricity by not doing things at the same time - (laughs) that's what I like to do - so that was a bit challenging. Getting a message helps though, like now you're using a bit much. Of course you turn things off, since you don't want the worlds largest electricity bill. And it's no problem, so you know. [persuasion][cost]

85. *No? So you felt it went OK even if you didn't get to do things like you wanted to initially?*

86. Yes, it was OK. It depends - you may want to prioritize what you do first, like if you're hungry then you make food before anything else if you're hungry. So doing what is most important for you then and there is probably smart. [planning]

87. *Yeah. So, these messages. How did it feel to get them - that is when you did get them?*

88. Well, it was like - OK, so it's over. That's not smart, you want to save money (laughs). So it's nice to have when you go above, and nice to get a confirmation when you go under again, so you don't just keep turning things off and end up sitting there like - (mimics nervousness) is it OK now? Do I have to order take-away tonight? (laughs). [cost]

89. *So it wasn't like - whaa, panic!*

90. No, the panic probably comes if you're stuck in a cycle already, like with the clothes washer and dish washer, and you get a message that you're above and can't do anything about it. (Mimics nervousness) But, but, I can't do anything about that! (laughs) [ability]

91. *Yeah. So as long as you can do something, turn something off, then it's OK.*

92. Yeah, but that means you just have to think and not turn everything on at the same time. So it's just about changing your routine I think. You get help, I mean it (the app) will help you, you learn that you can't use everything at once. [learning]

93. *Yeah, it becomes habit after a while. (jokingly) You were lucky enough to get seventeen messages at once here. How did you feel about the number of messages overall?*

Like when you got them and so - you mentioned it was nice to get a message when you weren't above the threshold any more. Would you have like a message earlier or later, or?

94. It's more like if I have a high consumption over time, then I'd like a message. Then and there it's probably OK, since you're aware that you have turned everything on. So more like if after the usual stuff is done, and if there's still a high consumption, then I'd like a message. [feature request]

95. *Over time, what do you mean by that? Five minutes, ten, fifteen?*

96. I think more like the duration of a clothes wash.

97. *OK*

98. So, like two hours. If the washer is on, and I do something else I know that my consumption is high, I don't need to be reminded. But if it stays high after that, then I'd like to know. And I'd like to know when it's fixed, when I'm under again. [feature request]

99. *Right. You mentioned that you had gadgets on pretty much all the time. Could you imagine having a tool like this on one of those gadgets? That you had like a monitor, that didn't necessarily give you messages, but let you check.*

100. Yes, if I can get the information on all devices that that would be great. You don't always have the phone with you everywhere. [electronic assistant]

101. *The more the better*

102. I mean, you usually - at least as an IT student - you sit with something in your hands all the time. So I'd like it everywhere, on all platforms. [experienced user]

103. *Fredrikstad Energi are running a project at Hvaler where they have equipped some houses with smart meters, and those homes get a subscription like the one you have had now during the test. Not with the same thresholds, but the principle is the same. They get a certain threshold, and if they go above that they pay a fee. And the way they see their own consumption is that they are offered three different product packages. One package is relatively advanced. Basically you replace the sockets in your home with programmable ones. They can be programmed to only be on at certain hours, temperature ranges, how much light there is in the room, so you can automate a lot of things. The simplest package is a small tablet, that is dedicated to showing the status. It's like a digital needle, like a speedometer that shows your current consumption. Could you see yourself using something like that, and in that case which one?*

104. I'm not sure if I'm a fan of the sockets turning themselves off, but I like automation and that the lights go on when they're needed, and if I can program them myself when they should go on and off that's great. To decide when things should be on and off, that's OK, but I don't want others deciding that. [electronic assistant]

105. *It would be you as home owner that configured them, or had the final say.*

106. OK. I could see that being good if it was a family, to have some control, but since I live alone it's fine without since I decide myself. The measurement bit, that's OK to have. If you have it on all platforms you can go and check whenever, even if you don't get messages - maybe you set your own goal that you want to meet, it's good to see so that you can actually do that. [electronic assistant]

107. *Looking at the app you've used now, and getting messages like that on your own phone - is that something you'd want at all? Like if you had an agreement like the one here today, and your power supplier offered such a tool, would you want to use it? Or would a display like at Hvaler be enough?*

108. I'd like messages, as long as it's not too much. [mobile assistant]

109. *What do you mean by too much?*

110. Well, when you use much and you know it, and you get a message - I don't really know how to put it. [relevance]

111. *If you are aware of it being high*

112. If I'm aware I don't want a message (laughs). I don't know how to solve that, or what I'd prefer. [relevance]

113. *It might be that after a period your habit changes, so you don't need the messages any more, so maybe you should be able to turn them off.*

114. Yeah, that would be good, to be able to turn off the messages. I imagine they would be good to have if you have children though, and they are at home, and you see that suddenly it becomes really high - (mimics phone-call) hey! (laughs). But if you are the only one home, then one notification should be enough, perhaps just have it so you check yourself. [feature request]

115. *Don't bug me when I know*

116. Yes. A bit difficult though.

117. *Yes, from a technical standpoint, but I'm sure there's a solution. Great! Thanks for valuable feedback and points.*

Appendix E

Disc

Attached is a disc containing the complete code for the prototype application, the back-end, and the administrator interface.