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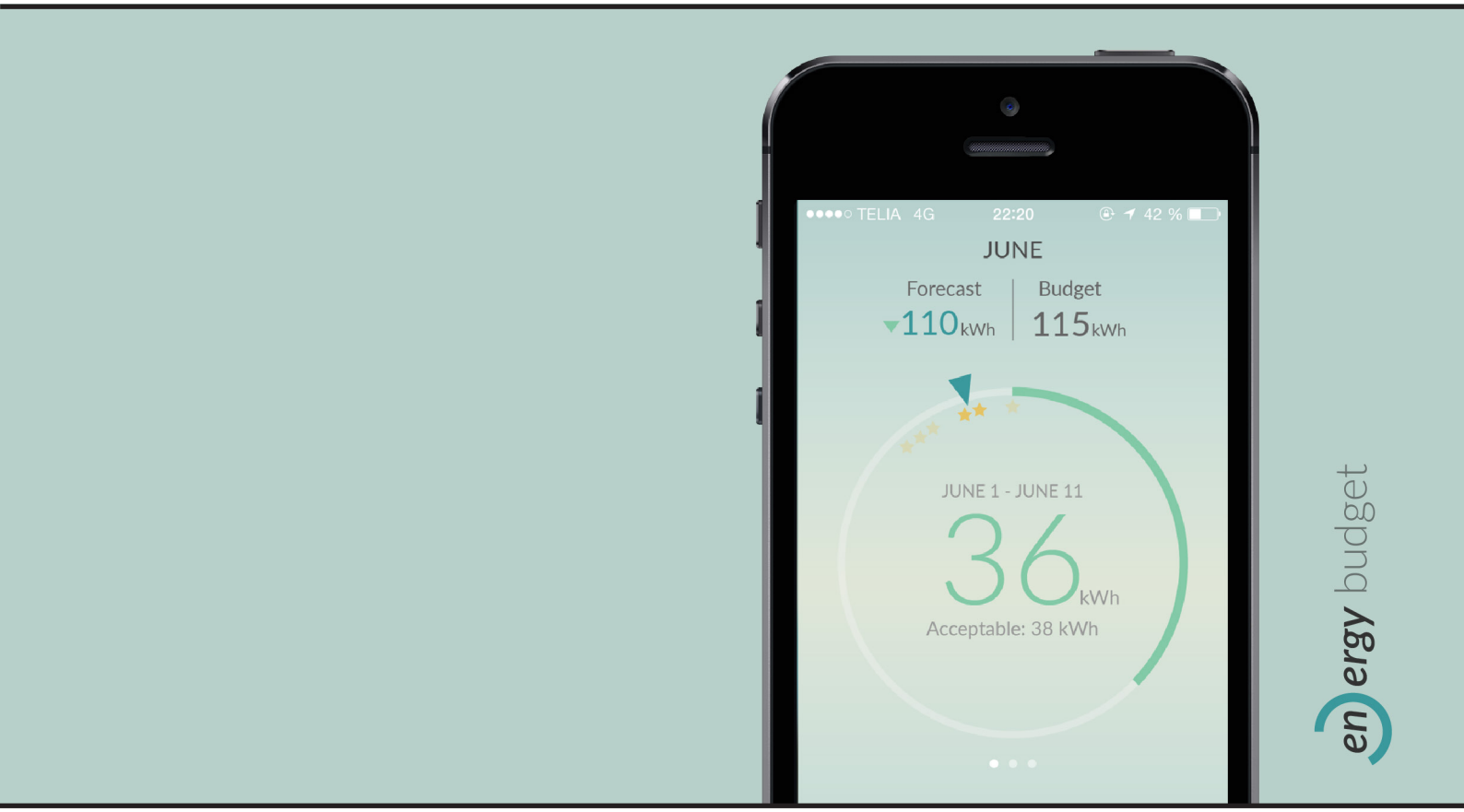

Energy Budget

Development of a service to support energy conservation in households

M.Sc. Thesis in Industrial Design Engineering

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FRIDA JOHANSSON

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2015

Department of Product- and Production Development
Division of Design & Human Factors

Master of Science Thesis

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ABSTRACT

The world's energy consumption is more than the planet can handle and action needs to be taken immediately. The European Union has set its goal to lower emission with 20% until 2020 according to the reference level of 1990. In order to meet this goal we need to challenge ourselves to live in a more sustainable way, both by developing more energy efficient solutions but also by changing the way we behave especially in our homes. The aim of this master thesis has been to identify the barriers that hinder people from reducing their domestic energy consumption. The goal has been to develop a product or service that enables, encourage and/or stimulates users to achieve low impact consumption.

An interview study with 25 people regarding their experiences of energy consumption was conducted in order to identify these barriers. These were verified by a questionnaire and a co-creation session. Design strategies for sustainable behaviour were used as base for the ideation phase.

The end result is a smart phone application called Energy Budget that provides users with an individual energy budget. The budget is customized to the user's current consumption level, making it reachable. Users get challenges and practical tips that teaches them how to lower their consumption in an exciting way. As the application doesn't require any installation on the electricity meter, it is also suitable for people living in apartments.

This master thesis has found that people have little knowledge about what an acceptable consumption is and whether they're above that recommendation. In order for people to become engaged consumers, eco-feedback and guidance is needed. This master thesis has found three characteristics that are important to consider when designing such a service; minimize overload, simplify and individualise.

Keywords: *energy consumption, sustainable behaviour, eco-feedback, interaction design, service design, user experience*

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First of all we would like to say thank you to all 25 interviewees who let us visit their homes and look at their appliances to help us gain an understanding of their everyday life. We would also like to thank the remaining 42 interviewees that were included in the study for letting us take part of the transcripts from their interviews and thank you to the other students who conducted these interviews. Being able to access such a wide study made it possible to gain more insights on the different age groups and their behaviours. Further we would also like to thank all participants in the co-creation sessions, who came with valuable thoughts and interesting ideas that inspired us.

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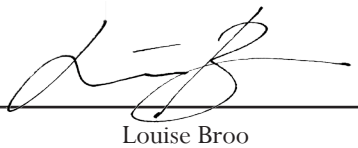
Thank you!



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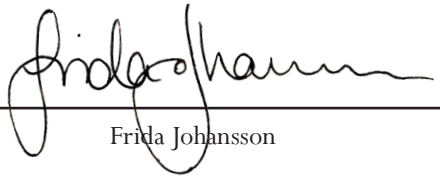


Frida Johansson

CONTENT

CHAPTER ONE

INTRODUCTION

This chapter describes the background, aim and goal of this master thesis, as well as the delimitations and deliverables.

1.1. BACKGROUND

It's no news that CO_2 emissions are higher than the planet can handle. In a constantly growing urban society, domestic energy consumption is increasing, as consumers grow accustomed to more and more electrical appliances (European Environment Agency, 2012). As consumption grows, the strain on the natural resources and the climate increases and with this development a need for decreasing consumption arises. We all know this, but we don't know where to start. The EU has set a goal to lower CO_2 emission with 20% until 2020 compared to the reference level of 1990 (European Commission, 2015). Using 20% less energy seems unreachable to most people because they can't imagine how this affects their everyday life. A lot of people don't even know how much energy they actually use and even fewer know even if they're using more or less than they should.

Europe's largest public-private innovation partnership focused on climate change is Climate KIC. Climate-KIC was created by the EU body; European Institute of Innovation and Technology (EIT) in 2010 and its mission is to *"Create opportunities for innovators to address climate change and shape the world's next economy"*. By integrating education, entrepreneurship and innovation they want to form new products and services to mitigate climate change (Climate-KIC, 2015).

Attempts to lower the consumption impact has been made through eco design, i.e. producing products using sustainable materials, reducing energy loss within the product, making products easy to recycle etc (Lidman, Rentröm, 2011). However, these attempts can only lower the impact to a certain degree. It's known that even in identical houses consumption can differ a lot due to the differences in behaviour (Darby, 2006).

Elias et al. (2009) describes two sources of energy loss in products; intrinsic losses due to the products technology and mechanics, and user-related losses that are determined by how the product is used. The user-related losses stand for a large portion of the losses and as technology evolves the user-related losses will become an even bigger influence on the total energy efficiency. Thus, focusing on the user's interaction with his or her appliances is an important aspect.

1.2. AIM AND GOAL

The aim of this master thesis is to identify the barriers that hinder the users from achieving low impact energy consumption in their household in order to aid development of solutions to support energy conservation.

The project goal is to create a product or service that enables, encourage and/or stimulates users to reduce their energy consumption with the overall goal to decrease the CO_2 emissions generated by the household.

1.3. DELIMITATIONS

As society evolves the number of people living in single households increase. In Sweden about 37.7% of the population lived alone in 2012, which made them the most common household type (Statistiska Centralbyrån, 2012). The rest of the population lived either in couples or in shared accommodations, with or without children. This project was limited to observing people in single households only. The setting for this study was apartments in the city of Gothenburg.

Further, this master thesis was limited to not include food consumption and waste management, but only to examine energy consumption.

Due to the time frame of this master thesis, the project was delimited from user testing over time.

1.4. DELIVERABLES

The deliverables of this master thesis was a theoretical report describing the process and the main research findings. The findings were to be translated into a concept for a product or service and be presented in the form of a simple prototype.

1.5. REPORT OUTLINE

This report defines the problem that was investigated in chapter 2 and the theoretical approach used is described in chapter 3. The process and methods used are presented in chapter 4. Analysis and result are described in the chapters 5-8, which presents the findings in different areas rather than sorted by method. Chapter 9 contains the discussion and the conclusion of this master thesis is found in chapter 10.

CHAPTER TWO

PROBLEM DEFINITION

This chapter describes the existing conditions for energy conservation and provides background information about the investigated area.

2.1. ENERGY CONSUMPTION

In the year 2013, households were responsible for about 51% of Sweden's total electricity consumption (Ekonomifakta, 2015) while the industry contributed with about 37%, the rest of the electricity went to transportation, district heating and losses from distribution. This implies that changes in people's behaviour in their homes could lead to great energy savings. The households' energy consumption includes heating, water and household electricity. The distribution of the whole consumption for a normal Swedish household is around 60% heating, 20% hot water and 20% household electricity (E.ON, 2015). According to Ekonomifakta (2015) lighting, refrigerator and freezer are the main contributors within household electricity. These appliances use electric energy to run, which is measured in kWh that is power (1000 W) over time (1 hour).

In 2012 the European Union (EU) was responsible for about 10% of the world's total greenhouse gas emissions (European Union, 2015). Until the year 2020, EU has committed to lower its emissions with 20% compared with the reference levels of 1990 (European Union, 2015). The long-term goal is to lower EU's emissions by 80-95% compared to 1990 levels until 2050. In order to reach these goals, changes need to be made. One factor in lowering greenhouse gas emissions is lowering household's emissions.

Carbon dioxide (CO_2) accounts for around 80% of greenhouse gas emissions in the world and can thus be considered the most relevant to measure (Energi- och klimatrådgivningen, 2015). The use of fossil fuels has strongly contributed to the emissions of greenhouse gases, which increases the greenhouse effect. When looking at climate effects, CO_2 emissions are commonly

used as a measurement. The use of electricity doesn't lead to any emissions, however the production of electricity causes emissions. Wind and waterpower both create almost no CO_2 while coal power plants create huge amounts of emissions (ibid). To calculate the CO_2 emissions, a numerical factor is used based on what country is being examined. To calculate the emissions in Sweden there are three different factors that can be used. Calculating according to the Nordic perspective means looking at the emissions for the whole Nordic region where 1 kWh on average creates 100 g CO_2 emissions. Looking at Sweden only, the main energy sources are water and nuclear power that gives a factor of 20 g CO_2 per kWh. However, some years there is a shortage of water and the factor then becomes 40 g. Finally, it's possible to calculate the emissions based on the energy source of the electricity if this is known, but usually consumers get an electricity mix (Kellberg, 2014).

2.2. ACTORS ON THE ENERGY MARKET

The process of getting energy to the houses start at an EU level where laws regulate how electricity may be produced, distributed and how it should be paid for. In Sweden the government regulates the energy taxes, which affect the price of electricity for the consumers. The power plants are run by electricity producers who distribute the electricity over the grid via the grid suppliers. The grid suppliers in Sweden have geographical monopoly, and in Gothenburg the grid supplier is Göteborgs Energi. This means that the residents cannot choose which grid supplier they want but are automatically connected to the supplier of that area. Electricity traders buy the electricity from the producers or other traders and sell it to its customers, the residents. Some traders also produce their own electricity (Lundgren et al., 2010).

The grid suppliers distribute electricity in return for a yearly fee in addition to a surcharge dependent on the resident's consumption. The traders usually also charge a yearly fee, but mainly get their income based on the consumption. The consumption is monitored by remote readings of electricity meters in the buildings of the residents. The resident's payment can be divided roughly to 40% based on consumption, 40% taxes and fees and 20% distribution fees (E.ON, 2015). This is further described in figure 1.

Since 2009 the Swedish law dictates that a meter reading of the electricity consumption should be done monthly (Hamilton, 2009). In former times the bills were based on an average value, which meant that even if the residents changed their behaviour the result would not appear on the next bill. Having bills based on actual consumption can be seen as a prerequisite for users to change their behaviour (Arvola et al., 1994).

The electricity law (Ellag SFS (1997:857) chapter 3 10 § and 11 §) states that grid suppliers are obliged to carry out the measurement of the electricity transferred and its distribution over time. The customers are able to get the information in retrospect divided hourly.

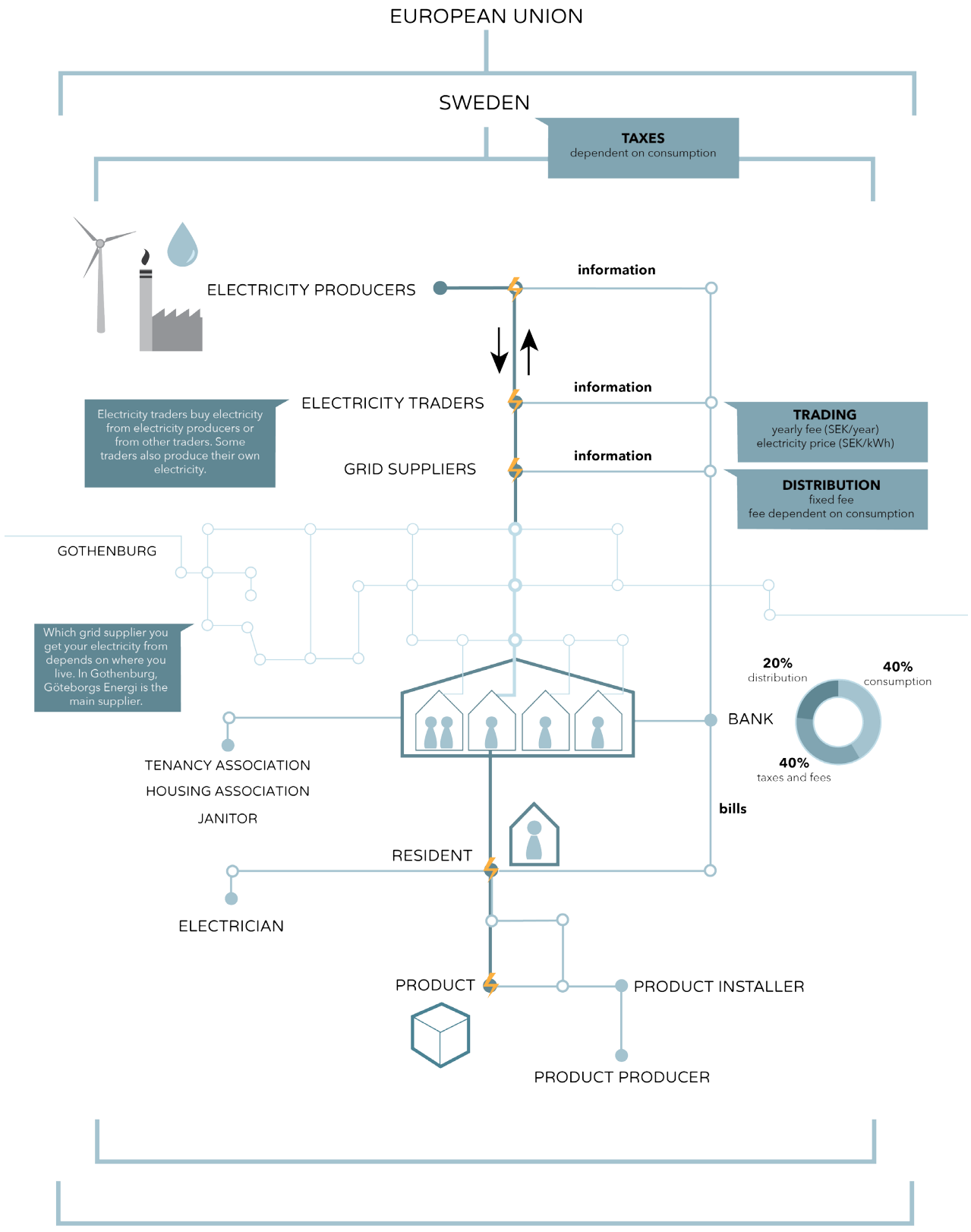


Figure 1. Actors on the energy market

2.3. DEVELOPMENTS WITHIN THE ENERGY SECTOR

The market for electricity is changing due to the increasing number of renewable energy sources that are introduced. The current grid faces issues with distributing electric energy from both large-scale producers and upcoming small-scale producers. There is a need for more flexibility and deeper involvement from the different actors using the grid; producers, grid suppliers and customers. This has lead to the term smart grids, which is defined in many different ways (Lundgren et al., 2010). The Swedish energy authority (Lundström, 2012) has one definition of what smart grids mean:

"Intelligent grid, or smart grid, is a collection of new technology, the function and regulations of the electricity market etc. which in a cost-efficient way facilitates the introduction and utilisation of renewable electricity production, leads to reduced energy consumption, contributes to a power reduction in peak load as well as creates the preconditions for more actively involved electricity customers" (Translated from Swedish by the project group).

For electricity consumers this means the introduction of a two-way communication where they can be more involved in their electricity consumption. Some argue that the introduction of so-called smart meters is essential for the smart grids, but this opinion isn't unanimous. According to the Swedish energy market inspection (Energimarknadsinspektionen) there is no accepted definition of smart meters, however there are two tracks that are discussed:

- Smart meters as an aid for short interval remote readings of electricity consumption. This could be at hourly basis or more often, some aim for real time readings. This would lead to a more advanced measuring, providing more advanced structures for grid tariffs and electricity pricing. This would also create possibilities for new customer services that could help the user keep track of their consumption (Lundgren et al., 2010).
- Smart meters can also be considered as the two-way communication between customers and their electricity trader or grid supplier. This would mean that customers could get access to real time electricity prices and tariffs while producers and suppliers could control the consumption and production based on demand.

These changes in the structure would require a new infrastructure for communication, data processing and databases for storing the information. It would also require further development of the measuring procedures. Also, in order to support changes in customer behaviour information about them is needed (ibid). Personal security and invasion of privacy needs to be considered when developing these systems.

2.4. AWARENESS OF ENERGY CONSUMPTION

Today many people are unaware of how much energy they consume in their household and how it affects the environment. They expect electricity to always be available but might not consider where it comes from or even that they are consuming it. One factor that creates a barrier for energy conservation is the lack of feedback of own consumption, although eco-feedback has been proven through studies to be promising in order to move towards an engaged consumption.

There are currently many eco-feedback systems available on the market that provides users with rich information about their energy consumption. Still, these systems don't fully support most users in conserving energy. While real time information, load bars and outdoor temperature correction may engage the interested user who enjoys analysing raw data, it doesn't suit all users. Also, as Strengers (2011) points out there is a focus on resource management that assumes that people make perfectly rational choices in their everyday life. It's assumed that people weigh the personal cost against the personal gain of every action. However, in reality people don't generally make active decisions when going through their everyday routine in their homes. Habits widely determine user's

behaviours in their homes, which make users perceive some everyday activities as non-negotiable. Feedback showing consumption for such an activity can lead to the user questioning the relevance of the feedback. For example pointing out that the consumption increases when a radiator is turned on may lead to the user thinking - ok, but I don't want to be cold so there isn't anything that I can do. Strengers (2011) found that this leads to irritation and that users in the end didn't think that the feedback was helpful. Even though initial savings in the range 5-15% have been seen, studies have shown that the savings may decrease over time.

Considering the everyday setting and how people actually can be supported by feedback is essential in designing successful eco-feedback systems.

2.5. SINGLE HOUSEHOLDS

As mentioned in Chapter 1.3 Delimitations, Statistiska Centralbyrån (2012) has found that 37.7% of the Swedish households were single households in 2014. These single householders are 16.5% of the Swedish population. Of these, 53% are women and 47% are men. Figure 2 shows that both men and women commonly become single householders in their twenties and from there the number decreases as people find partners and move in together. This recession continues until the age of 35 when it levels out and eventually starts increasing again. Fewer middle-aged women than men are living in single households. One of the factors is that children are more often registered as living with the mother in case of a divorce. Until the age 60 men are more frequently living alone but at that age the number of women in single households become more. One of the reasons for this is usually that the male spouse demises.

2.6. RESEARCH QUESTIONS

This chapter describes the current situation and the obstacles needed to tackle in order to create energy savings in households. The project aimed to answer the following questions:

- How do people use energy in their homes and what are their behaviours?
- What are the barriers that hinder people from lowering their energy consumption?
- How can those barriers be reduced?

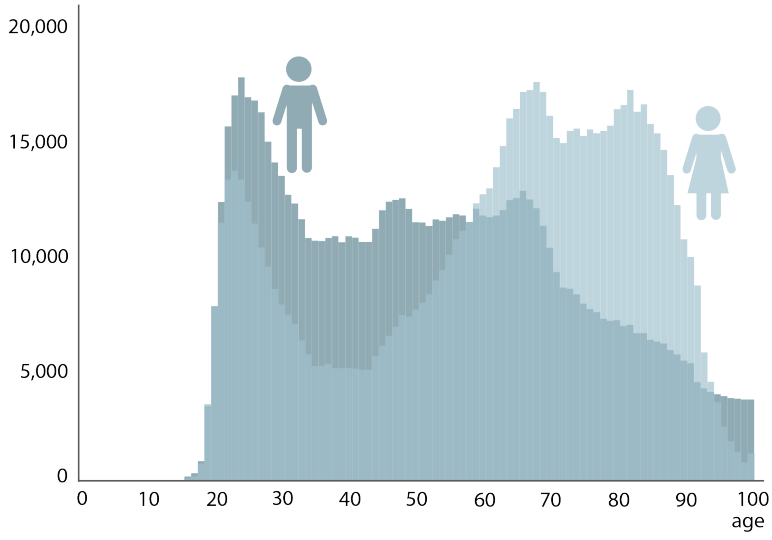


Figure 2. Single households in Sweden, 2014

CHAPTER THREE

THEORY

This chapter presents the theoretical framework used in the process of for the master thesis.

3.1. CO-CREATION

The design process is changing as the landscape of design approaches is expanding. Design has been given more focus in the early parts of development, defined by Sanders and Stappers (2012) as the 'fuzzy front end'. In this part of the process designers have been given more responsibility and often face what is called 'wicked problems'. These problems are defined by Rittel and Webber (1973), as *"Wicked problems are difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are more often difficult to recognize. Moreover, because of complex interdependencies, the effort to solve one aspect of a wicked problem may reveal or create other problems".* When faced with wicked problems a co-creative (collective creativity) mindset can be helpful.

According to Sanders and Stappers (2012), co-creation differs from the traditional design process in the overall approach as well as in the way roles are assigned. Figure 3 compares the traditional design process to co-design. Traditionally, designs processes have been lead by research and the designer is seen as an expert of the user's experience. Co-creative processes are led by design and regard the user as the expert of their own experience. In a traditional design process, researchers communicate with users and summarize the findings in a report that is read by the designer. In co-creative design processes, the researcher, user and designer all collaborate and the designer might even be the researcher. In co-creation the users are seen as the expert of their experience and they are given the tools to express their own creativity. The designer's task is then to provide the co-creators with suitable tools for

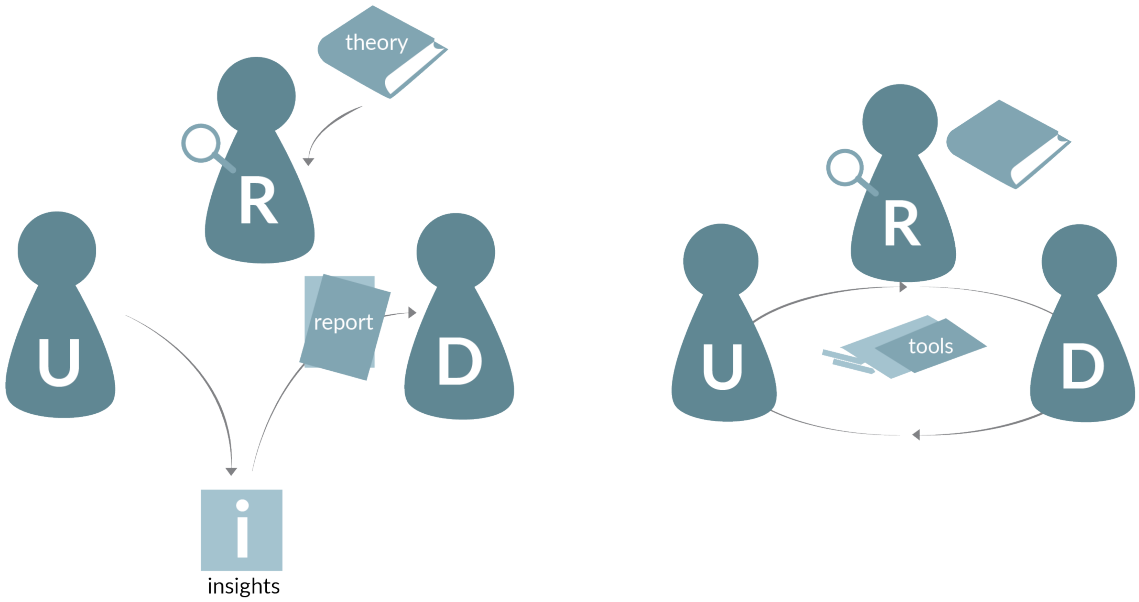


Figure 3. Traditional design process compared to co-creation process

them to express their ideas with. In some cases, the user could even become a part of the design team.

Co-creation can be found in all stages of the design process, from the pre-design and discovery to marketing and after sales. In the pre-design stage the problem is defined and researched, and the possibility to find innovations is the greatest. In the discovery stage possibilities are found and translated into guidelines for the design. In the design stage development takes place and a product or service is defined. From this the product or service is produced in the stage making. It's marketed and distributed and finally there is an after sales stage where the product or service is being used or experienced. In which stage of the process co-creation should be applied depends on what values one wants to gain. Co-creation can lead to three types of value being; monetary, use/experience and societal. Use/experience values are related to meeting the wants and needs of the users while societal values relate to creating sustainable results affecting the lives of the users. These problems are often wicked problems and solving them requires a close collaboration between designers and users. In the early phases the societal values can be elicited and it's also in this stage where the impact of co-creation is the largest. In the design stage of the process use/experience values are often found and it's not until the end of the process that monetary driven co-creation occurs. However, societal driven co-creation may lead to both use/experience and monetary gain.

Co-creation can be seen as a mindset, a method or a tool in the design process. When applying it as a mindset co-creation often takes place in the early phases and can have impact on people's lives. When seen as a method it's mainly used on the design stage and co-creation as a tool is mostly used in the later parts.

3.2. USER EXPERIENCE

User experiences can be thought of as the user's affective experience of an interaction or an anticipated interaction with a product. According Russel (1980, 2003) the experiences we have when interacting with products can be described by the term 'core affect'. Core affect is a combination of two dimensions; valence and arousal, which can be found in every experience. In each interaction with a product, the user's experience is a blend of the amount of valence (pleasant or unpleasant) and arousal (calm or excitement). Moods are also an experience of core affect, but not elicited from any interaction but rather as a result of internal and external circumstances. A product experience

can thus be defined as a change in core affect due to a human-product interaction.

According to the framework put forward by Desmet and Hekkert (2007) there are three components or levels of experience; aesthetic experience, experience of meaning and emotional experience. A product experience can be described as the sum of effects of these three levels. The aesthetic level concerns the impression a product makes on one or more of our senses. This can be a smooth surface, an interesting shape or even an exciting interaction. The meaning level refers to the cognitive response a user gets when interacting with a product. The cognitive processes such as memory retrieval, relating to semantics and associations are affected by individual and cultural differences. The emotional level is distinguished as an evaluation of a certain event or product that the user interacts with. The event is interpreted as either beneficial or harmful based on the user's own experience of that situation. This means that a product can cause the user to react as if it was harmful when in fact it's not. This process is known as appraisal and is a part of Desmet's basic model of product emotions, illustrated in figure 4. The model explains that emotions are the effect of an interaction with a product that stimulates the user to appraise the situation according to his or her personal concerns, which are to some extent individual and may be affected by cultural factors. Thus, to fully understand the emotions elicited by a human-product interaction one needs to be aware of the context and what concerns are important to the user in that situation.

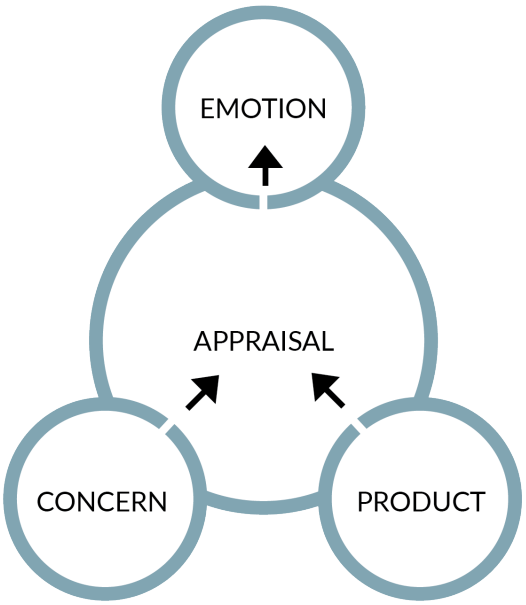


Figure 4. Desmet's model of product emotions

3.3. DESIGNING FOR SUSTAINABLE BEHAVIOUR

To achieve a sustainable behaviour, one needs to understand how people make decisions and what motivates them to carry out tasks. Based on this knowledge different strategies have been developed in order to create sustainable behaviour. This chapter will present a brief summary of how behaviours can be affected and a selection of strategies for changing behaviour that are relevant for this master thesis.

3.3.1. Describing sustainable behaviour

In the field of designing for sustainable behaviour, there are several theories explaining how to bring on a change in behaviour. The theories originate from various fields of expertise but can roughly be divided into factors concerning norms, motivation, habits and context. According to Zachrisson (2010) Comprehensive Action Determination Model (CADM) put forward by Klöckner and Blöbaum in 2010 describe these factors. The model builds on four previous theories; the Theory of Planned Behaviour (TPB), the Norm-Activation Model (NAM), the theoretical concept of habits and the Ipsative Theory of behaviour. However, there may be more factors influencing behaviour than the ones mentioned in the model. According to CADM sustainable behaviour is affected directly by habitual, intentional and situational processes, and indirectly by normative processes. This is further described in Figure 5.

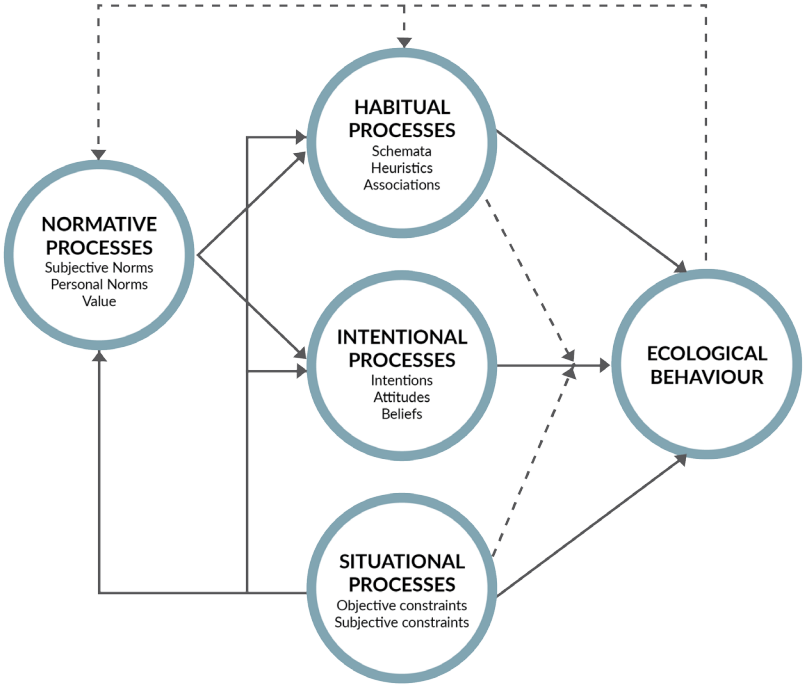


Figure 5. Comprehensive Action Determination Model (CADM)

Habits are useful for people because they minimize the cognitive load of frequent actions, meaning that a person can make a decision without having to go through a decision-making process but instead going right to the action (Jager, 2003). In CADM habitual processes are defined as schemata, heuristics and associations. These processes can be challenged if a habit is broken and new processes form as a result of this. However, habits form over time and there is a need for reinforcement for behaviour to actually become habitual. Normative processes can affect habitual processes.

Intentional processes include intentions, attitudes and beliefs, which are linked together and affect each other. Intentions are affected by attitudes, which are in turn affected by beliefs. Stern (2000) has found that attitude can strongly influence behaviour if the situational processes have low influence and vice versa. This means that when a user is in control in the decision-making, he or she can make decisions based on attitude but if the product is in control the user will choose based on the product's intention. Intentional processes can be influenced by normative processes (Zachrisson, 2010).

According to Selvefors (2014) there is another approach similar to intentional processes within the field of sustainable behaviour another called motivational aspects, which can be seen as complementary and somewhat overlapping with intentional processes. Research on motivational aspects claims that people are motivated to do things based on which of three overarching goals is dominant; they either have a gain goal, a normative goal or a hedonic goal (Lindenberg and Steg, 2007). The gain goal is equivalent to improving one's resources, the normative goal is to act in an appropriate way and the hedonic goal is favoured when one search for immediate satisfaction. Which goal will be dominant depends on the person's preference in that specific situation.

Situational processes can be described as objective and subjective constraints. Objective constraints enable or inhibit the user to perform certain tasks, while subjective constraints are what the user perceives to be possible or impossible. The use context or the product itself can create these processes. Situational processes affect both habitual and intentional processes.

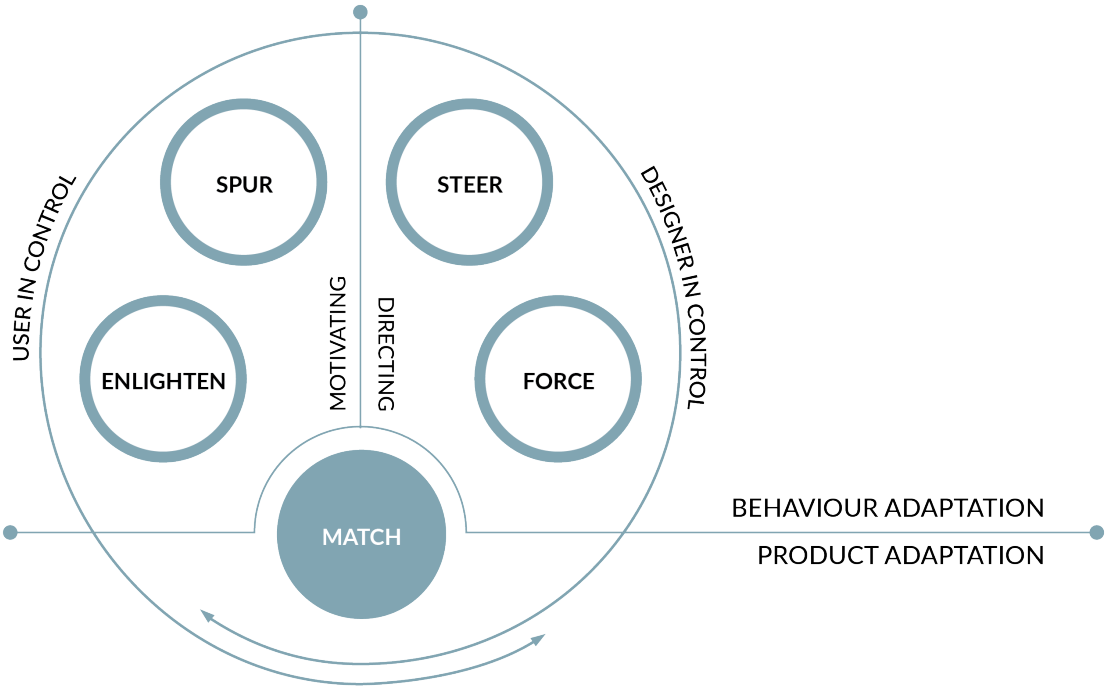


Figure 6. The model for categorisation of design strategies for sustainable behaviour

Normative processes are subjective norms, personal norms and values and they influence both habitual and intentional processes. Norms and values affect decisions as users rely on them when assessing if a solution is acceptable or not. This process is of importance when designing for sustainable behaviour, as users won't accept a solution that provides the desired effect if it violates his or her norms and values (Zachrisson, 2010).

In order to achieve a consisting change in behaviour, which result in persistent savings (Darby, 2006), people need to create new pro-environmental habits.

3.3.2. Design strategies for sustainable behaviour

Strategies for designing for sustainable behaviour can be categorised based on how much the user is in control and how much the product is in control. Lidman and Renström (2011) suggest dividing the strategies into five categories; *Enlighten, Spur, Steer, Force* and *Match*. The first four categories aim to change the user's behaviour while the last category aims to match the product's features so that the user's behaviour will lead to low impact. Strategies in the category *Enlighten* bring on sustainable behaviour by means of information and reflection. The category *Spur* encourages the user to behave sustainable by focusing on the behaviour itself and motivating the user to behave in that way. In the category *Steer* users are guided to behave in the wanted way by making it the obvious choice or constraining the unwanted behaviour. Strategies that use guidance in a more forceful way belong to the category *Force*. Finally, strategies for reducing the environmental impacts of the existing behaviour can be found in the category *Match*. The model is described in Figure 6.

3.3.3. Selection of design strategies for sustainable behaviour

For this master thesis an initial selection of strategies was made based on which strategies were found to be relevant to the scope. The selection was partly based on which strategies Lidman and Renström (2011) had found promising. However, mostly the selection was based on what the project group found to be promising from the user's perspective or interesting for the

project. The chosen strategies are presented below and described briefly.

Enlighten

Information

Information can be used to affect users by for example informing about environmental issues and informing about how to act sustainably.

Enlightenment through Interaction and Experience

Users can be enlightened about the effects of their behaviour through means of interaction and experience. For example the colour or intensity of light can be used to indicate how much energy is currently being used. This is a good tool for increasing the understanding of one's action as well as it supports users in creating a positive attitude towards sustainable behaviour.

Feedback

Feedback is information given after certain behaviour and can inform the user that the action has been carried out or indicate the effect of the action. Feedback is a good tool for educating users in what actions will help them achieve a certain goal.

Modelling

Showing the correct behaviour to users in a video or in person can influence people to behave in that way.

Value and Attitude Reminder

Reminding people that their sustainable values are relevant in a situation can strengthen the link between value and behaviour. For example, a sign in the restroom reminding people to only use one paper towel when washing their hands to spare the environment.

Guidance through Group Belonging

This strategy combines modelling and norm reminders and apply it in a group setting. This way people will be informed about how to behave and try to mirror the group's behaviour. This can lead to social incentives; meaning the one wants to act according to the group to get positive social feedback.

Spur

Support Autonomy

By making the user feel independent, he or she will be motivated to carry out the desired behaviour.

Support Competence

Providing sufficient challenges by making him or her feel competent but challenged can support a user's competence. This will motivate the user to carry out the desired behaviour. This strategy is often used in combination with *Support Autonomy.*

Provide Options

Providing options is a way to make the user feel free to make his or her own decisions. This is one way of supporting autonomy and competence.

Incentives

Incentives and disincentives are widely used to affect people's behaviours and can be found in many fields. Of the two, incentives have been found to be more effective in increasing the frequency of the desired behaviour.

Value-added Design

To enhance the competitiveness of products that only behave in a sustainable way in relation to other products, value can be added by using for example fine materials or by adding extra features.

Convenience

Inconvenience can be a significant barrier for sustainable behaviour and a more convenient design can remedy this.

Enhance Benefits

If a sustainable behaviour also brings other positive consequences this can be a driving force to carry out the sustainable behaviour.

Goal Setting

To set goals for sustainable behaviour can be the motivation that the users need to keep up the behaviour, although it must be sufficiently challenging.

Competition

Competition includes goal setting, incentives, feedback and social incentives and can thus be very effective.

Steer

Scripting

By making unsustainable behaviour challenging and making sustainable behaviour effortless scripting can guide the user to the right action.

Just-in-Time Prompt

Using visual and auditory reminders or prompts catches the user's attention to an action they might have forgotten otherwise.

Force

Forced Functionality

Forced functionality is similar to scripting but it hinders the user to carry out unsustainable actions in a more forceful way.

Habit Intervention

Habits can be broken by interventions such as making the habit impossible, changing the outcome of a habit or preventing the situation the triggered the habit from occurring. Creating a new product that triggers a different behaviour is one way of using habit intervention.

Match

Functionality Matching

Products can ensure a more sustainable use by matching the user's expectations, meaning that the user can utilise the product in the way he or she usually does but the outcome will be more sustainable.

Enabler

In some cases the user wants to carry out a sustainable behaviour but is hindered by circumstances. In this case a new design can reduce the obstacles and enable the user to behave sustainable.

3.3.4. Energy conserving actions

Electricity isn't consumed directly but rather through products and services. This means that pro-environmental behaviour starts by choosing which products to buy and is always present in the use phase. However, electricity use disguises itself in everyday activities such as cooking or watching a movie. Also, electricity isn't seen as a limited resource, people never experience that flipping a light switch doesn't turn the lights on. This invisibility and seemingly infinite stock makes it challenging for users to comprehend what it means to conserve electricity in their everyday life (Fischer, 2008).

Strengers (2011) further questions how energy conservation is currently focused. While there are many studies on how to use resource management as a motivation for conserving energy, results show that people may not perceive this as relevant. Strengers suggests focusing on everyday life instead, which reveals that some household activities are seen as non-negotiable. Thus forcing users to take a resource management approach to these activities creates irritation. For example letting the users know that showering consumes a lot of energy will not necessarily lead to a change in behaviours since it's seen as a necessity. A better approach would be to look at why people shower and consider feedback as a facilitation tool for gaining and sharing knowledge about how to shower shorter or less.

When considering what users can do to save electricity there are 5 categories of pro-environmental behaviours that have been summarized by Renström et al. (2013). These categories are:

- Changing how a product is used in order to reduce consumption by using the product less or using it in a different way. Specific actions are for example turning off the lights respectively using eco programs.
- Using a secondary product to facilitate reduced consumption such as using a product that

consumes less like boiling water in a kettle instead of on the stove.

- Regulating the product's resource use by using an additional product that modifies the resource use, such as using a timer or motion sensor to turn off a product.
- Maintaining a product in good condition, such as defrosting the freezer.
- Buy a product that uses less resource, such as a newer, more developed version of the old product.

3.4. ECO-FEEDBACK

Oxford English Dictionary defines feedback as: *"Information about reactions to a product, a person's performance of a task, etc. which is used as a basis for improvement".* Eco-feedback is information about how a household is performing in an ecological sense.

According to Darby (2001) there are different types of feedback:

- Direct feedback - for example using meter readings, direct displays, interactive feedback via PC, tablet or smartphone, etc.
- Indirect feedback - for example frequent billing with different types of feedback
- Inadvertent feedback - can be described as learning by association, for example by generating own power at home one can gain knowledge about energy consumption
- Utility-controlled feedback - feedback that is given by smart meters that is provided by the utility
- Energy audits - awareness can be derived by learning about the building's 'energy capital'

Through reviews of feedback studies, Darby (2006) has found that direct feedback can yield savings of 5-15% where high-energy users may respond more than low energy users. Indirect feedback was found to bring on savings of 0-10%. Indirect feedback is information that has been processed before reaching the user, usually via billing, and it's indicated to be better than direct feedback at showing effect of behavioural change.

Fischer (2008) states that information about the current state and what options are available as well as the consequences of these options are essential to get people to question their behaviour and judge it in terms of norms and motives. Disaggregated feedback provides the users with the power to evaluate the way they use their appliances. For feedback to be effective, Fischer (2008) claims that it should captures the user's attention, draw a close link between action and effect and activate motives that are relevant for the user.

Successful feedback can be described by a set of characteristics described below.

3.4.1. Frequency and duration

In order to raise the user's awareness about the effect of an action, successful feedback is given as quickly as possible after the action. To support the forming of new habits, feedback should be given over time (Fischer 2008). While billing given monthly or bimonthly can support the user in understanding their consumption, it's not likely to be a substitute for direct displays which show consumption in real time. While periodic feedback draws attention to the long-term effects, direct displays visualise the moment-to-moment effects. A combination of the two is likely to lead to savings and is relatively cheap according to Darby (2006).

3.4.2. Content

Feedback can be given on electricity consumption, cost and environmental impact. These different contents may motivate people in different ways and which of them is most effective may vary between individuals (Fischer 2008). However, Strengers (2011) argues that

focusing on feedback for resource management doesn't necessarily correlate with people's everyday life as they may be more concerned with for example having the time to relax and spend time with the family. This means that another approach to what content feedback should have may be necessary.

3.4.3. Breakdown

To further strengthen the link between an individual action and its outcome, breaking down feedback for specific appliances, rooms or time of day can be effective (Fischer 2008). According to Darby (2006), appliance specific breakdown is expensive and complicated to supply. Instead instantaneous feedback that is shown on an easily accessible display may suffice, as it will show changes in the energy consumption as a direct effect of an action.

3.4.4. Medium and mode of presentation

Feedback can be given in electronically or analogue format. Electronic mediums can be seen as favourable since they provide the possibility of interaction that can stimulate the user to explore and be curious. Also, electronic mediums are flexible in the way that different kinds of information can be displayed and real time data be given. The way data is presented also affects how well the user can interpret the feedback. Using the right text and graphics is essential to create understanding.

3.4.5. Comparisons

Comparisons can be historical or normative. Historical comparison can help users see their progress while normative comparisons gives an indication if the household is using about the average amount or not compared to others. This may spur user into conserving more electricity since they get competitive.

According to Darby (2006), the indication is that historic feedback is more useful than normative comparisons. While householders may find normative comparisons interesting studies show that they don't always lead to actual savings. Studies have shown that normative comparisons may cause a boomerang effect (Shultz et al., 2007), meaning that a low consuming user might actually use more then since they are doing better than the average (Darby 2006).

3.4.6. Additional information and other instruments

Feedback may not be sufficient to bring on all the changes needed in household consumption, however it's necessary for users to learn about how to consume energy efficiently. (Darby 2006) There might be a need for additional advice on how to actually save electricity. Information used to increase people's knowledge about energy consumption has been proven to work poorly by itself (Darby 2006), however a combination of feedback and saving tips can educate the users on how to take control over their consumption. Still there is often a need to add another element to get users motivated to conserve electricity. Strategies such as financial incentives, goal-setting or personal commitment can be used to achieve this (Fischer 2008).

3.5. APPLICATION OF THEORY

In order to find innovative and user-centered solutions that fit the everyday lives of people, a co-creative approach will be valuable throughout the process of this master thesis. Using co-creation as a mindset and a method can reveal aspects tied to the user experience, while the user experience framework supports the analysis of users' responses from the co-creative sessions. Further, analysis of user input will require knowledge from established models for describing sustainable behaviour.

Using strategies for designing for sustainable behaviour creates a framework for the design process. Since the reasons for not engaging in more energy conserving actions are still unknown, a wide perspective will ensure that the most suitable strategies are identified.

CHAPTER FOUR

PROCESS & METHOD

This chapter presents the process of this project and describes its methodology.

4.1. PROCESS OUTLINE

The project contained five phases: initiation, research, ideation, further development and final concept. However, since it was an iterative process there weren't always clear boundaries between stages and some phases overlapped. During some stages new insights lead to a repetition of parts of the previous phase. The process outline is illustrated in Figure 7.

In the initiation phase the scope was determined and a project aim and goal were defined. In this phase the problem was further explored, which set the theoretical approach for the project. This was followed by a user centered research phase where interviews were conducted in the homes of the user group. An analysis of the market was conducted in order to find an opening for the final design. In the ideation phase insights from the research phase were translated into concepts, which were evaluated based on how well they met the user needs and their potential on the market. A selection of desirable features from the concepts was further developed in the further development phase. During this stage features were developed and evaluated in an iterative way until a final design could be set. In the last phase the final concept was presented and a business case was suggested.

4.2. INITIATION

In the initiation phase a project plan including aim, goal and a timeline was made. The timeline was presented in a Gantt chart in order to get an overview of the project in an early stage. A Gantt chart is a planning tool where the different stages are presented as horizontal bars along a timeline. The length of the blocks varies depending on the time consumption of the specific

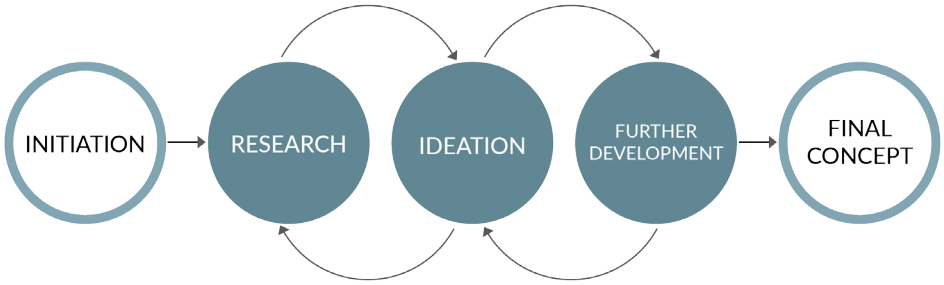


Figure 7. Process outline

stage. It also shows the relationship between different stages (Österlin, 2010). It was a useful tool in the beginning of the project in order to structure the different stages of the project. It was also useful during the project to make sure that the different activities were done in the right time. As the project carried on, the process became more and more clear and the planning was updated. The Gantt chart can be found in Appendix I.

4.3. RESEARCH

The research phase aimed to provide knowledge about the field of eco-feedback as well as looking at the market for potential openings. A user study was conducted in order to get an understanding of the users and their everyday life.

4.3.1. Literature study

In order to gain insight and knowledge needed for the project a literature study was conducted. The literature was found through recommendations from the supervisors as well as through searches on scholarly platforms. Areas that were investigated included for example eco-feedback, sustainable behaviour, co-creation and user experience.

4.3.2. Interviews and observations in households

In order to understand the user group, structured one-on-one interviews were performed with single householders in the Gothenburg area. An interview is a face-to-face dialogue that can reveal user perceptions, opinions, motivation and behaviour regarding a product, service or an area of interest (van Boeijen et al., 2013).

The aim of the interviews was to gain insights about the users, their knowledge and awareness regarding their energy consumption. In this project the interviews were carried out as a part of another project. The template of the interviews including the data collection and administration of the interview was therefore already set by the overarching project. However, it was possible to add further unstructured questions after the structured interview was done. The interviews took about one and a half hour and were conducted in the homes of the interviewees using a tablet to note down the replies as well as taking pictures of appliances. Some quotes were also written down by hand. In total 25 people were interviewed by the project group. Recruitment of interviewees was mainly done by the project in charge of the interviews, but the project group also recruited some additional ones. All participants were rewarded for their participation with cinema tickets.

The interview started with basic information such as living area and estimated consumption of the household. Interviewees were then asked about which activities they thought contributed most and least to the total consumption. After this, all electrical appliances were mapped out and the interviewees were asked to estimate their usage. Again interviewees were asked to point out which appliances they thought contributed

most and least. If there were any energy conserving measures taken, this was noted. In the end interviewees were asked to choose one or two products they didn't want to be without, one or two they could be without and one or two that they thought were hard to use in an energy saving way. The full interview structure can be found in Appendix II.

4.3.3. Benchmarking

In order to evaluate what opportunities for new solutions there are currently on the market, a benchmarking study was conducted. Benchmarking is often used to compare processes but can be used to gain insights about valuable features and design details by reviewing competitor's products (Bohgard et al., 2010).

The products to be assessed were chosen within the two categories eco-feedback systems and home automation systems. These kinds of systems were of interest since they in two very different ways can enable users to conserve energy. The products were found through information retrieval on the Internet, the technology magazine NyTeknik, technology websites and through recommendations from the project supervisors.

Parameters for comparison were based on the design dimensions of feedback mentioned in ÄChapter 3.4.

Eco-feedback. Further, the study itself identified some parameters that were of interest for the comparison. Products were also categorised by what strategy or strategies for sustainable behaviour they employed.

4.3.4. Co-creation session

A focus group concentrated on co-creation was conducted in order to gain more insights and inspiration from the target group. A focus group is a group interview focusing on one or a few topics related to an overall theme. The participants of a focus group are usually part of the target group for the product or service being developed. A focus group can be more or less participatory in its design; in some focus groups participants are asked to create own artefacts and sketches while in others they simply contribute with discussion. Focus groups can be conducted in several parts of the design process depending on what the aim is (van Boeijen et al., 2013).

The theme of this session was how to save energy in the future; with the goal of letting constraints go and imagining what could be done with new technology. The

Figure 8. Interview and observation in a household

participants then needed to be creative and innovative. Therefore four students from the program Industrial Design Engineering were recruited to participate. The participants were in the ages 22-26 years old. The session was divided into three parts were the two first focused on getting insights about the current situation and the last aimed to dream about the future. Probing was used throughout the session to invite the users elaborate their thoughts and comments. The session was led of one of the project members and the other recorded the session by taking photographs and taking notes. During the session sound was recorded and later transcribed.

The first part explored the user perception about how much of their energy consumption consisted of electricity, heating and water. The participants asked to individually fill in an empty pie chart to show the distribution and then they were asked to present to the group. They were also asked to rate how much they felt that they could affect the consumption of each part. Questions were asked about what information they received and how they paid for the services.

The second part concerned the user's feelings about energy savings and sustainability. The participants were asked to create collages with a selection of a predefined

Figure 9. Co-creation session together with users

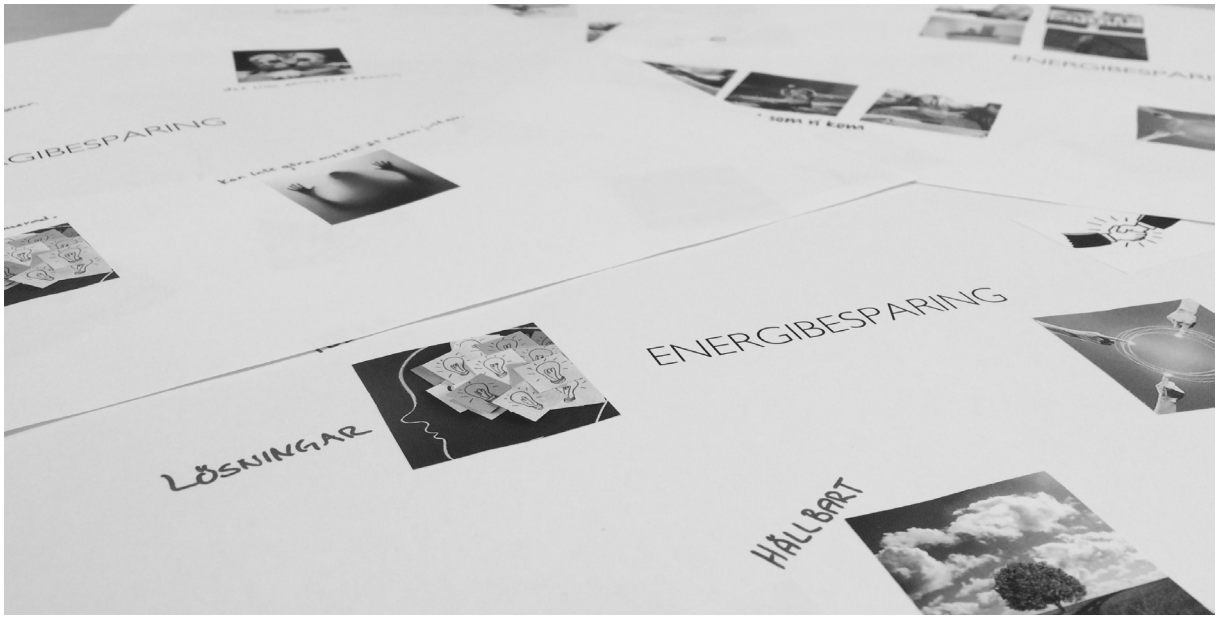


Figure 10. Collages from co-creation session

set of 48 pictures (Figure 9 & 10). Questions were asked about how they would like to feel about the topic, as well as what motivated and supported them and what barriers they faced.

Finally, the participants were asked to imagine landing in Gothenburg in the year 2040 and describe how that would be like. A big paper was shared in the middle of the table so that participants could draw or write down ideas and thoughts. Again motivations and obstacles for energy savings were discussed.

4.3.5. KJ analysis

Both the interviews and the co-creation session resulted in a large amount of data. In order to investigate the participants underlying opinions in the problem area insights from all quotes were written down. The transcript was examined closely and both project members extracted the insights. The insights were written down on insight cards, with the quote and the reader's interpretation of it. The insights were then compared in the project group and structured into different categories with help of a KJ analysis. This is a method for analysing large amounts of data in order to get an overview. Data are put on notes that are categories according to different themes and given a heading (Figure 11). The method uses a bottom-up approach where details are studied in order to get an understanding of the bigger picture (Bligård, 2011). The comparison of insights opened up for a discussion about what different statements meant and shared interpretations could be founded.

The identified categories from the KJ analysis revealed what barriers people face when trying to save energy. The barriers were categorized, and the ones that were most relevant for the project were chosen for further work.

4.3.6. Questionnaire

In order to verify the conclusions drawn about the most relevant and important barriers for the users, a questionnaire was constructed and sent out to the people that had been participating in the interviews. A questionnaire is a structured tool consisting of a set of questions or statements used to collect information from respondents. The available answers can be fixed or flexible, depending on the aim of the questionnaire (van Boeijen et al., 2013). Each barrier was made into a statement and the respondents had to rate how well the statement fitted them from 1 (don't agree not at all) to 6 (completely agree). An even number of steps was chosen to force the respondents to make a choice instead of letting them choose neutral. The full questionnaire structure can be found in Appendix III. In total 32 people answered the questionnaire.

Figure 11. KJ analysis

4.3.7. Personas

As a way of summarising and concretising the users, four personas were constructed based on the statistics from the user research. Personas are constructed archetypes of the intended users group and they are used to describe and visualise the user's behaviours, values and needs (van Boeijen et al., 2013). Four different personas were constructed to cover the different user types identified in the interviews. The different personas were described in terms of their energy consumption and awareness of energy. Based on the information from the interviews, apartment size, number of appliances, most used appliances and other relevant information could be included in the persona descriptions. A small back story and some quotes of what these people might say were added to make the personas feel like actual people.

4.3.8. Design goal and interaction vision

At this point the scope had become more clear and focused since the initiation phase. To further clarify and define the project, a design goal was created. A design goal is a statement about what the final design should achieve for one or many stakeholders in a specific situation or context. Also, an interaction vision was created to describe the desired interaction. Identifying an event that has the desired nature of the future interaction but is in another context than the one being explored creates an interaction vision. The interaction vision is presented as a textual statement describing the nature of the interaction. The statement is then explored to find the desired qualities of the future interaction (Boess et al., 2011). The interaction vision was found by creating a mind map of associations on the theme 'appealing experience'. The vision was analysed and a second round of associations was carried out to find the qualities of the desired interaction. Once the qualities were identified, a mood board was created to visualise how the interaction should feel. Mood boards are collages that can represent values and moods that are relevant to the users. Mood boards can be used as inspiration for details, shapes and colours that are desirable (Österlin, 2010).

4.3.9. Guidelines

As new insights were gained a set of guidelines for the design was created with the chosen barriers as a basis. Due to the fact that the project was open-ended, it wasn't valuable to create a list of requirements but rather to have a framework for the design. The aim was to gather all valuable insights as checklist of what the final design should achieve. However, since they are guidelines it wasn't said that the final concept must be based on all of them. The guidelines were updated as more insights were gained.

4.4. IDEATION

The ideation process started out with a very wide perspective, which meant that much iteration was needed to focus the project.

4.4.1. Idea generation

In the idea generation phase the aim was to create as many ideas as possible and by iteration achieve qualitative ideas. Since the scope had been very wide, the first part of the idea generation aimed to explore what types of ideas the different strategies could produce. The intention was to limit the number of strategies from the initial 21 to a more manageable number that could be explored more thoroughly. In this phase brainstorming was used to create quantitative ideas. Brainstorming is an ideation method where many ideas are created in a group. During a brainstorming session criticism isn't allowed and participants are encouraged to come up with ideas that don't have to be realistic and the goal is to come up with as many ideas as possible. The idea is that quantity will lead to quality (van Boeijen et al., 2013). In this project a structured version of brainstorming was used, where two inputs were combined and ideas were generated.

The first combination applied a strategy to a barrier to see how the different strategies could lower the different barriers. This was done in a matrix format which created a very structured, and in that way also limited, brainstorming. The next combination applied strategies to the energy conserving actions in a mind

map format, which was less structured than the matrix. In order to get a quantitative result, brainstorming was done on each action combined with each strategy. When the initial ideation was complete, a selection of ideas was made based on the research findings and on intuition. Ideas were then categorised by how much the user was in control and conceptual areas were found. However the categories were re-evaluated and updated as the work went along.

The idea generation continued with ideation on the different personas and an exploration of what the different persona needs might be. This was done in a co-creation session as well as within the project group (Figure 12 & 13). The session consisted of four participants between the ages 23 to 26 and was lead by one of the project members. The aim was to be inspired by each other to see if there were more interesting ideas that hadn't been found during the earlier brainstorming sessions. During the co-creation session different strategies, barriers and personas were considered as

Figure 12. Ideation

Figure 13. Ideation together with users

base for ideation and combined in order to support the participants.

During the idea generation phase iterations were constantly made and ideas were shifted between the project members to be used as inspiration for new ideas. Ideas were visualised by hand sketching which made them more concrete and a second round of idea selection could be made.

4.4.2. Evaluation of persona

The aim of exploring the different personas was to get an idea about their everyday life and what needs they might have in order to see what potential solutions might be of interest. Mind maps were used as a tool to make associations about what the persona's lives would be like. The focus on different persona needs revealed that one of the personas showed more potential for innovative solutions. This led to another round of brainstorming based on those needs.

4.4.3. Creation of four concepts

After making the final selection of ideas a comparison with the guidelines were conducted. Ideas were categorised by how much the user was in control. All ideas were evaluated on how well they met the guidelines and the ideas that didn't meet enough guidelines were eliminated. The remaining ideas were put on cards and grouped into different formations that were visualised by sketching. An evaluation of the different formations was made and four concepts were chosen to be further developed. The aim was to make four very diverse concepts that would show the width of possible solutions, where on one end the user was in control and on the other the product was.

The concepts were described using key paths, scenarios and what technology they required. Wireframes were produced to visualise the layouts and elements of the different concepts, which were then developed to digital screenshots of the most important features. Vector graphics were used to visualise the concepts and they were styled generically in order to make the concepts comparable. The scenarios were visualised as short stories. This material was used as presentation material during the evaluation with the project initiators.

4.4.4. Evaluation of concepts

Concept Scoring

In order to evaluate if the ideas were meeting the user needs, an evaluation against the guidelines was conducted. The four concepts were scored on how well they fulfilled each guideline on a scale from 0-3, where 0 meant that the guidelines wasn't fulfilled at all and 3 meant that the guideline was completely fulfilled. The aim was to gain insights on which concept would fit the user need the best. However, since the guidelines weren't absolute requirements not all needed to be fulfilled. The goal was to get an indication of the concepts' potential rather than making a formal evaluation.

SWOT Analysis

In order to evaluate the concepts on their overall potential, including their potential to yield profit, a SWOT analysis was conducted for each of the four concepts. SWOT stands for Strengths, Weaknesses, Opportunities and Threats and is often used in business as an evaluation tool (Ullman, 2010). The analysis means diving a paper into four squares areas divided by a cross where the top left corner is for Strength, top right is for Weaknesses, bottom left is for Opportunities and bottom right is for Threats. The column on the left then describes the possibilities internally and the right one describes the external conditions. The top row will reveal what the positive aspects of the idea are and the bottom row reveals the negative aspects (Österlin, 2010). Strengths and Weaknesses indicated if the idea was providing benefits for the users while Opportunities and Threats indicated the market potential. Aspects such as if the idea was unique on the market or not was helpful in deciding how to move forward with the project.

Business Cases

To further determine the business potential business cases were constructed using Business Model Canvas, which is a strategic tool for creating and describing a business model (Figure 14). The canvas consists of nine building blocks that describe how revenues can be made. The blocks concern the business' customers, offer, infrastructure, and financial viability (Osterwalder & Pigneur, 2009). The Business Model Canvases were mainly used to reveal what potential partners the different concepts could have. It was important to identify solutions that would create profit for someone, since the project didn't have a business originator.

Design Goal and Interaction Vision

To ensure that the concepts were in line with the project's goal an evaluation of how well they fitted the design goal and interaction vision was conducted. The aim was to create concepts that followed the overall theme of creating an appealing experience for the chosen target group.

4.4.5. Evaluation with the initiators

During a meeting with the initiators of the project four concepts were presented. The initiators contributed with their experience and expertise to provide some guidance to the next step. The intent of the meeting was to discuss the concepts and combine desired features into a final concept that could be further developed. The meeting consisted of a presentation of the work

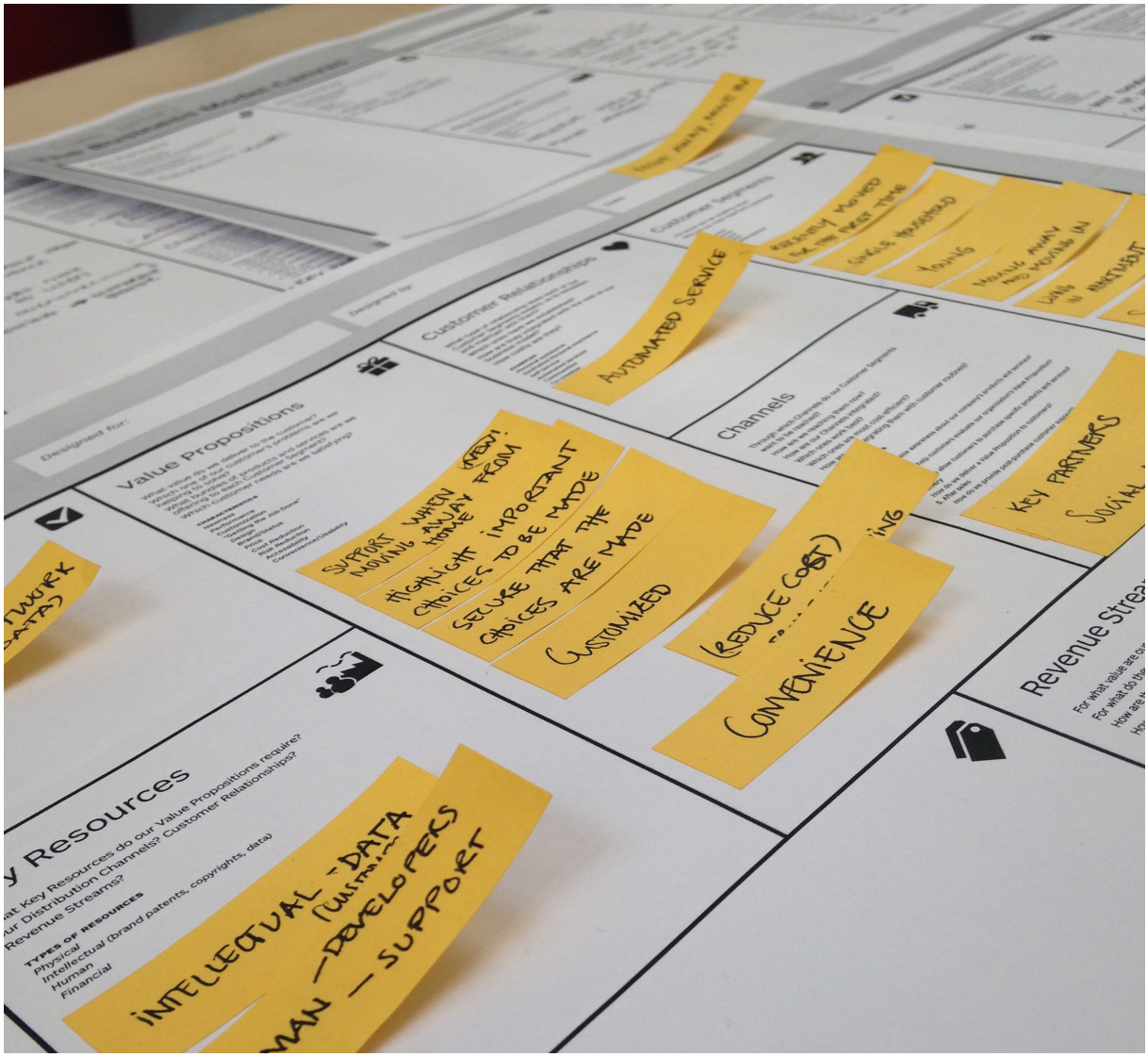


Figure 14. Business Model Canvas

so far, followed by a discussion about the different concepts.

4.5. FURTHER DEVELOPMENT

After the evaluation with the project initiators, different features were combined into one concept. This phase was iterative and small improvements were constantly followed by evaluation.

4.5.1. Pro-Con Analysis

The different features of the two concepts and some additional features that had been identified were analysed using Pro-Con analysis. This analysis means listing the positive and negative aspects of an idea into two columns (Ullman, 2010). In this part of the process, it was of value to find out what potential the different features had. This was used as foundation for choosing features since it revealed what areas that needed more research.

4.5.2. Evaluation of technology

The two concepts required various technologies in order to work. Some important technologies had already been identified but at this stage it was necessary to explore the options more thoroughly. This meant further literature studies that were complemented with contacting two possible partners in order to get an idea of the possibilities. The goal was to gather enough information to make a decision about which direction the project should take. It was found that technology was a limiting factor for the further development and a decision about whether to focus on creating something that could be realisable at the moment with the current technology or that required further development of technology in order to work. Since the end goal had been quite open in the beginning of the project both options were possible.

4.5.3. Evaluation of business case

Parallel to the evaluation of different technologies, an evaluation of the business potential of the two concepts was made. Based on the Business Canvas Models created during the ideation phase, possible partners were examined and different business scenarios were created depending on what technology would be used. It was decided to refrain from contacting the possible partners at this point and instead consider how the concept could be presented in different ways to fit different scenarios.

4.5.4. Iteration of concept creation

Combining different features created three different mock-up concepts. During the creation of the concepts,

Figure 15. Wireframes used during evaluation with users

sketching and brain drawing was used to communicate ideas between the project members and to create new solutions. Brain drawing is a form of brainstorming where the group members write or draw ideas and then switch papers and further develop each other's ideas (van Boeijen et al., 2013). This stage was fairly unstructured as discussion about one feature could lead to improvements of another. As the concepts became more detailed they were digitalised using vector graphics in a generic style. The aim was to make the concepts equally detailed and styled so that they could be evaluated based on the functionality and not the appearance. A series of screenshots were created of each concept showing a sequence of actions that would describe the functionality of the concept.

4.5.5. User evaluation

In order to gain insights of which concept would be most suitable for the users in terms of experience and what improvements were needed, an evaluation with two potential users was conducted using the mock-ups. The participants were given initial instructions about the goal of the mock-ups (Figure 15). Each mock-up was then examined individually in an informal way where the participants shared their thoughts on the different features and how well they thought they might work. During the evaluation discussions about different aspects were encouraged and the project group was also involved in the discussion. The participants were encouraged to express their own ideas about improvements and desired functionality during the session, which lead to many inspiring insights.

The insights from the user evaluation were analysed and another round of iteration started as the final concept evolved even more.

4.6. FINAL CONCEPT

4.6.1. Scenario

In order to describe the user experience a written scenario was constructed. A written scenario is a story about either the current or the possible interactions with a product or service (van Boeijen et al., 2013). The scenario described the intended interactions with the final concept and the emotions that these interactions evoked.

4.6.2. Wireframe

Wireframes of the final concept were produced to describe the details of the interface as well as the interactions between the different screens. Wireframes is a tool that is used to visualise conceptual design. Wireframes are documentation of the structure, content and controls of the concept (Preece et al., 2012).

4.6.3. Prototype

An interactive prototype based on the wireframes was produced make the interactions more tangible for the project group. The prototype was also used to demonstrate the final concept to potential users. The online tool *InVision* was used to create the interactive prototype.

4.6.4. Look and feel

When visualising the concept it was important to consider what expression it should have. The interaction vision and mood board were used as foundation for the look and feel. The words describing the vision were translated into visual guidelines, which were completed by findings from the user study. The mood board was used as a reference for the feel of the concept and the interactions it would provide. The mood board was also used to find inspiration for colours. Further inspiration was found by looking at other user interfaces with similar functions.

CHAPTER FIVE

RESEARCH FINDINGS

This chapter presents the insights from the research phase regarding the users and their experiences of energy conservation, the market today as well as guidelines for the development of the concepts.

5.1. USERS

From the user study insights about the users could be elicited. As the interview study was part of another ongoing project, new interviews were conducted during the time of this master thesis. This meant that more interviews than the ones conducted by the project group were available for analysis. In total 67 interviews were analysed. The interviewees were divided into four age groups; young adults (-29 years), young middle age (30-49 years), middle age (50-64 years), seniors (65+ years). A selection of attributes that were of interest when describing the different user groups was made from the interview data. The attributes were: gender, yearly salary, education level, dwelling size, number of rooms, dwelling type, energy awareness, estimated yearly energy consumption, average number of appliances and what appliances they believe contribute most and least to the total energy consumption.

5.1.1. Young adults (-29 years)

In the interviews 26 young adults participated. This was the user group with the lowest salary level, the reason for this is that most of the young adults were students. Around 75% of the young adults were or had been studying at university. Their homes were often quite small, the average person in this group lived in a one room 33 m^2 apartment, that was either a first hand tenancy or a condominium. The young adults believed that they were fairly or somewhat aware of their energy consumption, but 50% didn't know how much energy they consumed on average during a year. Of those that did think they knew, most thought they were in the lowest range, 0-5000 kWh. Few actually knew what their consumption was, but they estimated that since they lived alone in small apartments they didn't consume that much.

The young adults had on average 25 appliances in their homes. Of these they thought that stationary computers, laptops, TV, refrigerator and freezer contributed the most to their electricity consumption. The reasons why these were chosen were either because they were often used or because they were big, and it was believed that this meant using more power. When it comes to products that contribute the least, these were different depending on the person, but they were all products that were either never or almost never used or they were used only very short periods.

5.1.2. Young middle age (30-49 years)

In the age group 30-49 years old, 15 people were interviewed. The young middle-aged group had significantly higher salaries than the young adults. Around 87% of them had studied at university and they had a salary in the range 240,000 to 360,000 SEK per year. Most of the people in this group lived in a condominium, which on average was 55 m^2 and had two rooms. Almost 50% of the young middle aged people thought they were fairly aware of their energy consumption, 20% thought they were somewhat aware, 20% though they were very aware and 13% didn't think they were aware at all. Over half of the people in this group didn't know how much energy they consumed. Of those who thought they knew, most estimated their yearly consumption to be in the range 0-5000 kWh.

The average household had 31 appliances. Of these appliances, the young middle-aged people thought that their refrigerator, freezer, washing machine, laptop and TV contributed the most to their consumption. Again, the most common reason for believing that these products contributed most had to do with how often the product was used. Also, they too believed that larger products used more power. For example, one person believed that her electrical toothbrush contributed least to the total since it was so small. When asked what products that contributed the least, most people mentioned products like sewing machine and hand mixer that they didn't use that much. The products that were seldom used varied between individuals. However, there were some that had products they believed used little energy by design. For example, one person believed that his laptop was energy saving since it charged quickly and he had a feeling that it wasn't using as much energy.

5.1.3. Middle age (50-64 years)

In the age group 50-64 years old, 12 people were interviewed. Amongst the middle aged people the average salary had increased to between 360,000 and 480,000 SEK a year. In this age group around 83% had studied at university level. Also in this group most people lived in condominiums, with and average size of 78 m^2 and three rooms. More than half of the people in this group thought they were fairly aware of their energy consumption, 20% thought they were somewhat aware. However, a fourth of the middle-aged people didn't know much energy they consumed on average during a year. The rest believed they used 0-5000 kWh per year.

The average middle age household owned 38 appliances. Of these appliances, they thought that their refrigerator, freezer, ceiling lighting, washing machine and TV contributed the most to their consumption. As in the younger age groups, most of the middle-aged people believed that products that were used often contributed the most to the total consumption. In this age group, some mentioned their way of using the products as a contributing factor to the product's high consumption. For example, one participant washed her clothes often without using a full load and at high temperatures, 90°C for sheets and 60°C for other things. This age group also mentioned lighting more frequently, both as a high and a low contributor. Many mentioned that they had the lights turned on often and that they were very hot, but also that they had products with LED, which they thought used little power. Before the emergence of low energy bulbs and LED, lighting often made a large contribution to the total consumption, and people still believe that it's very important to turn off the lights. When interviewing people of all ages this was mentioned as something they did to save energy, or that

they felt they could improve. It was also common that people were unsure about whether they should turn off the lights or leave them on since the lifetime of regular bulbs are affected negatively if they are often turned on and off. However, this isn't the case for newer bulbs. It's possible that the middle aged people were more aware of lights as an energy thief since they have been told so to a greater extent when they grew up.

5.1.4. Seniors (65+ years)

In the last age group, over 65 years, 14 people were interviewed. Amongst the seniors, the average salary was in the range 240,000 to 480,000 kr. Around 77% of the seniors had a university education. The average senior lived in a 77 m^2 condominium with three rooms. Of the seniors almost all believed that they were fairly aware of their energy consumption and the rest either believed them to be somewhat or very aware. In this age group the two most common answers regarding the estimated energy consumption were 0-5000 kWh for around 60% and 17% didn't know how much they consumed.

The average senior household owned 33 appliances. Of these appliances, the senior people thought that their refrigerator, freezer, stove, oven, microwave oven and TV contributed the most to their consumption. Again, people reasoned that products that were used often also contribute much, and the senior seem to focus even more on the fact that heating and cooling requires large amounts of energy. Since most of them are home during the day, they have different habits than the other age groups. It's noticeable that these people may spend more time cooking and baking and that they believe that these activities are strongly affecting their energy consumption. Like the other age groups they believe that products they use the least also contribute the least.

5.1.5. Comparison of age groups

In general the statistics from the different age groups indicated that there weren't really any significant differences between them. Most of the interviewees were uncertain about how much energy they consumed even though they believed themselves to be to some degree aware of their consumption. There are some differences between the age groups in what appliances they believe contribute most and least, but the reasons for believing so are similar. All age groups seemed to believe that large products use more energy than smaller ones, and that how often they are used strongly affects their total energy consumption. Many commented that they believed that screens consume much of energy. Many people also based their assumptions on feelings or something they just believed to be true but couldn't explain.

There were demographic differences between the groups, but most people seemed to reason fairly similar. Especially the older people seemed to see themselves as economical with their resources, while the younger often seemed to be of the opinion that they probably were using a bit too much. For example, some people in the middle aged group often spoke about how little they used in comparison with when living in a villa, while some seniors talked about how they had been brought up with very little resources and that had made them quite thrifty in their way of life.

All age groups talked about the importance of switching off lights. Some were of the opinion that having switched to low energy bulbs was sufficient. Others also expressed that they made sure to turn off the lights when leaving a room. What was common for all age groups was that they were uncertain about whether it would be more energy efficient to turn of the lights every time they left a room, or if they should just keeping them on. This made some people sceptical about if they really had to go through the trouble of turning the lights on and off. Lighting seemed to be regarded as something that could be used differently, perhaps due to the fact that regular bulbs actually use a lot of energy. In general few other energy-conserving actions were mentioned. Many people were of the opinion that the only thing they could do differently was to use their products less, and they didn't want to do that.

5.1.6. Persona

In order to describe the most important characteristics of the user group found in the research phase four personas were developed. The personas were based on the four age groups above, but it was decided to summarise the two middle age groups into one persona and add a second persona for the young adults. The reason for having two personas in the same age group was that two significant user types in that category had been identified during the interviews. This wasn't only based on the statistics but rather on what the project group had noticed when visiting different people. The older age groups had seemed more homogenous but the younger had two different types, the uninterested and the highly aware. The personas are presented in Figure 16-19.

Jack, 20

Jack has just moved away from home to start university. He has never lived alone before and everything is new to him. He uses a lot of entertainment products and therefore believes he's using a lot of energy, but since he lives in a small apartment it's not that much. He's new to living alone and doesn't know how everything works in his home, he does his best and sometimes he has to call his parents for some help. During the days and evenings he's usually in school or out with friends, everything is new and exciting.

Nina, 26

Nina has lived alone for a few years now and enjoys taking care of her home. She usually works from home since she's writing her thesis, so she spends a lot of time in her apartment. She cares a lot about the environment and tries to live environmentally friendly in any way she can. She's a vegetarian and buys her things second hand, but she finds it more difficult when it comes to energy. Since she doesn't own that many electric appliances and tries to not use unnecessary electricity she doesn't consume that much.

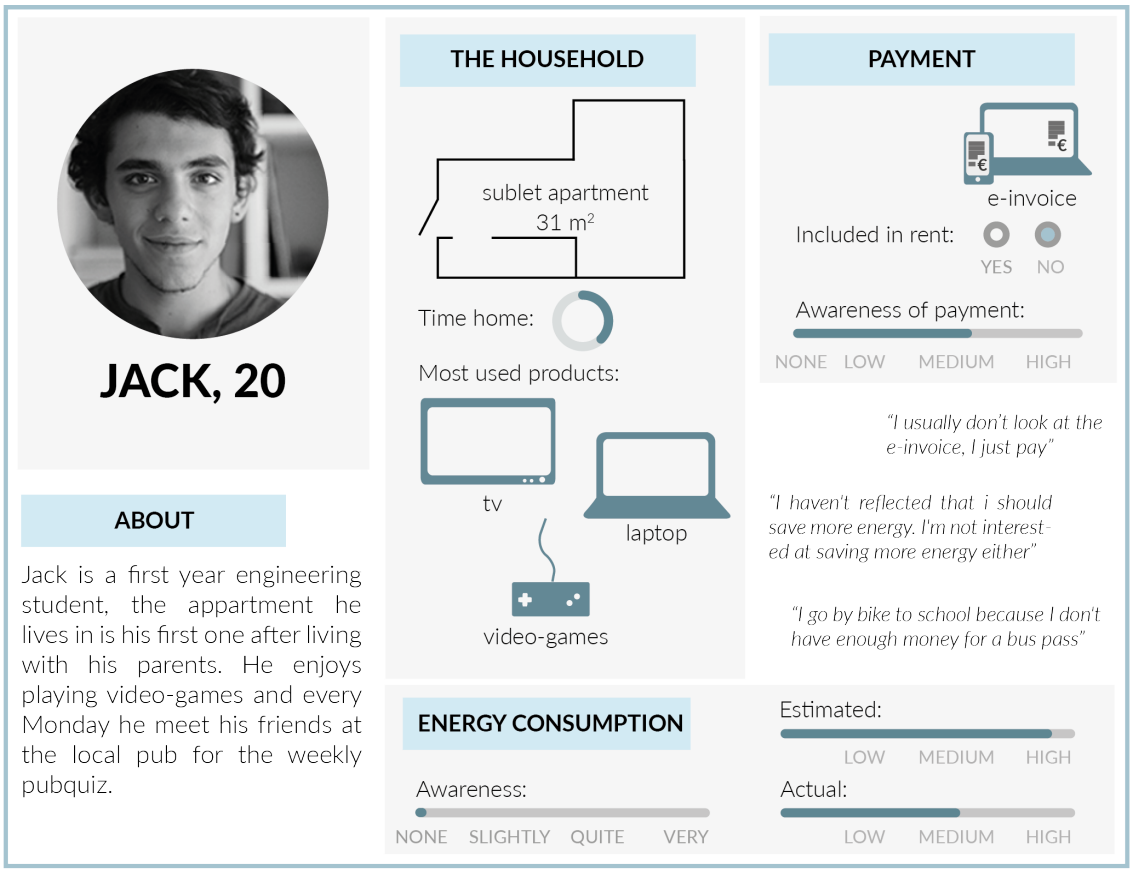


Figure 16. Persona Jack

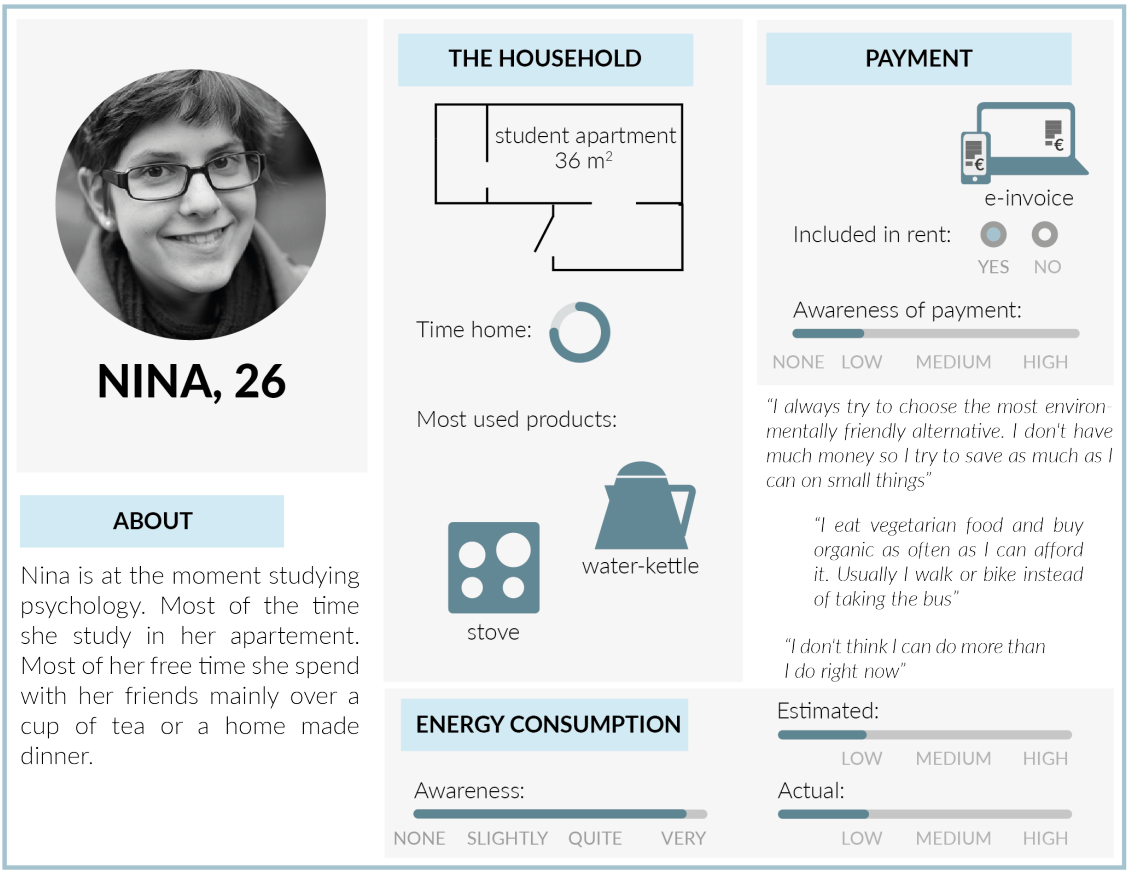


Figure 17. Persona Nina

Tom, 50

Tom works at a well-paid job and spends a lot of his time working. When he's home he just wants to relax, he doesn't really think about how much energy he uses, he just wants to be comfortable. He owns quite a lot of things, he is very interested in new technologies and likes to buy new products. Before he moved to the apartment he lived in a house, compared with that he doesn't think he's consuming anything.

Edna, 75

Edna is retired and spends most of her days at home. She likes the fact that she now has time to listen to radio and drink her tea in peace and quiet. She was brought up in a time when there wasn't as much money so she's pretty economical in most things. When it comes to energy she's aware and tries not to spend too much, but when it comes to being comfortable she's less strict.

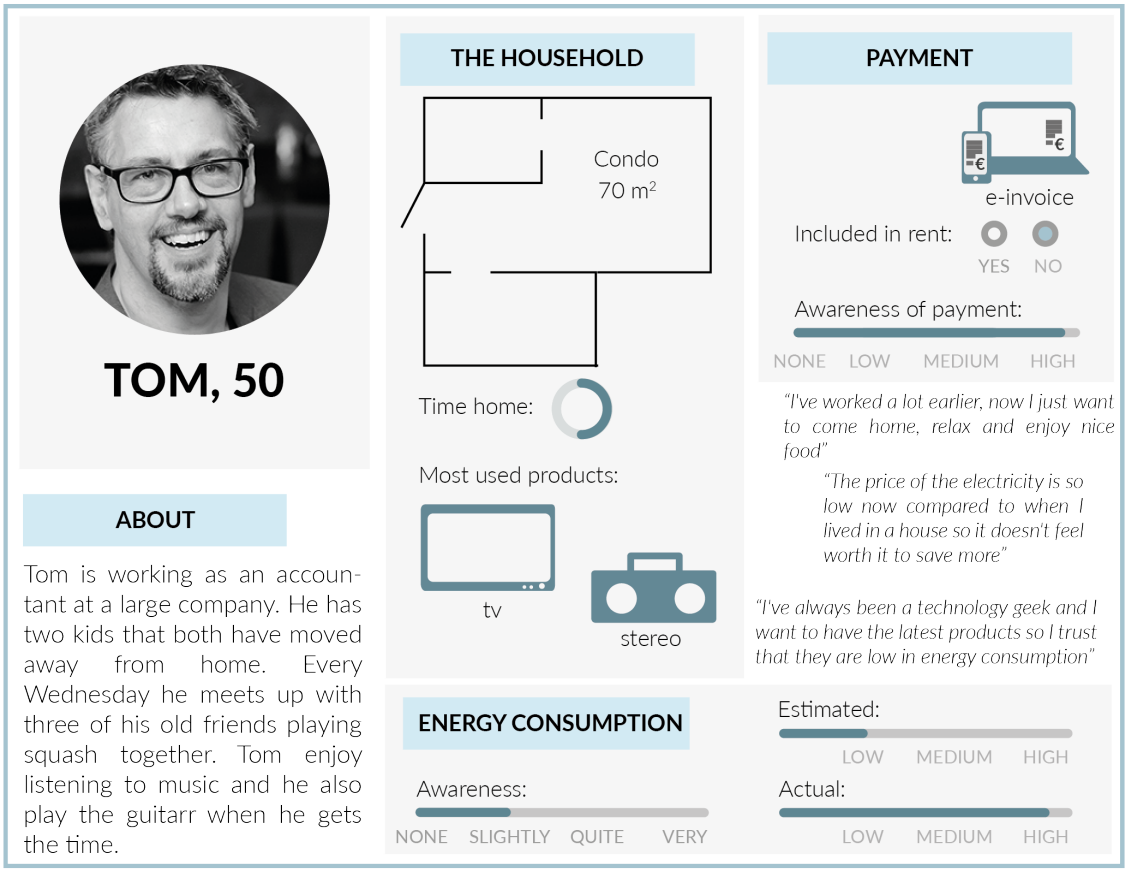


Figure 18. Persona Tom

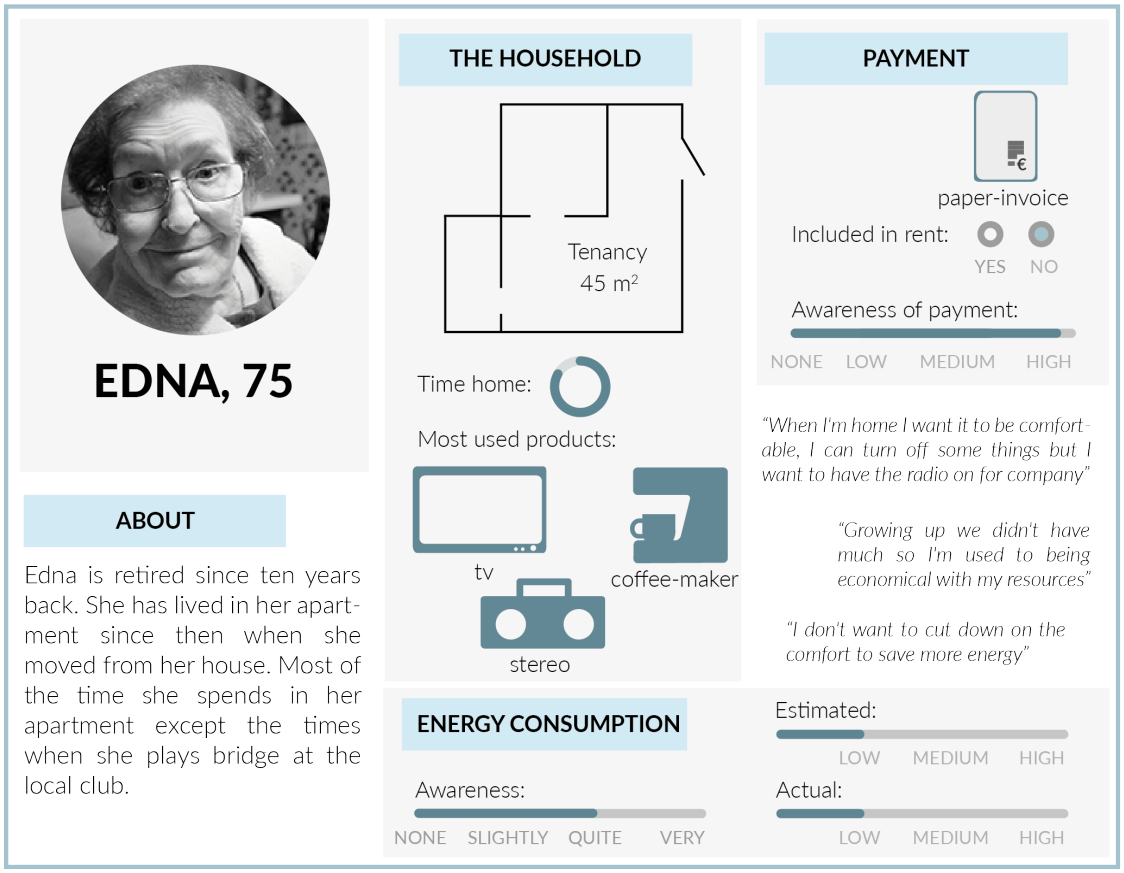


Figure 19. Persona Edna

5.2. ELECTRICITY PAYMENT

Depending on type of living, there are different ways to pay for electricity. During the study two main types of payment were identified for people living in apartments. Either the cost is included in the rent or it's paid on a separate invoice. The cost is either a fixed amount included in the rent each month or it's paid on a separate invoice from the electricity trader where the amount varies for each month depending on the energy consumption.

In rental units and student housing, residents often have electricity included in the rent. This means a fixed price based on what the landlord think will be the normal consumption regardless of how much energy the tenants consume. This may lead to unnecessary electricity consumption, since the tenants feel like they can spend as much as they want without paying more for it. What is estimated to be normal consumption vary between different property owners. One way is to base it on how many square meters the apartment is. It can then sometimes be a pretty unfair estimation if someone lives alone compared to a family that live in an apartment with the same size. As one of the participant mentioned; *"I have a fixed fee that is based on how many square meters my apartment is. I live by myself in a pretty big apartment, so I probably pay much more than what I actually use"*. In some cases they have solved it by giving the tenants money back if they haven't reached the normal consumption level at the end of the year. When the electricity fee is included in the rent the tenants usually don't get any feedback at all on how much energy they have consumed.

In most condominiums the residents choose their own electricity trader and get a separate electricity bill. The payment is then dependent on both the energy consumption as well as the current price per kWh. When a person gets a separate invoice it usually includes some feedback on their energy consumption. How the feedback is structured vary between different company traders, but most commonly the user receive feedback on the total energy consumption divided into the different months during the past year.

5.3. IDENTIFIED BARRIERS

The user study gave a lot of insights about people's feelings and attitudes towards energy consumption in their household.

During the research many different barriers were identified why people in single households don't lower their energy consumption. All barriers are illustrated in figure 20. Some of the barriers were identified as being of greater importance because they were mentioned by many of the participants as well as being strongly emphasized. The chosen barriers to the problem are highlighted in figure 20 and also presented further below.

The project group have translated the quotes from the user study from Swedish.

5.3.1. Inaccessible feedback

In many cases feedback on one's own energy consumption is hard to find. According to the study, one's energy consumption isn't anything people in general are interested in and search for themselves. One user mentioned that she wouldn't be bothered with her own consumption if it wasn't connected to the invoice in a good way.

The research showed that there are many different kinds of products and services on the market today that provides the user with feedback about their energy consumption. However, none of the participants were currently using these products and services.

5.3.2. User gets no feedback

The users that have their electricity included in the rent don't get any feedback at all on their own consumption and therefore have no idea about how much they consume. Since they will pay the same amount regardless of how much they consume, they have a feeling that it doesn't really matter if they change their behaviour. They wouldn't even know if they have decreased it at all. One participant stated *"I have never seen an electricity invoice in my whole life since it's included*

Figure 20. Identified barriers

in the rent, so I have no idea at all about how much energy I consume". Another participant who lived in a student apartment and had her energy included in the rent said that she was pretty lazy, so she would never try to find out about her energy consumption.

5.3.3. Feedback is hard to interpret

When users actually get feedback about their energy consumption, for example on the invoice from their electricity trader, most of them expressed that it was really hard to interpret the information into something understandable. One participant with a separate monthly electricity invoice expressed that he looked a bit on the bars showing the difference between months, but he couldn't use the information from them in any way since he didn't understand it.

Several participants stated that it's really hard to draw a parallel between how much energy they have consumed and how much they pay for it. One participant mentioned that he knew how much he paid for electricity, but he had no idea of how much energy in kWh he had used. Another participant mentioned that she only got feedback about her energy consumption in how much money she had used on energy but not on how much energy (kWh) she had consumed.

One reason why the little feedback that was given was hard to interpret was that people in general lack knowledge about how much power their products consume. Therefore they can't relate to the actual energy consumption in a good way. According to the users there is also little knowledge of what's considered to be an acceptable consumption for the size of the household in order to know if one is consuming a lot or a little.

There are also a lot of comments made among the participants regarding what's considered to be a normal energy usage compared to other people's behaviour. For example one of the participant said; *"I charge my phone on average once a day, so that's not very much"* and another one stated; *"I don't make that much coffee, average one to two times per day, so that can't be considered as being a lot"*.

The combination of little knowledge of the products wattage together with what's considered to be a lot creates confusion and an overwhelming feeling to understand energy as a whole. One participant stated; *"What is 100 kWh? Is that a lot?"*

Another participant expressed that it would be of great interest to know how much all of her products contributed to the total consumption, since it was otherwise hard to know what she could do better at.

5.3.4. Too much effort

During the study many participants expressed that most of the energy conserving actions required a lot of effort. This was considered a barrier for performing them. One of the participants expressed that she knew that it consumed energy to leave the cord to her phone plugged in, but she still didn't unplug it. Another participant stated that she tried to turn everything off as often as she could, but when it required too much effort she wouldn't do it as often.

During the study it was observed that several of the participants used additional products such as timers and power strips with power off buttons in order to minimize the effort of turning off many products. Some of the participants usually unplugged the cord when they were going away for a longer period, but would never do it on a daily basis because of the effort.

5.3.5. Don't know what the right action is

Several of the participants expressed that they often had a hard time knowing what the right action would be in order to not consume more energy than needed. The difficulty was based on the information that was given about energy consumption is usually very difficult to relate to. As one of the participants stated; *"I don't have much knowledge, the information is really hard to relate to"*. And another one said; *"I feel a bit like an American who doesn't know how to eat healthy"*.

Their assumptions about energy consumption in their household were in general based on feelings, what

they've heard from other people as well as how long time the different products were used, and not so much taking the wattage of the product into account. Some of the things that the participants stated were; *"It feels like the stove consumes most energy out of all products I have, but it's just a feeling, I don't know"*, *"It's really hard to know what's the right thing to do"*. *"Even though I use the sewing machine very often I don't think it consumes a lot of energy because it doesn't have any displays or anything like that"*. Another expressed that he felt like a bigger product consumed more energy than a small one.

Most products have their wattage printed onto them, but it's usually hidden and hard to see on the different products. One has to be interested to actually try and find the power of the different products in one's household. When looking at the wattages of the different products, one of the participants was very surprised to see how much power the water kettle used since he had heard how much better it was to use than the stove when boiling water. He then considered that it takes less time to boil water with the kettle than the stove, and thought that is was maybe the right assumption after all, but he still wasn't sure. For most of the participants it was really hard to compare the different products in an understandable way. One participant stated; *"I have a lamp that is on during the same period of time as the stove so it maybe consumes as much, but I don't know"*

Several of the participants expressed that they are interested in sustainable behaviour in other fields and tried to practice what they preached. However, when it comes to energy consumption even they have little knowledge since it's hard to understand and relate to. As one of the participants expressed; *"I think it is strange that I don't care more and are more aware of my energy consumption because otherwise I feel conscious in other environmental questions"*.

5.3.6. Don't want to change lifestyle

From the user study it was discovered that most of the users aren't willing to cut down on their current lifestyle in order to save energy. They would for example never lower the temperature in the apartment and be cold in order to save energy. Energy is considered to be a basic need in the apartment and not something that people can cut down on.

Another insight from the research was that it's hard to change habits that have been formed earlier. One person stated; *"I still persist to live in old habits, like with lamps, I still always turn them off, even though they are energy efficient nowadays and there are probably products that are more important that I need to turn off that I don't"*. Another participant expressed that he had no other energy saving habit from his childhood than turning the lights off. He also expressed the importance of forming habits when one is young in order for them to persist over a longer time. For example he mentioned that he wasn't allowed to throw out any food in school and therefore he still never wanted to throw out food.

One participant also stated that he used all the electrical products that he owned and couldn't be without any of them.

5.3.7. Disinterest

In general there was little interest amongst the interviewees regarding energy. People don't really care about what provider they have or how it provides them with energy, it's just something that has to work in the household. Many of the participants expressed that they know that it's possible to read about it, but since they aren't interested it's too much effort to learn about it so they won't be bothered.

Another aspect that was mentioned, which also leads to disinterest, is that there is little interaction with the actual payment and how much it costs. One participant compared it with getting notifications on your phone when using more than the data traffic-limit, then you can buy more or continue with reduced speed. That increases the interest in keeping the usage under the limit as well as it provides knowledge about what is a normal usage and when it's out of the ordinary.

Figure 21. Selection of quotes from users

The timing of the payment was mentioned by another participant as an important aspect that contributed to the barrier 'disinterest'. He stated that he doesn't really care as much when he gets the invoice afterwards. If he instead would have to pay beforehand, and he had to choose between paying for example 700 or 900 SEK he would choose the lowest and then really try to stay under the limit during the whole month.

5.3.8. Believe one is already doing everything possible

One of the participants mentioned that he didn't think he could do anything about the energy consumption of his products, *"If they are on, they are on",* he expressed. Another participant expressed that there's not much more she could do rather than buy new products in order to consume less energy in the household.

Another factor that contributed to the feeling that one is already doing everything possible is the price of the electricity. One participant thought that it wasn't possible to save any energy since the cost was as low as only around 300 SEK over two months.

5.3.9. Believe one is doing right but it's wrong

As mentioned earlier most of the participants had no idea about their products' wattage. Due of the lack of knowledge some actions might be performed in the wrong way but the user might actually think it's right and keep doing the wrong action.

5.3.10. No visible result, no commitment

The group of participants that had electricity included in the rent expressed that it didn't matter if they would lower their energy consumption because they would still have to pay the same amount of money for it. Similar opinions were expressed by the group that pay separately for their energy, but in this case they felt like it was such a small amount of money they would save compared to the total cost of their household it wouldn't feel worth it. As two of the participant expressed; *"The energy for a whole year doesn't cost that much compared to everything else in the household, so it feels like it doesn't really matter if I reduce my consumption throughout the year"*, *"It is embarrassingly little how much you will save per year on energy consumption. If you do all this stuff that seems to be difficult and take time to do, you earn 700 SEK per year. Then you wouldn't do it"*.

One of the participants expressed how little he actually thought of the cost for the energy compared to other expenses he had; *"We're talking about pennies when buying a mobile phone, but the energy cost is constantly ticking"*. Another participant expressed that when buying food he always thought about what things cost and make choices according to that in order to save money even though it's small amounts. However he didn't at all think in the same way regarding his energy consumption, even though he knew he could save some money in that area too. One participant compared the cost of energy with other costs in the household and said; *"I pay more for internet than energy. You get a lot of value for the money"*. Another compared it with earlier households; *"I lived in a villa before so now when I live in an apartment it feels like it's for free now, so I don't really know how much I pay anymore"*.

Some of the participants mentioned that if they didn't know that more people were doing the same thing it didn't feel motivating enough to save energy since they couldn't make such a big difference alone. As one participant stated; *"It doesn't really matter if I do it or not if not everyone's doing it"*. It was mentioned that it would be more motivating to save more energy if it was a collaboration with people around you such as in the same building or the neighbourhood.

It was expressed by one participant that energy savings never gave any positive feedback or feeling and therefore it was highly unmotivating to save more energy. As another participant said; *"I can do something, but nothing happens for me. It's a luxury problem, but I can't see that something happens if I save. I want something in return."*

5.3.11. Can't do all, don't know what to prioritize

Many of the participants were aware that they could change their behaviour in order to save more energy. However, they felt overwhelmed by all the actions they could perform and they weren't willing to do all. Since they didn't know which was the most important, they often didn't do any of them.

5.3.12. Product hinders energy efficient use

According to the user study many of the products hinder the user in some way from using them in the most energy efficient way. For example many products don't have a button or something similar placed on the product that can be used to turn it off completely. Instead in many cases the cord needs to be unplugged. One participant stated that she couldn't find the power off button on the TV so she left it in standby even though she knew it consumed energy. This has led to many of the participants using a power strip instead to make it easier to turn off products. As one of the participants said; *"I have a power switch with switch-off to be able to turn off multiple devices simultaneously"*. Although far from all participants in the study used them. Some of the participants weren't even aware that many of their products were in standby mode since they thought that the button on the remote turned them off.

One participant expressed that she wasn't allowed by the property owner to turn the floor heating off during the summer even though she didn't need it at all.

Many of the participants were aware that some products have an eco-program, but only a few actually used them because of reasons such as they are hard to discover, they think they take too long or they don't think they gain anything from using it. As one participant mentioned; *"I don't even know if the dishwasher has an eco-program"*.

5.3.13. Evaluation of barriers

A questionnaire was sent out to the interviewees concerning the identified barriers. The respondents were asked to rate how well they considered that the barriers described their reasons for not saving energy. Two barriers were not included in the questionnaire, *"Believe one's doing right but it's wrong"* and *"Product hinders energy efficient use"*. These were excluded because they don't regard the participants' own perception, but rather observations that some users have the wrong idea about some actions. Since the participants didn't seem to know what was energy efficient for different products, it was decided to not ask them about whether the product hindered energy efficient use or not.

In total there were 32 responses. Amongst the respondents 66% were women and 34% men. Of these people 44% were working, 25% were retired, 25% were students and 6% were unemployed. The respondents were asked about how they paid for electricity, as this could affect the answers. Most people paid for their electricity separately, of these 38% paid via e-invoice and 28% paid via paper invoice. Of the rest, 28% had electricity included in the rent and 6% paid for electricity by other means. This could for example mean that they lived in a sublet apartment and paid directly to the tenant.

The results from the different barriers are presented in appendix V. The responses didn't provide any clear indication on which barrier was the most challenging. Neither was it completely confirmed that the users experienced these barriers. However, the responses were quite different which means that some people experienced these barriers when trying to save energy. Since no assumptions could be made based on the questionnaire about what barriers were worst, it was decided to work further with all barriers.

5.4. MARKET

In total 25 eco-feedback systems and 11 home automation systems were examined. A list of the included systems can be found in Appendix VI. Of these 4 systems were both in the feedback segment and the home automation segment. The systems were both from the Swedish and the European market. Some of

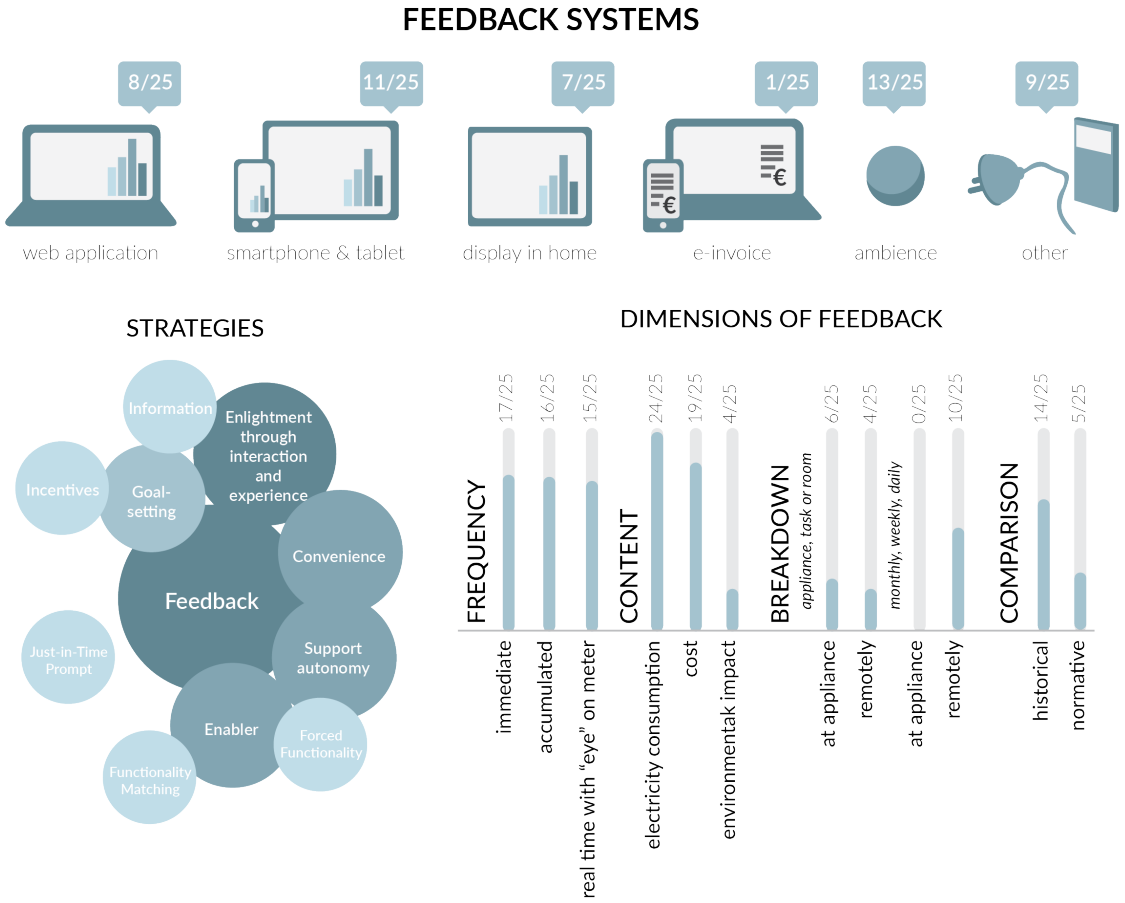


Figure 22. Benchmarking, feedback systems

the most interesting aspects are presented in below and illustrated in Figure 22 & 23.

5.4.1. Eco-feedback systems

General

The eco-feedback systems varied from simple feedback in the form of lights to raise awareness around electricity to advanced systems that show consumption in real time and break it down on appliance level. The more advanced feedback systems can go into detail and help users determine which products use the most energy and find products that might be using energy even though they aren't being used actively. Most of the systems that were investigated are meant for one household but there are some that can monitor whole buildings or let users set up different channels that are linked to for example their house or their holiday house. Many of the more advanced feedback system are tied to the electricity trader that provides the service but some can be bought for any household. The simplest systems are mostly smaller physical products, such as a plug that give ambient feedback by varying light intensity based on energy consumption. These products aren't tied to any electricity traders.

Some eco-feedback systems enable the users to set consumption limits, and notifies the user with an alarm when the limit is reached. This way the user can play a more active role in his or her consumption by actively choosing an appropriate limit.

Feedback dimensions

Frequency, duration and content

The more advanced systems can present real time consumption data by using an "*eye*" on the meter that communicates with a device that's installed in the home with access to wifi. The data is then processed in the cloud in some cases and sent to a user interface or displayed directly. The accumulated consumption is usually displayed in graphs or diagrams, enabling the user to compare the consumption between different times of the day, week or month. Energy use is strongly related to season and outdoor temperature, and many feedback systems include outdoor temperature in their graphs to support the users in analysing their consumption correctly. The data can be visualised in energy consumption (kWh) and cost (€, $, SEK) and in some cases the environmental impact is indicated by the amount of CO_2. One system uses a virtual simulation of a tree that grows or decays depending on how much energy is used. Another system relies on affective design by giving the user a cute avatar that is happy when consumption is low and gets exhausted when consumption is high. The simple feedback products mainly give ambient feedback in the form of light of different colour and/or intensity to indicate how electricity consumption or electricity price changes. Some systems also display immediate feedback, i.e. how much energy is being used this moment, which is presented in watts.

Breakdown

The more advanced systems can provide appliance, room and/or task specific breakdown either by having a smart plug connected to the devices or by disaggregation technology. This information is used to inform the user about which products are on or in standby mode as well as supporting the users in analysing their aggregated consumption.

Comparisons

The systems that record consumption instead of only giving immediate feedback all give historical comparisons for the user to see their progress and learn more about how consumption is linked to for example season. Only a few systems provide normative comparisons, which can spur users to improve if they consume more than the average. One system uses normative comparison linked with breakdown to indicate if a product is using more or less than it could. This provides further tools for the users, as they might not know what is a reasonable consumption for different products.

Interactivity / medium

Most feedback systems are interactive and enable the user to choose different ways of monitoring their consumption. The user interface of these systems is applications for the web, tablets or smartphones while the more immediate monitors are usually in-house displays. One smart phone and tablet application also shows the user's e-invoices, combining frequent feedback with bi-monthly feedback.

Strategies

The eco-feedback systems employ different strategies but all of course use feedback. The simpler products use the strategy *Enlightenment through interaction and experience*. The more advanced systems also work with *Competition* and *Goal-setting* to motivate the user to save energy while those systems that are also used for home automation use the strategies *Support autonomy, Convenience* and *Enabler*.

Price range

The price for eco-feedback system vary from being free for the users that are customers to a specific electricity trader to about 200 British pounds, which is equivalent to around 2600 SEK.

5.4.2. Home automation systems

General

Home automation systems come in different designs, some are simple plugs that can be controlled remotely and others can control entire homes. All these systems

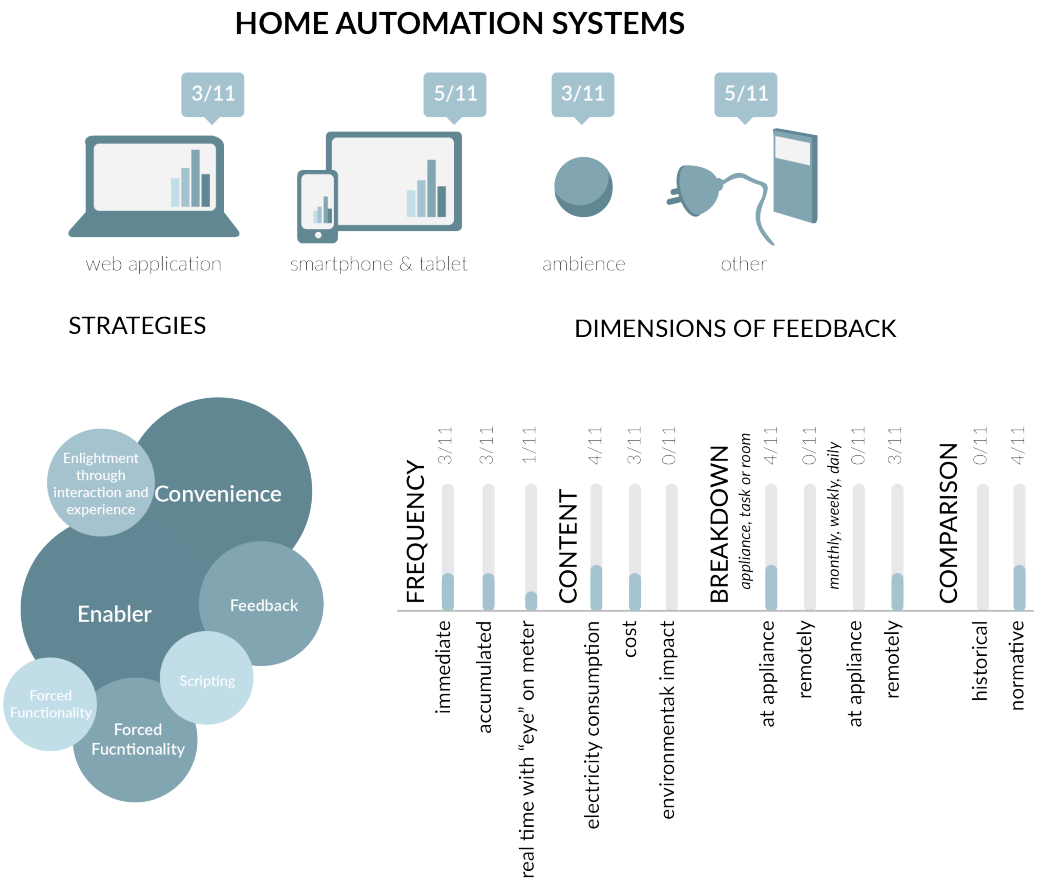


Figure 23. Benchmarking, Home automation systems

are part of the development towards smart homes. The more advanced systems enable the user to create scenes or scenarios for different action via a smartphone or web application. This way the user can easily control and monitor their home with minimum effort. However, the setup time for these systems is quite long.

Smart homes are a product of the shift towards Internet of Things (IoT), meaning that objects are connected by the Internet and it becomes possible to control them remotely. The current smart home systems use RFID (radio frequency identification) and sensor network technologies to link the products in a mesh network. This produces huge amounts of data, which need to be stored, processed and presented to the users in an easily understandable way. For this purpose, cloud based computing is needed (Buyya et al., 2013). To connect all devices, the system needs access to WiFi or 4G Internet. In this report one system has been reviewed, which uses Z-wave protocol to achieve. This is a RF based technology that is widely used in products that are in the Z-wave Alliance. Z-wave can be used to create a smart home where all appliances are connected can be controlled.

Smart plugs are placed at the appliance that can be switched off remotely. Larger home automation systems can control more than one appliance. The smart plugs come in various designs; the simpler ones are controlled with a remote controller and the more advanced use smartphone and tablet applications.

Strategies

The home automation systems aim to empower the user to control their surroundings, using strategies such as *Support autonomy*, *Convenience* and *Enabler*.

Price range

The price of home automation systems varies from the very low tech and simple ones at 29 SEK to the most advanced smart home system at 440 British pounds, which is equivalent to around 5700 SEK.

Safety

One selling point that characterises home automation systems is safety. The user is notified when leaving the house while still having products on and they can control the home environment and can turn on appliances remotely. For example this can be used to turn the lights on upon arrival or to make it look like someone is home to avoid burglars. These features are packaged into one solution for the entire household.

5.4.3. Comparison of available system

The main selling point of most eco-feedback systems is that the user can make drastic savings on their energy bill if using the system. This is often true for house owners who consume a lot since they're often more people in the household and has a lot of space compared to apartments. Also house owners often pay for heating and water, which people living in apartments don't. The current eco-feedback systems often require access to the electricity meter, which is not always possible in apartments since meters are often placed in a part of the building that may not be reachable by the user's wifi (which is required for sending data). This means that the current eco-feedback systems providing detailed data to save money aren't really adapted to people living in apartments.

The home automation systems require the user to spend a lot of time on setup since they need to identify every appliance the user wants to control. The currently available systems provide the users with a wide selection of feature and data, but this has resulted in very complicated interfaces. These applications may fit the enthusiast who enjoys trying out new features and doesn't mind doing a bit of programming themselves. However, for the uninterested user these systems are overwhelming and they may be discouraged to use it at all. The high price of the more advanced systems might again be acceptable to the expert users, but the less interested will most likely not feel motivated enough to spend that much money.

The existing eco-feedback systems are either both very complicated and advanced or they're very simple. The more advanced systems provide raw data presented in graphs, which can be overwhelming for the user. The data presented leaves the user with the difficult task of making sense of the information. This may fit the interested user, who enjoys analysing graphs and looking back to remember what he or she was doing at different times. However, it's not well adapted to people who don't want to spend that much time on energy conservation and it can cause them to give up before they even start. The simpler systems mainly use light to create an interesting experience and raise awareness about energy. However, they don't provide the users with the right tools to understand what to do about their consumption. In order to reach those who aren't particularly interested, a simplified version of the advanced systems are needed. The new solution should provide tools for the users to understand what their consumption data means and give relevant advice on what to do to lower the consumption.

An advantage of automation systems is that they are attractive to people that don't want to put too much effort into conserving energy. At the same time the more advanced systems are not really promoting energy conservation but rather giving the user control over their appliances. They are fitted for people who are enthused by smart homes and want to be able to make automated sequences for tuning on or off devices based on different occasions. A disadvantage with using any technology like Z-wave, which requires products that have the right electronics inside them, is that

people may own only some products or none that are compatible with the technology. Making it standard to use that technology in all new appliances would reduce this problem, however people may not be able to buy new products just in order to work with their smart home system. As the evolution of smart homes continues more and more products will of course be compatible with these systems, however the transition will not happen overnight so it's still relevant to look for a solution that can be used during the transition.

In summary, there are some negative aspects with both types of systems in regards to people living in apartments. There also seems to be a lack of solutions that fit a user who's not overly interested in energy savings or likes to spend time on setting up automation sequences. There are some simpler systems, such as smart plugs that require less effort from the user but in return need to be places at every appliance.

5.5. DESIGN GOAL AND INTERACTION VISION

The analysis of the user study revealed that people currently feel that energy conservation is difficult and that they don't get anything of value for doing it. It was therefore desired to make people feel differently about energy conservation. This idea was described in a design goal and an interaction vision. The purpose was to give further direction to the project and to in an early stage create a framework for the user experience.

The design goal was based on the fact that energy conservation currently is perceived as challenging and not very rewarding. The goal then became: Create an appealing experience for single householders when saving energy.

In order to reach this goal, a vision for the interaction with the final concept was created. The vision was to make energy saving feel more rewarding, both for the user and for the planet. The vision was therefore to create a win-win feeling when interacting with the concept. This interaction was described by the qualities Satisfying, Beneficial and Relieving, which are presented in a mood board in figure 24.

Create an **appealing experience** for single householders when **saving energy**

Figure 24. Design Goal and Interaction Vision with Mood board

5.6. GUIDELINES

The research showed that users are quite unaware of how much energy they use and what that amount means. Also, they aren't certain about how different appliances and tasks affect the total energy consumption. This indicates that feedback showing either task or appliance specific breakdown would be helpful to the users. It's however uncertain how the accumulated consumption is broken down into different appliances and if this requires an extra device on the electricity meter. Some indications of this have been found but further investigation is needed. It's desired to avoid extra devices, installation by an electrician or access to the electricity meter since this will be more expensive and all users won't have access to their meter.

The low awareness and the lack of understanding of kWh indicate that the final design needs to explain energy in a way that is easily accessible to the users. Also, it's important to not just provide feedback but to help the user analyse the information. Even though providing diverse feedback can help the user analyse their consumption, there is a risk of overwhelming them with too much information. Instead the information should be processed in some way to fit the specific user so that they receive relevant feedback.

The benchmarking revealed that while home automation reduce the effort of carrying out some energy conservation actions, they also require long set-up times and cost a lot of money. Some simpler versions have shorter setup time but then require many smart plugs in order to control all appliances. Eco-feedback systems on the other hand can be less expensive, but don't really reduce the effort of the actions. Creating a product or service that is free for the users would be beneficial in order to reach out to as many people as possible and in that way lower the emissions as much as possible.

The research findings were translated into guidelines in order to make the findings more concrete. The guidelines were intended to create direction in the project rather than being a specification of what the final concept should be. A concept could fulfil only some guidelines and be considered as successful. The guidelines are presented in figure 25.

GUIDELINES
Increase possibility to perform energy conserving actions
Provide easily accessible and easily understood feedback
Reduce effort of carrying out energy conserving actions
Create an interest in energy conservation
Create an interesting experience when conserving energy
Fit into current lifestyle but support user in creating own energy efficient routines
Inform user about what the right action is
Guide user in prioritizing which action to focus on
Indicate effect of an action
Possibility to see progress over time
Increase probability to start using the service
Increase probability that service will lead to change in behaviour
Individualize - by making information understandable
Simplify - be adapted to that specific user (and his or her routines)
Minimize overload - not provide too much information

Figure 25. List of guidelines

CHAPTER SIX

IDEATION

This chapter describes the path from the research findings to evaluation of four concepts, ending up in a final concept.

6.1. IDEATION OVERVIEW

The idea generation resulted in a large number of ideas that were evaluated and further developed in several stages. In each stage a selection was made and some ideas were eliminated. In order to refine the ideas further decisions about how to focus the project needed to be made. At this point ideas that were tied to one specific product, such as a solution that would only affect the energy consumption of the fridge, were eliminated since the project group wanted to focus on products or services that would affect the users interactions with more than one product. To further focus the ideation it was decided to consider the needs of the different personas in order to find inspiration.

6.2. EVALUATION OF PERSONA

Different aspects of each persona were discovered regarding what values they have, how their everyday life looks like as well as specific needs they have. The evaluation of the personas revealed that the youngest persona, Jack, was of more interest for the project. It was therefore decided to focus on people in that specific user group. The decision was based on the fact that this age group is a common group that live in single households. Also, it's a group that hasn't or recently has moved to their first own apartment. This is of interest since they then haven't had the time to form their own habits. Therefore this is a user group that can more easily be influenced to form new habits towards engaged consumption.

The chosen group was also according to the research findings a group that have little knowledge about their

own energy consumption. They're also curious about new products and services, and they can easily adapt to them. This increases the possibility that the final concept would make a significant difference in their awareness of their energy consumption. However, due to their lack of interest about their own energy consumption they wouldn't actively look for a product or service in that area. Therefore it was of great importance to discover other needs for that specific user group that would provide means of reaching them and possibly add more value to the final concept. Several areas of interest were discovered.

The first area of interest was that these people haven't lived by themselves before and they are in need of guiding and help with tasks related to their household. Although they might need this help they might not want to feel like they're getting too much help, creating a feeling of independence is therefore important. These people would also need some help regarding their economy. There are several expenses that they haven't had before and in combination with the lack of experience in how to live on a low budget they need some help. Another interesting need that could be considered was the lack of experience in how to make up a plan in order to optimize their life with all the additional household tasks. Especially since they spend little of their time in their household, but more in school, at work or with social activities. Another interesting aspect discovered was that there are a lot of tasks that need to be carried out before moving. They would therefore need some practical help to make sure that they have done all the important tasks in the right time. Finally, like most people they are interested in social activities and therefore that might be an interesting aspect to consider.

After smaller evaluation on the areas, one idea was identified as most promising since there seemed to be a lack of current solutions in that area. The area of interest was to help the user with important tasks connected to moving. The further idea generation became focused on solutions in this area.

This lead to an update of the design goal; *Create an appealing experience for newly moved in single householders when saving energy*.

6.3. CATEGORIZATION OF IDEAS

The decision to focus on one persona made it possible to make a new selection of ideas. In order to get a better overview, the chosen ideas were organised by how much the user is in control when interacting with solution (Figure 27). The applied strategies range from having the user in control of their actions to the product forcing them to perform the most sustainable action. The ideas were therefore divided into three different

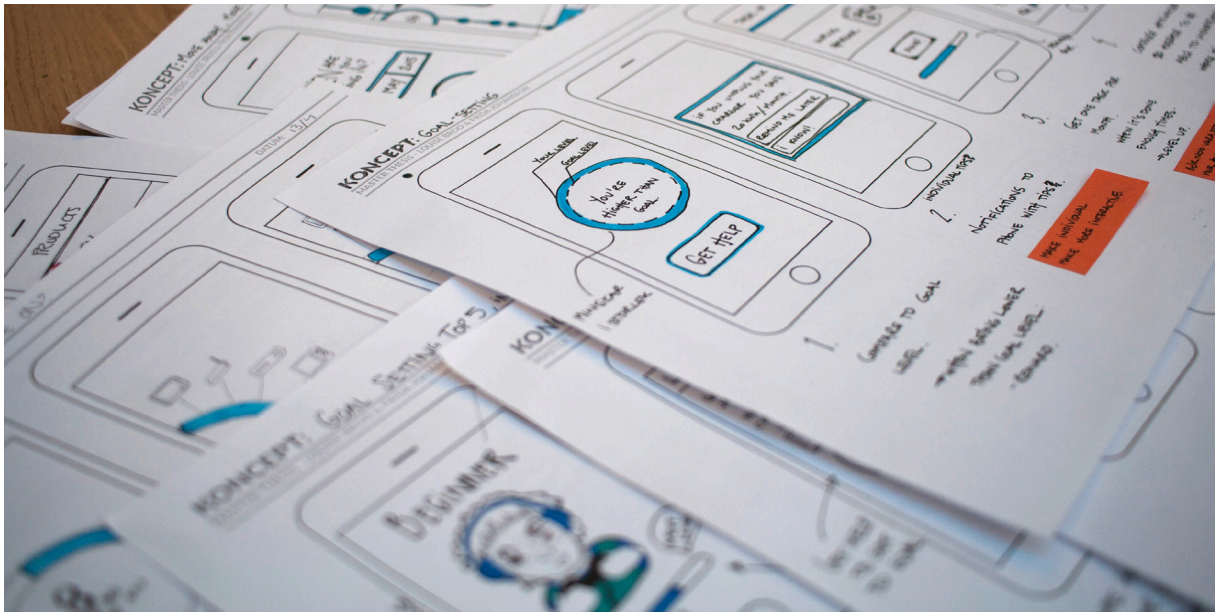


Figure 26. Ideation

categories: information, feedback and automation. In total there were 18 ideas of which 6 were in the information category, 8 in the feedback category and 4 were in the automation category. These ideas were evaluated according to the guidelines and 16 of them were kept and combined into different concepts. Two ideas were eliminated since they met too few guidelines.

The process of combining ideas was iterative and different ideas were combined based on intuition and then evaluated. From the combined concepts, four were chosen to be further developed. The selection was based on the wish to have concepts that represented the different categories - information, feedback and automation. The goal was to eliminate concepts that were too similar to each other.

6.4. CONCEPTS

In order to better grasp the different ideas they were combined into four different concepts that are presented below. They use different strategies such as feedback and goal setting, and solve different barriers. The concepts help the users perform different actions to lower their energy consumption; some only affect a few actions while other can have a wider impact. It was intended to create concepts that differed from each other in order to show a wide range of ideas for the purpose of then choosing different ideas from different concepts to create the final concept.

All four concepts are all mobile applications and should complement smart homes in order to be suitable in the future rather than being a competitor to the smart homes. They are described further in figure 28-31.

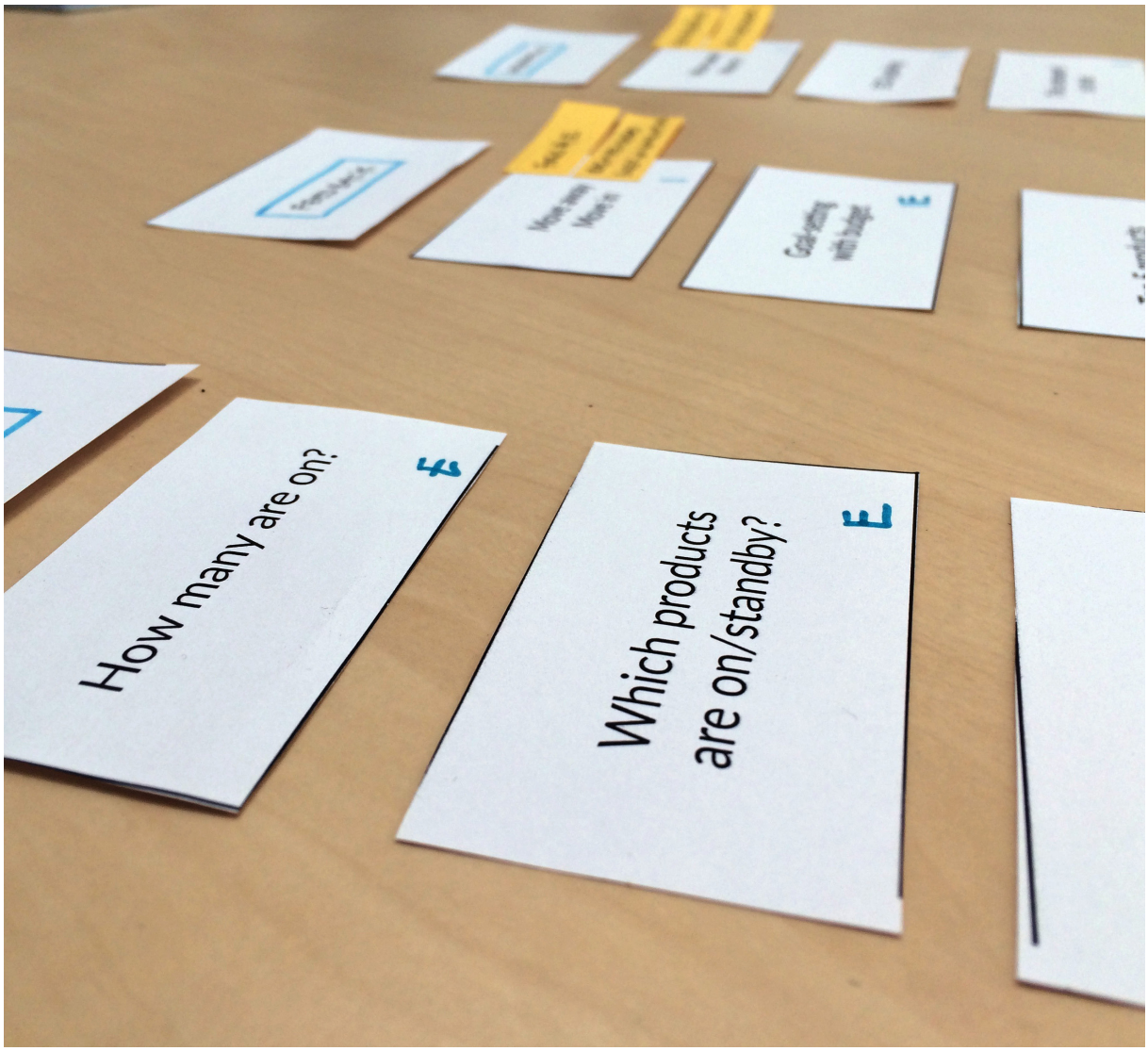


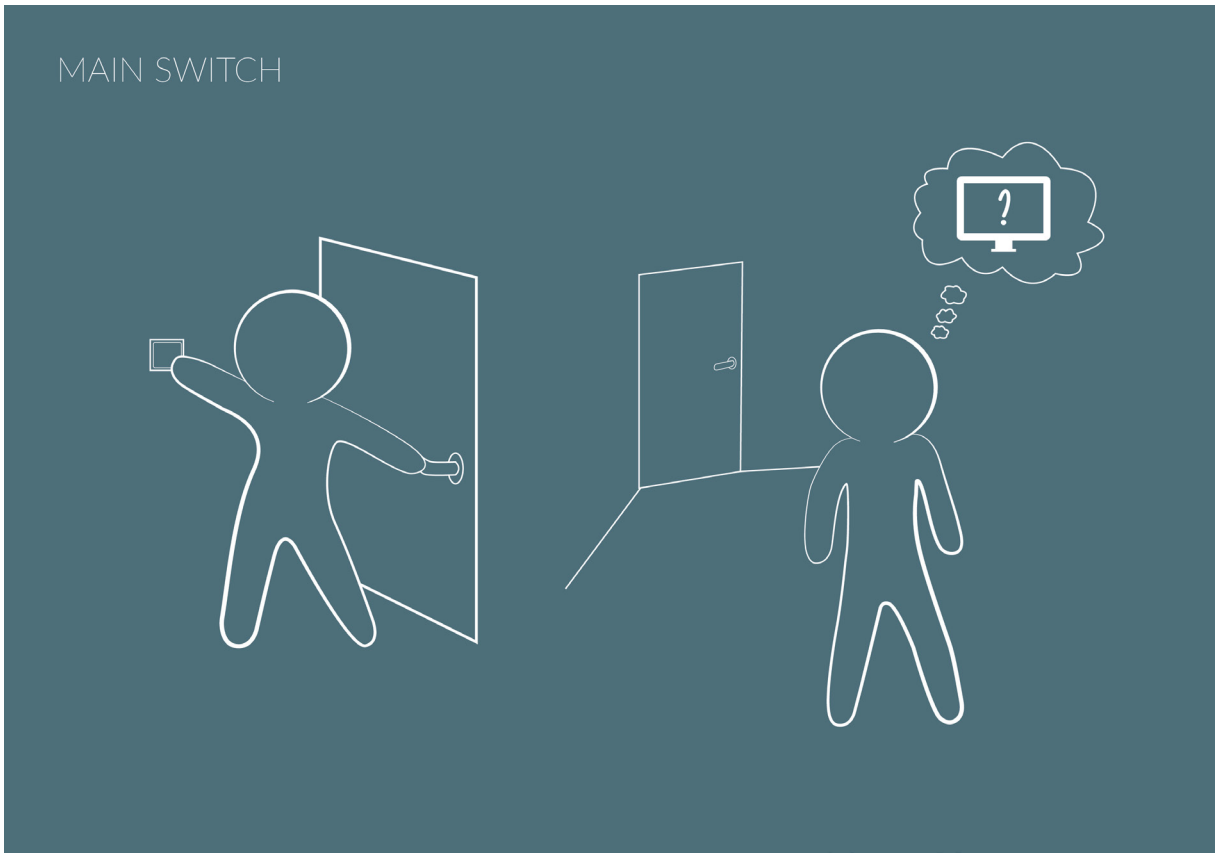
Figure 27. Categorization and combination of ideas

6.4.1. Main switch

The concept *Main Switch* is a smart phone application that helps the user to turn all products off when leaving home in a simple way. It's focused on solving the barrier that the users thought it required too much effort to save energy. In this case it's too much effort for the user to turn off all their products when leaving home on a daily basis. The interface shows how many of the products that are turned on as well as off together with a button that allows the user to turn all its products off or on at the same time.

The system also notifies the user when the phone senses that the house has been left while products are still on. The application then asks the user if he or she wants to turn off all products. This works in the same way when the user enters the home.

The concept simplifies an action that is for most people a habit and at the same time makes the user pay attention to how many products that are actually on or in standby that the user doesn't know about. The concept is a first step towards the smart homes.



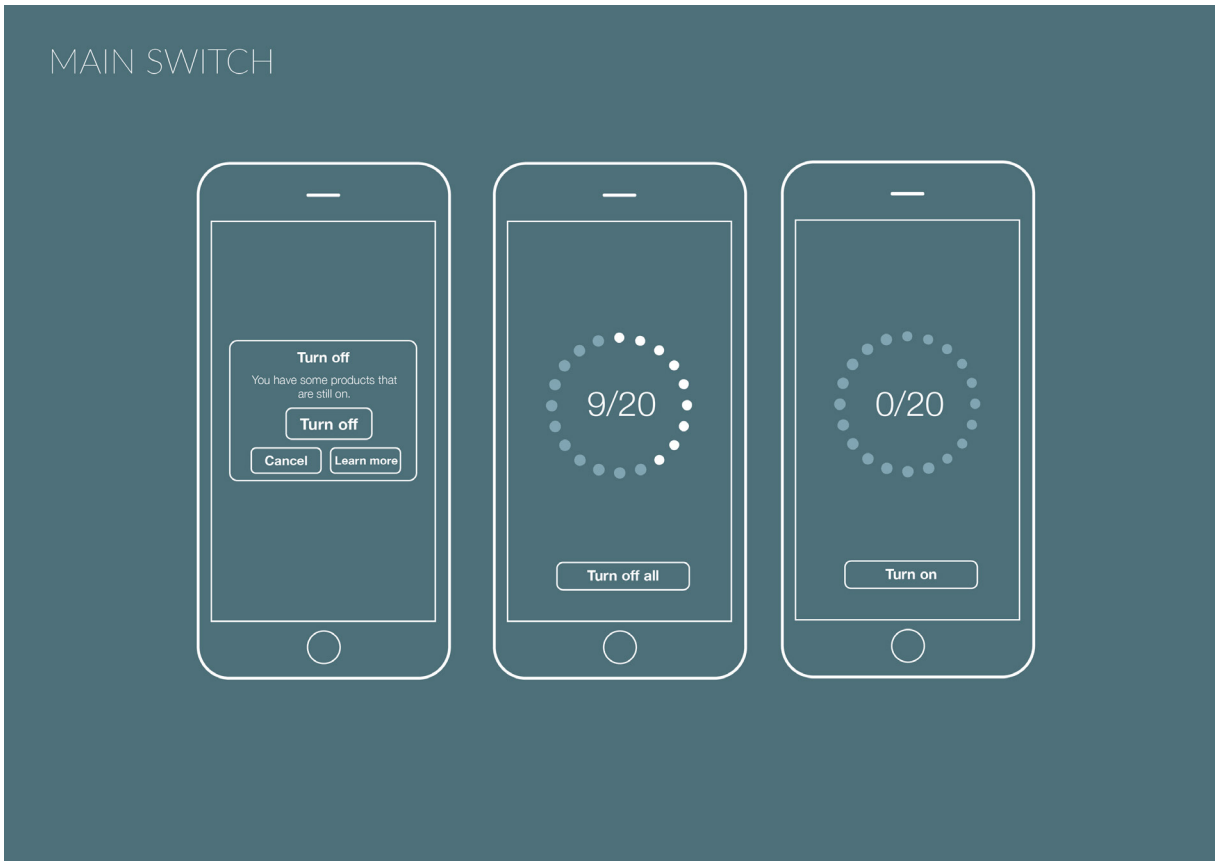


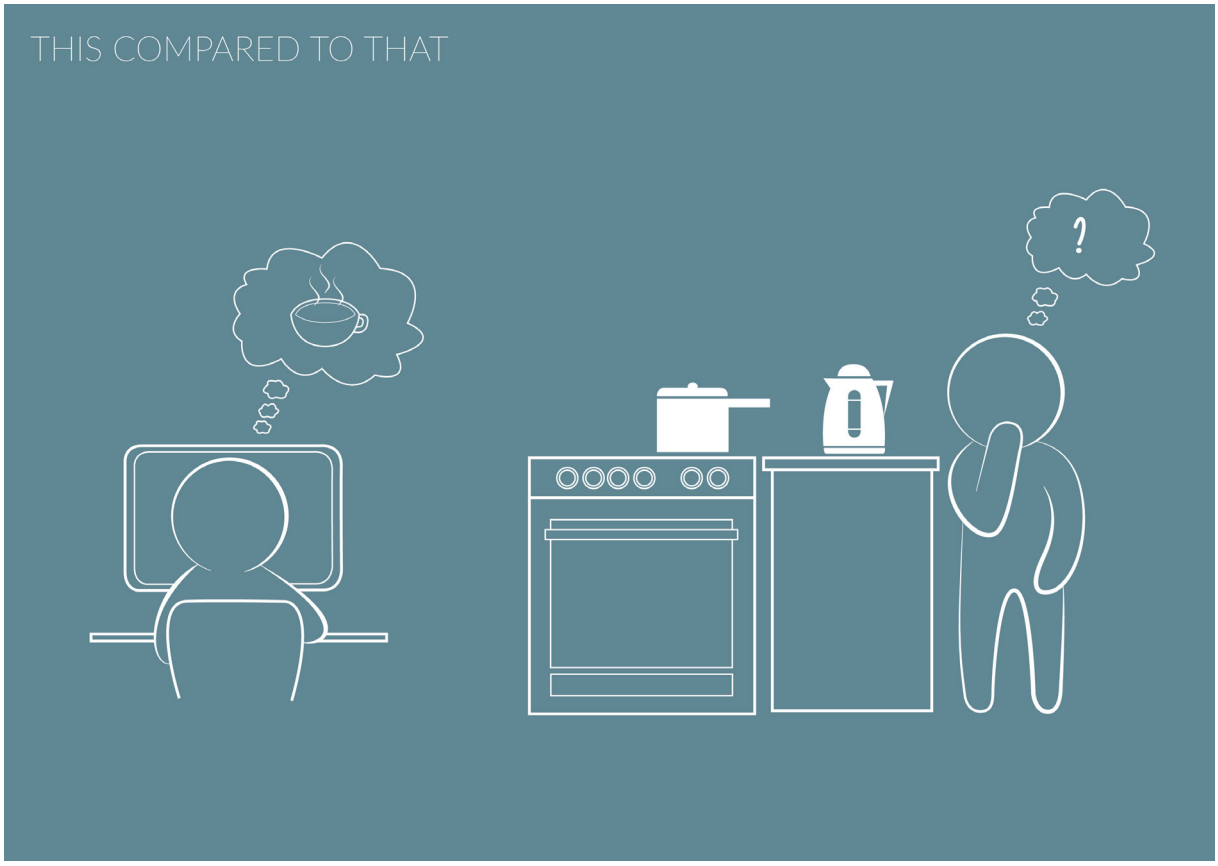
Figure 28. Concept - Main Switch

6.4.2. This compared to that

This compared to that is a concept that focuses on informing the user about what the right action is in different types of situations that occur when using their electrical products.

With this service the user can simply choose a product and compare it with another, which performs the same task, and in order to compare them. The application then generates the most sustainable option by providing approximated information about energy consumption and price. It can also be used in order to compare the same product when using it in different ways, such as a full load in the washing machine compared to half-full or an eco-program compare to normal program on the dishwasher.

From the research study it was stated that many of the users mainly choose how they use their appliances based on feelings and what they have heard and little on actual facts. This concept helps the user understand what the right action is.



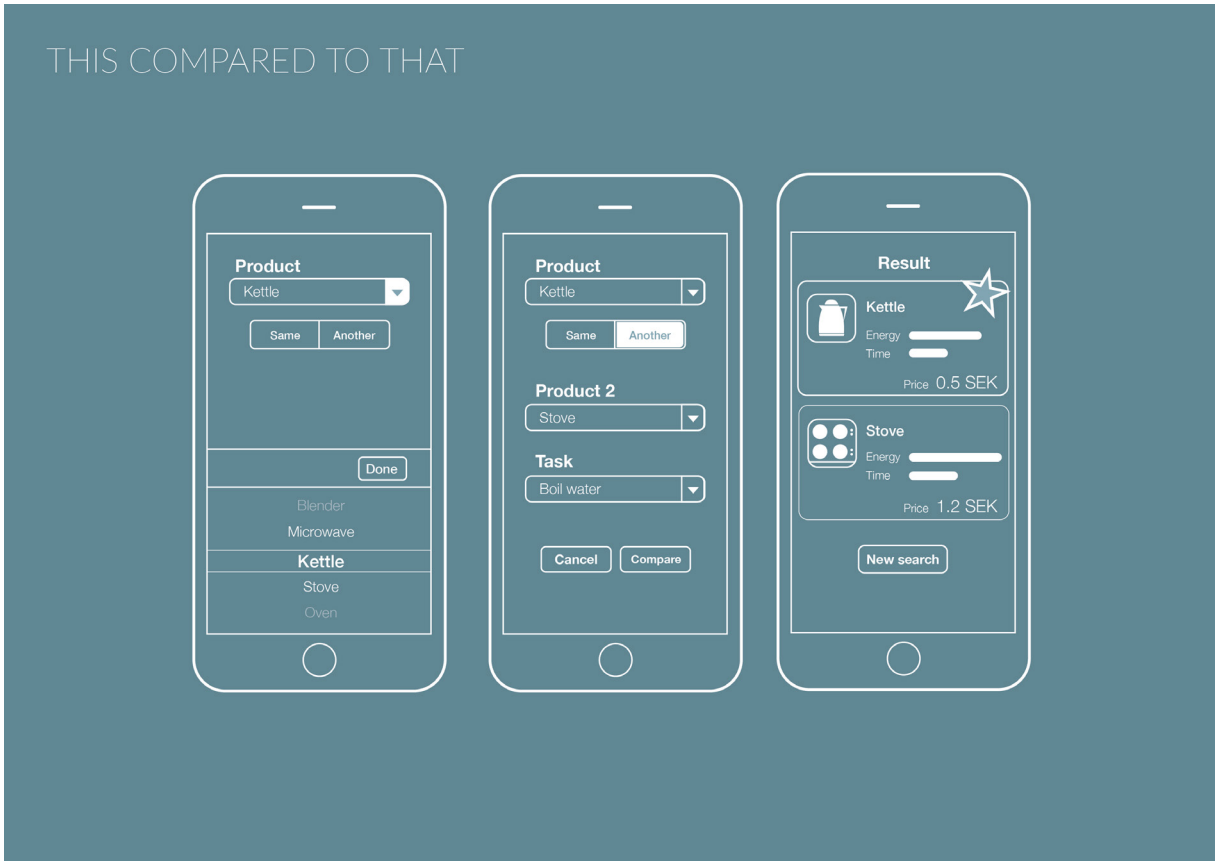


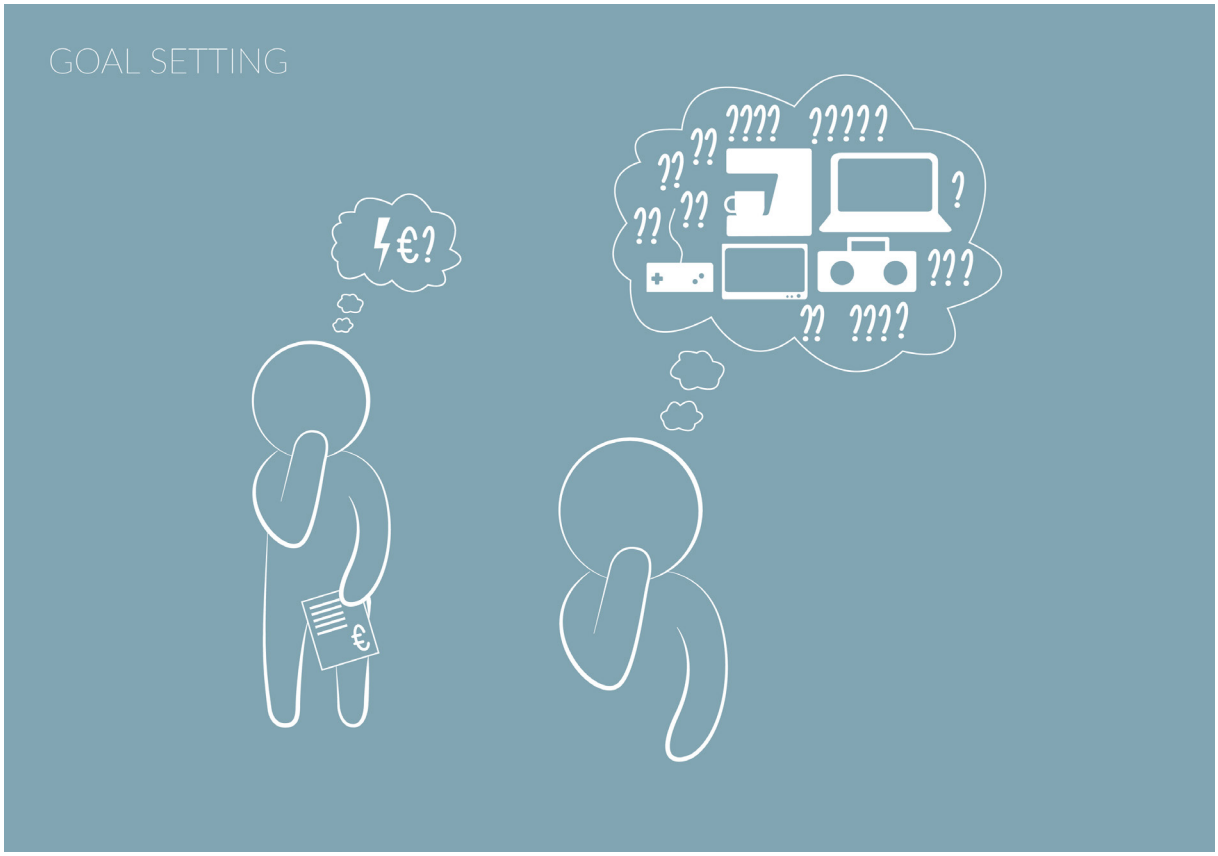
Figure 29. Concept - This compared to that

6.4.3. Goal-setting

The main screen of the concept *Goal-Setting* shows the user's accumulated energy consumption. Feedback is broken down into the different appliances and the five most used products alternatively the five most energy consumed products are shown. The aim is to create awareness about the energy consumption but at the same time not overwhelm the user with too much information. It's also possible for the user to either get the feedback on cost or energy consumption (kWh). The user can also see how many percent of the total consumption these five appliances represent.

The concept includes a level-system where the user gets a goal-level according to his or her consumption, which is represented by the circular dotted line. The goal-level is customized for the user in order to not feel overwhelming, but still challenging. When the user reaches the goal he or she gets access to the next level and then gets a new goal to aim for. The main screen shows what level the user is on as well as a forecast for the month if he or she continues in the same way. The user also gets goals for each of the five products that consume most energy, in order to give them a reference level to work towards. Another feature of the concept is that it's possible to see the trend according to how well the user is making progress according to the goal. In order to guide and support them in creating new habits the user gets specific challenges for the five most used or most consumed products, which are presented in the second screen where he or she also can see the progress of the challenge over time.

The concept is using positive feedback in a way that tells the user when he or she has done something good in order to minimize the energy consumption instead of giving feedback when the user has done something wrong and can't get better.



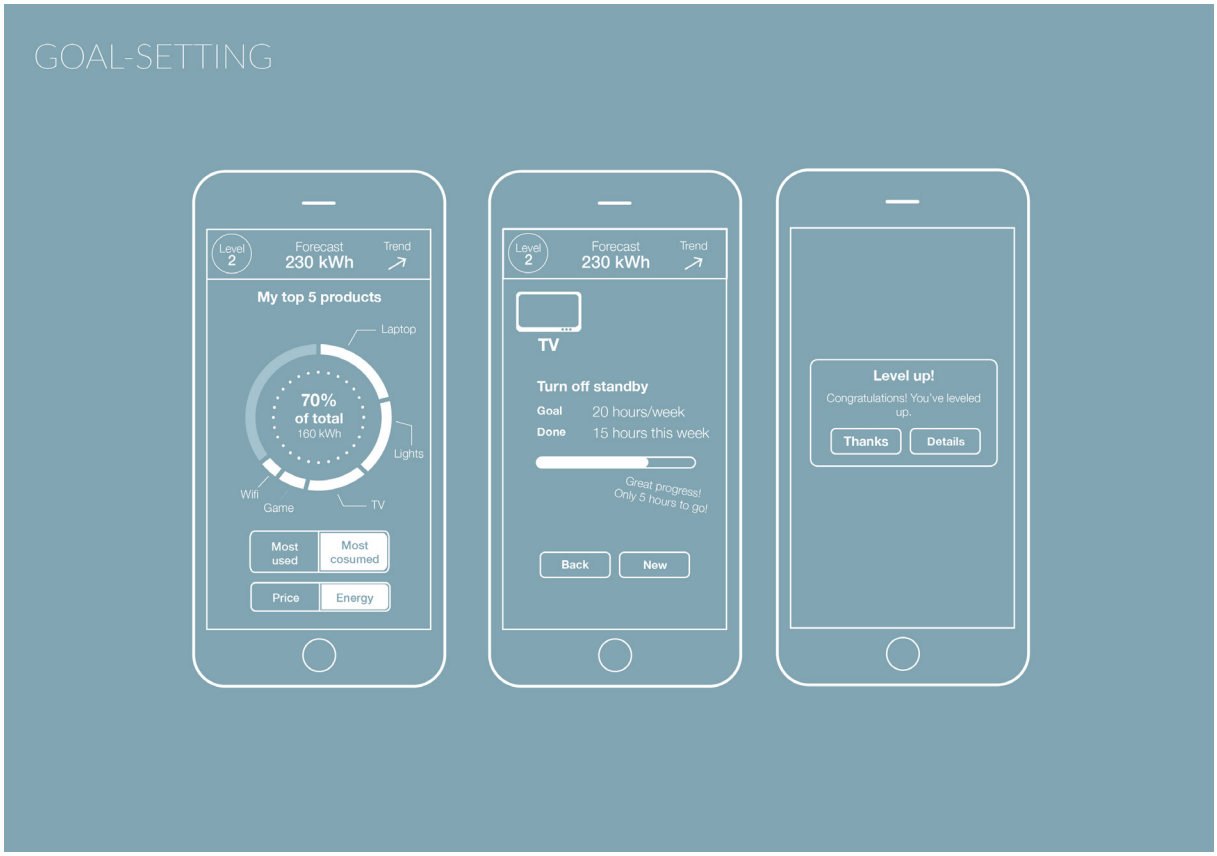


Figure 30. Concept - Goal-setting

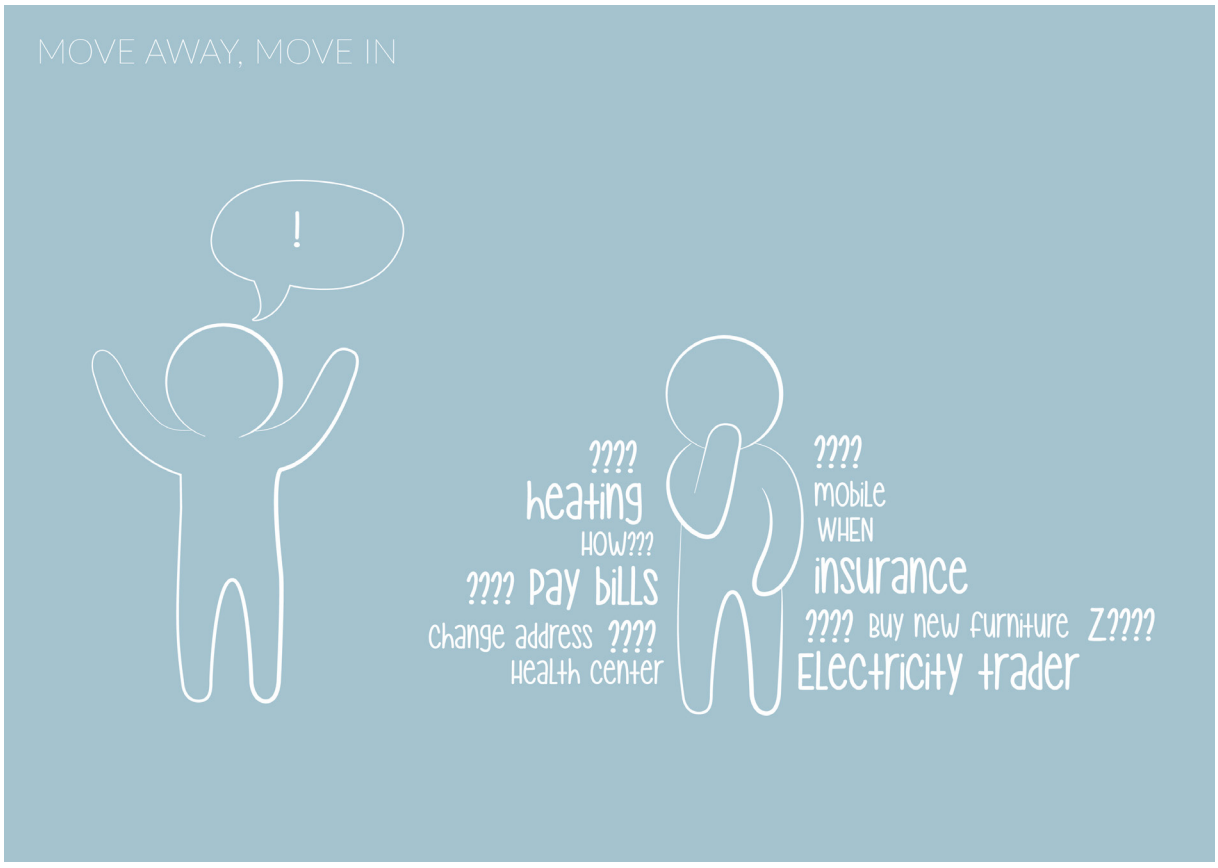
6.4.4. Move away, move in

The concept *Move away, Move in* includes three main parts; 'feed', 'my page' and 'living'. The feed is a timeline where all important tasks that need to be done when moving into a new place are included. These tasks are for example *"sign up for electricity contract", "sign up for home-insurance"*, *"change address"*, etc. All tasks are based on the moving in date since most of them are important to do at a certain time relative to the moving in date. Therefore the timeline will help the user both to remember to perform the task as well as doing it at the right time. All tasks that are performed in the feed are summarized in 'my page' in order to get a good overview of what the user is signed up for.

With the 'living' part of the concept, the user can get an overview of the accumulated energy consumption for the current month. A recommended level is also shown in order for the user to know where it's acceptable to be. The recommended level is based on the goal that the European Union set up for 2020 to decrease the total energy consumption with 20% in relation to the 1990 level. However the recommended level is also based on the user's' own consumption in order support them to gradually decrease their energy consumption and not make them feel overwhelmed.

It's possible to get feedback on energy consumption as well as on price. The user also has the possibility to get help to save more with helpful energy saving tips. The user can then rate how easy or difficult the tip was in order to customize the following tips even more.

From the research study it was expressed that many of the people in the chosen target group wouldn't actively look up their energy consumption. Therefore they might not download this application to get access to the living part, but rather they want it because of the moving planner. The feed will makes the transition to monitoring one's energy consumption more natural. This way the feedback becomes more a natural part of their lives, which in turn supports them in creating new habits and lowering their energy consumption.



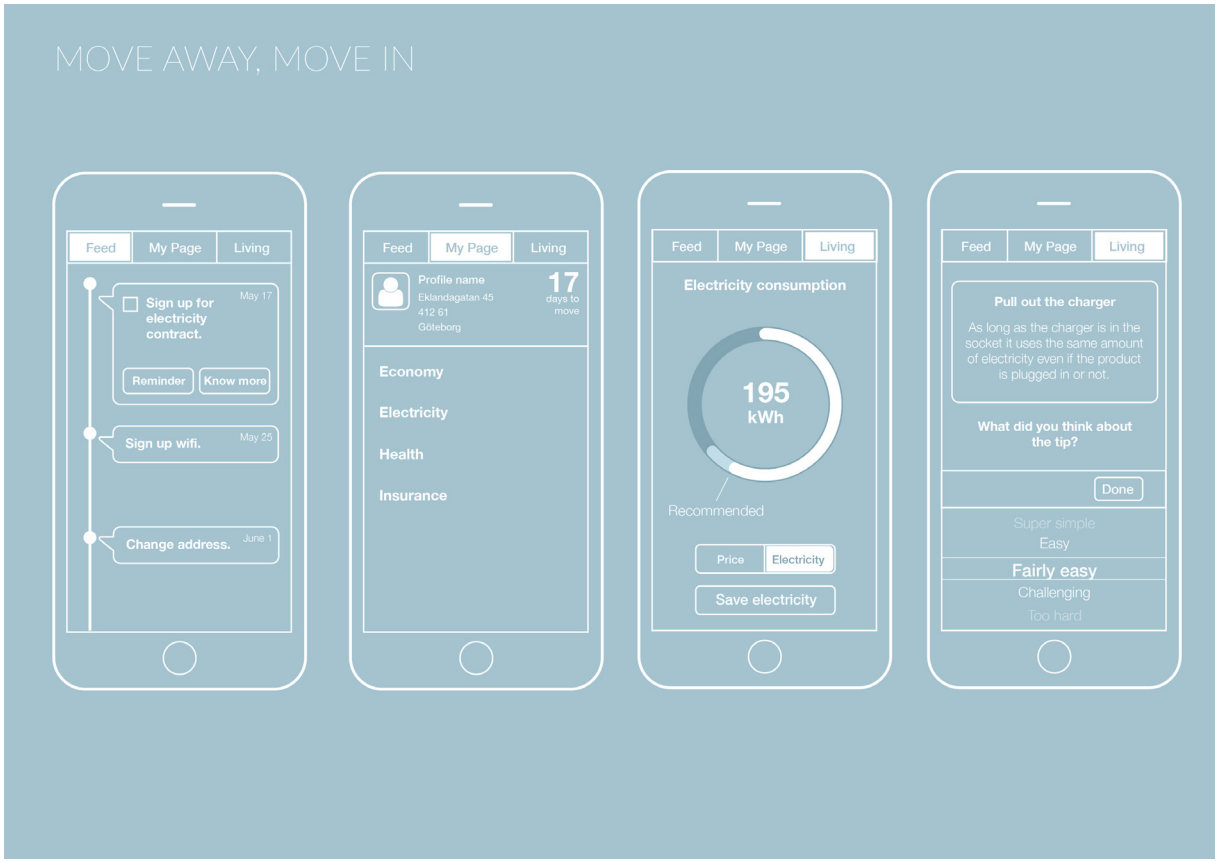


Figure 31. Concept - Move away, move in

6.5. EVALUATION OF CONCEPTS

An evaluation of iterative character was conducted on the four concepts as well as the different ideas included in the concepts separately in order to combine the most promising ideas into one final concept. A variety of different methods were used with different stakeholders such as potential users and the initiators of the project.

6.5.1. Concept scoring

In order to see how well the concepts fulfilled the guidelines, a concept scoring was conducted. This was helpful to be able to compare the concepts even though they were of such different character in regards to what specific problem they solve. The result of the Concept scoring is illustrated in Figure 32.

The concept that scored best and therefore met most of the guidelines was *Goal Setting* followed by *Move away, Move in*. An important aspect to consider is that those concepts provide the user with feedback about own energy consumption, which touches upon several guidelines. However, *Main Switch* is the only concept that really reduces the effort per se in order to reduce the energy consumption. Although the other concepts might do that by enlightening users about the problem which makes it easier for the user to know what can be done.

It's important to consider that the total score might be misleading because the concepts are focused on such different aspects and solve different parts of the problem of reducing the energy consumption.

6.5.2. SWOT Analysis

Due of the difference in the concepts' character it was of great importance to evaluate the concepts individually in order to find their strengths and weaknesses in a wider sense than fulfilling the guidelines. Therefore, a SWOT analysis for each concept was developed. The SWOT analyses for the concepts are shown in appendix VII.

In the SWOT analyses the focus was to determine different concept's potential in regards to meeting the user needs as well as their possibilities on the market, especially in regards to potential partners and business cases for the different concepts. In that regards, the concepts *Goal-Setting* and *Move away, Move in* had greatest potential since they had many potential partners and had clear means of reaching its customers.

Another important aspect was to consider how easily the different concepts could be realized according to what technology they required. At this stage technology was considered on a general level and the analysis was based on assumptions about how complex the different technologies would be. It was decided to further investigate technologies in more detail later, as there were indications that all technologies required were somewhat available or being developed in the near future. These assumptions lead to the conclusion that the concept *Goal-Setting* could be considered to be the most challenging to carry out due to the limited knowledge of appliance specific breakdown and its current applications. The benchmarking had revealed one system that seemed to be using the technology, but its limitations were not known. In this phase it was decided to regard the technology as an uncertainty but it didn't seem impossible.

The SWOT analysis also revealed some other interesting areas that were important to consider such as how high probability the different concepts had of being used over a long time. Because of the project's limitation in time it wasn't possible to include testing of the concepts with users over a longer period of time to further investigate that.

The SWOT analysis also uncovered some uncertainties about the concepts such as how *Main Switch* would work if the user sometimes wanted to for example leave a charger on when he or she wasn't home. Then the consequences might be that nothing would be turned off instead and it would have a reverse effect than intended. Another aspect that was found through the SWOT analysis was that in the concept *Goal-Setting*

CONCEPTS / GUIDELINES	Main swtich	This compared to that	Goal Setting	Move away move in
Increase possibility to perform energy conserving actions	3	1	3	3
Provide easily accessible and easily understood feedback	0	0	3	3
Reduce effort of carrying out energy conserving actions	3	0	0	0
Create an interest in energy conservation	2	2	1	2
Create an interesting experience when conserving energy	1	2	3	2
Fit into current lifestyle but support user in creating own energy efficient routines	3	1	2	1
Inform user about what the right action is	2	3	2	2
Guide user in prioritizing which action to focus on	1	2	3	2
Indicate effect of an action	1	3	3	3
Possibility to see progress over time	0	0	3	3
Increase probability to start using the service	2	1	1	3
Increase probability that service will lead to change in behaviour	3	1	3	2
Individualize by making information understandable	2	0	3	3
Simplify be adapted to that specific user (and his or her routines)	3	3	2	1
Minimize overload not provide too much information	3	2	2	2
TOTAL	**29**	**21**	**34**	**32**

Figure 32. Concept scoring

there was a possibility that it would show that same five products all the time and therefore it would be too static and maybe not of that great interest for the user.

6.5.3. Business Case

According to the SWOT analysis there was a need for further investigation of the possibility to create a successful business case around the different concepts in order to see which concept that would have the largest potential to succeed. A Business Model Canvas was therefore created for each concept.

The business case for the concept *Move away, Move in* s based on the value proposition to support people when they first move away from home. The concept highlights important choices that need to be made and reminds the user to do them in time. Possible key partners are the different companies that the user needs to contact before moving in, such as electricity producers and broadband companies. Different authorities such as national registration and the municipality might also have interests in the service. Further it would be possible to customise the concept to different student housing associations, tenancy companies and tenant companies in order for them to provide their residents with their own service.

The concept *Goal-Setting* provides its users with a service that's customised to the specific user and the goal-level lets them know how they were doing. The customer segment for this concept is wider than for the concept *Move away, Move in* since it fits all households. Possible key partners could be electricity traders, which is a setup that is already found on the market today.

The value proposition of the concept *This compared to that* is to give users a better source for energy saving tips than the current websites, which present too much information in a way that isn't relevant to the users. The concept provides an individual response that makes the information more easily understood by the user. This service also has a wide customers segment. Possible key partners are companies that sell appliances who could advertise their energy efficient products.

The concept *Main Switch* can be a starting point for the smart home, providing the users with a convenient way so save energy. Although this concept creates value for the customers, it's not as clear what possible partners would profit from this service. Companies providing home automation systems might find this concept interesting.

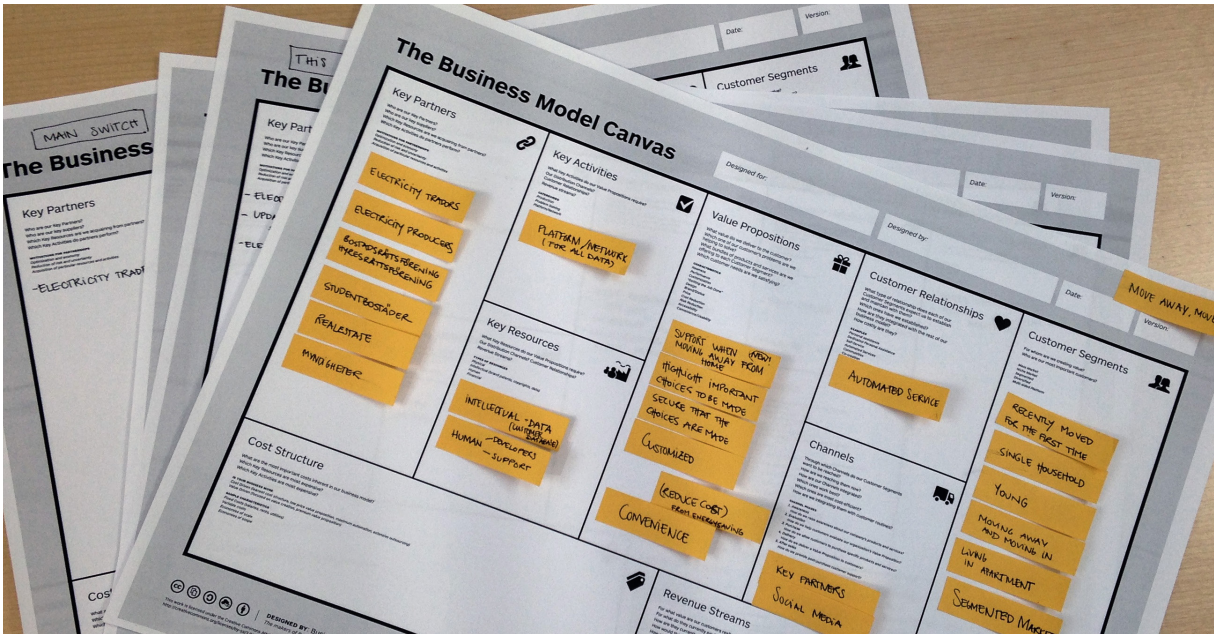


Figure 33. Business Model Canvas

The Business Model Canvases revealed that the concepts *Goal-Setting* and *Move away, Move in* had the greatest potential, mainly due to the large amount of possible partners together with their value propositions. *This compared to that* was also regarded to have some potential in possible partners to collaborate with, however mainly for educational purposes and therefore the revenue streams are harder to find.

6.5.4. Evaluation with design goal and interaction vision

In regards to how well the different concepts fulfilled the earlier defined design goal to *"Create an appealing experience for newly moved in single householders when saving energy"*, the concept *Goal-Setting* was considered to provide the most appealing experience because of the competition-like character together with positive feedback.

Main Switch was considered to be the concept that met the interaction vision the best because it would make everyday life more time efficient at the same time as making the user save more energy, making it a win-win situation. The concept *Move away, Move in* was considered to be most appealing for the chosen user group since it supported a clearly identified need of help when moving in somewhere for the first time. It would also give the user a more natural transition to energy consumption that was considered to be an important aspect. In that regard it fitted the design goal well.

The concept *This compared to that* was considered to fit the goal to some extent since it would mainly support a user who has moved away for the first time and don't know that much about different household appliances. However it wasn't clear if the interaction would live up to the vision of a win-win situation.

6.5.5. Evaluation with initiators

Discussion with the initiators of the project gave a lot of valuable insights for the further development of the final concept, mainly according to their potential on the market. All four concepts were perceived as interesting in different ways.

The concept *Main Switch* was considered being an interesting concept in the sense that it would definitely reduce the effort of an action that would reduce the energy consumption on a daily basis. Although it was discussed that this would be solved with the growth of smart homes and therefore the lifetime of the concept would be very limited.

The concept *This compared to that* was considered as a smart solution of a well-known problem; that people have a hard time knowing what impact different actions trying to choose the most energy efficient task. Although the lack of precision in the result was questioned since it might sometimes be a bit misleading. For example it depends on what model of the product that is used in terms of its wattage, from what year it is etc., as well as how the product is used. This isn't included in the concept. Therefore an idea was to include a possibility to add the products that the user owns in order to get a more accurate result. Another idea was that the service could be used for people living in new apartments with standardized products from the property owner. The concept was considered to be a more valuable tool for educational purposes more than on a daily basis. But it was discussed that it would preferably be used together with some of the other concepts such as *Move in, move away* or *Goal-Setting*.

The idea of showing feedback broken down into the different appliances in the concept *Goal-Setting* was considered to have great potential. Also the features of showing trend together with forecast received very positive feedback in regards to the understanding of energy usage.

The goal part of the concept was also considered to be a good feature in order to spur the user to change their behaviour. It was discussed if it was needed to indicate that more people did the same thing in order for it to engage the users, such as all the people in the same apartment house or all people in the same city.

Also it was argued whether or not it would be better to connect the goal with another incitement such as some kind of reward or similar in order to inspire and trigger more people.

The 'feed' in the last concept *Move away, Move in* received diverse feedback in the sense that the idea seemed excellent in providing people with an incitement for starting to use the service. This would provide a more natural transition to create awareness about their energy consumption. On the other hand it didn't seamlessly fit the actual energy feedback part of the concept. It was therefore discussed whether the feed would be better suited standalone in order to solve the identified problem that people needed support during the move between different households. This would mean to only focus on further developing the feedback part.

6.6. CONCLUSION

The ideation phase revealed that young adults that recently have or will move into their first apartment are an interesting user group for this project. Since they haven't formed their own habits regarding household chores yet there is great potential to support them in becoming engaged consumers. Making an impact early in life could lead to more pro-environmental habits being passed down to the next generation.

Based on the evaluations that were made, the concepts *Goal-Setting* and *Move away, Move in* showed greatest potential and it was decided to continue exploring these concepts. They both included interesting aspect that would preferably be combined in order to achieve the desired effect, but aspects such as technology needed further investigation. Additionally, new possibilities had been identified with the introduction of some kind of reward as an incentive for using the service. This feature was considered to be very promising but also needed to be investigated further.

CHAPTER SEVEN

FURTHER DEVELOPMENT

This chapter describes the further development of the chosen concepts described in ideation into the final design.

7.1. PRO-CON ANALYSIS

The first step of the further development phase was to assess which of the features discussed in the ideation phase to further explore. The features were: appliance specific breakdown, aggregated feedback, goal-level or recommended level, trend, forecast, individual tips and a timeline for actions connected to moving. The concept *Goal-Setting* included both a goal-level for the total consumption and different levels for the top five products. These two features were considered to fulfil similar user needs, but they require different technologies.

The appliance specific breakdown would provide the user with a good understanding of their consumption, as it would show which products contributed most. This is also a feature that isn't that common on the market and no other identified system focuses on only showing the products that are used the most. However, further investigation was needed to determine if the technology would work without any additional devices. If it wouldn't be possible to disaggregate the consumption, this would mean that it wouldn't be possible to provide goal-levels for different appliances. In the concept *Goal-Setting* this had been used to create tasks or challenges that worked as individual tips. The user could then get a challenge to do a certain action for an appliance in order to reach the goal-level. This would not be possible unless the user would manually input the actions they did in the application. Tips could however be individualized by basing them on what level the user's currently on.

Providing aggregated feedback on total electricity consumption is more common and can easily be implemented. It wouldn't give as much support as

disaggregated feedback would but it can be regarded as sufficient for raising the user's awareness of their consumption. In the concept *Move away, Move in* it was suggested to combine the aggregated feedback with a recommended level, which was similar to the goal-level. Combining this with forecast and trend would be beneficial since it provided further support for the user when trying to understand their consumption. These features aren't that common on the market, which would make this combination more unique.

The timeline in the concept *Move away, Move in* was considered to be innovative and new on the market as well as it addressed something that is challenging for people. This feature might interest many partners, since they could advertise their own services through the application. However, the concept would only reach its full potential if all companies and authorities whose services were of interest were included. The aim was to encourage and enable the user to actually sign up for things by using the service.

The feature reward was also included in the further investigation to see if it could add any value. Since it was an idea that was initiated in the evaluation process it required some ideation in order to find possible solutions. It was investigated how rewards could be implemented to add value to the other features and create more incentives to lower the energy consumption. Many different kinds of rewards were explored based on different partners involved. One idea was to collaborate with property owners since they would benefit from their tenants using less energy. They could then for example offer a rent-free month as a reward for tenants who lowered their energy consumption. Another idea was to collaborate with the city of Gothenburg (Göteborgs Stad), who would be able to promote their sustainable initiatives. By providing rewards in the form of discounts on events in the city, the city of Gothenburg could also get residents more involved in the city and saving energy together. A third option was to collaborate with the local public transport company in order to enlighten residents about sustainable travelling alternative in exchange for lowered energy consumption.

Further, it was seen as essential to keep the number of features to a reasonable amount to not overwhelm the users. Due of this, it was decided to exclude the 'feed' from the final concept. Even though this was regarded as a valuable feature that provided a different way into energy savings, it wasn't seamlessly fitting with the feedback part. Including the 'feed' would not be in line with creating a focused service and the 'feed' was considered to be more valuable as a service by itself.

Rewards were considered to add value to the concept since it could provide greater incentives for using the service. Although they would be motivating for people, there was a need for further investigation in order to match the rewards to the actions so that the rewards would be sufficient. Also, a focused service was seen as more desirable and it was therefore decided to leave the rewards at this point. Possibly it could be added on to the concept depending on what partners that are interested in it.

7.2. EVALUATION OF TECHNOLOGY

According to the Pro-Con analysis there was a need for investigating some areas where technology might be a decisive factor to make a decision for the final concept. The investigated areas were the possibilities to provide appliance specific breakdown as well as how to retrieve the data of the energy consumption in order to visualise it in a more understandable way.

7.2.1. Disaggregating data to provide appliance specific breakdown

By providing appliance specific breakdown, users can more easily understand what made their aggregated consumption and what they can do to lower it. The aggregated consumption can be broken down using a technology called NILM (Non Intrusive Load Monitoring) or NIALM (Non Intrusive Appliance Load Monitoring), which uses machine learning algorithms

to recognize which products are turned on when. According to Makonin (2012) the technology is called non intrusive since it doesn't require any changes to the house's infrastructure. This technology was first researched as early as in the 1980's. NILM measures on the power line and can detect different events based on the product's different electrical signatures (startup, use and shutdown). The technology then identifies which types of products that were on and presents the user with this information.

Compared to other solutions for disaggregating energy consumption, NILM may become a relatively cheap technology, however some aspects need to be considered which will affect the outcome of NILM.

- There are different electrical characteristics that are needed for an accurate disaggregation but increasing the number of characteristics that are analysed leads to an increase in price and complexity.
- The sampling rate of which new electricity data is extracted with will also affect the accuracy. However, to achieve a high sampling rate requires costly and inconvenient equipment.
- The technology is not yet precise enough to be able to separate multiple simultaneous load events, meaning that if two products with the same load are turned on at the same time there is risk for misclassification.
- All products don't simply have on/off modes but have modes in between, such as an oven. This increases the complexity of event detection and classification.
- The appliances' loads are noisy and some products only create small fluctuations in the consumption when turn on/off which are hard to detect.
- Households aren't all behaving the same and the number of appliances in one household changes over time. This means that NILM must be able to account for a dynamic and changing appliance usage.
- NILM processes data online and in real time which requires a high computational cost. In order to lower this cost approximation algorithms are used, however this leads to a lesser accuracy in the classification.
- Finally, there is not yet a standard for accuracy measurement with NILM, which causes mixed results and accuracy.

NILM technologies require real time data in order to disaggregate the consumption. Since meter values need to be documented hourly if customers are billed by hourly use, most current electricity meter can now be remotely read. This means that the grid supplier can give users feedback hourly. However, to get continuous feedback to the user, feedback systems need to know the used effect in real time. This can be done by attaching an optical eye on the IR diode, which can scan the optical pulse emitted by the diode. (Hudson & Lea, 2010). The diode will pulsate with a frequency, which is related to a certain kWh. A common frequency is 1000 imp/kWh (Vattenfall, 2015). The optical eye then sends the information to a transmitter via wifi (Exibea, 2015).

This means that users need to have access to their electricity meter in order to use this technology, something that people living in apartments don't always have. Also, the meter needs to be in the range of the user's wifi in order to communicate the real time data. According to the research findings is was of great importance to not include an extra device in order to avoid the added barrier it would create for the user group to start using the service. Therefore the idea of having the appliance specific breakdown feedback had to be excluded to continue with for the final concept.

7.2.2. Retrieve hourly data to visualise consumption

Eco-feedback can also be given by providing accumulated data instead of real time. As mentioned

earlier, the grid suppliers measure this data. This way, eco-feedback systems can show consumption on a hourly basis, often with around 24 hour delay. In order to get the information from the grid supplier into a user interface, APIs are used to retrieve the data from the grid suppliers' database. API stands for Application Programming Interface, which is a set of rules and specifications for how one software program should access another software program and make use of its resources. This means that the API works as an interface between the two programs. APIs have received a lot of attention lately since they are useful when building services (3Scale Networks, 2011). An API used in an eco-feedback system can access the electricity consumption database using the identification of the user as a key. The API can then retrieve the user's consumption and send it back to the eco-feedback application, which processes the information and presents it in a way that makes sense to the user.

According to these findings, API was seen as a suitable technology to use for the final concept. The technology was also confirmed to be promising for a service of this kind during a meeting with the company Energimolnet. They have an open platform where they collect the data from the grid suppliers and can deliver it through API, which makes it possible to develop services in the area of eco-feedback (Energimolnet, 2015). This meant that it wouldn't be possible to set goals for specific appliances but it would still be possible to set a level for the total consumption.

7.3. ITERATION OF CONCEPT CREATION

At this point another round of concepts were created in order to try different versions of the selected features. Three concepts were created in order to visualise different ideas about how the features could be improved. Mock-ups of the concepts were later used during evaluations with users.

7.3.1. Electricity consumption

During the iteration an idea about creating an electricity budget emerged from the recommended level. Due to this, all concepts included an energy budget, which was shown in relation to how much the user had already consumed. A circular progress bar that either was filled or emptied illustrated this. The feedback could be shown in cost, electricity consumption and environmental impact and could be divided into days, weeks and months. All concepts included a forecast that gave an estimation of how much the user would have consumed at the end of the selected period of time. Also, all concepts showed consumption trend, which was indicated by an arrow heading up or down depending on the user's behaviour.

Figure 34 shows concept I. In this concept the circular bar is filled up accordingly to the accumulated energy consumption. An arrow that represents how much the user should have consumed at that time in order to make the budget indicates the goal-level. In order to further indicate to the user that he or she is doing well, stars are given as a reward at the end of each period. The user would get one star if they make the budget, two if they're under it and if the do really well they get three stars. The stars are shown below the budget in the history part of the interface. The budget for previous periods as well as the user's corresponding consumption are also showed in history in order to give a visual feedback on their progress. The horizontal bars are space efficient and provide a good overview of the previous periods. Just above the historical comparison there is a progress bar that indicates the user's total progress since they started using the service.

Figure 35 shows concept II. In this concept the indication in order to reach the goal-level is shown as another colour filling the circular bar. The two bars are identified by name tags in order to clarify what they mean. In concept II the historical comparison is shown as two graphs, one represents the own consumption and one represents the goal-level. The graphs are recognised by colour, which corresponds to the colours of the bar. The user can then pick a specific time to look

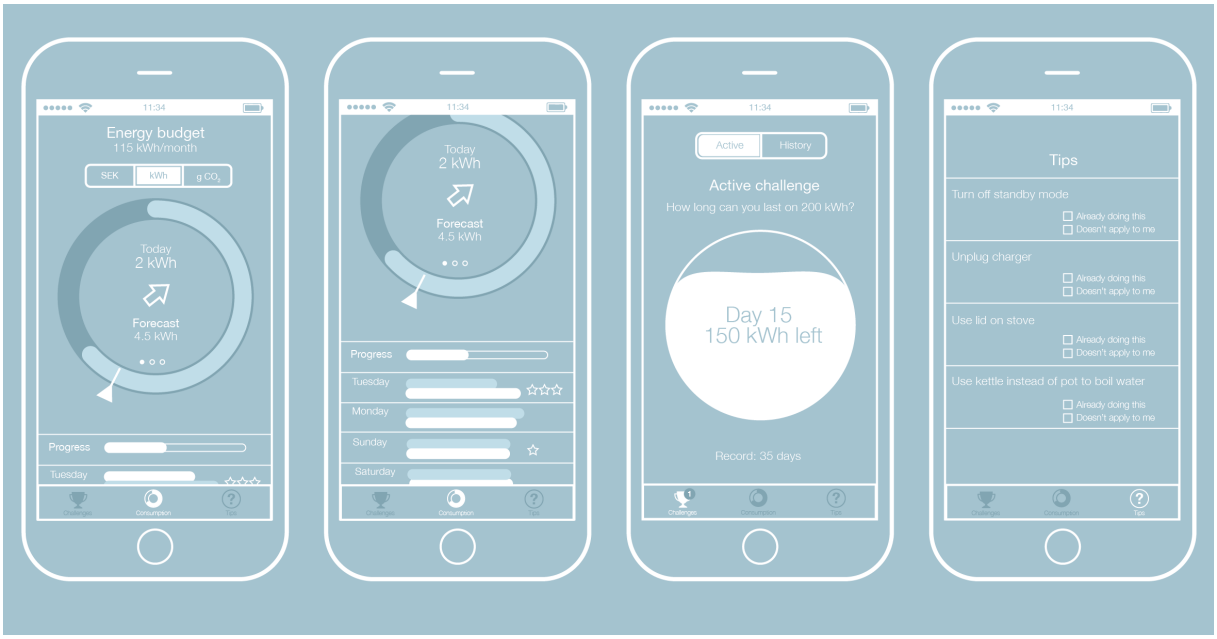


Figure 34. Concept I

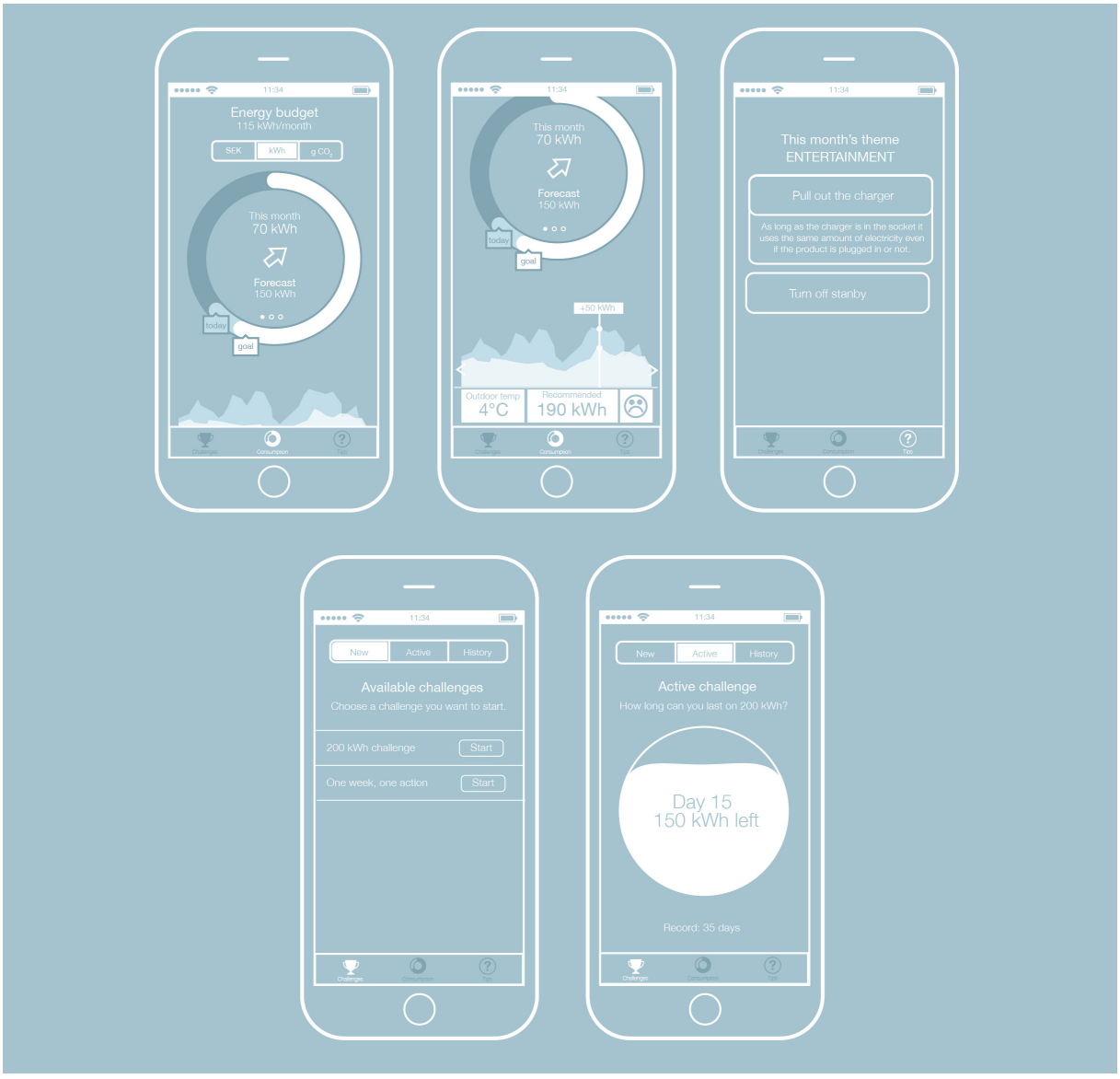


Figure 35. Concept II

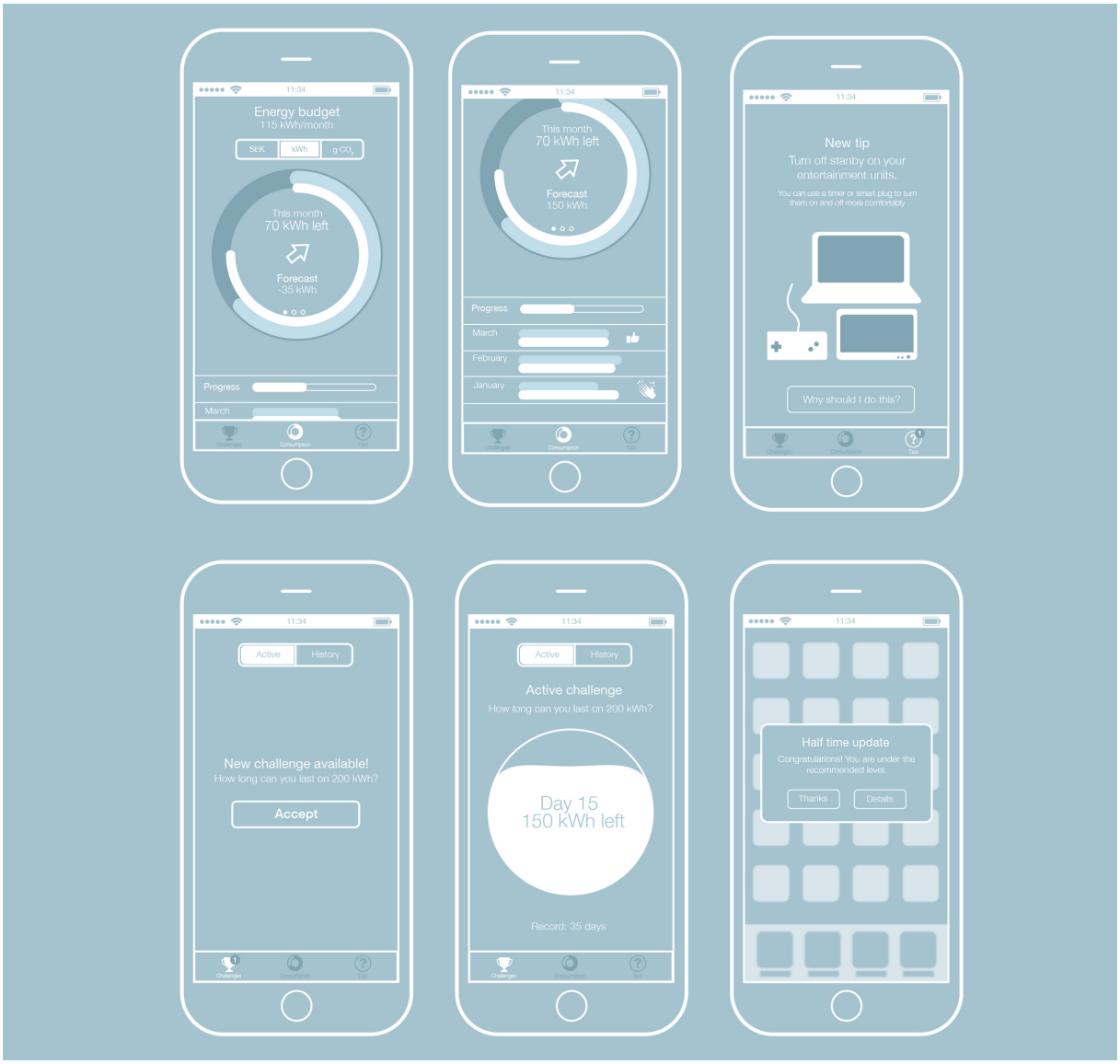


Figure 36. Concept III

into detail. Outdoor temperature is also shown for each time period, as this can affect the consumption. To further clarify if the user had kept the budget or not, a sad or happy face was shown for each time period.

Figure 36 shows concept III. In this concept the goal-level and own consumption are indicated by parallel bars with different colours. This concept is different from the others because the bars are being emptied instead of filled. This will give the user a feeling of energy as a limited resource that can run out. In this concept, the user gets an indication of how well they performed by getting a thumb up if they don't go over the budget. If they do really well they get applause.

In the third concept the user gets a halftime notifications informing them about how they're doing compared to the goal-level. This way they still have time to change before the end of the month if they're over the goal-level. If they're under the goal-level they get positive feedback and confirmation that they're on the right way.

7.3.2. Challenges

Different ways of using challenges were also investigated to see how this could contribute to the experience.

In the first concept the challenge starts automatically and is active in the background. The user is notified that a challenge has started by an indication on the icon

for challenges. This would ensure that the function was used and the user could get a positive surprise when they notice it. In the second concept the user can choose a challenge from a list of available challenges when they feel like it. In the third concept, only one challenge is available at a time and the user can accept it during a limited time.

In all concepts it's also possible to see what challenges have already been completed together with the record for each challenge.

7.3.3. Tips

In order to not overwhelm the user, the tips are made individual in the sense that they correspond to the consumption level that the user is on. However, the tips are presented in different ways in each concept. In the first concept the tips are presented in a list and the user can choose either if they are already doing that action or if it doesn't apply on them. Being able to say if the tips are helpful would enable further customisation to that specific user. In the second concept the users get tips on a new theme each month, which are presented in a list of tiles with icons that describe the tips. Focusing on one theme at a time will help users prioritize what actions to do as well as it makes saving feel more reasonable since they don't have to do everything right away. In the last concept the user only gets one tip at a time in order for them to focus rather than trying to do everything, which can be overwhelming.

7.4. EVALUATION WITH USERS

The different alternatives were tested during a smaller evaluation with users (Figure 37). The evaluation focused on the overall experience of the different features and how they worked together. The participants got a short description of the main idea and were then shown one concept at a time. They described their emotions and reactions to the different features.

7.4.1. Consumption

The participants found the budget option that was emptied hard to relate to since their mental model was that it should be filled.

When it came to the indication of the goal-level, the participants perceived the arrow as the most understandable. The nametags were said to help understanding what the two bars represented, but it wasn't clear to the participants what *"goal"* stood for. The word goal may make users believe that they should try to aim for that, and if they're under the budget they might feel like they haven't reached the goal yet. The word 'recommended' was also suggested, but it was also a bit unclear to the user. The participants had a hard time figuring out what the goal-level was, but when it was explained to them they found it helpful. It's worth noting that no similar elements had been found by the project group when investigating successful interfaces. It's possible that this feature hasn't been seen before, which means that the users don't have a mental model of this element yet. It can therefore be acceptable that it's not fully understood immediately but that the user will figure it out as they use the application. Another element that was challenging for the participants to understand was the trend indication. It was described as being hard to interpret, the participants didn't connect the arrow to the total consumption.

In the historical comparison, the bars were perceived as more intuitive than the graphs since they more clearly indicated what the budget was and what was the own consumption. The participants found the graphs interesting for further analysing their consumption. The rewards were also discussed. The stars were considered to be most clear and motivating. It was also confirmed that the stars could be a sufficient reward, at least for some people. The applause and thumb up were considered by the participants to be ambivalent, they didn't know what the difference between the two was. The sad smiley connected to the graph got negative feedback, the participants thought that it would feel discouraging to see that you did bad, it didn't feel like a reward. The other options only appear when the user

does something good, which was seen as more desirable by the participants. Also, the smiley was more dynamic and a happy face wouldn't be visible unless the user moved the indicator to a time when they had actually done well. The other options provided a quick overview of when the user had succeeded. During the evaluation the need for indicating how many stars the user would get in the end of a time period was also discussed. This was further explored in the final concept. Another aspect was when the user should get stars. Getting stars for days and weeks might be too much since it makes it less special when receiving a star. Perhaps it would be more exciting to only get them at the end of each month.

7.4.2. Challenge

The challenges were overall positively received, but there were uncertainties about whether it should be possible to choose challenges or not. One opinion was that it's preferable to let the user choose when they want to do a challenge since it gives the user more control. On the other hand the participants expressed that they might be compelled to accept a challenge whilst being away from home in order to get a good result. A combination of the two was discussed, where the automated challenges would create awareness of their existence and the one's that the user could pick from would be useful if the user wants to further improve. Further discussions also addressed whether the challenges should be more social by letting users compete with each other. Another option that was found promising was to have challenges for all users at the same time so that they could get a feeling of doing it together.

7.4.3. Tips

The list of tips without any icons or illustrations were seen as the worst alternative since it made the look just like a to-do list of things they didn't want to do. Having an icon or illustration made the experience quite different, the participants agreed that it was more attractive and felt more compelling to actually do the tasks. There were different comments made regarding how many tips should be available. On one hand it was considered to be desirable to be able to choose from all tips in order to explore what they could do. On the other hand getting too many tips to choose from might feel discouraging since all users might not be that interested and curious. Dividing the tips into themes was considered to be of great interest since it would minimize the options for the users. However, it might

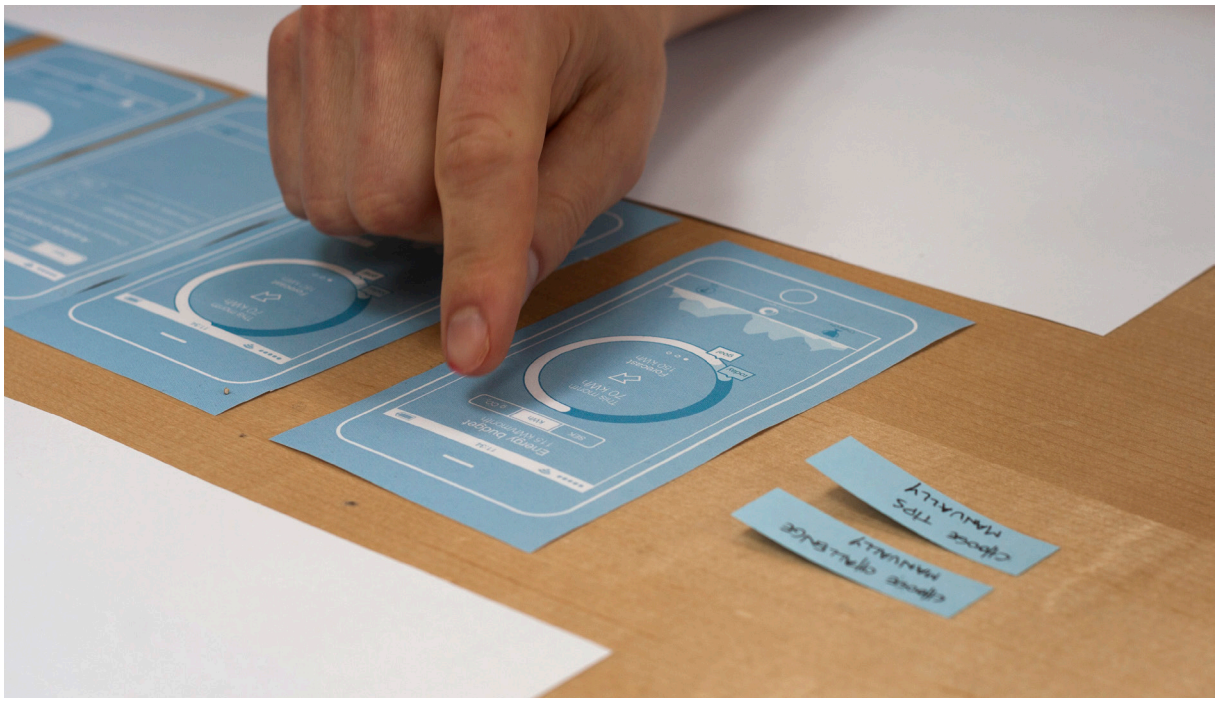


Figure 37. Evaluation with users

be suitable to let the user choose which theme they want to focus on.

7.4.4. Additional

Another insight from the evaluation was that giving notifications should be done carefully since it can cause irritation. It was commented that if the application would use notifications to remind about the application in a too large extent then the participants would abandon the application altogether. The participants recommended that notifications should be optional.

7.4.5. Further evaluation of graphical elements

Since the evaluation revealed some weaknesses in the graphical elements connected to the consumption part, further developments were made and evaluated. The purpose was mainly to determine whether users could relate to the emptying circular bar or not. Different clustering of elements as well as the appearance of the *"goal"* marker were also evaluated along with a suggestion of calling it *"advised"* instead. A selection of the ideas are shown in Figure 38 & 39.

The evaluation showed that the emptying bar didn't match the participant's mental model and it was decided to let the bar be filled. Comments about the markers indicated that it was hard to understand at first, however when the feature was described it was appreciated. The participants preferred the triangular marker, and it was decided to work further with that. Some comments were also made about the groupings of the text inside the circle, for example writing 80/155 made people think about measuring blood pressure. Finally, it was requested to indicate where on the circle users should be at the end of the month in order to gain stars. One participant suggested a cursor similar to the one in cruise controls in cars. It was discussed about indicating on the side of the circle where the different star levels could be shown, however there were some problems with implementing this. Having a cursor would enable an indication of both star level and a forecast of where the user would end up, since these two are connected. However, adding another cursor to the interface confused the users. Further ideation was needed to evolve this feature.

7.5. BUSINESS CASE

During the further development some features such as the timeline were eliminated, which lead to an update of the previously discussed business cases. Therefore the authorities that had been of interest before were no longer considered as possible partners. After discussion with the grid supplier Göteborgs Energi it became evident that they were no longer of interest as a partner. One reason for this was that since the company provides the grid and have monopoly they will always have customers, providing the service wouldn't necessarily provide any benefits for them. Instead the electricity trader Göteborgs Energi Din El were seen as more promising as they would benefit from promoting themselves by providing a service for their customers. Property owners were still of interest at this point, since they could make the service available for many people. However, if the partnership only consisted of one property owner only few people would be reached by the service.

The company Energimolnet was found to be of interest as they have developed an API that can retrieve energy data from different grid suppliers. They could benefit from the service since they could promote their own service through it.

7.6. IMPLICATIONS FOR FINAL DESIGN

The further development phase resulted in implications for the final design, which are presented below.

7.6.1. Technology

The evaluation of technology indicated that even though appliance specific breakdown can create benefits for the users, it's currently limited to households that have access to their electricity meter. Having to invest in additional equipment would also create a further obstacle for the

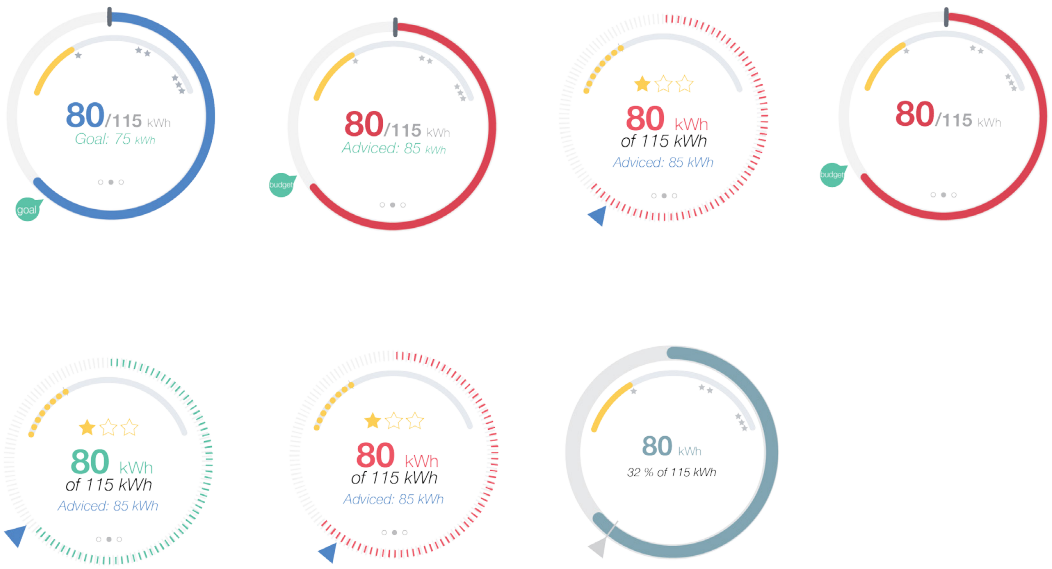


Figure 38. Sample of circular bars being filled

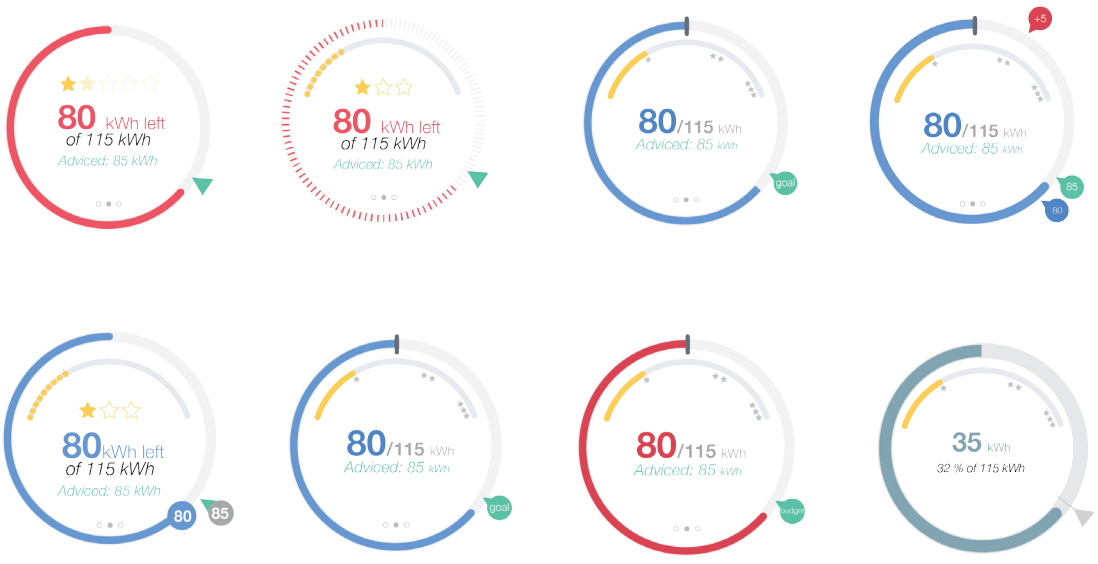


Figure 39. Sample of circular bars being emptied

user and they might not feel that it's worth the effort. The further development phase has also revealed that there can be advantages with aggregated consumption as it would keep the application simple and minimize the overload. Getting aggregated data without adding any extra device can be done with APIs.

7.6.2. Consumption

It was found that having a circular bar that was filled representing an energy budget was a promising visualisation of the user's energy consumption. The consumption level where the user should be in order to make the budget should be given a more suitable name than goal or recommended. It has to be clear that this is a level to aim for but it's preferable to be under. The evaluation indicated that the different elements of the consumption part were valuable to the users and that they didn't seem to overload the interface. Especially forecast and trend were considered to add value to the service.

Regarding the historical comparison it was suggested to focus on providing an overview in order to show the user's progress rather than providing detailed data. Getting rewards in the form of stars was seen as promising, but some alterations would be suitable in order to indicate to the user how many stars they would get at the end of a time period. Also it was found to be more motivating if the users wouldn't gain stars too often, just providing this feedback per month would be sufficient.

7.6.3. Challenges

When designing the challenges two ideas were explored; having the users start the challenges themselves or having the challenges start automatically. One possibility was to allow for both ways. However, this would again make the service more complicated and it was decided to only allow for one possibility. Making challenges run at the same time for all users of the application was also seen as promising since it would show to the users that more people also do it.

7.6.4. Tips

Regarding the tips there were also some uncertainties about how much the user should be in control. However since it was found to be important to simplify and minimise overload, it's implied that it might be more suitable to let the service be more in control. Dividing tips into themes was considered to be a good way of giving the service more control as well as including large icons to simplify the interpretation of them.

energy budget

Figure 40. Energy Budget

CHAPTER EIGHT

FINAL CONCEPT

This chapter presents the final design described by its features, the user experience related to it.

8.1. ENERGY BUDGET

Saving the world can be overwhelming; Energy Budget helps users save energy step by step by providing an individual and achievable monthly budget (figure 40). Most people don't know how much energy they use. And if they do they don't know if it's a lot or not. The budget provides them with a reference level of how much energy that is acceptable for them to use. Energy Budget is a smart phone application that uses goal setting to create an appealing experience when saving energy. The user gets a customized budget for each month that provides a reachable and dynamic goal level that follows user's improvement. The progress is shown by stars and levels, which provide the user with positive feedback. The budget gives the user feedback about their consumption in a way that is relevant to them and that supports them in understanding their electricity consumption. Energy Budget simplifies the information and makes it easy for the user to know how well they're doing. The user can boost their savings by accepting challenges and can get individual advice on how to reach the goal.

Energy Budget can be used by anyone, independent of what electricity provider they have since energy data is gathered directly from the grid supplier using an API. The solution doesn't require any extra devices, neither in the home nor attached to the electricity meter. The user just needs to create an account and can start using the application right away.

Energy Budget is suitable for people who want to keep track of their electricity bill but aren't necessarily interested in energy savings. It provides an engaging way of saving energy that feels easy and fun. Users can follow their consumption trend and get forecasts on

what their monthly consumption will be. This way they can see when they use more than they should and still have time to do something about it. By comparing the consumption to an acceptable value, users can quickly see how they are doing.

8.2. FEATURES

The features of Energy Budget are explained below and in figure 41.

8.2.1. Create account

When the users start using the application, they first need to create an account. This is easily done as it only requires the users to input some basic information about them. The user's personal number and mobile bank identification are used to let the API to access the user's energy data from the grid supplier. The historical energy data is analysed and the user's level is determined. A suitable budget is decided based on what level the user is on, the size of the home and how many people there are in the household. If the user has electrical heating this is specified to make sure that the budget is correct. If there's no historical data available the user will get a first budget based on the average level for a household of that size. As the application is used, the budget is corrected accordingly.

8.2.2. Budget

Each month the users get a budget for how much electricity they are recommended to use. The budget is based on the size of the dwelling, how many residents there are and on what level the user is on. The level is determined by how much their current consumption is. The individual budget is calculated based on a ratio of average energy consumption per square meter for one person, which is then applied to the current living situation of each user. The average consumption in Sweden per square meter and person is placed at the middle level. The last level is based on the EU goal of lowering emissions with 20% in relation to 1990 until 2020. The aim is to match the user's capacity so that they aren't discouraged.

Once the user has kept their budget over time they move on to the next level and get a new budget. The user reaches the next level by earning five stars. Stars are gained at the end of the month if the budget has been kept. The user is rewarded with one star when they end in the region 2% over to 2% under the budget. If the user is in the region 2-5% under the budget they receive two stars and if they end up even further under budget they get three stars.

The budget is shown in kWh, but the user can also browse between the cost (SEK) and the environmental impact (grams CO_2). The budget is represented by a circle, which fills up as the user's accumulated consumption increases. The budget is customised for the household and is gradually decreased so that the user will not be overwhelmed by how much they need to improve.

The consumption is updated hourly with around 24 hours delay. The accumulated consumption is shown in relation to the budget. An acceptable level is also indicated, this means where the user should be in order to make the budget at the end of the month. The acceptable level is indicated by a marker as well as with how much energy that is. The colour of the accumulated consumption and its corresponding amount indicates if the user is over or under the acceptable level. If the accumulated consumption is red, the user has used more than what is acceptable at this point and if it's green the user is at the acceptable level or they have used even less.

Since seasons influence the energy consumption, the budget changes to fit the current season. Estimations about outdoor temperatures are also made based on previous years and global warming effects are taken into account to make the budget as accurate as possible.

8.2.3. Forecast

A forecast based on the accumulated energy consumption gives an estimation of what the month's total consumption will be. The forecast shows how many kWh over or under the budget the user will be

Figure 41. Overview of features

at the end of the month if they continue using the way they do now. Colours are used to further clarify when the user will be over or under the budget. Red means that the user will use more than the budget and green means under. Both text and the circular bar have the same colour to create a connection between the two. As numbers may be hard to relate to, a meter indicates how many stars the user will gain at the end of month. This creates a more graphical feedback on where the user is heading. The star meter is an indication based on the consumption so far, and the stars are only gained at the end of the month. The forecast is connected to a halftime update, which notifies the user about how they're doing so far. In this way users can do something about their consumption before it's too late. If the users prefer to check their status themselves in the application the notification is possible to turn off when wanted.

8.2.4. Trend

The users can get further indication of their progress by seeing their consumption trend, which is based on how consumption has changed the last days. The trend will indicate the effect of different actions more clearly as it explains how consumption changes due to different behaviours. For example if the user changes how often they do an action or if they do it for a longer time, the trend will indicate the change. The trend is visualised by an arrow whose direction and colour indicate if the consumption is going up or down. A red arrow that points upwards means that the trend is up, and a green arrow pointing downwards means that the trend is down.

8.2.5. Positive Feedback

Positive feedback in the form of stars is used to motivate the user to save more and to draw attention to their progress. Highlighting when the user does well instead of telling them that they aren't good enough will encourage them to keep saving energy. Giving positive feedback will encourage people and make them feel good about themselves even if they are still using more than they should. It's important to reward progress to ensure that people keep using the service and aren't overwhelmed by the challenge of lowering their consumption.

8.2.6. Historical Comparison

Although Energy Budget provides tools that enable the users to get simple feedback on how they're doing, comparisons between months can give deeper understanding of energy consumption. A historical comparison also enables the user to see their progress over time. A simple comparison is given by showing previous months and how well the user met the budget of that month. A graphical representation of the previous month's budget is combined with a percentage of how much above or below budget the user was. The number of stars gained that month is also shown. A list of the previous months gives the user an overview of their progress (figure 42).

More details about different months can be obtained by expanding one month into a more detailed view. This reveals more detailed information about consumption on a daily and hourly basis. When it comes to creating a deeper understanding the user needs to create a link between their actions and their effects. However, this may be more relevant for the experienced user and is therefore given a less prominent place.

8.2.7. Challenges

Users can accept intriguing challenges that keep them motivated to improve themselves. The challenges start at a certain date and users must actively join during the time of the count down. The challenges are available for all who use the application and when a challenge is running they can see how many others are doing that challenge. Being able to see that other people also commit to energy savings can reassure people that their actions matter and the feeling of doing it together encourages them to keep improving (figure 43).

The challenges are a fun way of making a directed effort that motivates the users. Challenges provide short term goals such as *"What's the smallest amount of energy I use for 10 days?"* and *"How long can you last on 30 kWh?"*. During

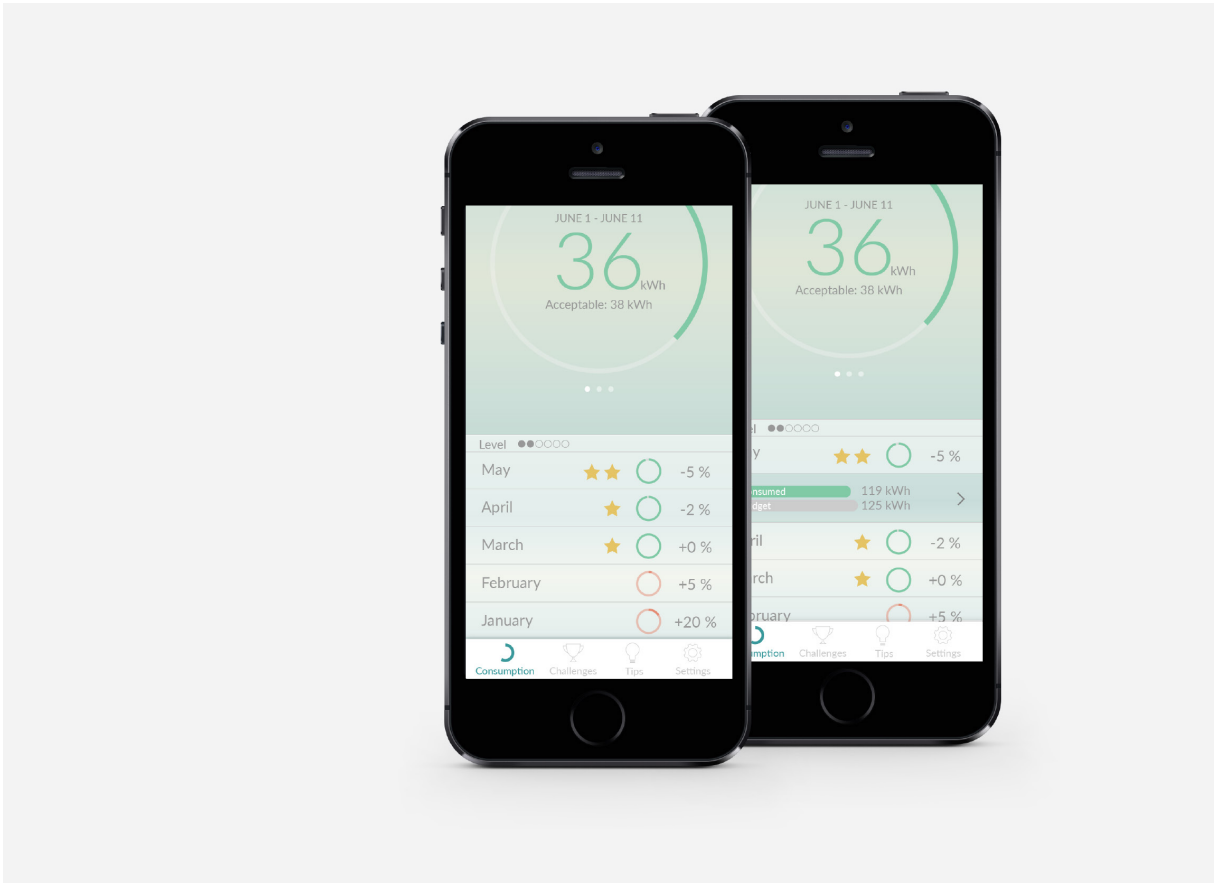


Figure 42. Historical Comparison

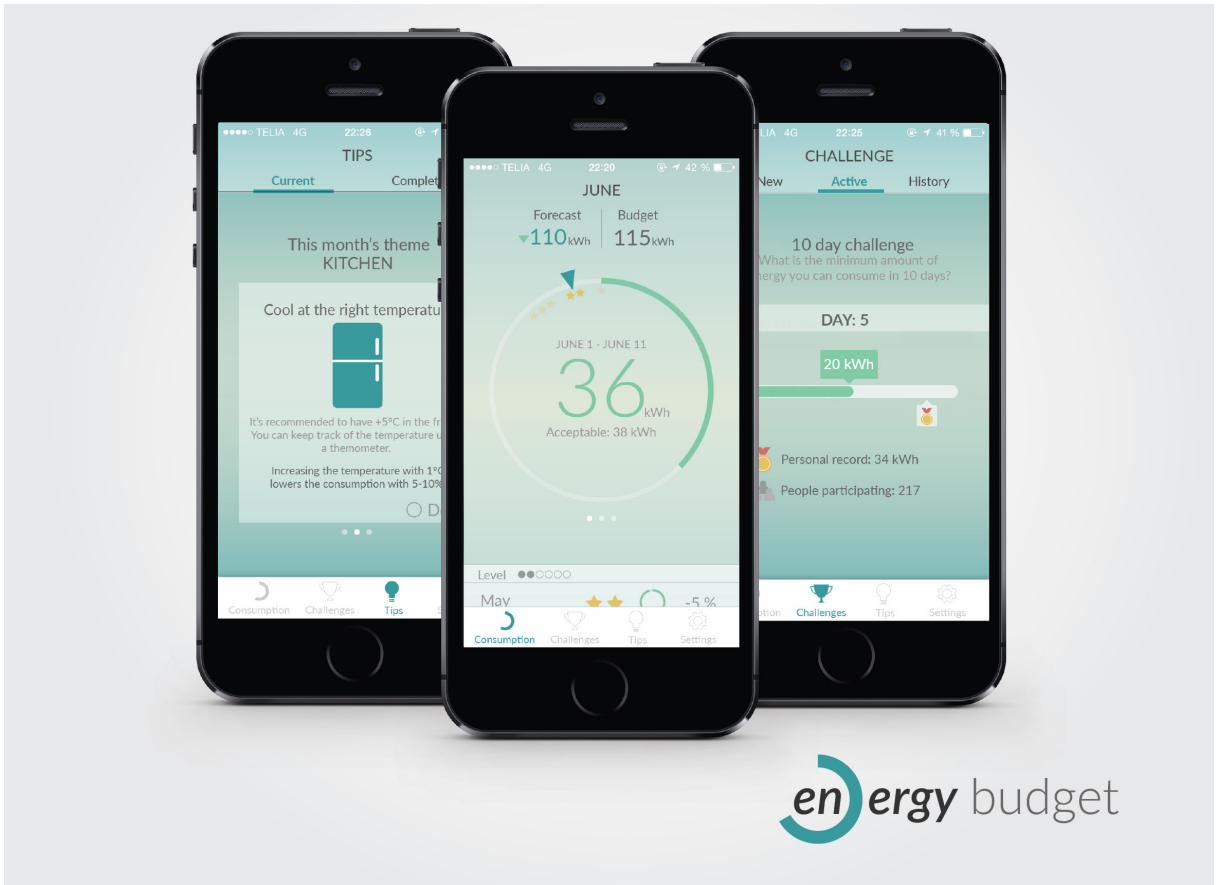


Figure 43. Tips and Challenges

the challenge the user gets notifications about how they're doing. At the end of that period the own results are shown as well as the total savings of all people who joined the challenge. The savings are translated into more relatable terms instead of just kWh, such as how many homes could be sustained by that amount of energy. Previous challenges are shown so that the user can compare their performance.

8.2.8. Tips

Energy conserving tips are given to help the user understand what they can do to lower their consumption. In order to avoid overwhelming the user with too many options, only a few tips on a theme are shown at the same time. These tips are based on the user's level to make them feel capable. The theme of the month decides which tips will be shown to the user. The reason for this is to provide one area at a time so that users can focus their effort on one task or room at a time. In order to further customise the tips, users can click the done button if they feel like they're already doing this action. These tips are removed from the current tips and gathered in a list so that the user can see what they've already done.

To make the tips more helpful they are described practically together with information about why the action should be done is also included. When possible, there are also examples of how much energy could be saved by doing the action. One such example is that cooking food with the lid on the pot can save around 30% energy.

8.3. DESIGN GOAL AND INTERACTION VISION

The final concept creates an appealing experience since it simplifies the eco-feedback in order to make it understandable and not overwhelming. Furthermore, it's individual which makes it more clearly connected to the user. The design goal is connected with the interaction vision to create a win-win feeling, which is also an appealing experience. It's relieving because it lowers the cognitive load of having to analyse a lot of data. Instead the user gets clear and easily understandable information presented in an attractive way. Providing a budget that is achievable makes the concept feel beneficial because the user can save some money without having to completely change their lifestyle overnight. The reward system clearly indicates when the user has done well which creates a feeling of satisfaction.

8.4. LOOK AND FEEL

The look and feel of the final concept is based on the qualities of the interaction vision; beneficial, relieving and satisfying. These words are summarised in a mood board, which was used as a base for the colour palette of the final design. Figure 44 shows the colour palette. The qualities were combined with the words Simplify, Minimize overload and Individualize that were identified in through the research. The individuality is however mostly represented by the budget and tips, not by the look and feel. The aim was to create an interface that didn't feel too analytic and serious, but at the same time users should feel like they can trust the information. The words were translated into the following visual guidelines.

Figure 44. Colour palette

Clean and simple - the interface minimizes overload by using a clean design by showing a lot of information in a way that makes it easily understood by the user. Elements use simple shapes that aim to be easy to understand. Focus is put on the most important elements by letting those take up more space.

Light feeling - which was realised by the use of a light background with low opacity. Background elements were also given different opacities in order to feel lighter. Also graphics have been given a light feeling using outlined icons and thin lines.

Dynamic - the interfaces gets a dynamic feeling since the background changes depending on whether the user consumes more or less than the acceptable amount.

8.5. BARRIERS

Energy Budget aims to lower barriers that hinder people from using less energy in their homes. Energy Budget provides a budget that the user can commit to and that clearly shows the progress and effect of different actions. This lowers the barrier of 'no visible result, no commitment'. Trend and forecast helps users understand how their behaviour affects the consumption, which can help them determine if they're doing things right.

Levels indicate if the user consumes a lot or not, which can enlighten people about their possibilities to lower their consumption. This is connected to the barrier that people may think that they're already doing everything possible. Also, since the budget is based on the household's size the recommendation won't feel too challenging and this may keep the users from feeling that it's too much effort to save energy. Although the actions still require the same amount of effort Energy Budget relieves the cognitive load as it provides easily understandable feedback in a clean and simple way.

By having tips explain why users should do specific actions, users can more easily tell what the right action is and can be enlightened about things that they might be doing wrong. Only showing a few tips at a time also reduces the need for the user to prioritize what action to do when they feel like they don't have the time or energy to do all.

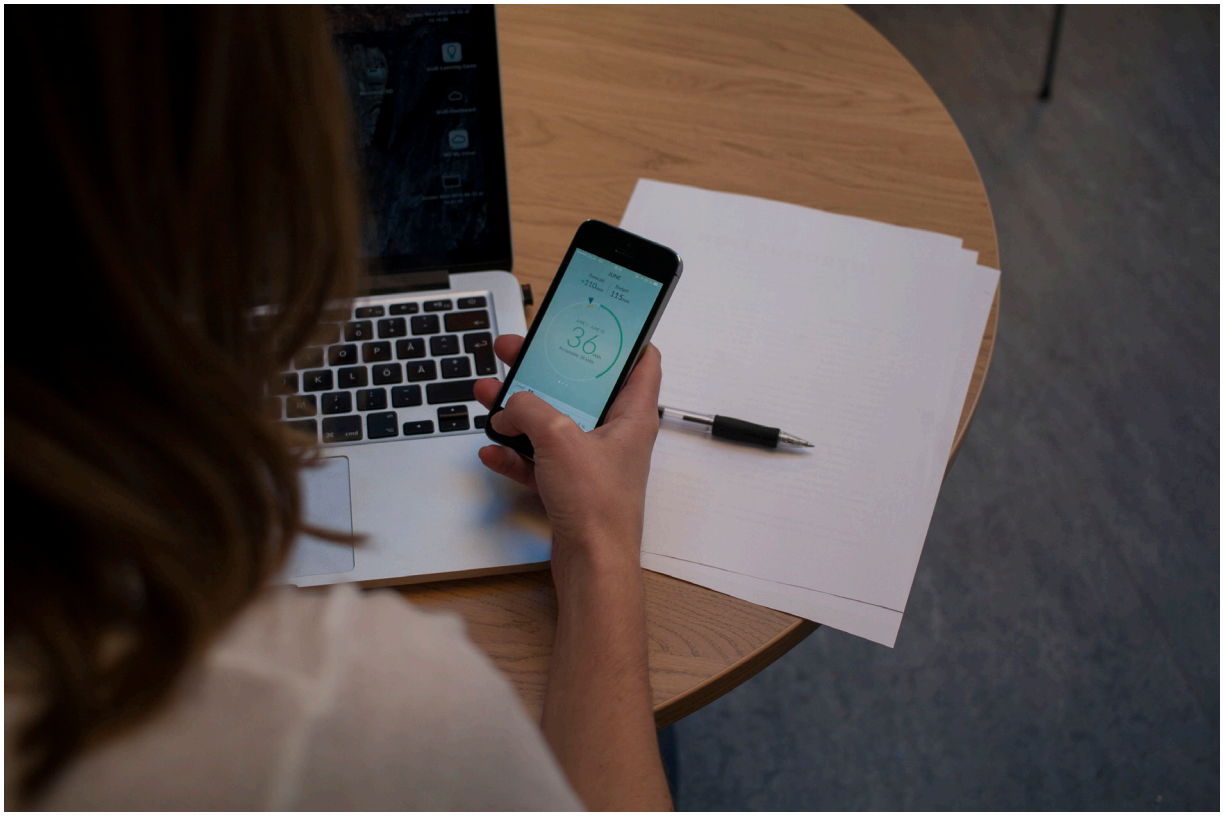


Figure 45. Usage of Energy Budget

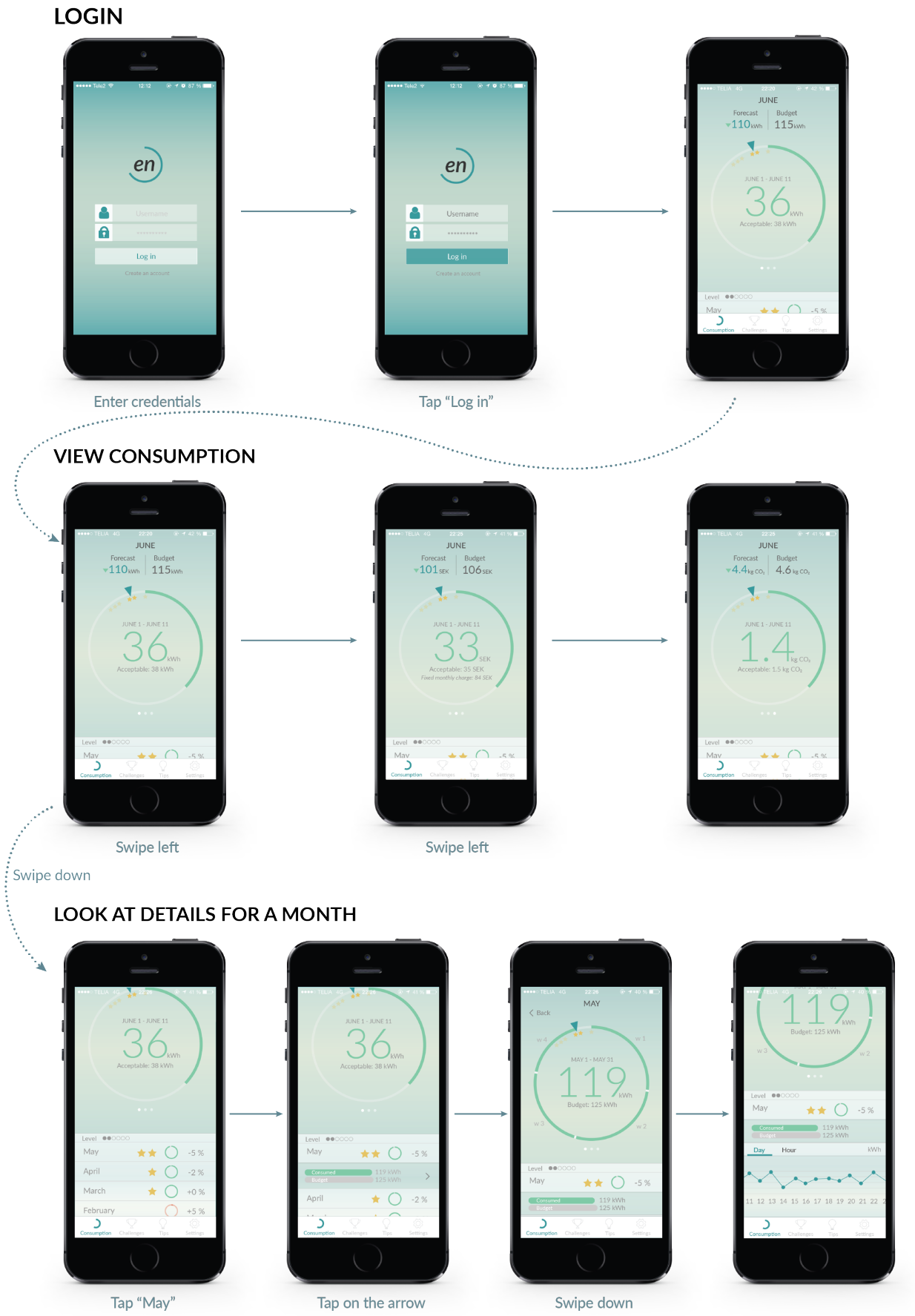


Figure 46. Walkthrough of Energy Budget (part I)

Figure 47. Walkthrough of Energy Budget (part II)

8.6. SCENARIO

Energy Budget is a service that creates energy saving over time. This scenario describes examples of the user's experience when using Energy Budget.

Jack has just gotten accepted to Chalmers and is excited about moving to a new city. His friend Jennifer moved there last year, so he calls her up to tell her the good news. She is thrilled to hear that Jack is moving. They start talking about the move and Jennifer explains that she's learned a lot about taking care of her home in the past year. She tells Jack excitedly about an application she has on her smartphone, which helps her keep track of her energy consumption. The application's called Energy Budget and she got it for free when she moved in. She says that before she didn't even know how much she was using, but the application makes it feel easy to keep track of and she never spends unnecessary money on electricity. *"At the end of the month I have saved like two beers"* she says and laughs. Jack thinks that this application sounds interesting, he wonders if he can get it too.

After waiting all summer Jack finally arrives at Chalmers, he's looking forward to being at the university and meeting new people. He spends most of his time in school, there are just so many fun activities. When he gets home one day he looks through the mail and notices an envelope that contains some of vouchers for grocery stores and information about the nearest healthcare center. Amongst the paper she finds a one with the name Energy Budget and a QR-code on, which takes him to the downloader for the application on his phone. He's looking forward to trying the application that Jennifer was talking about. He thinks, *"I wouldn't mind having some extra money this month"*. He downloads the application and starts exploring it.

He creates an account and can see right away how much he's used this month. He's surprised to see that it doesn't look like a boring analysis tool, it looks really nice and clean. He examines the interface and quickly realises that he has been using too much. He has already used up 50 kWh but the acceptable level is only 45 kWh. As he feels a bit discouraged he notices that there are saving tips available in the menu. He taps the icon and a tip appears. This month's theme is the kitchen and it says that increasing the temperature of the fridge with one degree will lower its energy consumption with 5-10%. He wonders if this will keep his food fresh so he reads on. It says in the text that the food will keep fresh if the temperature is +5°C. He goes to the refrigerator and sees that it's on +7°C and lowers it to +5°C. Then he checks the *"done"* box and the tip is added to his *"completed"* list. He's surprised that it could be so simple to save energy. He had expected to feel like saving energy would feel impossible, but the simplicity of Energy Budget made it feel reachable. He's excited to see how this action affects his consumption, hopefully he's now on the acceptable level.

Later that week he checks Energy Budget again and sees that he's now just under the acceptable level. He notices that the interface has changed, it has gone from a red tone to a green and the numbers have been updated. He also notices that this month's forecast is now lower and that the arrow beside it points down. He feels encouraged that his action had an effect. At first he had been a bit unsure if he could make the budget, he has never even seen an electricity bill, but now it feels like he can do it.

Jack has used Energy Budget for some time now and has managed to keep his budget for some time, he's even gotten himself some stars. He gets really motivated by working towards a goal and thinks it's fun to be a bit more economical at the end of the month just to get another star. He has recently discovered that there are challenges going on. He thinks it's really great to see how many others are in the challenge, it feels motivating to know that he's not the only one. Last time he and 300 other saved enough to supply five households for a year.

One evening Jack and his new classmates are at a pub quiz. The group is discussing the upcoming exam when Jack gets a notification from Energy Budget; he has just levelled up. He cheers and his friends wonder what has happened. He explains that he is using this helpful

application to keep track of his electricity consumption and that he has just reached a higher level. His friends are curious about the application, so he shows them how it works. His friends are surprised that it's so much fun, they'd never expect that energy saving could be that engaging. They're intrigued by its simplicity and the fact that the budget is based on their own capacity. They all download the application to try it out at home. It's so convenient not to need any additional devices, they can create their accounts right away and start comparing their consumption.

A year later Jack only looks at Energy Budget once a month or so, he just wants to see that he's on track. The tips he has gotten has become habits and he doesn't need to look at them anymore. The tasks he thought required too much effort now feel natural to do. In just a year Jack has mastered his energy budget and is now living a sustainable life without feeling like he has to compromise on being comfortable.

8.7. BUSINESS CASE

Energy Budget is a unique eco-feedback system that employs goal-setting in order to encourage people to lower their electricity consumption. There are many possible partners that could profit from providing this service, two that have been identified as highly suitable are Energimolnet and the electricity trader Göteborgs Energi Din El. These companies have different reasons for being of interest. Energimolnet is a start-up company that has developed an API for retrieving energy data. Their goal is to make energy data available for everyone as a tool for developing energy services (Freyhall, 2015). By providing Energy Budget, Energimolnet could promote their services and gain new customers. This service wouldn't need to be tied any electricity trader and would then fit their vision of making energy data available for everyone. During a meeting with the company it was confirmed that such a service might be of interest for them. Din El is a company of interest since it doesn't currently provide an eco-feedback service to their customers. Many other electricity traders have their own services, providing Energy Budget could be a way for Din El to compete with the other traders. By providing an attractive service they could gain more customers.

CHAPTER NINE

DISCUSSION

This chapter discusses the process of the project and the relevance and validity of its findings.

9.1. PROCESS

9.1.1. Starting point

The scope for the project was very wide with the overall goal to create a product or service that enables, encourage and/or stimulates users to reduce their energy consumption with the overall goal to decrease the CO_2 emissions generated by the household. Because of the open end about what the final result would be, it was challenging to set up specific milestones throughout the process. The wide project scope also contributed to the broad approach during the research phase in order to understand the area and the users behaviour.

Having only an organisation focused on innovation and not a particular partner company contributed to that the decision-making during the project had little restriction. This was challenging to be decisive in the crucial selections when there were so many possibilities. At the same time, the low degree of restriction also allowed for the project group to follow their own inspiration. From the project group it was desirable to keep the scope wide far into the project, which quickly made the process become complex. This contributed to too many very diverse ideas being kept for too long.

Because of this it was necessary for the project group to make a restriction regarding what target group to focus on. It turned out to be a successful decision to have a more narrow focus since more interesting and unexpected ideas were generated. The final concept even resulted in that more than only the people included in the user group could use it. Although, if it was narrowed down earlier even more unforeseen ideas might have been generated and changed the character of the chosen final concept.

9.1.2. Theoretical approach

Having a co-creative approach was useful for the project as the close involvement with users enabled the project group to gain a deep understanding of the users' everyday life. However, the co-creation sessions didn't produce as much creation as was expected. This might have been due to the way the co-creation sessions were structured. In the first session the participants were asked to fantasize about how they would save energy in the future. Even though there had been exercises before this to prepare the participants, they found it challenging to let go of the current restrictions. During the second co-creation session barriers, strategies and personas were used as mediating objects that could support the participants' creativity. While this worked better, there might have been too many options and only a few were included in the end due to time limitations.

This master thesis has been conducted with a user experience approach, which has meant that the different levels of experience have been considered when creating the final concept. Although the goal has been to create an appealing user experience, the different levels of user experience haven't been considered in all stages of the process. Instead the focus has been to consider the overall experience in all stages and to make decisions accordingly. The experience of meaning has gotten most attention, as it was of great importance that the final concept was easily understandable and that the cognitive load was kept to a minimum. The emotional experience has been explored during the development of the final concept. The emotional level is connected to whether or not the user will feel overwhelmed, which may cause them to refrain from using the service. Since the goal wasn't to create a very detailed final result, less effort has been put on the aesthetic experience. This level was only considered in the final stage of the development. Having worked with the levels in a more structured way might have been preferable in order to fully implement a user experience approach.

The design strategies for sustainable behaviour were a useful tool during this master thesis as it added structure and limitations to the ideation phase. In an early stage of the project a selection of strategies was made in order to further limit the project and to only work with strategies that were relevant for the project. However, the selection was made early based on the first insights. This affected the course of the project as it set the boundaries for ideation and in that way the final concept. Since the selection was quite wide it's not likely that it limited the ideation much. An even narrower selection would actually have enabled the project group to go further into detail on some strategies.

9.1.3. Research

Because the master thesis was part of a larger research project the questions for the structured interviews were already set for the project group and there was little opportunity for the project group to add more questions during the interviews. The interviews were focused on electricity consumption, without considering heating and water consumption. While the interviews provided a good overall picture of the current situation, further exploration of the total energy consumption might have revealed other valuable insights. Having had an even wider starting point might have revealed unexpected aspects that would have been of interest when designing the final concept. On the other hand a wider approach might have added more complexity to the project.

Most of the people that participated in the interviews had been invited through their property owner and had on beforehand agreed to be involved in the study. Therefore many of the participants had to some extend an interest in sustainable behaviour and might not be a valid representation of the population. Therefore some of the existing barriers for energy savings may not have been represented during the interviews. In order to get a better representation and increase the validity of the interviews, the project group tried to as great extend as possible to include other people as well. Although many of the participants weren't knowledgeable in the area of energy consumption, their barriers might differ from people that aren't interested at all in sustainable

behaviour. Especially since the chosen target group was people who aren't particularly interested, it would've been more interesting to include more user of that type to gain more insights.

One aspect that was of great importance during the user research was that many people wanted to give the impression that they have a sustainable lifestyle and answered the questions accordingly. Therefore it can in some cases be hard to know if what they said about their behaviour is corresponding to how they actually behave. Because of that it has been of great importance to consider the users attitudes and emotions regarding their consumption. One example of this was during interviews when the participants were asked how aware they were about their energy consumption, many of them stated that they were fairly aware. However, when they had to estimate their own consumption many participants answered, *"I don't know"*. Many people consider themselves to be aware, but they actually don't know.

Since the master thesis was part of a larger research study, all interviews that were analysed weren't conducted of the project group and therefore the comments from those interviews might not have been totally correctly interpreted during the analysis regarding their emotions and attitudes. It was therefore harder to draw a parallel between what they answered and their actual emotions and attitudes towards energy consumption if they differed.

The intention of the question about their own estimated energy consumption was to see if the participants actually knew how much they consumed. Although it wasn't clear whether the participants had looked it up beforehand or just guessed it. The number that answered, *"I don't know"* might then have been higher.

Another source of error from the user study was that some of the participants had already looked up the wattage of all their products beforehand since it was said to do so on the invite. Therefore when answering the question regarding what products they estimated to consume least respectively the most energy in the beginning of the interviews some of the interviewees already had some knowledge about how much their different products consumed and based their answers on that. The answers in that question might have differed if they didn't have that knowledge.

Regarding the market analysis there were many eco-feedback systems that had to be excluded because they were tied to a specific electricity provider and therefore weren't accessible for non-customers.

9.1.4. Ideation

In order to not exclude something that could've been of interest because of the broad scope the ideation part was kept wide. Although to make the ideation more focused it would've been preferable to narrow it down earlier since it can limit creativity to not have any restrictions. Although many attempts were made to structure the ideation and easily create new ideas, for example when combining each barrier with each strategy. Unfortunately that didn't work as well as predicted. It became too structured and limited the creativity. It was therefore hard to find the right balance between enough restrictions, but not too many.

Since the guidelines were only guidelines and not requirements it was hard to exclude solutions with help from them during the ideation process. Another factor that contributed to that as well was that one idea didn't necessary need to fulfil all guidelines to become successful if it instead fulfilled one or some of them exceptionally good.

In the ideation phase of the project a design goal and an interaction vision were created to describe the experience and interactions connected to the final design. It might have been suitable to define these in the early stages of the project, in order to set a direction. While it would have been helpful to have further restrictions in the project, the open scope made it challenging to define a design goal and interaction vision before insights were gained.

9.2. FINAL CONCEPT

Energy Budget is an eco-feedback system that provides the user with an energy budget. During the project, guidelines were created and used to make sure that the final concept helped lower the barriers. The final concept lowers most of the identified barriers by its simple energy budget, which makes it easy for the user to see how they're doing. Helpful tips are given to explain what can be done, but only a few are available at a time to not be overwhelming. The final concept doesn't affect how other products function. However, to both change the users' and the products' behaviour may not be possible with one product or service. To some extent the barrier of not wanting to change comfortable lifestyle can be considered as lowered, as the service doesn't require a lot of set-up or any additional devices. However, the service does promote changing one's behaviour, which would mean changing one's lifestyle. The aim was to make these changes in behaviour feel less challenging as it happens gradually. Therefore the final concept can be considered to fulfil the goal of this master thesis since it enables, encourages and stimulates the user to reduce their energy consumption by lowering the barriers that the users experience.

The final concept can be regarded as effective feedback since its simplistic and attractive design catches the user's attention. By showing feedback on consumption on an hourly basis, with indications on where the user will be at the end of the month using forecast and trend, the application draws a close link between action and effect. What's unique about the final concept is that it activates relevant motives for the user by providing an electricity budget. By giving the users a guideline for how much they should consume they can easily comprehend if they're using too much electricity. While this is a clever way to create more relatable feedback, it still concerns making decisions based on resource management which may not be connected to how people actually go about making decisions in their everyday life. However, the final concept also provides tips that are related to everyday actions and what effect changes in behaviour can have. In this regard, the concept is more adapted to the everyday life of the users. The combination of feedback and tips help educate the user in energy conservation.

In the final concept the interval of new themes for the tips is given every month. It can be discussed whether that is a suitable interval or if it's too short or too long. On one hand it is important to keep the user interested in the service and not forget about it in the daily life. If the service is too static the users might get bored and stop using it. On the other hand it is of great importance to not making the users feel overwhelmed by providing them with too much new information and actions. To find the most suitable interval to give new themes more testing with users would be preferable.

9.2.1. Graphical interface

One limitation of this master thesis has been to not focus on creating a fully developed product or service that could be tested over time. However, there is still a need for testing the final concept over time still to make sure that the assumptions about users' behaviours are true. Had the project had another direction or continued for a longer period of time, usability tests of the interface would have been conducted in order to ensure that the interface is easily understood.

During the development of the graphical interface a lot of attention was given to the circular bar describing the budget and accumulated consumption since this was considered essential for the concept. Incorporating budget, accumulated consumption, acceptable level, forecast and trend so that they were all connected was challenging. Much effort was put on exploring how to connect the graphics with the users' mental model of how it should work, since there were few other interfaces that were similar to rely on. In particular explorations concerning whether the circular bar should be emptied or filled were made. Having it emptied would closer connect the visuals with having only limited resources, which would then promote a more engaged consumption. However, during the evaluations the participants didn't relate to this since

their mental model was that it should be filled. As mentioned earlier the project was limited to not test over time. Having conducted tests might have revealed if it was possible to understand the emptied bar over time.

9.2.2. Realisability

Because of the open end it was not set from the beginning of the project whether the final concept should be something that could be realised with current technology or be of a more visionary character. However, it was in the project group's interest to develop something according to the first alternative. Therefore it has been of great importance to investigate the technology when needed to ensure that the final concept would be able to reach the market with the current technology. Therefore ideas that didn't live up to that demand has been excluded during several evaluation sessions.

In order for the final concept to be realized experts in the area of programming need to be contacted in order to understand if there are any parts in the concept that would be hard to accomplish.

Because there was no partner company involved there is a need of contacting potential partners in order to investigate who can be interested in the final concept produced by the project. In this report suggestions have been made based on what companies might gain from the concept. Furthermore, specific grid suppliers need to be contacted in order to get more information about at what frequency they would be able to deliver the energy data since this in some cases can differ between suppliers.

9.2.3. Market potential

There are many products and services on the market today with the goal to make users lower their household energy consumption. It has therefore been a real challenge to come up with something unique and innovative and many alternatives during the process have been excluded for just that reason. Because of the large need for a lowered energy consumption, new solutions are also constantly popping up on the market around the world.

The project group has as far as possible tried to stay updated in the area in order to be able to create something that isn't on the market today. Because of that the final concept is considered to be something innovative and unique in the sense that it attracts a user type that might have been overlooked today. Many of the current solutions on the market are filled with a lot of data to be analyzed by the user. This is only attractive to people that are already interested in their energy consumption and therefore interested in very detailed information. Instead, the final concept of this master thesis is focused on giving the user more individual support in what is regarded as being an OK level of energy consumption for them in a simple and less overwhelming way. Because of the fast growth of new services on the market it is essential that the final concept gets introduced on the market as soon as possible.

Due to the limited timeframe the project couldn't include a longer test and therefore many assumptions had to be made regarding how people would behave over a longer time. So in order to know if people would use the service for a longer time further evaluations would have to be performed. However, because of the simplicity of the final concept it has succeeded even if it's used for short time because it has made users that didn't know anything about their energy consumption aware of the situation that is a large step in the right direction.

RECOMMENDATIONS

In order for Energy Budget to be realised some further development and testing is needed, as well as further investigation of business cases is of importance to make sure that the service can be distributed on the market. This requires…

- That the service achieves the desired effect and that it's in line with the users' needs, a test of the application should be conducted over a longer period of time.
- A usability test of the graphical interface should be conducted to reveal if the users understand it easily.
- Further investigation on how the levels should be calculated.

CHAPTER TEN

CONCLUSION

This chapter describes the conclusions drawn from the different parts of the project.

The research showed that people believe themselves to be fairly aware of their energy consumption, but they don't really know how much energy they use. This lack of awareness creates barriers for the users when lowering their energy consumption. Another important finding is that people have little knowledge about what an acceptable electricity consumption is and if they're over or under that. Furthermore it was found that people who live in apartments often aren't included in the current eco-feedback systems, which makes them an interesting user group. In order for people to become engaged consumers, eco-feedback and guidance about electricity consumption is needed. This master thesis has found three characteristics that are important to consider when designing such a service; minimize overload, simplify and individualise. Current eco-feedback solutions tend to provide the user with a lot of information that the he or she needs to analyse. This can be overwhelming and can make the user stop utilising the service. Instead highlighting the most important information and providing tools that simplify the analysis of the information should help avoiding this overload. Finally, there is a need for guidance that is relevant to the user. This should be done by customising the acceptable level and tips for lowering consumption to the individual.

Energy budget is a smart phone application that provides its users with an individual energy budget, which changes as the user improves. The energy budget is customized to the user's current consumption level, making the goal reachable. The users can keep track of how their consumption changes, get feedback on consumption trend and get a forecast of what the consumption will be at the end of the month. Users can accept challenges that are posted to all users and together they can jumpstart their savings in a fun and exciting way. Further helpful tips to learn how to keep their electricity consumption at an acceptable level support the users. The application targets people who don't want to spend time or money on equipment to help them to lower their energy consumption. It's especially suited for people living in apartments, as it doesn't require any installation on the electricity meter.

REFERENCES

ARTICLES

Buyya, R., Gubbi, J., Marusic, S., Palaniswami, M., (2013) Internet of Things (IoT): A vision, architectural elements, and future directions, *Future Generation Computer Systems*, Vol 29(7). pp. 1645-1660.

Darby, S. (2001) Making it obvious: designing feedback into energy consumption, *Energy Efficiency in Household Appliances and Lighting* (ed. by Bertoldi, P., Ricci, A. & de Almeida, A.), pp. 685-696. Berlin, Springer-Verlag.

Darby, S. (2006) The Effectiveness of Feedback on Energy Consumption. A Review for DEFRA of the Literature on Metering, Billing and direct Displays. Environmental Change Institute, University of Oxford, Oxford.

Desmet, P.M.A., & Hekkert, P. (2007). Framework of product experience. *International Journal of Design* Vol 1(1). pp. 57-66.

Elias, E. W. A., Dekoninck, E. A. & Culley, S. J. (2009) Designing for 'use phase' energy losses of domestic products. Proceedings of the Institution of Mechanical Engineers, Part B. *Journal of Engineering Manufacture* Vol 223. pp. 115-120.

Fischer, C. (2008) Feedback on household electricity consumption: a tool for saving energy? *Energy Efficiency* Vol 1. pp. 79-104.

Lindenberg, S. & Steg, L. (2007) Normative, Gain and Hedonic Goal Frames Guiding Environmental Behaviour. *Journal och Social Issues*, 63, 117-137

Rittel, H., & Webber, M. (1973) Dilemmas in a general theory of planning. *Policy Science* Vol. 4. pp. 155-169. Elsevier Scientific Publishing Company Inc., Amsterdam

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology* Vol 39(6). pp. 1161-1178.

Russell, J. A. (2003). Core affect and the psychological construction of emotion. *Psychological Review* Vol 110(1). pp. 145-172.

Schultz, P.W., Nolan, J.M., Cialdini, R.B., Goldstein, N.J. and Griskevicius, V. (2007) The Constructive, Destructive, and Reconstructive Power of Social Norms. *Psychological Science* Vol 18(5), pp.429-434.

Stern, P. (2000). Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues*, *Promoting Environmentalism* Vol 56. pp. 407-424.

BOOKS

Bligård, L., (2011) *Utvecklingsprocessen ur ett människa-maskinperspektiv*. Gothenburg: Chalmers University of Technology (Department of Product and Production Development)

van Boeijen, A.G.C., Daalhuizen, J.J., Zijlstra, J.J.M. and van der Schoor, R.S.A. (eds.) (2013) *Delft Design Guide*. Amsterdam: BIS Publisher

Bohgard, M., Karlsson, S., Lovén, E., Mikaelsson, L-Å., Mårtensson, L., Osvalder, A-L., Rose, L., Ulfvengren, P. (2010) *Work and Technology on human terms.* Stockholm: Prevent

Jager, W., 2003. Breaking 'bad habits': a dynamical perspective on habit formation and change. In: L. Hendrickx, W. Jager and L. Steg eds. Human Decision Making and Environmental Perception: Understanding and Assisting Human Decision Making in Real-life Settings. Groningen: University of Groningen

Osterwalder, A., & Pigneur, Y., (2009), *Business Model Generation*, Amsterdam: Self Published.

Preece, J., Rogers, Y., Sharp, I. (2012), *Interaction design: beyond human-computer interaction*. West Sussex: John Wiley & Sons Ltd

Sanders, E. B.-N., & Stappers, P.J. (2012), *Convivial Toolbox - Generative research for the front end of design*. Amsterdam: BIS Publishers

Ullman, D., G., (2010), *The Mechanical Design Process 4th edition,* New York: McGraw-Hill Companies, Inc.

Österlin, K. (2010) *Design i fokus för produktutveckling.* 3rd ed. Malmö: Liber

CONFERENCE

Renström S., Selvefors, A., Strömberg, H. (2013) Pathways of Sustainable Behaviours. Proceedings of the ERSCP-EMSU 2013 conference, 16th Conference of the European Roundtable on Sustainable Consumption and Production (ERSCP) & 7th Conference of the Environmental Management for Sustainable Universities (EMSU), 4 – 7 June 2013, Istanbul, Turkey. pp. 1-18. (2013)

Strengers, Y. (2011) Designing eco-feedback systems for everyday life. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp.2135-2144.

Zachrisson, J. (2010) When to apply different design for sustainable behaviour strategies? Proceedings of the Knowledge Collaboration & Learning for Sustainable Innovation ERSCP-EMSU conference, Delft, The Netherlands, October 25-29, 2010

LAWS

Ellag SFS (1997:857) chapter 3 10 § and 11 §

REPORTS

Lidman, K. & Renström, S. (2011) *How To Design for Sustainable Behaviour? - A Review of Design Strategies & an Empirical Study of Four Product Concepts.* Thesis for the degree of Master of Science, Department of Product & Production Development, Chalmers University of Technology, Gothenburg.

Lundgren, J., Granström, S., & Pålsson, M. (2010) Ökat inflytande för kunderna på elmarknaden Timmätning för elkunder med abonnemang om högst 63 ampere, Report/ Energimarknadsinspektionen EI R2010:22. Eskilstuna: Energimarknadsinspektionen.

Makonin, S., (2012), *Approaches to Non-Intrusive Load Monitoring (NILM in the home*, Simon Fraser University, Canada

Selvefors, A., (2014) *Understanding Energy Behviour - A Necessity for Supporting Domestic Energy Conservation through Design*. Thesis for the degree of Licentiate of Engineering, Department of Product & Production Development, Chalmers University of Technology, Gothenburg.

WEBSITES

3Scale Networks (2011) *What is an API? Your guide to the Internet Business (R)evolution.* [Online] Available from: http://www.3scale.net/wp-content/uploads/2012/06/What-is-an-API-1.0.pdf. [Accessed: 14th May 2015]

Climate-KIC. (2015) *About Climate-KIC*. [Online] Available from: http://www.climate-kic.org/about/ [Accessed: 29th May 2015]

Ekonomifakta. (2015) *Elanvändning*. [Online] Available from:http://www.ekonomifakta.se/sv/Fakta/Energi/Energibalans-i-Sverige/Elanvandning/. [Accessed: 22nd April 2015]

E.ON. (2015) Bästa tipsen för att spara energi. [Online] Available from:http://www.eon.se/privatkund/Energieffektivisering/energiradgivning/Energispartips-for-hemmet/spara-energi/. [Accessed: 28th January 2015]

Energimolnet. (2015) Profilerade mätvärden. [Online] Available from: http://www.energimolnet.se/profilerade-matvarden-v2/. [Accessed: 25th May 2015]

Energi- och klimatrådgivningen. (2015) *Energi & miljö*. [Online] Available from: http://www.energiradgivningen.se/miljo-klimat/energi-miljo. [Accessed: 13th May 2015]

European Commission. (2015) *EU action on climate*. [Online] Available from: http://ec.europa.eu/clima/policies/brief/eu/index_en.htm. [Accessed: 9th May 2015]

European Environment Agency. (2012) *Household consumption*. [Online] Available from: http://www.eea.europa.eu/themes/households/intro. [Accessed: 12th May 2015]

European Union. (2015) *EU greenhouse gas emissions and targets*. [Online] Available from: http://ec.europa.eu/clima/policies/g-gas/index_en.htm. [Accessed: 13th May 2015]

Exibea (2015) *Installation*. [Online] Available from: http://eliq.se/produkter/installation/. [Accessed: 13th May 2015]

Hudson, G., Lea, T., (2010) *Reading pulses from meters with pulse outputs*. [Online] Available from: http://openenergymonitor.org/emon/buildingblocks/introduction-to-pulse-counting. [Accessed: 4th May 2015]

Vattenfall (2015) *Upptäck vad som drar mest el i hemmet*. [Online] Available from: http://www.vattenfall.se/sv/energywatch.htm. [Accessed: 4th May 2015]

Kellberg, C. (2014) *Hur mycket koldioxid medför din elanvändning?* [Online] Available from: http://www.svenskenergi.se/Elfakta/Miljo-och-klimat/Klimatpaverkan/Hur-mycket-koldioxid-medfor-din-elanvandning/. [Accessed: 13th May 2015]

Lundström, F. (2012) *Definitioner av smarta elnät*. [Online] Available from: http://www.energimyndigheten.se/Forskning/Kraftforskning/Elnat-och-elmarknad/Definitioner-av-smarta-elnat/. [Accessed: 4rt May 2015]

Statistiska Centralbyrån. (2012) *Två personer i snitthushållet*. [Online] Available from: http://www.scb.se/sv_/Hitta-statistik/Artiklar/Tva-personer-i-snitthushallet/. [Accessed: 30th March 2015]

Hamilton, C. (2009) Elmätning i realtid spar pengar och energi. *Göteborgs Posten*. [Online] 23rd November 2009. Available from: http://www.gp.se/nyheter/debatt/1.254221-elmatning-i-realtid-spar-pengar-och-energi?m=print. [Accessed: 3rd March 2015]

FIGURES

Figure 2: Adapted from Statistiska Centralbyrån. (2012) *Två personer i snitthushållet*. [Online] Available from: http://www.scb.se/sv_/Hitta-statistik/Artiklar/Tva-personer-i-snitthushallet/. [Accessed: 30th March 2015]

Figure 3: Adapted from Sanders, E. B.-N., & Stappers, P.J. (2012), *Convivial Toolbox - Generative research for the front end of design*. Amsterdam: BIS Publishers

Figure 4: Adapted from Desmet, P.M.A., & Hekkert, P. (2007). *Framework of product experience*. International Journal of Design Vol 1(1). pp. 57-66.

Figure 5: Adapted from Zachrisson, J. (2010) *When to apply different design for sustainable behaviour strategies?* Proceedings of the Knowledge Collaboration & Learning for Sustainable Innovation ERSCP-EMSU conference. October 25-29, 2010, Delft, The Netherlands.

Figure 6: Adapted from Lidman, K. & Renström, S. (2011) *How To Design for Sustainable Behaviour? - A Review of Design Strategies & an Empirical Study of Four Product Concepts*. Thesis for the degree of Master of Science, Department of Product & Production Development, Chalmers University of Technology, Gothenburg

APPENDICES

APPENDIX I: GANTT CHART

APPENDIX II: INTERVIEW

APPENDIX III: QUESTIONNAIRE

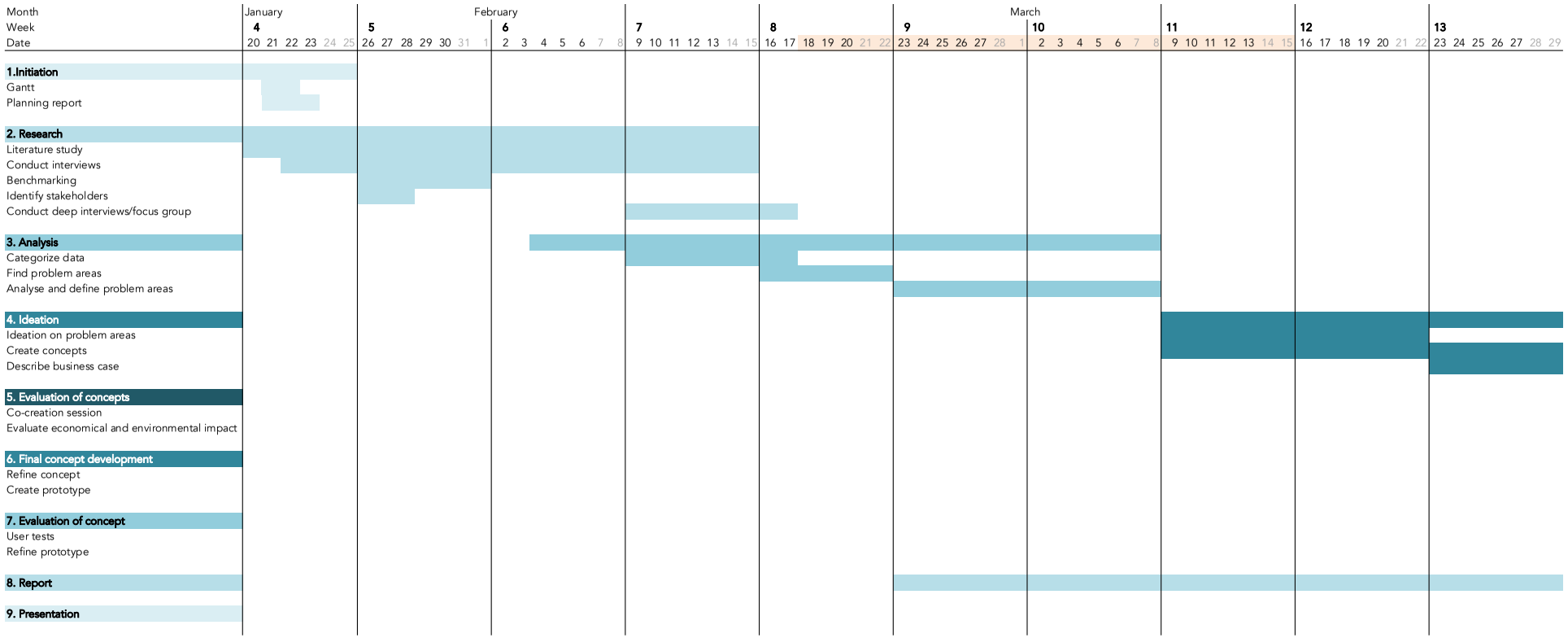
APPENDIX IV: RESULT OF THE INTERVIEW

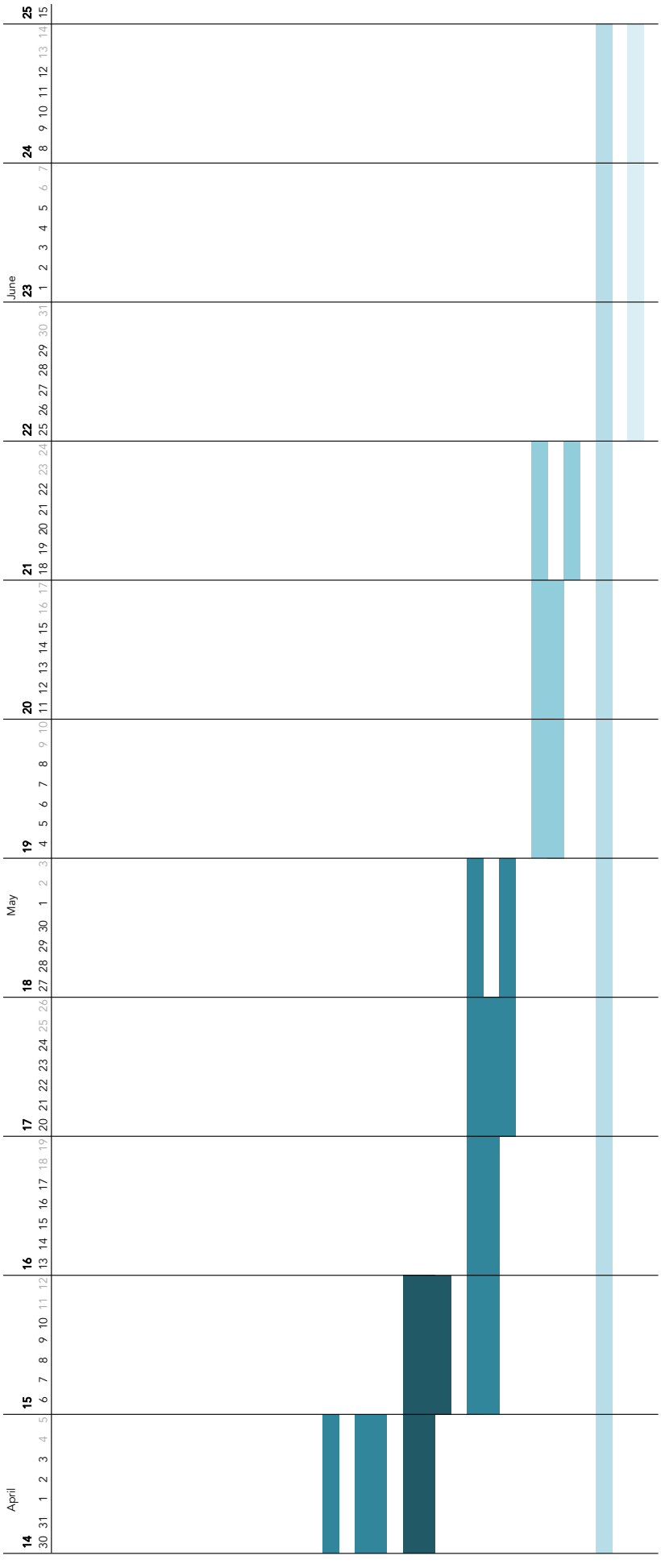
APPENDIX V: RESULT OF THE QUESTIONNAIRE

APPENDIX VI: SYSTEMS INCLUDED IN BENCHMARKING

APPENDIX VII: SWOT-ANALYSES

APPENDIX I: GANTT CHART




April
May
June
14 15 16 17 18 19 20 21 22 23 24 25

APPENDIX II: INTERVIEW

The interviews were conducted in the beginning of the project and the aim was for the project group to create an understanding of the users and use environment. In total 25 participants of different ages were interviewed. The interviews started with some general questions about the participants and their energy habits, and then a inventory of electrical devices was made. This appendix presents the interview structure that was used.

BASUPPGIFTER

Namn

Adress

Postnummer

Ort

Telefonnummer

Epostadress

Ålder

Kön

Uppskattad årsinkomst för hela hushållet (inklusive eventuell pension, studiemedel, a-kassa, bidrag etc.)

- Mindre än 240 000 kr
- 240 000 - 360 000 kr
- 360 000 - 480 000 kr
- 480 000 - 600 000 kr
- Mer än 600 000 kr
- Vill ej ange

Utbildningsbakgrund

- Ingen
- Grundskoleutbildning
- Gymnasieutbildning
- KY-utbildning eller liknande
- Folkhögskoleutbildning
- Högskole-/universitetsutbildning
- Annat:

Uppskattad medvetenhet kring egen energiförbrukning:

- Inte alls
- Något medveten
- Ganska medveten
- Mycket medveten

INVENTERING AV LJUSKÄLLOR

Antal taklampor

Antal vägglampor

Antal golvlampor

Antal småbelysning

APPARATERNAS BIDRAG TILL HUSHÅLLETS ENERGIFÖRBRUKNING

Vilka 5 apparater tror du bidrar MEST till ditt hushålls energiförbrukning?

Ange dem i hierarkisk ordning och börja med den som bidrar mest. Motivera.

Vilka 5 apparater tror du bidrar MINST till ditt hushålls energiförbrukning?

Ange dem i hierarkisk ordning och börja med den som bidrar minst. Motivera.

ENERGIBESPARANDE ÅTGÄRDER

Har du försökt att minska energiförbrukningen för några av dina apparater? Välj max 5 stycken.

Beskriv kort vad du gjorde.

Har åtgärden varit effektiv?

- Ja
- Nej

(Upprepades för de 5 valda apparaterna)

ANVÄNDNING AV APPARATER

Beskriv apparaten och hur du använder den

Apparat I

Beskriv hur ofta apparaten är påslagen eller igång.

- Den är alltid igång (antingen helt eller i energisparläge)
- En eller flera gånger dagligen
- En eller flera gånger per vecka
- En eller flera gånger i månaden
- En eller flera gånger per år
- Nästan aldrig
- Den används aldrig

Hur länge använder du apparaten i genomsnitt per användningstillfälle?

- 5 min
- 15 min
- 30 min
- 1 tim
- 2-3 tim
- 4-6 tim
- 7-12 tim
- 12-24 tim

Har apparaten ett energisparläge (t. ex. stand-by, sleepmode inaktivt läge)?

- Ja
- Nej
- Vet ej

Vad har apparaten för effekt, dvs hur mycket Watt drar den i aktivt läge?

(Upprepades för alla apparater)

APPARATER DU INTE VILL VARA UTAN

Välj max 2 stycken

Märk ut en apparat som du använder ofta och inte vill vara utan.

Ta ett foto på apparaten tillsammans med den gröna markören

I vilka situationer och till vad använder du apparaten?

Tror du att din användning bidrar mycket till din totala energiförbrukning?

- Ja
- Nej

Varför/Varför inte?

Gör du något för att påverka energiförbrukningen som apparaten ger upphov till?

- Ja
- Nej

Om ja, vad gör du?

Går apparaten att använda på ett energisnålt sätt?

Varför tycker du det?

APPARATER DU INTE ANVÄNDER

Märk ut en apparat som du egentligen inte använder och skulle kunna vara utan.

Ta ett foto på apparaten tillsammans med den röda markören.

Hur kom den i din ägo?

- Köpte själv
- Ärvt
- Gåva
- Tillhör lägenheten
- Annat:

Varför använder du den inte?

Använder du någon annan produkt istället för apparaten?

- Ja
- Nej

Berätta varför

Finns det någon anledning till att du har kvar apparaten?

- Den fungerar fortfarande
- Jag använder den någon någon ibland
- Jag har det som backup
- Jag tror jag kommer få användning av den i framtiden
- Jag planerar att ge bort den snart
- Det krävs en ansträngning om jag ska göra mig av med den
- Jag vet inte var jag kan slänga den/lämna in den
- Annat

APPARATER SOM ÄR SVÅRA ATT ANVÄNDA ENERGISNÅLT

Märk ut en apparat som du anser är svår att använda på ett energisnålt sätt

Ta ett foto på apparaten tillsammans med den grå markören

Varför är det så svårt att använda apparaten på ett energisnålt sätt?

Hur påverkar det din användning av apparaten och de aktiviteter du använder apparaten till?

AVSLUT

Har du några kommentarer som du vill lyfta fram utöver det vi har pratat om?

APPENDIX III: QUESTIONNAIRE

A questionnaire was used to verify which of the identified barriers were the most common amongst people. In total 32 people responded to the questionnaire. The structure that was used is presented in this appendix.

1. Ålder:

2. Kön:

○ Kvinna ○ Man

3. Sysselsättning:

- ○ Arbetar som anställd
- ○ Egen företagare
- ○ Studerande
- ○ Pensionär
- ○ Långtidssjukskriven
- ○ Tjänsledig eller föräldraledig
- ○ Arbetssökande
- ○ Annat: _____

4. Boarea (kvm):

5. Hur betalar du för din el idag:

- ○ Pappersfaktura
- ○ E-faktura
- ○ Ingår i hyran
- ○ Annat: _____

Hur väl stämmer anledningarna in på varför du inte sparar mer el i ditt hushåll:

1 = Stämmer inte alls

6 = Stämmer helt

6. Jag tror inte att jag kan göra mer än jag gör

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6

7. Jag vet inte vad jag kan göra för att spara mer energi

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6

8. Jag kan inte göra allt och jag vet inte vad jag ska prioritera

1 2 3 4 5 6

9. Jag tycker det är för omständigt

1 2 3 4 5 6

10. Jag vill inte skära ner på bekvämligheter för att spara energi

1 2 3 4 5 6

11. Jag har svårt att se konsekvenserna av att jag sparar mer

1 2 3 4 5 6

12. Jag är så liten del av hela världens energikonsumtion så jag tror inte jag kan göra så stor skillnad

1 2 3 4 5 6

13. Priset på elen är en så liten del av vad jag betalar för hushållet så det känns inte värt att försöka spara

1 2 3 4 5 6

14. Elen är inkluderad i hyran så jag skulle inte få ut något av att spara energi

1 2 3 4 5 6

15. Jag bryr mig inte

1 2 3 4 5 6

16. Jag är inte intresserad av att spara energi

○ ○ ○ ○ ○ ○
1 2 3 4 5 6

17. Jag har inte reflekterat över att jag borde spara energi

○ ○ ○ ○ ○ ○
1 2 3 4 5 6

18. Jag tror att elektriciteten är så liten del av min totala energiförbrukning (jämfört med vatten och uppvärmning) så jag tror inte jag kan påverka den så mycket

○ ○ ○ ○ ○ ○
1 2 3 4 5 6

19. Jag har investerat i nya produkter och litar på att de är energisnåla

○ ○ ○ ○ ○ ○
1 2 3 4 5 6

20. Det känns för överväldigande att minska min energikonsumtion att jag inte vet var jag ska starta

○ ○ ○ ○ ○ ○
1 2 3 4 5 6

21. Andra anledningar:

APPENDIX IV: RESULT OF THE INTERVIEW

The wide scope of the interviews mean that not all results were relevant to the project. This appendix presents the results that were used in the project.

GENERAL

-29

SALARY

-240,000 SEK — 69.2%

240-360,000 SEK — 23.1%

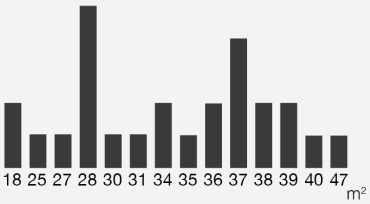
360-480,000 SEK — 7.7%

EDUCATION

76.9% University
19.2% Upper secondary school
3.8% Post-secondary education

DWELLING

SIZE



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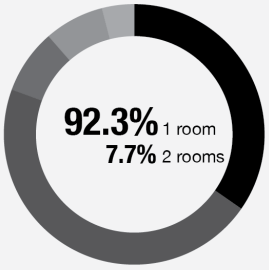
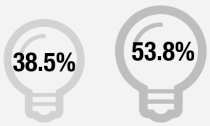


34.6% Condominium
46.2% 1st hand tenancy
7.7% 2nd hand condominium
7.7% 2nd hand tenancy
3.8% Student apartment

ENERGY

AWARENESS



7.7% not at all
38.5% somewhat
53.8% fairly
0.0% very

CONSUMPTION

Estimated average yearly energy consumption

50.0% Don't know
34.6% 0-5000 kwh
3.8% 5001-7500 kwh
7.7% 7501-10000 kwh
3.8% 12501-15000 kwh

PRODUCTS THAT CONTRIBUTE MOST

Stationary computer

"It has a big screen, it just feels like it takes a lot of power to cool it down, it becomes very hot"

"I always use it when I'm home"

Fridge and freezer

"It's always on"

TV

"I have it turned on a lot, I turn off and on but I also keep it on for long periods of time"

"It's big and needs cooling"

Laptop

"I always have the charget plugged in"

"I use it a lot, I also use it as a stereo"

AVERAGE

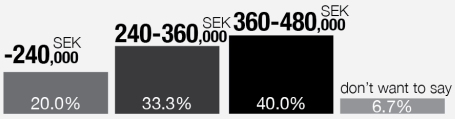
25

Products per household

GENERAL

30-49

SALARY

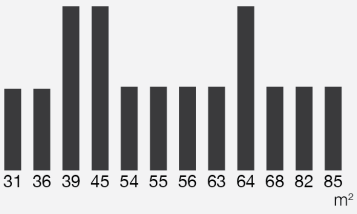


EDUCATION

86.7% University
6.7% Upper secondary school
6.7% Post-secondary education

DWELLING

SIZE



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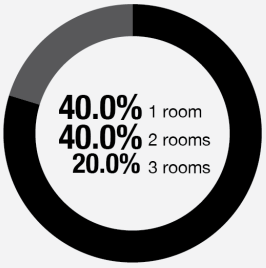
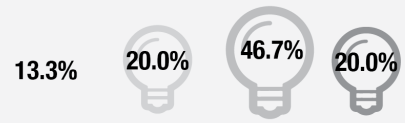


80.0% Condominium
20.0% 1st hand tenancy

ENERGY

AWARENESS



CONSUMPTION

Estimated average yearly energy consumption

55.6% Don't know
38.9% 0-5000 kwh
5.6% 5001-7500 kwh

PRODUCTS THAT CONTRIBUTE MOST

Fridge and freezer	TV	Washing machine	Laptop
			
"It's always on"	*"I don't turn it off, it's always plugged in"*	*"I wash several times a week"*	*"I use it a lot"*
"Uses a lot of power"	*"It's often on, even in the background"*	*"It has high power"*	*"It's a bit bigger so it probably uses a lot of power"*

AVERAGE

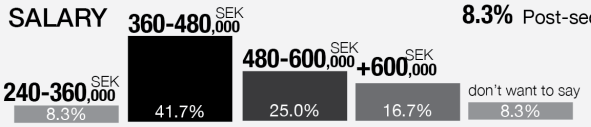
31

Products per household

GENERAL

50-64

SALARY

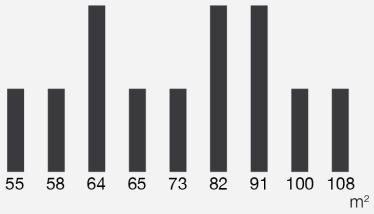


EDUCATION

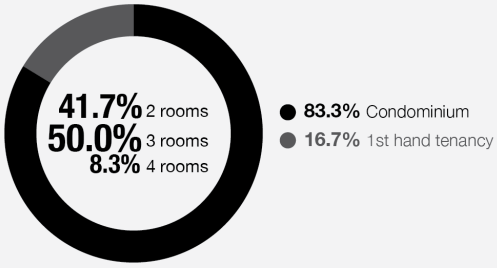
83.3% University
8.3% Upper secondary school
8.3% Post-secondary education

DWELLING

SIZE

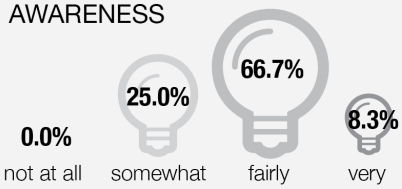


TYPE



ENERGY

AWARENESS



CONSUMPTION

Estimated average yearly energy consumption

25.0% Don't know

75.0% 0-5000 kwh

PRODUCTS THAT CONTRIBUTE MOST

Fridge and freezer

"It's always on"

TV

"It's on every evening from 6 pm"

"I use it most of my entertainment products"

Washing machine

"I wash almost every day, with small loads and high temperatures"

Ceiling lamp

"Lightbulbs that are on alot, but I stick to 40 W to save energy "

"I have the spotlights in the kitchen on almost all the time"

AVERAGE

38

Products per household

GENERAL

65+

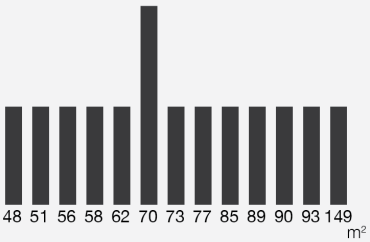
SALARY

EDUCATION

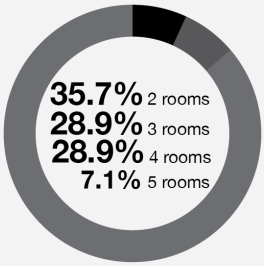
76.9% University
15.4% Upper secondary school
7.7% Post-secondary education

DWELLING

SIZE



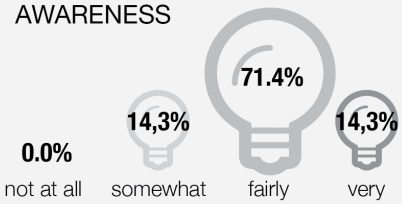
TYPE



- **7.1%** 2nd hand condominium
- **7.1%** 1st hand tenancy
- **85.7%** Condominium

ENERGY

AWARENESS



CONSUMPTION

Estimated average yearly energy consumption

16.7% Don't know
61.1% 0-5000 kwh
11.1% 5001-7500 kWh
5.6% 7501-10000 kWh
5.6% Other

PRODUCTS THAT CONTRIBUTE MOST

Fridge and freezer

"I'm bad at defrosting the freezer"

"I open the door a lot"

TV

"I use the whole package, with box and sound system"

"I don't know how much it consumes but I have it turned on every evening"

Microwave oven

"Heats quickly"

"I use it every day"

Stove and oven

"I cook more now that I don't work"

"It feels like it uses a lot of power, I mean it has to warm up and then it's on for a long time"

AVERAGE

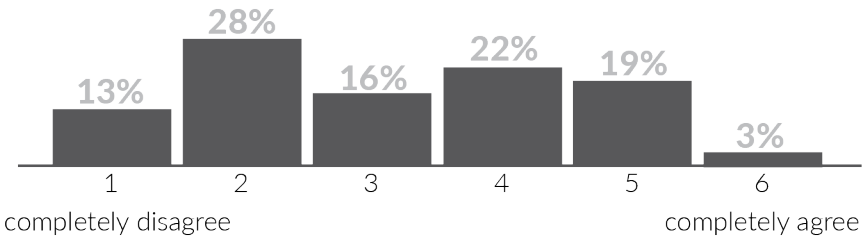
33

Products per household

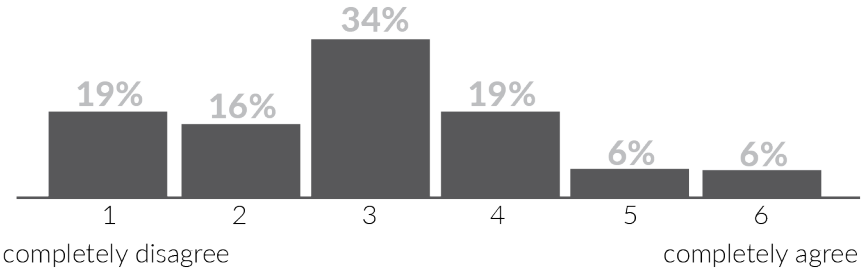
APPENDIX V: RESULT OF THE QUESTIONNAIRE

This appendix shows the results of the questionnaire.

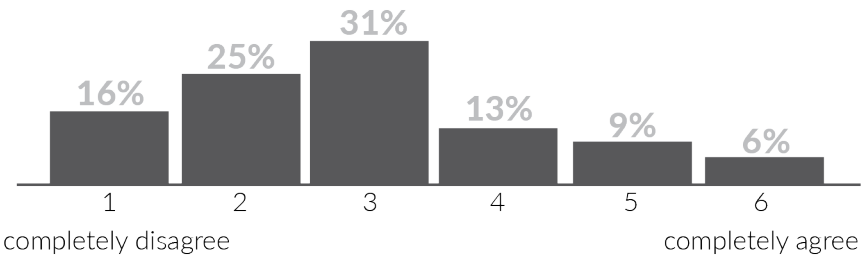
Believe one is already doing everything possible



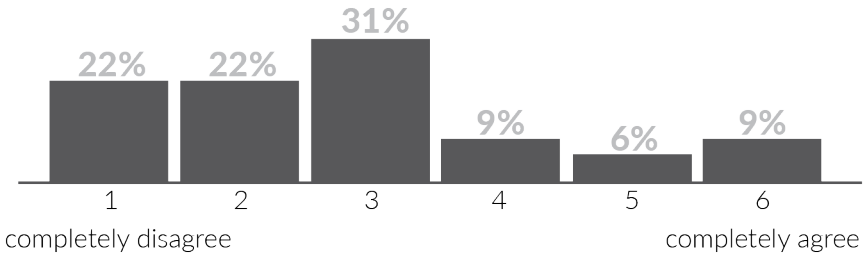
Don’t know what the right action is



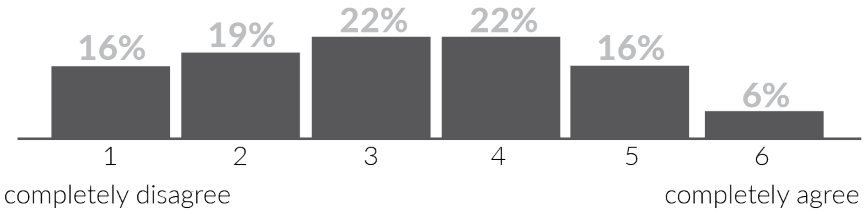
Can’t do all don’t know what to prioritize



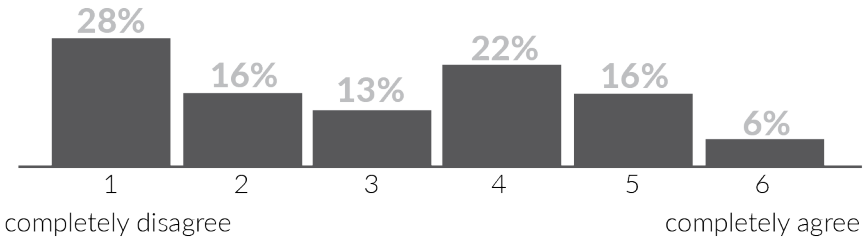
Too much effort



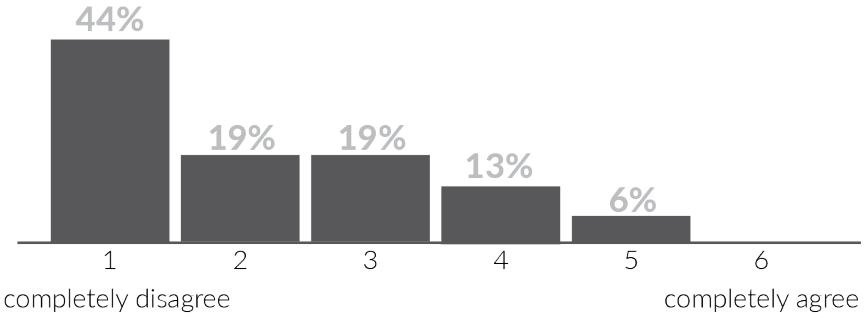
Don’t want to change comfortable lifestyle



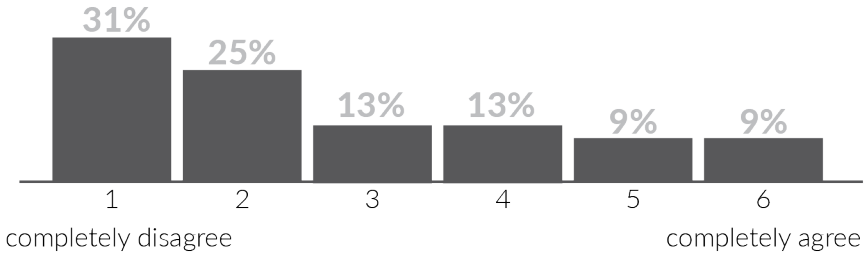
No visible result, no commitment

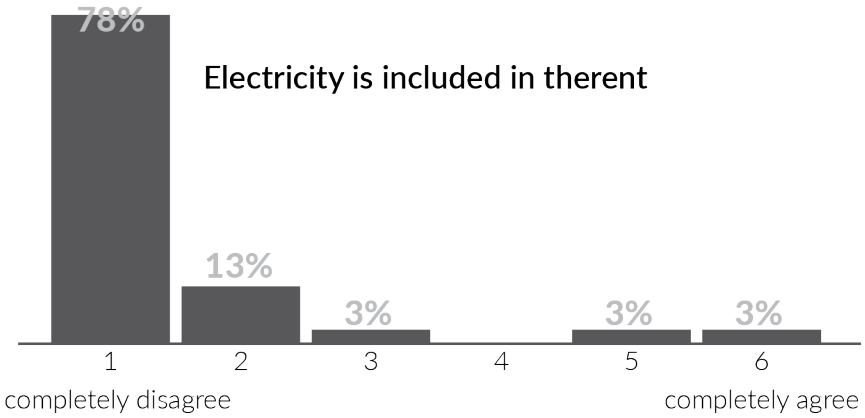


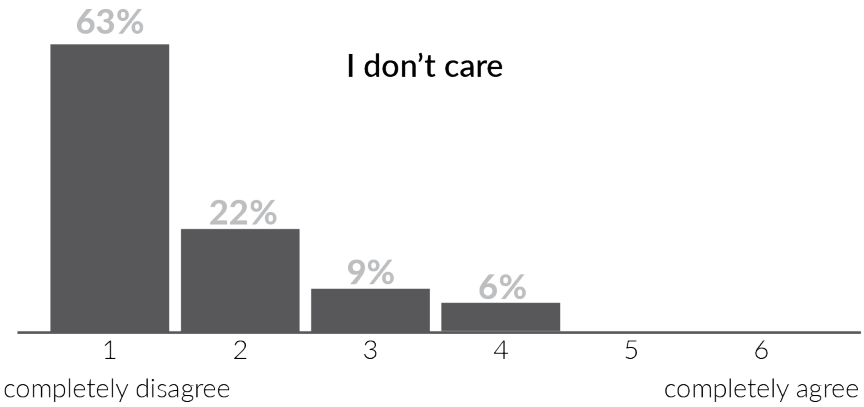
I'm such a small part of the whole, it doesn't matter if I save

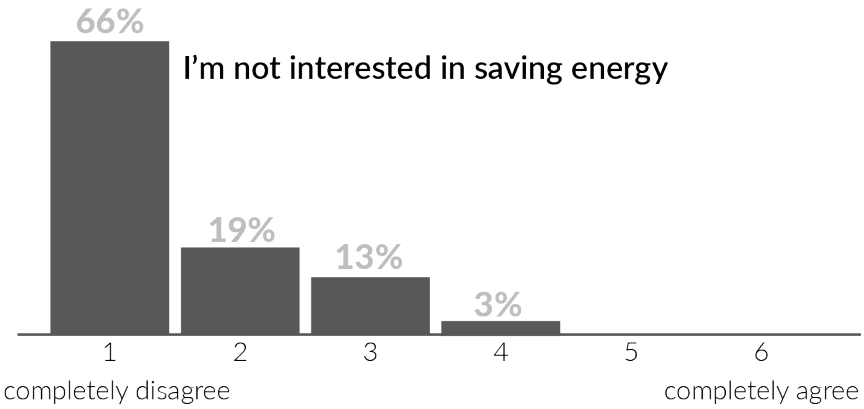


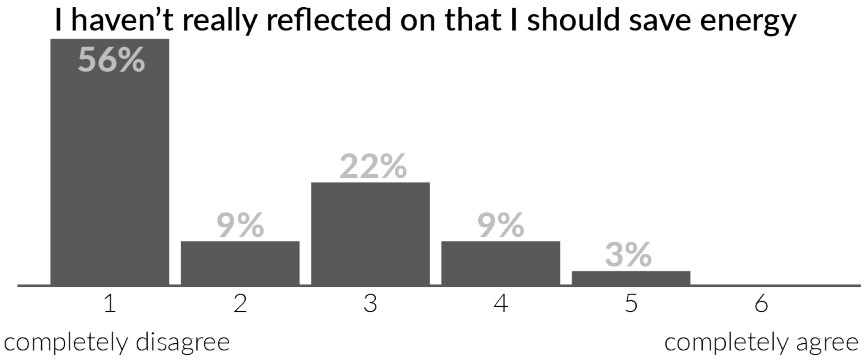
The price of electricity is very low, so I don't feel like I earn anything



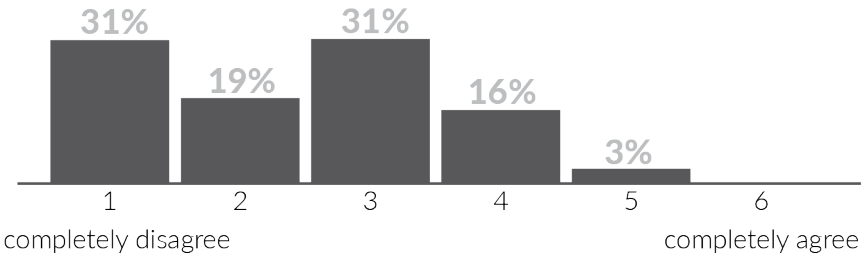



63%
I don't care
22%
9%
6%
1
2
3
4
5
6
completely disagree
completely agree

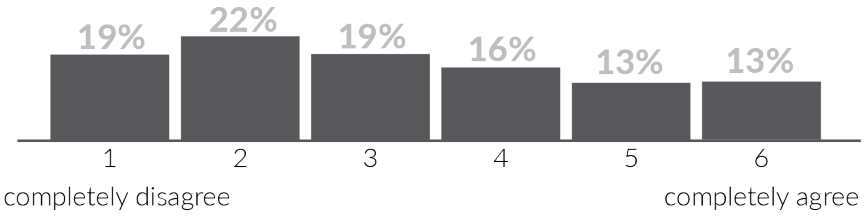

66%
I'm not interested in saving energy
19%
13%
3%
1
2
3
4
5
6
completely disagree
completely agree


I haven't really reflected on that I should save energy
56%
9%
22%
9%
3%
1
2
3
4
5
6
completely disagree
completely agree

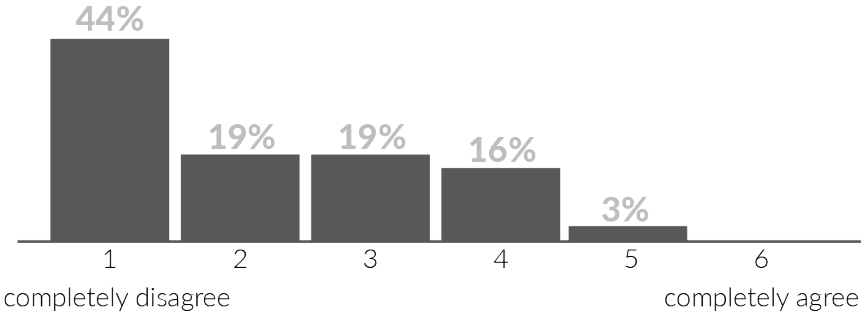
Electricity is such a small part of my total energy consumption



I have bought new appliances and I trust that they are energy efficient



It's so overwhelming, I don't know where to start



APPENDIX VI: SYSTEMS INCLUDED IN BENCHMARKING

This appendix lists all the products that were included in the benchmarking.

Company/designer	Product	Eco-feedback	Home automation
e.ON	100kolI	X	X
Exibea	Eliq	X	
Fibaro	Home Center 2		X
Fibaro	Home Center Lite	X	X
Fibaro	Wall Plug	X	X
Vattenfall	EnergyWatch	X	
Fortum	Mina Sidor	X	
Fortum	Energy Display	X	
Greenely	Greenely	X	
Öresundskraft	Kraft-O-Meter	X	
Smappee	Smappee	X	
Watty	Watty	X	
Eaton Cooper	xComfort		X
Telldus	TellStick		X
Nexa	Self-learning remote switch		X
Ambient	Energy Joule	X	
Ambient	Energy Orb	X	
Ambient	Energy Dash	X	
Energeno	Wattson Classic	X	
Energeno	Wattson Anywhere	X	
P3 International	Kill A Watt	X	
P3 International	Save A Watt		X
P3 International	Save A Watt Edge		X
P3 International	Save A Watt Phantom	X	
Lucid	Building Dashboard	X	
Eco button	Eco button	X	
Beverly Ng	Spark Lamp	X	
Gilles Belley	Nootan	X	
Gilles Belley	Power Peg		X
Gilles Belley	Energy Saving Adaptor	X	X
Gilles Belley	Semaphore	X	
Swedish ICT Interactive	Power Awareness Cord	X	

APPENDIX VII: SWOT-ANALYSES

SWOT analysis was used as a tool to evaluate different concepts during the ideation phase. The analysis of the four concepts “Move away, move in”, “Main switch”, “This compared to that” and “Goal-setting” is shown in this appendix.

MAIN SWITCH

S

Simple way to enlighten about own energy consumption

Easy to use

Usage will lead direct savings

Easy to adopt

Draws attention to standby

Time efficient

W

Only solves one part of the total consumption

Doesn't educate about energy savings

Might ignore it after a while

O

Easily implemented

Uses current technology

Can lead to new (building) standard

Introduction to smart homes

Works even if user doesn't pay for electricity

T

When don't want to turn off all, will not use it?

THIS COMPARED TO THAT

S

Possibility to change all actions

Focused

Timing - ask for what you want when you want it

W

Can be hard to translate the information into an action

Hard to make people use for a longer time

Hard to motivate people to use it, requires an interest

O

No other similar solutions

Educate users about the subject

Works even if user doesn't pay for electricity

T

Hard to individualize
But possible with smart homes

Hard to decide which numbers to base comparions on

Might be hard to find partner

GOAL-SETTING

S

Motivating and encouraging

Positive approach

Focused on only 5 products - sufficient challenge

Guides a lot (when comes to energy savings)

Comparison between appliances

Comparison with goal

W

Might feel a lot of pressure

Hard to make people use for a longer time

Only focused on 5 products at a time - reduced impact

May be the same 5 products all the time

O

Connects to theory about energy conservation

Works even if user doesn't pay for electricity

T

Technology - hard to keep track of users actions

Technology - uncertainties regarding breakdown

MOVE AWAY, MOVE IN

S

Hepls with many problems with moving

Another way in to energy savings

Motivating to use because it supports user to move away

Guides a lot

Comparison with recommendation

W

Hard to make people do daily actions to save energy

Hard to make people use for a longer time

Not focused on one thing

Hard to get timing of notifications good

O

No other similar solutions

Works even if user doen't pay for electricity

Many possible partners

Partner with EU: set goal level (recommended consumption)

T

Might not get all partners, creates less value for customer

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