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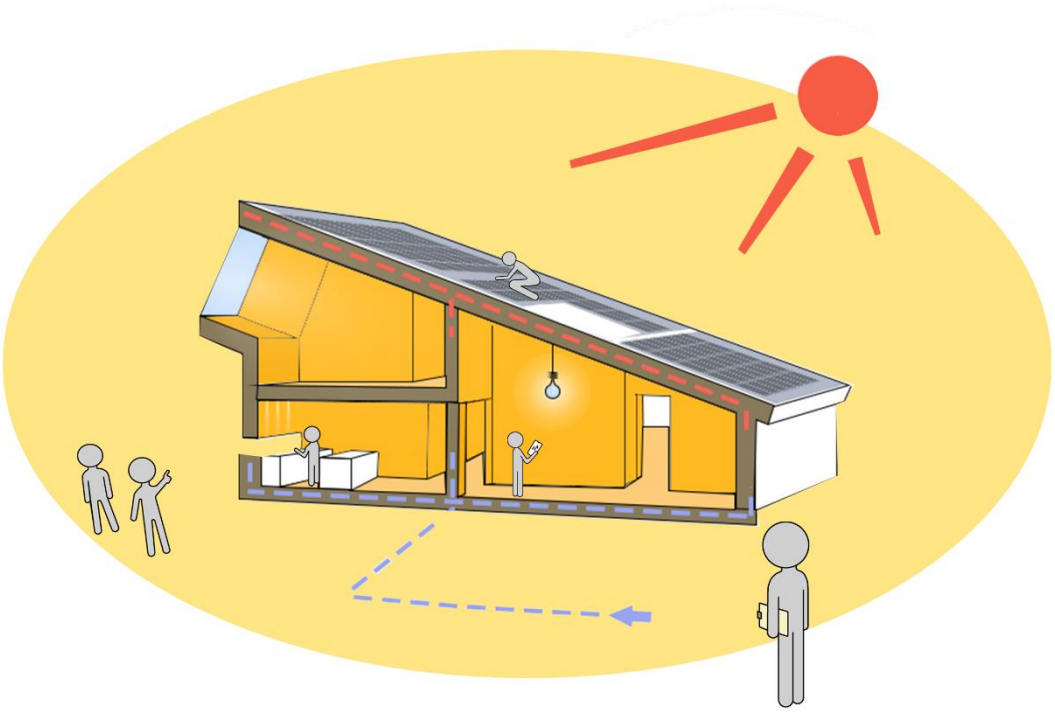

Reimagining Everyday Life with Residential Solar Panels

Master's thesis in Industrial Design Engineering

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2022
www.chalmers.se

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Cover illustration: Combination of scenarios about living with solar panels with all the stakeholders
Illustration made by Jinhong Guo and Yodit Kinfe

Chalmers digitaltryck
Göteborg, Sweden 2022

Abstract

Solar panels for residential usage have been increasingly widespread in recent years with a continuing growth. Even though this renewable energy source is environmentally sustainable, it is of great importance that solar panels follow a socially sustainable path as well. The project Sun for All from RISE examined the female experience of the purchase process of solar panels. In parallel to Sun for all, this thesis is conducted, however, with an emphasis on the post-purchase process and consideration of a larger variety of users. By taking a norm-creative approach, the aim is to examine how solar panels influence everyday life and how that can be challenged.

As a complement to the previous research in the area of solar panels, norm-creativity as well as domestication theory, data collection was collected from studying users and other stakeholders. With the help of the findings, the current situation of living with residential solar panels was better understood and the scaffold for the norm-creative approach to be applied in the conceptual design solution could be found. The succeeding iterative ideation-phase was extensive, with a broad variation of both physical and digital ideas, which finally settled on a booking system concept. After iterating from a user test, the final concept was presented as a solar panel booking system implemented for households in apartment buildings. This concept challenged the current lifestyle with solar panels by reversing several norms, especially in relation to the energy production monitoring behavior. With the norm-creative approach, an alternative way of living with solar panels was presented, with diverse potential to further develop on.

Keywords: solar panels, solar energy, domestication theory, social sustainability, norm-creative

Acknowledgments

This is a Chalmers master's thesis at the Department of Industrial and Material Science under the program Industrial Design Engineering. We would like to show our appreciation to the people who supported us and this thesis.

Firstly, we would love to thank Sara Renström and László Sall Vesselényi for offering us the opportunity to work on this intriguing project. You guided us into a fascinating mindset with this research project and we appreciate the passion, care and wisdom you shared with us.

We would also like to thank Helena Strömberg for being with us along the whole process and giving us valuable feedback.

Thank you to everyone in the neospace-office at RISE for offering us a great environment to work in.

Lastly, we would like to thank all the participants for taking time to share their experiences with us.

Gothenburg, June 2022

Jinhong Guo and Yodit Kinfe

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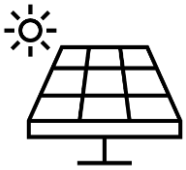


1. INTRODUCTION

This chapter presents the origin of the project, its purpose and what it sets out to answer.

As a renewable energy source, solar panels– a solid-state semiconductor device that converts light energy into electrical energy, have the potential to take a big portion of energy production in Sweden in the future. Over the years, Sweden has seen a continuous increase in solar panels. The Solar Energy Association of Sweden estimated that 30 000 solar systems were installed last year, the total being around 100 000 systems (Dammberg, 2022). However, Solar energy could only take 1 percent of Sweden's energy production in 2021. While hydropower is the leading source at 43%, followed by nuclear power (31%), wind power (16%), and conventional thermal power (9%) (SCB, 2022).

Although installing solar panels is sustainable from an ecological aspect, it is of high importance to address their social sustainability, which often tends to be forgotten. One solution is therefore to take a norm-creative approach. This offers a lens through which it is possible to reveal social norms that can be the cause of exclusion or discouragement toward potential solar panel installers. Although extensive research has been done on different aspects surrounding solar panels, attention has not been given to applying a norm-creative approach. Thus it would be of great meaning to conduct research and bring insight into the relationship between norms and everyday life with solar panels.

1.1 Background

This master thesis is in collaboration with Research Institutes of Sweden (RISE), where the research project *Sun for All* is conducted. The research project mainly focuses on the earlier stages of the customer journey of solar panels from a female perspective, with the goal to get insights and make the solar panel industry in Sweden more inclusive. Since the majority of current solar panel customers are men, which can point to social norms that exclude the importance of female customers.

However, there is still a gap in the knowledge of the post-purchasing experience, meaning after installing the panels, and its adaptation to an even bigger variety of users. The thesis will therefore continue conducting research into everyday life with solar panels, in parallel with Sun for all. Although, the focus is on exploring how more users can be included in everyday life with solar panels after installation.

1.2 Aim & scope

By following a human-centered design process, the intention of this thesis is to understand the relationship and interaction between stakeholders and solar panels. With a particular emphasis on the Swedish market. Although the full user/customer journey will be taken into consideration, an emphasis will be placed on the post-purchasing phase of the journey. Further, by following a norm-creative approach, the intention is to distinguish ways in which current everyday life with solar panels can exclude users and how that can be counteracted. Based on the findings obtained, a design solution will be developed with the goal of including a wider variety of solar panel users by considering sustainability and norm creativity.

In a bigger perspective, the goal is to encourage and engage in discourse and reflection around societal norms, energy consumption, and sustainability.

1.3 Research Questions

The thesis aims to address the following research questions:

- In what way do solar panels influence the users' lifestyle?
- What is the most prominent interaction between solar panels and users in the post-purchase process?
- How can norm creativity be applied into a life with solar panels?

2.

RELATED WORK

This chapter covers previous research with importance to the project. The subject of solar panels and norm-criticism will be explained further. Additionally, an introduction to domestication theory will be given, which covers how technological solutions are integrated into everyday life.

2.1 Solar panels

Photovoltaics (PV) refers to the conversion of sunlight into electrical energy and describes the process occurring in solar cells. By connecting many solar cells together, bigger components called solar modules are created. These can be used for bigger plants such as open-air plants (e.g. solar parks) or installed on pitched roofs of households (Mertens & Hanser, 2014). Solar panels is another term used to describe a group of solar cells that are connected (The Swedish Energy Agency, 2018b).

2.1.1 Grid-connected system

Residential solar panels are commonly part of systems that are connected to the public electrical grid (figure 1). For grid-connected systems, the electrical current created by the solar modules is first converted from direct current to alternating current by an inverter. It can thereafter be fed to the public electrical grid or be used for domestic purposes. For the electricity that is fed to the grid, payment can be collected through a feed in tariff, which is commonly how the system is refinanced. Or the electricity can be bought from the grid. To measure the generated solar energy as well as the energy that is fed or taken from the grid, the system also includes meters. Although there are several different units to measure energy, kilowatt hours (kWh) are often used for electrical energy. The energy production of the system can therefore be visualized by presenting the amount of kWh generated as well as charts showing the production over time (Mertens & Hanser, 2014).

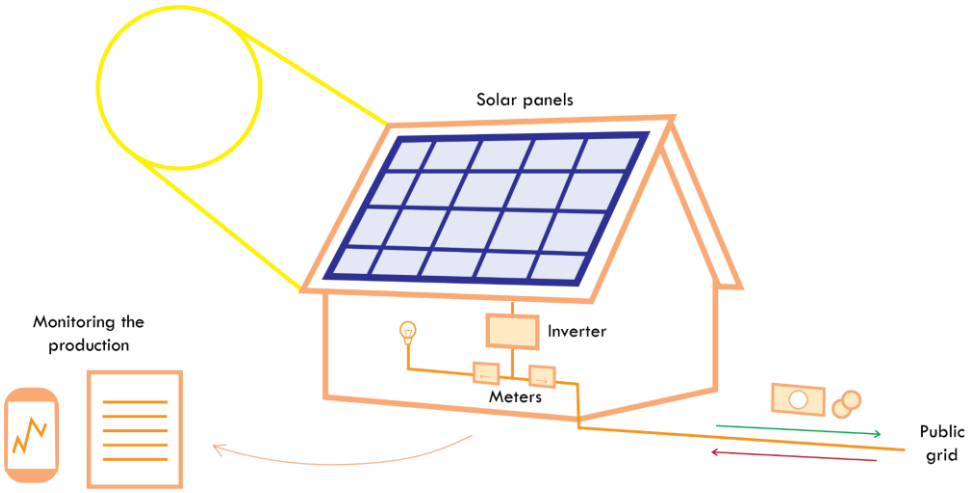


Figure 1. Grid-connected solar panel system

An optional addition for a grid-connected system is to install batteries to store the excess solar energy. Batteries can lead to the system being less affected by power outages and raised energy rates, although it can be expensive to install (The office of Energy Efficiency & Renewable Energy, 2021).

2.1.2 Factors influencing the production

The most common types of solar panels are monocrystalline and polycrystalline solar panels, which are both based on silicon. These have a black respectively blue color and an efficiency around 20 % (The Swedish Energy Agency, 2019). Apart from the efficiency, there are other factors that can affect the amount of energy the solar system

generates. For example: the angle, direction and amount of shade the panels are exposed to (The Swedish Energy Agency, 2018a).

The climate, such as the weather and temperature, also has an effect on the amount of energy the solar panel system can produce. The functionality of systems installed in Nordic climates may therefore be questioned. According to Benjaminsen (2018), a Norwegian research project examined how weather affects solar cells, with findings that speaks in favor for installing panels in Nordic climates. Firstly, the voltage increases in colder temperatures, which benefits the solar cells' output. Additionally, solar radiation can be high during winter and the snow can function as a reflector. However, if the panels are covered by snow, it can cast a shadow which decreases the production. Lindh et al (2020) presented a couple recommendations for solar panels installed in Nordic climates. The main advice was to choose locations where the solar radiation is high but with low snow accumulation. This included for example to inspect the area beforehand and in certain cases to clean the panels from snow.

2.2 Life with solar panels

With the aim of understanding the everyday life of the solar panel lifestyle and sorting out the interrelation between the post-purchasing phase and purchase phase, a customer/user journey map was completed as a result of the literature research (figure 2). The map covers both the journey of customers and users, a distinction that will be explained in the stakeholder analysis (chapter 3.1), but for simplicity it will here on now be referred to as a customer journey map.

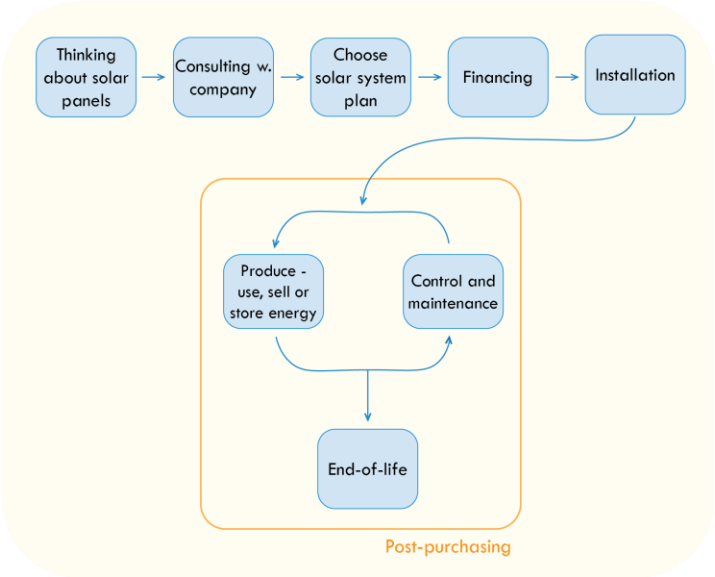


Figure 2. Customer/user journey map

To understand the interaction of information flow, literature related to living with solar panels are introduced here in two parts: the purchase phase and the post-purchasing phase.

The purchase phase leads from thinking about solar panels to installation. The post-purchase phase consists of three elements: produce, control and maintenance as well as end-of-life. Here, the produce and the control and maintenance elements interact in a

loop throughout the life of the solar panel. The final stage for the solar panel is its end-of-life.

2.2.1 Purchase phase

There are characteristics found that many solar panel users have in common. Fundamentally, typical PV adopters tend to be more open to new technologies, which can be seen by them being described as "early adopters" (Wolske, 2020) or as innovative people (Lundheim et al., 2021). They are also often motivated by environmental concerns or economic incentives (Winther et al., 2018, Palm, 2017).

As for the motivative intention, an interesting change in Swedish family PV adopters' environmental motivation was discovered by Palm (2017), who performed a study comparing early PV adopters with later adopters. In the study it was found in 2008-2009, adopters enjoyed producing their own energy with a macro perspective of contributing to the environment, which was a bigger part of their lifestyle. While in 2014-2016, adopters showed more interest in other parts of their life such as solar panels being a benefit to them having electrical vehicles or the ability to become independent from electrical companies. On the other side, there are barriers and uncertainties that require potential adopters to consider. Firstly, a common concern is financial risk. Even though customers in Sweden became less stressed over time since they could earn money from selling electricity back to companies, the financial return requires a long time period to break even. It was also found that when consulting to companies about the process of installation, many adopters were forced to conquer administrative issues, such as lack of information, which further led to the difficulty in deciding between companies (Palm, 2017).

The perceived difficulty when performing such a high-cost operation is very important when it comes to the influence of the installation intention. Being skeptical toward innovation could therefore work against people's intention of being adopters (Lundheim et al., 2021). At the same time, the intention of installation can be positively affected by the peer effect, encouraging more people to become PV adopters and install solar panels. When looking at Sweden, the existing or close social networks appear to be effective for the distribution of installed solar panels all over Sweden (Palm, 2017).

2.2.2 Post-purchasing phase

When it comes to the post-purchase phase, additional people are involved in life with solar panels. Apart from the customers there can be users who live with the customers but also users who moved into houses with solar panels already installed, without them being active customers previously (Winther et al., 2018). In this phase, the behavior of utilizing, controlling, and maintaining the system interact with each other in a loop.

While utilizing a solar energy system, users are able to interact– to control and receive feedback from various resources such as phone applications, websites, and displays. Winther et al. (2018) found that the level of interest in interaction with their PV system depends on their motives for acquiring them. One possible electricity usage habit is the users consuming electricity with awareness and trying to maximize the efficiency of utilizing solar energy. In this situation, users either consume more energy on days when the system produces more (Qui et al., 2019), or they move the electricity usage to

periods when the panels are producing electricity (Hansen & Hague, 2017). Additionally, co-adoption, where electricity demanding products are acquired following the installation of solar panels, could be the reason for increased electricity consumption (Beppler et al., 2021).

In a study by Hansen & Hague (2017), the participants got to live in a neighborhood where the houses had solar panels. It was found that the residents' increased energy consumption could be due to comfort. However, another unique reason was resentment towards energy companies. Due to the setup of the study, the excess energy that the households did not use was given for free to the energy company. This caused residents to feel resentment and a feeling of wanting to consume more electricity because of that reason.

Hondo and Baba (2010) found that households with increased awareness of the PV system, which was referred to as households being engaged in 'PV-checking behavior', had an increased environmental behavior in their everyday life.

Another aspect of the post-purchasing phase that can be taken into consideration is the end-of-life part. Normally, the life expectancy of PV panels is around 25 years (Chowdhury, 2019). This can mean that a customer is not likely to interact with the solar panel until its end of life. Another implication of the lifespan of solar panels is the increased awareness of handling the waste that will be necessary in the future. The PV waste, which will only increase, can be harmful, especially for vulnerable regions (Chowdhury, 2019, Daniela-Abigail., 2021). This is essential to consider when it comes to ethical concerns.

2.3 Norm-critical and norm-creative approach

Social norms facilitate determining which actions to take or avoid in life and are essential in social relationships (Gross & Vostroknutov, 2022). By taking the norm-critical and -creative approach, norms created by the stakeholders of the solar panel industry and other people in the society are to be discovered. Since everything is affected by norms, it is no exception that life with solar panels also enables or is influenced by certain norms.

Although norms have an important function, they can also lead to issues of exclusion and discrimination. In the area of design, social norms can be communicated in various ways. For example, a building without wheelchair access determines who is able to access an environment and the appearance of a product can be used to communicate which gender is expected to use it (Nilsson & Jahnke, 2018). To address social norms in design, approaches such as inclusive design and critical design can be used. The disadvantage of these approaches is that their focus on one area may neglect other perspectives from being addressed (Orling et al, 2018).

One option is therefore to approach design through the lens of norm-creative innovation, which consists of being norm-critical followed by being norm-creative. The idea of norm-criticism is to consider how social norms can exclude people based on physical and social factors. Meanwhile, norm-creativity aims at addressing and counteracting these norms through design solutions (Nilsson & Jahnke, 2018).

The norm-critical and -creative approach does not have a set of methods or a clear framework that is followed. However, to support norm-creative innovation, Alves et al. (2016) has developed NOVA, which is a collection of tools that can be used. NOVA contains 54 cards that are divided into four different types of tools. Among the tools, there are examples of previous norm-creative innovations that have been developed. The tools also include 12 tactics that can assist norm-creative innovation (Alves et al., 2016).

Having a norm-creative approach in the context of solar panels is still an unexplored territory. Previous research of norms connected to solar panels tends to examine social norms related to peer-effect for example, without focusing on counteracting the norms. Norm-creative design solutions for solar panels are therefore lacking. There is however a case study conducted by Ehrnberger et al. (2016) that challenges norms in relation to household energy systems. The result is the Energy AWARE Clock, which is an electricity meter that visualizes the daily electricity consumption with an appearance similar to a wall clock.

2.4 Domestication theory

The concept of domestication examines the place technology has within the complexity of everyday life, which has been studied in both the field of media and communication and sociology of technology. The process of domestication can be observed when users face new technologies that need to be "integrated" into their life and the environment, which usually is the household. This process is often incomplete since the technology and users have a continuous influence on each other (Berker et al, 2005).

In this project, domestication theory can help with understanding and analyzing the process of integrating solar panels as a technological product. It can therefore provide an additional perspective to the customer journey map created. Domestication theory has also previously been used in connection to solar panels (Winter et al., 2018). Thus it speaks in favor of the theory being included in this project.

Previous research within domestication can also be found to cover areas with connection to social norms, which is of no surprise considering that the household, much like the rest of the society, is influenced by social norms. Domestication theory has, for example, been researched in relation to social exclusion and digital divide (Haddon, 2007). Additionally, technology being gendered following gendering relations in households as well as the marketing of it have also been studied (Silverstone et al., 1992). Domestication theory can therefore complement the norm-critical approach being taken.

Silverstone et al. (1992) developed a framework to describe the relationship between household, outside world and (communication and information) technology. The household is described as a moral economy, where it is connected to the economy of exchanging goods but also the exchange of meaning. Within the moral economy of the household, there are four different elements: appropriation, objectification, incorporation and conversation. Appropriation takes place when the technology is sold and the individual/household takes ownership over it. Objectification regards the

display of the technology, which covers the physical attributes/characteristics of the object and the environment created for it to be displayed. Incorporation emphasizes the usage of the technology and how it can be incorporated into everyday routines. Conversion regards what the technology, that has been defined and claimed by the household in a certain way, communicates to the outside world.

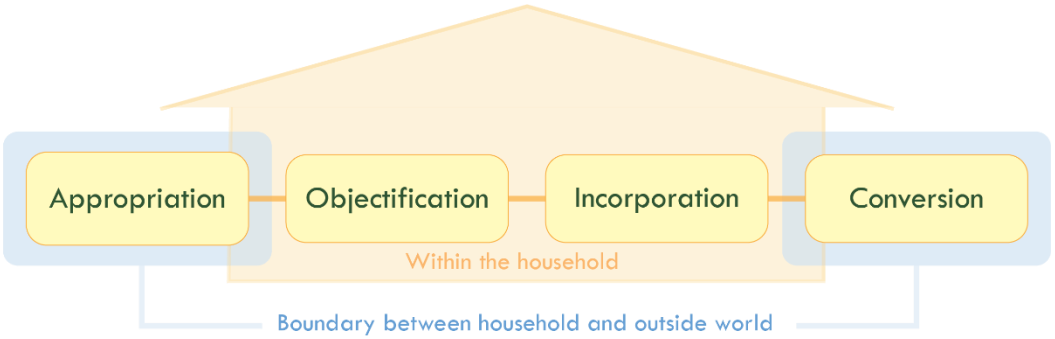


Figure 3. Four elements describing a process within domestication theory

The domestication theory can be connected to the customer journey map. The purchase phase includes the phases that lead up to appropriation, meaning until the panel is sold. During the installation, the panels are attached to the roof e.g. and other parts of the system are connected which concerns objectification, how the technology is displayed. After installation, the customer enters the post-purchase phase. Here the household members incorporate the technology into their everyday life, which includes the monitoring behavior for example. During the post-purchase phase, there is also conversion occurring, where the household communicates certain messages to their surroundings based on how they live with the solar panels.

3.

METHODOLOGY

This chapter presents the methods used for the project.

The starting point for the methodology will be the four steps of the human-centred design (HCD) process (figure 4).

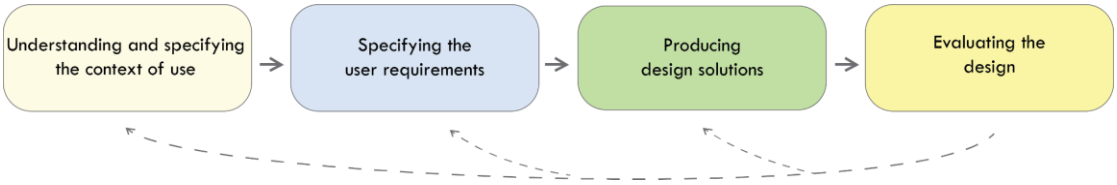


Figure 4. The human-centred design framework

The human-centred design for interactive systems applies knowledge from human factors and usability. By being centered around the human, rather than just the user, the aim of HCD is to consider the impact on other stakeholders as well. The framework is an iterative process consisting of four steps (Swedish Standards Institute [SIS], 2019).

Each step has suggestions on activities that are included, which will be complemented with knowledge of methods that have been used previously and that can aid the goal of the particular step. Although the HCD process provides a framework to take inspiration from, it can also contradict norm-critical approaches. For example, the HCD process encourages following guidelines when developing the design solutions. However, a norm-creative approach may question or go against current guidelines. Therefore, the activities in each step are also adapted to provide necessary freedom to follow a norm-critical and -creative approach. The timeline of the methods can be seen in the figure below. Since some of the methods include collecting user data, GDPR is followed to ensure an ethical handling of the data.

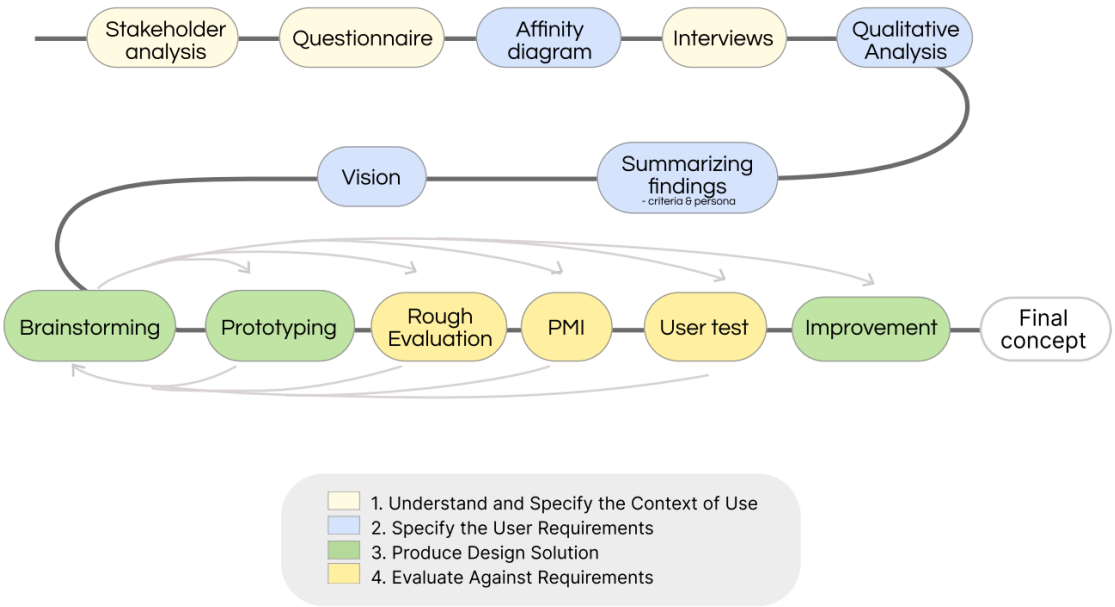


Figure 5. timeline of the process

3.1 Stakeholder analysis

To understand the situation in an exhaustive way, the people and actors who have an influence on everyday life with solar panels were mapped out with the help of the previously presented customer journey map (see chapter 2). Identifying the phases in the customer journey map facilitated finding stakeholders that were involved in these phases. However, it also helped showcasing uncertainties regarding the role of certain stakeholders, which needed to be addressed in the following questionnaire.

3.2 Questionnaire

With sufficient literature and a comprehensive view of the process of owning solar panels, a decision was made to reach out to solar panel owners to gain an overview of their everyday life by putting out a questionnaire online (appendix 1). The aim of the survey was to explore more aspects of solar panel owners' life based on literature. Apart from basic information, such as age, gender and time with solar panels, open questions were arranged to gain insights to their attitude and opinions about solar panels. Aspects surrounding monitoring behavior and the users' connection to co-adaptation of products as well as the fluctuation of their electricity consumption were included in the questionnaire. At the end of the questionnaire, a section was arranged to collect email addresses for volunteering participants that wanted more information about the following user study.

The questionnaire had both a Swedish and English version. It was posted in Facebook groups called "Solceller Energilagring Mikroproduktion Forum" (~12 000 members) and "Solceller & Solenergi Forum & Tips" (~1500 members). It was also shared on Facebook and LinkedIn. In total, the survey had 43 respondents and 15 people showed interest in getting further information about the following user study.

3.3 Affinity diagram - questionnaire

In order to analyze the result of the questionnaire, an affinity diagram was made for the qualitative analysis. Affinity diagramming includes writing quotes on separate post it-notes and then clustering them together into categories (Hanington & Martin, 2012). To start the process, the answers given in Swedish (32 in total) were translated into English and then all the quotes were written on separate notes in a Miro board. Thereafter, the answers were categorized and summarized in order to find different themes within the answers. Additionally, it provided an overview to identify aspects that the following interviews could take the opportunity to explore further.

3.4 Interviews

To get a deeper understanding of the experiences of solar panel users, interviews were conducted. The participants were firstly recruited through the questionnaire. Due to a lack of participants, posts were also made in two forums related to house owners, although it was done without success. Another attempt was then made to recruit more participants by making a post in the Facebook-group "Teknikkvinnor" (Eng: technology women) which led to more interviews. In total, 8 solar panel users were interviewed (4 men and 4 women). The interviews were mainly conducted through Microsoft Teams,

although two of the interviews were conducted through phone calls. All interviews were recorded with the consent of the participants. The language the interview was conducted in was either English or Swedish based on the participants' preference.

The interview had six different parts (appendix 2 & 3). The first four parts followed the model of domestication theory presented by Silverstone (1992): appropriation, objectification, incorporation and conversation. Applying domestication theory to the structure of the interviews was a decision made in order to better follow how solar panels were integrated into the everyday life of the users. The fifth part of the interview was named wish and motivation. This part included questions which were outside of domestication theory, yet still of interest for the project. For example, regarding the future of solar panels. The questions in each of these parts were also complemented with questions based on previous findings that needed further investigation.

The final part of the interview was an activity to add a playful and reflective element, in order to inspire the participants to express thoughts that were not given the opportunity to be expressed. Additionally, it served as a way to wrap up the interview. The method used was inspired by the construct theory and the repertory grid technique. Constructs were defined by psychologist George Kelly as being used to make sense of the world. There needs to be at least three elements, two who have something in common and a third that differs from them, in order to describe a construct. Repertory grid technique is a method that produces a matrix with the identified constructs (Goffin et al., 2010).

In the final activity of the interview, the participants were presented with a group of three pictures and they got to say which two they perceived had something in common along with a motivation to why. In total, four separate groups of pictures were shown to the participants. The pictures were chosen with a connection to electricity or the findings from the questionnaire. Seven out of the eight participants took part in the final repertory grid inspired activity.

To find the perspective of other stakeholders, two more people were interviewed. The first stakeholder was an energy and climate advisor at the Swedish Energy Agency, who works with giving advice to companies, households and organizations. The second stakeholder interview was conducted with a business developer at the branch organization Svensk Solenergi. The interview questions were adapted towards each stakeholder and were based on insights gained after a couple of users had been interviewed.

3.5 Qualitative analysis - interview

To summarize the findings from the interviews, each interview was transcribed and if needed, translated from Swedish into English. Thereafter, quotes were taken from each answer and placed on a Miro board. Based on this, the answers could be categorized in an affinity diagram. The quotes were also color coded based for each participant so they could be distinguished from each other and if there were similarities, it was possible to see how many of the participants shared the same viewpoint.

The responses for the repertory grid inspired activity was summarized by adding quotes to the pictures, showing each participant's choice and comments they made.

3.6 Summarizing the findings

At the end of the user study, a proper angle to treat the complex situation of everyday life study of solar panel owners was important. Firstly, the most important findings from the user studies were connected to the customer/user journey map, where it could also be related to domestication theory. Inspired by norm-criticism and the feedback that was received from the supervisors, a list of tensions was found in the user study materials. The tension in this context represents the friction or contradictions surrounding users' behavior and interaction. Additionally, it touches upon their thoughts on an individual as well as a social level. An example of a tension could be if what a user claims contradicts their actions, since it can indicate an underlying norm. These tensions could be the entry point to challenge users and customers, and further challenge social norms.

These tensions also inspired an attempt to list criteria for the design concept, describing attributes it should have or goal it should fulfill. Additionally, as a way to communicate the findings, personas were also made. Personas incorporate characteristics of the users in order to have a humanized representation of them (Hanington & Martin, 2012). In this case, three personas were made with different relationships to solar panels and in different stages of adopting them. Each persona was described with characteristics relevant to living with solar panels, for example house type, household situation and current relationship to or view on solar panels.

3.7 Vision

With the uncertainty of norm creative design, the criteria list could not be specified with more details. To assure having a goal to strive towards, the criteria list as well as the personas were used to formulate a vision statement of the design solution. The statement was formulated in one sentence encompassing the aim of the design solution.

3.8 Brainstorming and norm-creativity

The production of design solutions relied heavily on brainstorming in different forms and cycles. The initial brainstorming was done to discuss the problem area in order to know the aim of the solution. When it was established, the brainstorming focused on generating ideas for the solution.

The norm-creative approach taken does not have specific methods but rather requires a mindset of continuously questioning the surrounding but also oneself, which the ideation needed to reflect. One version of brainstorming used was negative brainstorming, which is about ideating on negative solutions that the users would not want, and thereafter converting these into the opposite, positive solutions (DTU Skylab, 2021). The brainstorming was also done using different themes as inspiration such as other settings or time periods.

Additionally, NOVA (se chapter 2.2) was also used. This deck of cards helped to give inspiration from different tactics and cases that were presented. One of the tactics used was "the level bar" where solutions are designed in favor of the excluded individuals. "Roleplaying" was also attempted by taking on a fictional role and solving the problems

based on them. Additionally, NOVA provided encouragement to prototype more as well as changing to different environments to find inspiration.

3.9 Rough evaluation

The generated ideas required filtering in order to find the ones to refine. Since the ideas were still at an early stage during the first cycle of evaluation, it was done in a rough manner by weighing the potential of the idea. General criteria that was considered were the feasibility of developing the idea and how well it fitted the vision. Although an idea might not have passed the first evaluation, it could still be revisited again since the design process was iterative.

3.10 Prototyping

A mix of both digital tools and physical materials were used to create prototypes of the concepts. Physical materials included lego, paper and fabric, for example, while digital tools were software such as Figma and Photoshop. The prototypes were used to convey the ideas of the concepts. They also facilitated finding areas of the concepts that were not specified or needed further development.

3.11 Plus, Minus, Interesting (PMI) technique

The iterative ideation process resulted in the development of three concepts. To choose between them, the Plus, Minus, Interesting (PMI) technique was used. It is applied by listing the positive (plus) , negative (minus) and notable, but neither positive nor negative, (interesting) aspects of an idea (Lamm & Brewer, 2014). By having a list or matrix of the different aspects, it is possible to distinguish the concept with the best ratio between them. Meaning the concept with most positive aspects while the negative aspects are either low or able to be addressed.

3.12 User test

An interactive prototype of the concept made in Figma was used in a user test. Participants were recruited through the department where the thesis was held as well as through a post in Yammer, a channel for internal communication. In total, five participants were reached.

The aim of the user test was to examine how the concept would interact with the participants' everyday activity. Therefore, three sections were planned: initiation, interaction, and closure in which the participants got to experience within one week (figure x).

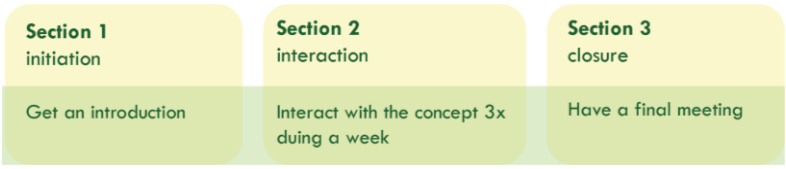


Figure 6. User test

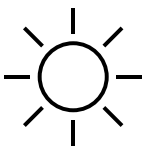
The first section was done in person or through a video call. The participants were briefly introduced to the concept, without the norm-creative aspect being disclosed. The link to the three scenarios in section 2 were sent to the participants throughout the week, together with instructions and questions to reflect on.

The two participants who could be met in person received the questions in physical envelopes instead. When they received a link, they were prompted to open the corresponding envelope to read the instructions, and after the interaction, they could write down the answers to the questions on the other side of the card.

At the end, a final meeting was scheduled to get participants' thoughts and discuss their experience. Towards the end of the meeting, full intention of the concept was disclosed.

3.13 Improving the concept

Based on the feedback received from the participants in the user test and how their experiences matched the purpose of the design solution, a final iteration could be done. The improvements to the concept lead to them being visualized as a prototype with higher fidelity.



4.

UNDERSTANDING

This chapter explores the context where solar panels are used by mapping the stakeholders involved as well as collecting quantitative and qualitative data.

4.1 Stakeholders

For solar panels systems, where many stakeholders are involved , mapping out the stakeholders helps to make the project more comprehensive. Out of the consideration of customer and user journey, as well as how information flows within it, five types of stakeholders were categorized: customer, user, acquaintances, municipality and company (figure 7).

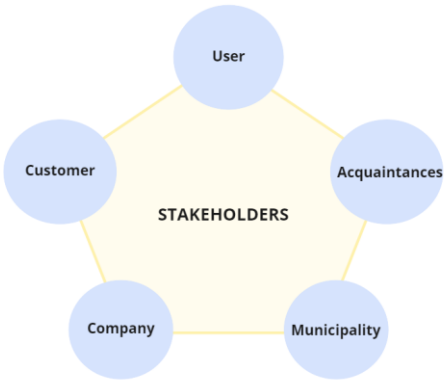


Figure 7. The five main stakeholders identified

One distinction to make is between users and customers, who often intertwine. Customers are those who initiate or are actively involved in acquiring solar panels. The users are those who have solar panels installed and use the electricity from it. Oftentimes, a person can be both a customer and a user. However, there are situations where household members become users without being customers. For example, if people move into houses that already have solar panels installed (Winther et al., 2018).

Customers and users are connected to their acquaintance, who gives advice and reference and even shaped their personality, thus influencing their decisions. It can also go the other way around, where the customers and users might influence their acquaintances. The company could be an installation company or an electricity company with sellers and consultants. It could also be a real estate company that cooperates with a solar panel provider. Lastly, the fifth stakeholder, the municipality, might occur as an energy advisor for the customers, or as policymakers.

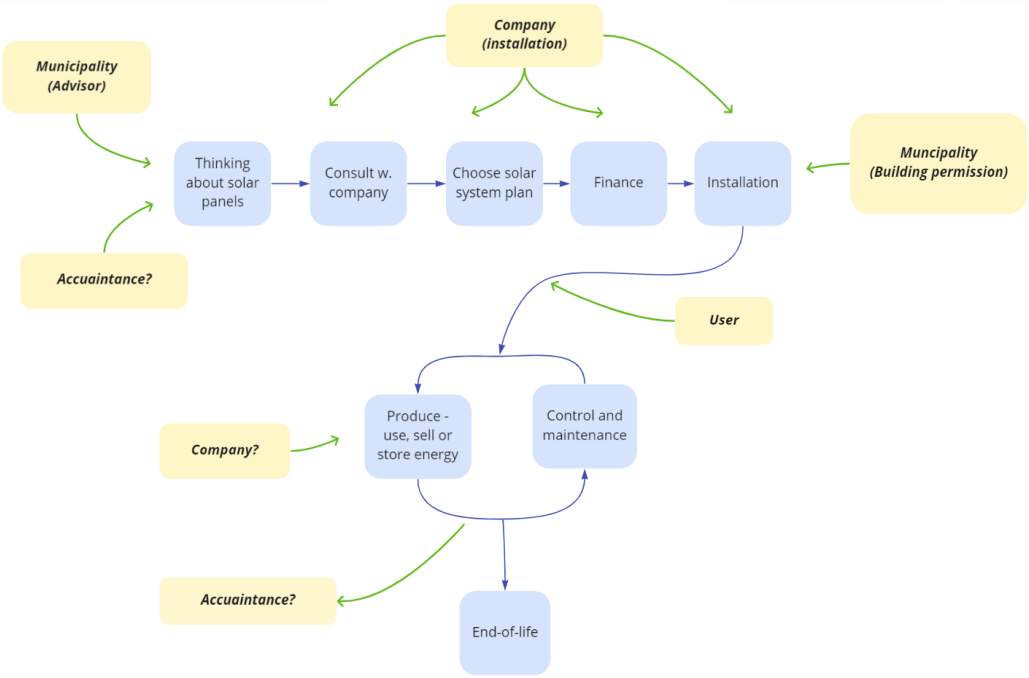


Figure 8. Stakeholders' relationship to the customer journey map

These stakeholders depend on each other and are widely covered in society. By mapping the stakeholders, they could be connected to the phases of the customer journey map (figure 8). This could be of great help to determine which stakeholders to include or find out more about in the user study. One uncertainty was for example if the company had any relationship with the customer after installation, which could be examined in the questionnaire that followed.

4.2 Questionnaire

The questionnaire was designed based on the literature, customer journey map, and the identified stakeholders. The aim was to obtain data that was lacking in the customer journey map and to complement findings from the previous research. Further, some clues of the norms present in the current lifestyle of households with solar panels were aimed at being found. With quantitative and qualitative analysis, aspects such as household situation, motivation, interaction, opinion, and changes in the way of living of participants were summarized.

Qualitative data such as gender, age and amount of household members were collected from the 42 respondents (table 1). The majority of respondents were men between 41-60 years old. The majority of the respondents had their panels for 1-3 years, followed by an almost equal number of participants that had it for <6 months as the amount that had it for 3+ years. The questionnaire respondents were also the most active household members in acquiring the solar panels. Additionally, many claimed that their energy consumption remained the same after installing the solar panels.

Table 1.
Quantitative data from the questionnaire

Gender	Men	38
	Women	4
Age	20-30	1
	31-40	5
	41-50	12
	51-60	13
	61-70	5
	70+	6
Household members	1-2 members	18
	3-5 members	23
	6 or more members	1
PV time	< 6 months	12
	6-12 months	3
	1-3 years	16
	3+ years	11
Role	most active	37
	others were the most active	0
	as active as others	1
	moved into a house with PV	1
Electricity consumption	Increased a lot	3
	Increased slightly	8
	Remained the same	19
	Decreased slightly	9
	Decreased a lot	3

Involvement with the purchase decision can be one of the factors influenced or steered by the household dynamic. According to the survey, most participants lived with other

household members. Yet, the overweighing majority described themselves as having the most active role in acquiring solar panels in comparison to other household members. This points at differences in roles within the household, but also that there are many users who have not ever been customers.

The qualitative data shows that the post-purchase phase includes a high frequency of monitoring the production. The respondents mentioned monitoring every day or several times a day. Some respondents monitored less frequently by doing it weekly or a couple times each week. The reason for the monitoring was based on different types of enjoyment for many of the respondents. Words such as: fun, interesting and out of curiosity were used as their reason. Additional motivation for the monitoring was being able to check that everything was working properly or to adjust consumption according to the information. The monitoring frequency was dependent on the weather as well. One respondent stated: “When the sun is shining I want to see what it gives”.

The questionnaire also covered changes in electricity consumption and co-adoption in the phase after purchase. Although the electricity consumption stayed the same for most participants (45%), the number of respondents mentioned an increase is the same as those who mentioned a decrease. The most common reason for consumption change was having an electrical car which can suggest co-adoption occurring together with solar panels. Another reason stated was the increased awareness of the electricity consumption after getting solar panels. Some also mentioned the high electricity price during the winter being a reason.

A third of the participants did not indicate any co-adoption behavior, as they stated not getting any new products or services after installing the solar panels. For those who did, the most common products were electrical vehicles (EV) and chargers. Batteries were another product mentioned by a few respondents.

In the open question regarding changes in the participants’ life after installing solar panels, the majority stated that their lifestyle had not changed. Some did however mention increased awareness and steering the consumption of certain appliances. “I use things when the production happens, for example washing machine” one responded stated. Meanwhile another responded wrote that they “looks at spot price and think about use along that”.

Open questions about participants' opinions of solar panels were arranged in the latter part of the questionnaire to capture other directions of possible existing norms. Opinions about the best parts of living with solar panels could mainly be divided into three categories: economy, environment and energy production. The economy included the financial benefits the users saw with having solar panels such as getting lower bills and having more predictable costs. Respondents stated the positive environmental impact as a benefit of having solar panels as well. However, an interesting finding was that the environment was rarely stated as the sole benefit. Instead, it was usually mentioned together with the economic benefit of having solar panels. The last category, energy production, was related to the satisfying feeling users felt of producing electricity on their own.

Interestingly, when it comes to negative opinions towards solar panels, 'the worst part of living with solar panels' did not exist according to one fourth of the participants. If they did mention a reason, it was mainly associated with the weather. Most specifically the snow that affects the production. One of the respondents answered the question with: "you get even more annoyed about snow and winter than previously". The respondent did however have areas they wished could be improved. Increased effect or efficiency was a common response. As one respondent questioned: "what is it that we can get out today, 20% of the sun's capacity?". Otherwise, they mentioned improvements in relation to batteries so they could store their excess energy cheaper.

Additionally, questions toward peer effect were saved to the end to verify whether this effect could apply to the participants or not. With the questions about things they would spread about solar panels and the suitability of living with solar panels, the respondents had a positive outlook on being users and would certainly recommend it to others. In terms of advice to spread, some was to compare different offers and to negotiate the price. Two of the respondents also suggested considering the appearance. Even though the respondents all agree that the suitability of solar panels is for everyone, some disagree with preconditions: the location and construction of the area need to be fitting for the solar panels. As one respondent explained: "it would be foolish to invest if you do not have the conditions for good production". One respondent also highlighted that it could be difficult for people living in rental housing.

The result of the questionnaire is rich yet general; thus the findings were reviewed and aspects that need to be explored in the following work were set up. To understand more about the interaction surrounding the solar panel owners, content could be listed for further user study to discover. Firstly, in the early purchase phase, the motivation of the solar panel adaptation process needed more supplement in reasoning so that it could be interpreted how potential customers made their decisions. Secondly, the major interaction in the post-purchase phase, the monitoring behavior, needed to be explored more as it was more or less mentioned by every respondent. Thirdly, how solar panels were integrated into the everyday life of their owners was barely answered in the questionnaire, which was a gap without a clue. Lastly, the peer effect input toward the users themselves was missing in the questionnaire and was essential to explore as well.

4.3 Interviews

With the insights from the questionnaire, the direction and content of the interview was prepared purposefully with more clarity. This chapter consists of two parts: interview with users and interview with other stakeholders.

4.3.1 User interview results

The interview questions were designed in the order of the four sections of domestication theory presented by Silverstone (1992). With an addition of one section for their future wishes as well as a final repertory grid inspired activity. In order to target the interaction, reflection and changes of solar-panel-involved lifestyle, the analysis of the data led to 7 themes being distinguished from the interviews: general information, monitor, consumption, knowledge, change, wish and social interaction & opinion.

General information:
To begin with, the first theme consists of fundamental questions about the general situation of participants' journey: motivation, installation, impression of adoption, the expectation of solar lifestyle and visibility of solar panels.

The most important factors that motivated the participants to become customers are environmental concerns and economical concerns, or a bit of both. The interest in solar panel technology also occurred. Some participants mentioned the panels being a part of a bigger goal they had in life, the underlying cause being either economical or environmental reasons. "I have an energy plan, I'm preparing for my retirement…" one participant mentioned while the other said: "Because it's part of my life plan, this is something I really want to do."

Half of the participants regarded the installation process as smooth and easy. However, there were smaller issues that occurred for the participants. These were handling the paperwork, getting the app started or the company not responding. One participant also experienced a company making errors in the installation which needed repair. The most difficult part of the installation mentioned was to choose between offers. "The biggest obstacle was to learn about it. To read references and the studies, for which panels and which companies to engage and install them".

The difficulty and impression of adoption barely existed. It was described as "flowing" and "nothing". However, the only participant who did not actively choose solar panels, but rather bought and moved into a house with solar panels, said the adoption existed as raised awareness of electricity consumption and that it felt positive to consume more electricity during the day with sun shining outside.

Not all of the participants had particular expectations prior to installing the solar panels. Some expected their solar panels would empower them with independence during power off, but it was shown not to be possible in reality. One participant said the panels were over productive to the level that they: "even got to shut down the plant a couple of weeks in one year to not produce too much".

Many participants had the panels installed on the roof, however the level of visibility varied. For some, they were able to see their solar panel system from the outside. For others, the panels were not visible at all, since they could not see their roof properly. One participant expressed the lack of visibility as an advantage due to the appearance. "... I am lucky that my solar cells aren't noticeable at all. If I live in an old house that is over 100 years old, it wouldn't have been so fun to put the solar cells on that house I think. Because it would have spoiled the appearance".

Monitor
For the users to keep track of the production, using the app/website or checking the bill were the most common monitoring channels. One participant developed an app on their own, to be able to get even more specific and reliable data. Another participant did not have an app, but had a physical meter instead, which reduced ease of accessing the information. The participant therefore described a much less frequent monitoring behavior compared to the users with digital services.

The monitoring behavior for the household members showed that there were differences. For most of the households the person who monitored the most was the male partner. When asked about who monitors the most, some replies were: “My sambo, because he was the one who bought them” and “yeah, that is probably me... she [the wife] doesn’t care. She trusts me”. There were also households where both people in the relationship were monitoring. “I think we're pretty much the same there. It's so much fun”. However, it can be noted that in those cases the female partner had a background related to energy or other fields of technology. It can therefore suggest that there are differences in solar panel systems’ relation to gender and roles.

For the households who mentioned having kids at home, they spoke of them not understanding the different aspects of having a solar panel system to the fullest. For example, the monitoring information. However, it was expressed how sustainability was of big importance for their children’s’ generation. “... children become a little frightened and worried about the future and that we then show that we have a drive to be involved and work on the change, I think that feels really good. And I think the kids think so too” one of the participants explained.

The main information the users had access to through the monitoring was related to production and selling the energy. They could see the kilowatt hour produced at the moment. Through the app or website, they could also go back in time and see the weekly, monthly or yearly production. The participant with their own app could also see more specific information related to the weather.

When it comes to what the participants do based on the information, they mentioned charging their electrical vehicle. It also occurred that they steered the heating according to it. “I have a big workshop. If I’m going to heat it up then I start the heating when I know I have excess electricity” one participant explained. Another participant gave an interesting perspective on the monitoring by comparing it to a competition “I'm a competitive person so it was sort of a competition to be able to produce as much as you use” the participant said.

Monitoring frequency varied, but it occurred more often when the sun was shining. The feeling the participants felt was often positive. Which corresponded with findings from the questionnaire. Although it could be done excessively, and it does not always add value. One participant even jokingly described their high frequency of monitoring as “a problem”.

Consumption

In general, there was no change of electricity consumption that could be noticed by the participants. Using solar panels does not make households consume less electricity even though the bill declined obviously.

Regarding the attitude toward economical consideration of participants, they mentioned not precisely maximizing their savings. However most of them cared about the economic benefit from having panels by steering their electricity consumption somehow. Especially in relation to heating and EV charging where they attempted to use as much excess electricity from the panels as they could. “ I have, for example, a swimming pool in the summer. Then I make sure to start the heating in the pool just in time when the

solar panels start to give so much. So I avoid buying electricity for it." one participant explained. Meanwhile, other additional services could be of help with as well. "I have changed electricity company now to this Tibber. And then they have an app that helps me make sure to charge the car when it is the cheapest."

When it comes to selling the excess electricity, participants showed satisfaction because the selling and buying process works well on its own. They choose to sign contracts with the companies with the best price while they are not fully aware of what was the basis during the pricing adjustment. There are two interesting phenomena in this electricity trading behavior. Firstly, participants wish for cheaper storage service for the excess electricity instead of selling them. "I would like to have a company where the overproduction goes to a box, when the winter comes I can take the power from the box that I have invested in the power company. But I haven't found the right company yet. From time to time, I look." Secondly, according to some of the participants, the electricity trading companies "give you one offer for you to become a customer and one year later is not the same offer anymore". Thus participants have to keep changing contracts to pay "new customer" prices.

The electricity consumption of the household still relied on the public electrical grid, since none of the participants had any batteries. Some of the participants pointed out that batteries are currently too expensive. They even got recommended to not acquire batteries during installation due to lacking economic benefits at that point. Although, participants showed interest in what it would be like to have batteries.

Knowledge

Regarding where the participants got their information before installation, finding it through the internet was the most common source of information. It also occurred that the users got the information through a company connected to the solar panels. One of the participants worked for a company that provides solar panels for example. There was also a participant with an academic background that simplified getting acquainted with solar panels. "I am educated in energy, so [it's] quite easy to acquire those tasks I feel. Which I wanted. But it is very much about asking the different solar suppliers the question" the participant explained. Another participant had an acquaintance with solar panels who could share his experiences.

Even though the users had to acquire new knowledge before installation, the majority of the users expressed having the necessary knowledge about their solar panels at the time of the interview. They mentioned having read more about the subject over time which led to this. Some participants brought up that it was not so complicated. "Like electricity is electricity. It's like buying a new machine. It just works. Nothing different happens" one participant said. Other participants did emphasize the aspect of there being more to know. Encountering a solar panel related situation or a subject, where they lacked sufficient knowledge, contributed to the feeling of there being even more that they need to learn.

When asked if the participants could make full use of the solar panels, they commonly confirmed that they could. The time it took for them to do so varied from a day to a couple of months, however they did not express any dissatisfaction with how long it took. Rather, they explained that it was an easy process. "I think it was almost from day

one. Because it was so simple. So user-friendly. You don't do anything" one user said. Another one explained: "it took practically only a few weeks, that you had gotten this app to work". One obstacle mentioned for not taking full use of the system was lacking a battery to store the excess energy allowing the user to become more self-sufficient.

New things the participants learned related to the pricing of the electricity and the installation of the solar panel system. They also became more aware about the function and in some cases, a higher degree of dependence on the public electrical grid than they expected. One participant explained: "if there is a war and someone strikes out the electricity then we don't have any electricity even though we have solar panels". The conversation about not having electricity during power outages was also an association participants made during the repertory grid inspired activity. Another participant became more aware of the amount of electricity certain appliances used in the home; however, this was due to the person's previous knowledge in combination to the self-made app with more specific information that the participant had access to.

The repertory grid inspired activity at the end of the interview also included a group with a robot, an inverter and a washing machine. One finding was that some of the participants recognized the inverter directly. Others did not know exactly what it was, although they could recognize it was part of the system that was installed. Although the purpose of the repertory grid inspired activity was to find which associations they make, these findings can suggest a variation in the technical knowledge about the system's components as well.

Change

Changes that solar panels brought into participants' lives were mostly connected to their mindset. Using solar panels as part of the resource of electricity brought a good feeling of producing their own energy. More importantly, many participants raised their awareness of their environmental impact. Some think twice before purchasing other products, for example by explaining that: "you should choose to think before you like buy something crazily and from anywhere". However, some said the solar panels compensated for their "bad" behavior, which was not in favor of the environment. As one participant explained: "yeah, you think about it [the environment] more and more. Then I may have a whole lot of other things that I do that is not so nice for the environment". Speaking of a more visible change, there were participants who mentioned that they had bought electrical vehicles after they installed solar panels.

Wish

There are some aspects that participants wish to improve about their current solar panel product. Firstly, they wished for more capacity of the product, some wanted to expand it, others wished it to be more efficient in harvesting electricity. Secondly, many participants said their digital monitoring information was not enough "I can only see how much I produce. But I have no connection to how much of it actually goes to the property and what goes right out on the grid". Again, other additional digital services fulfilled this wish, showing more info with comparison.

Additionally, participants all wished independence from the grid in the beginning but it turned out to be unrealistic. One of the participants expressed interest in being able to become an island producer, referring to having a stand-alone solar panel system that is

not connected to the electrical grid. This type of system had been discussed by the members in the solar panel group.

Participants were also questioned in their imagination of living with solar panels in 20 years. Most of them wished for a lower price. There were also some specific wishes for the product such as better efficiency when converting the solar energy and more adaptive appearance that blend into the surroundings. About the storage, participants wished there could be an improved way to store the excess solar energy, for example the EV having the ability to charge back to the house as a battery. Lastly, a participant speculated on the possibility that there would be a policy from the municipality that encourages installing solar panels and regulates the process in a better way.

Social interaction & opinion.
By being solar panel users, the participants also came to advertise them to others. If the subject comes up, they explain their experiences to others. A couple of participants had even teased their colleagues by showing them their low electricity bill due to the solar energy. “At work. There are some people that had solar panels and electric cars. We used to tease the other ones“ a participant said. The participants also had experienced successfully convincing others to install solar panels.

Subjects the participants could discuss with others is for example the economic aspects such as how much the produced electricity is sold for. One of the participants explained that the questions people ask are often non-technical, “normal people don't have the technical angle. What they sort of lean towards to ask is ‘what do you think about them’ or ‘do they make noises?’, ‘are they hard to take care of?’”.

Although the participants were met with curiosity about their solar panels, there was also some skepticism that they encountered. As one participant put it: “most think it seems intriguing. Someone else says it won’t pay off in one hundred years, it is better to buy a new bubble pool. Then I ask: how long does a bubble pool pay off?”. According to the participants, the obstacle for others to install panels was either economical, them having a misconception or both. The participants explained that even though there is a high initial cost, it is a worthy investment. There are also possibilities to lend on the house to afford the panels and even though a resident might move from the house before the pay-off time, the panels could increase the value of the house.

4.3.3 Stakeholder interview results

The two stakeholders interviewed had different roles, the questions were therefore customized according to their work content. Their interview result is summarized into several aspects: potential users’ motivation and concern, situation of public interest, and their own opinion on the future of the solar panel industry.

According to the climate and energy advisor from the Swedish Energy Agency, most commonly asked questions were “how much do we earn, how long do they live, the guarantees for the different part in the system”, all of which are concerns for cost and quality. When it comes to the motivation of installation, the advisor answered from his perspective of those who called to consult: “Oh, definitely money. It's all about money today”. The advisor also mentioned there had been a change of motivation through the years, “Yeah for a couple of years we are looking to have that type of questions, that type

of remarks, that it feels good in the heart, now it's more about the money". The motivation from an environmental perspective was fading since the price of electricity pushed economical concern to the major place, which was also mentioned by the business developer from Svensk Solenergi. Although the economical aspect could motivate people to adopt solar panels in many instances, the major concern that pushed away potential users was still economical: the pay off time of solar panel investment.

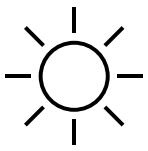
Meanwhile, energy safety and self-sustained electricity is also a motivation because of the situation and security in Europe. Additionally, there was no certain type of household that was mostly motivated. According to the energy advisor, there were a variety of people calling to get a consultation.

The situation of public interest is very positive with an increase worth taking note of. According to the advisor, there has been an increasing interest in installing solar panels. Simultaneously, at Svensk Solenergi, there has been a 66% increase of preregistering installation since last year. Furthermore, the business developer noticed particularly more interest in solar energy in rural areas. The interest in these areas was from the perspective of producing their own electricity for the household, rather than charging electric vehicles. This fact offered a broader view of the demand of solar panels and the battery use.

While looking at the measures taken by the companies to include more users and draw attention, both of the participants said there are lectures hosted by companies to expose themselves more. More specifically, last year, Svensk Solenergi hosted 15 webinars about topics such as sustainable supply chain and new technology. By showing up on TV, being active on social media, they wanted to be seen. Additionally, they attempted getting the problems from their members addressed and updated, such as working on solar panel installers' screen systems to stand out from the installation industry and gain interest from the public.

When talking about the future, the business developer speculated that people in the future would regard solar panels as a part of a more integrated smarter home system that lower the energy cost itself, rather than focusing on solar panels as an attachment to install. Furthermore, the possibility to take advantage of empty areas not suitable for agriculture and use them for solar panel plants was also brought up. Additionally, the business developer had a positive view on the possibility of sharing solar panels with neighbors due to the recent law addition.

Finally, there were some incentives and policies mentioned by both of the stakeholders which indicated that the municipalities are leaning towards encouraging people to install solar panels and offering them as smooth and simple a process as possible.



5.

SPECIFYING

This chapter summarizes the findings from the collected data and indicates the direction for the design solution.

The findings from the user study could be summarized and connected to the customer map in the following way:

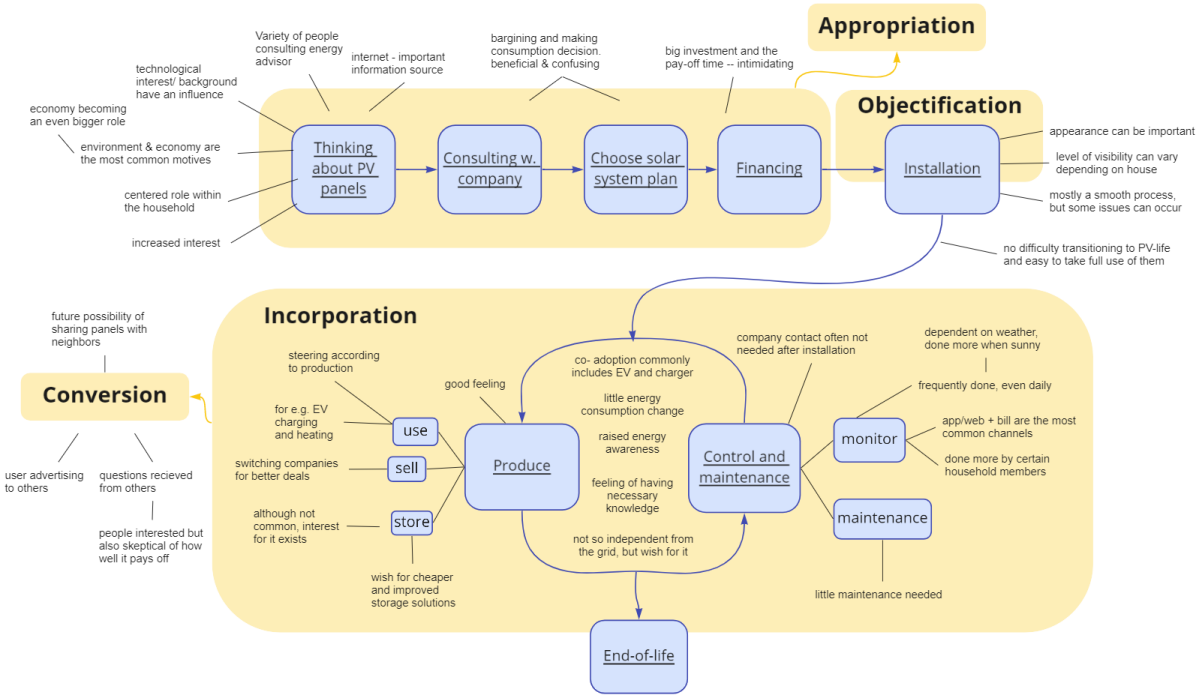


Figure 9. relationship between findings and the customer journey map

5.1 Tensions within the findings

A perspective of looking for tensions was used to summarize the findings. Tensions referred to contradictions that could be present in the participants' behavior and opinions. This perspective was taken to facilitate locating areas to address where there is a presence of norms. From the user study, there were five areas that were identified where tensions occurred: monitoring, interaction, social connection, the individual and hindrance for new users.

Interaction:
The first contradiction identified was the highly limited interaction between the solar panel system and the users, although there was a hint of users wanting to have more ways to interact with. Despite being a huge investment according to the users, they oftentimes did not notice having solar panels since the electricity moves in the house silently and the installation was often not visible. The solar panel system was, besides, also self-reliant and did not require any maintenance. Additionally, the main way of interacting with the system was through monitoring the production, which is one-sided.

Monitoring:
The monitoring behavior showed a contradiction in being an interactive activity that could steer the electricity behavior of users yet was limited by imbalance. Generally, users who monitor often monitor excessively, knowing they would not do anything with the information. Thus making the interaction meaningless in a sense. Furthermore, while looking into the households, there is always a member that is obviously more involved, which creates an uneven household dynamic. For example, the monitoring

was mainly done by one household member, always the adults in the household and most often the male partner in a couple.

The individual:
Although the solar panel installers described themselves as not changing much, there were two main changes identified. Firstly, the users became spokespersons for solar panels. Whether it was people asking them questions or the users convincing others to install, they found themselves promoting a life with solar panels to their acquaintances. The second change was learning more about electricity and increasing their awareness regarding their consumption. The users became aware of the big fluctuation of the electricity price that could occur within a short time period. They also improved their ability to determine when it would be advantageous to use electricity demanding appliances.

Social connection:
Living with solar panels often includes individual activities, such as monitoring or choosing when to use a certain appliance, which contradicts the importance of social connection within this lifestyle. Both from the perspective of peer effect and the perspective of how users attempted to find ways to incorporate solar panels into social settings. Peer-effect was mentioned by previous research as contributing to the spreading of solar panels systems. This was reflected in the findings as well, where the participants either influenced others to get solar panels or were influenced themselves. The social connection could also be noted in how many users brought up the lifestyle with solar panels when socializing. For example, users often spoke with acquaintances about solar panels and several of them found online forums, such as those used to distribute the questionnaire, to discuss solar panel-related topics.

Hindrance for new users:
The most outstanding contradiction was that both the motive and the barrier often were related to economy. As an obstacle it should be overcomable since, on one hand, solar panels have a promising pay off and the users often mention being satisfied. Especially due to the recent, unusually high, electrical grid price. On the other hand, the users could take loans to manage the high initial costs. However, it appeared to be difficult for many non-installers to look beyond and they found it hard to believe that it would pay off.

The lack of awareness and knowledge about solar panels was a contributing factor for new users not installing them. The acquaintance of the users had asked many questions regarding aspects that were not applicable for solar panels, such as “how much noise does it make?”. Additionally, the users’ own increased electricity awareness after installation can point to many non-installers lacking awareness of their electricity consumption or the possibility to produce their own energy.

5.1.1 Attempted criteria list

The tensions were used in an attempt to make a list of criteria for the design solution. However, the criteria were hard to define and measure. Another risk with the criteria was that they could reinforce norms. For example, addressing the unbalanced monitoring behavior within a household could be done from the perspective of creating a solution adapted for the non-monitoring members. However, this can exclude current

monitoring users instead. The attempt to define criteria did however lead to phrases that could inspire the direction of the design solution. These were:

- Can be used by household members who currently have no contact with solar panels
- Emphasize the existence of solar panels
    - increase interaction
    - increase conversation about it
    - make it still 'alive' on winter days
- Increase energy awareness
- Weaken the abstraction of electricity
- Concretize the sunshine and electricity supply
- Decrease the boredom associated with energy

5.2 Personas

Considering the difficulty of defining criteria, personas were used as a complement to guide the design phase. Three personas were defined with different entry points and perspectives to living with solar panels (figure 10).

Figure 10. Personas

Persona 1. The couple - typical users

The first persona was inspired by the typical solar panel users that were encountered in the questionnaire and interviews. The persona consists of an older couple that has

installed a solar panel system. They monitor frequently, sell their excess electricity and advertise solar panels to others on spontaneous occasions.

Persona 2. The considerer
The second persona is thinking of getting solar panels but is yet to be fully convinced. This persona has similarity to the acquaintances that the current users had, where the person is hesitating due to the cost as well as the doubts about the functionality. However, current solar panel users that surround the persona contribute to a more positive view, although the other household members are less eager.

Persona 3. The unaware person
The third persona has neither knowledge or the preconditions for solar panels (e.g. lives in an apartment) and is in many ways the opposite to the typical user. The persona is aware of the electricity bill increasing but does not know of other options of how the situation can be improved. The persona is also intimidated by the thought of solar panels, since they seem to be complicated to install and to live with.

5.3 Vision

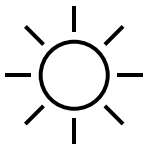
The personas that were defined could present the users of the future solution. However, since there were three different personas defined, they could require different types of solutions and steer in different directions. Therefore, the final method to offer guidance in the design phase was to develop a vision statement. The purpose of the vision was to express what to aim for achieving.

Keywords used as inspiration were taken from the tensions and the attempted criteria. These were:

- decrease the threshold for interacting w solar panels
- spread awareness and increase interaction
- challenge norm
- include everyone
- playful
- invite users
- challenge interaction

The vision statement defined was:
Recreating/reimagining life with solar panels by challenging interaction

By including the words “challenging” and “recreating/reimagining”, the vision statement incorporated more of the norm-creative approach. The vision also meant that the design could incorporate provocative elements and lead to reflection, which norm-creative solutions can do.



6.

DESIGNING

This chapter describes the exploration of ideas, the development of concepts and external feedback received.

6.1 Ideation and concepts

The process of finding ideas included different brainstorming variations. Although the vision statement offered inspiration, there were still difficulties in navigating the solution space. Considering that the solar panel system included both physical and digital components, it also opened up for even more ideas and concepts to explore. A useful method to provide enough limitation to start ideation yet enough room to explore a variety of ideas was to have brainstorming sessions with different themes. The first one was negative brainstorming, where ideas that the users would dislike were explored. This included having to complete complex tasks in order to get the monitoring information or that the panels made noise/sound when they were working. The original purpose of negative brainwriting is to eventually revert the ideas and create solutions that the users would appreciate instead. However, in this case, the negative ideas provided more inspiration than the positive ones and could be further built upon.

Another theme, inspired by the NOVA tactic "the level bar", was to brainstorm based on an excluded user group. The theme for the corresponding brainstorming session was to design a solar panel system adapted for children. Ideas included having a solar energy powered character to take care of or to translate the monitoring information to more playful and understandable units. Several other themes were also explored during the brainstorming sessions, such as different time periods and locations.

Out of the ideas, three concepts could be developed, which were feasible and aligned with the vision. These were: the PV booking system, the 3D monitoring house and the inverter pet (figure 11).

Figure 11. Early sketches of the three concepts

6.1.1 Concept 1 - PV booking system

Inspired by laundry rooms that can be booked in apartment buildings, this concept makes solar panels accessible and flexible through a digital system that allows short term booking (figure 12). The concept will be realized by a website to push users from their phone as well as the over-monitoring behavior. Based on a future scenario with more supportive policy, this booking system is built upon the situation where solar panels exist in most of the apartment building roofs and suburban solar panel parks. The target group is people who live in the apartment buildings without their own roof. Making the accessibility of solar panels no longer limited to only house owners with their own roof. As a result, this concept can eliminate the financial stress of investing in solar panels. Furthermore, in this concept, the solar panels are given personalities to reverse the conventional situation by being skeptical about the users' behaviors. Thus the interaction becomes unpredictable and reflective. Additionally, the potentiality of being educational around energy usage is positive.

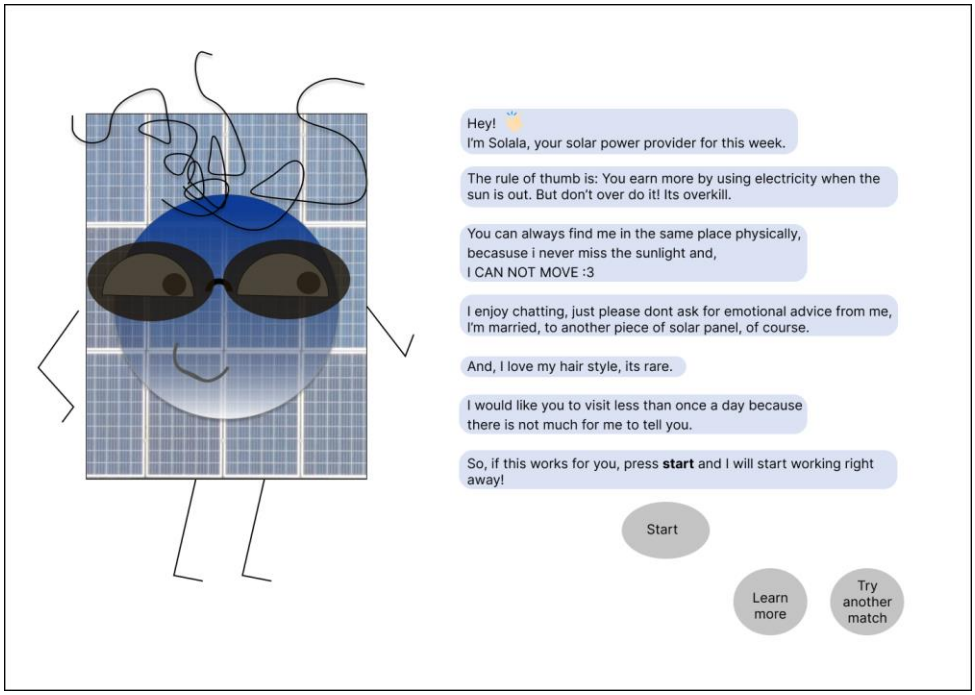


Figure 12. Wireframe of concept 1

The detailed design corresponding to the tensions are explained below.

The design implications towards tension of 'monitoring' behavior are:

- Regulating the frequency: By setting up the boundaries within the system, there will be limitations to the frequency of monitoring, to prevent over monitoring.
- Unpredictability: All the information comes through a matched personality with unpredictable feedback, which creates a personal relationship between solar panels and the users. Also, this might help with the boredness from winter break of the panels due to seasonal shortage of sunlight in Sweden.

The design implications towards tension of 'interaction' behavior are:

- Booking: the interaction is a short term flexible commitment with solar panels
- Conversation: new way to interact and receive information is possible
- Personality: unpredictable interaction that can add an element of excitement.
- Explorative: this concept offers users a chance to explore various paths of living with solar panels instead of a certain way being offered or forced onto them.

The design implications towards tension of 'individual' behavior are:

- Outside interest: the novelty and playful aspects can draw attention to solar panels and garner an increased interest from others to learn about them.
- Easier to learn: by having more interaction with the system, the users can learn even more about solar panel systems, energy and their own consumption.

The design implications towards tension of 'social connection' are:

- Not individual anymore: neighbors as well as household members can be connected
- Balancing household dynamic: the household members adapting differently to the solar panel personality might change the dynamics within the household and evening out the interest towards the system

The design implications towards tension of “hindrance for new users” are:

- Removing economical barrier: a trial with less cost and thus eliminating the intimidating commitment of making a huge investment
- Easy transition: users can gradually gain experience about solar panels without prior knowledge needed while also having a chance of reflecting on the lifestyle.

6.1.2 Concept 2 - 3D monitoring house

To visualize electricity flow in the house more vividly and increase the involvement of household members interacting with the solar panel system, concept 2 gamifies solar energy monitoring with a physical 3D model of the house (figure 13). This concept would require the users to build the house model on their own with components similar to LEGO, which would encourage more interaction within the household. The energy flow shows as a light path that distinguishes between electricity flow from the grid and solar panel by different colors. While monitoring, there has to be two people putting their hands on two deceives simultaneously, one on the inverter and one on the house model, which prevents the monitoring from being done individually. The monitoring information is haptic feedback in the form of pulse that indicates the strength of energy supply from either the grid or the panels. To introduce more playfulness of the gamified monitoring activity, the concept is accompanied by a booklet describing different patterns of using electricity. The users can then unlock achievements by following the different patterns from the booklet. With these gamified mechanisms, this concept would steer user’s behavior, create family dynamic, and raise their awareness of energy usage.

Figure 13. Prototype of concept 2

Corresponding to the tension, the detailed design is explained in the way below.

The design implications towards tension of ‘monitoring’ behavior are:

- Unique monitoring: By gamifying and uniting household members, the meaning of monitoring behavior is transformed to an activity where users can interact with their own house and with their family while having fun.
- Limited time: users are prevented from over monitoring by limiting the time of monitor in a week and further initiating reflection for users to find an appropriate monitor frequency on their own.

- No numerical data presented: the monitoring info is presented as haptic feedback and energy flow is visualized without any quantitative or digital information. This way of presenting information makes this concept reflective for users to rethink their need for the information.
- Social activity: at least two people are required to trigger the monitoring interaction, which brings household dynamics into the interaction and introduces a measure to even out the unbalanced relationship members have to the solar panel system. Meanwhile, this contributes to the peer effect applied to the household members and their acquaintances.

The design implications towards tension of 'interaction' are:

- Manually crafted house model: as a beginning of the interaction, experience of crafting the house model could engage users with this physical base of interaction and increase their bond to it as well.
- Haptic feedback: instead of showing the digital information, this concept offers haptic feedback through a pulsing sensation and heat, symbolizing the supply of energy from different sources (grid and solar panels)
- Level challenge: with the booklet, users can explore different patterns of their electricity consumption during different times, which could add extra playfulness and sources of interest to the interaction.

6.1.3 Concept 3 - Inverter pet

The inverter of solar panels is often hidden in the house and incapable of interacting with the users. Concept 3 is therefore an interactive inverter pet functioning as a family character that emphasizes the existence of the solar panel system and makes it become part of the daily interaction within the household (figure 14). The petting interaction works as a trigger for the inverter, where if the user does not pet the inverter, the system will temporarily stop working. Since the inverter is installed on a fixed location, the interaction is also physical for the users, moving the interaction from the digital sphere. One additional potential this concept has is to create a pet community within the neighborhood, where it connects with other pets and further connects users in different households.

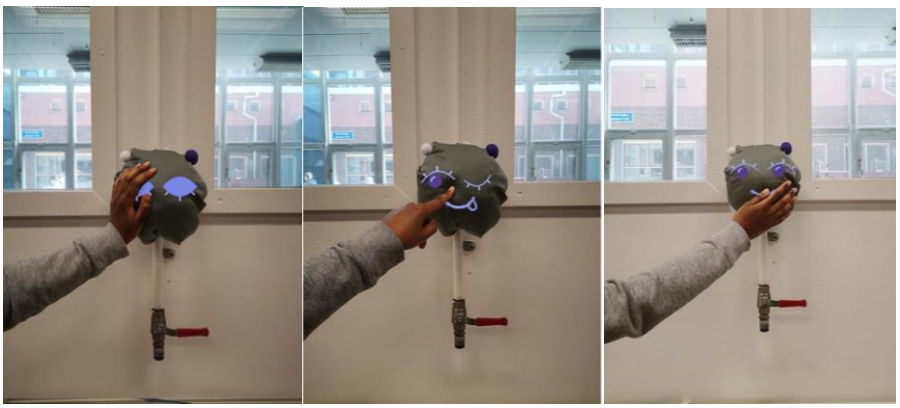


Figure 14. Prototype of concept 3

The design implications towards tension of 'interaction' are:

- Availability: every household member can interact with the concept, regardless of age or technical knowledge for example.

- Petting the character: the interaction introduced through petting an inverter is new to solar panel systems.
- Role: the pet changes the role of the solar system within the household and makes it easier to involve it in daily life.
- Haptic: the soft and bouncing pet-like texture introduces another sense users can utilize for the interaction, while it can mediate a comforting feeling.

The design towards tension of 'social connection' are:

- Connectivity: potentially, the social interaction of users could increase by connecting pets in different households with each other. It could also function as an additional entry point that can be utilized by the users when speaking about the panels.

6.1.4 Evaluation 1 - the PMI method

To choose between the three concepts, the PMI method was implemented. The positive, negative, and interesting aspects were listed from the perspective of its functionality, feasibility, and possibility of challenging current norms (appendix x). After weighing the different aspects of each concept against each other, concept 1, the PV booking system with a personality, was chosen for further development. Although it had the largest number of negative aspects, several of them could be improved upon. More importantly, the concept had the largest number of positive aspects with a clearer connection to the norm-creative aspect.

6.2 Concept development

The concept had several functions and aspects which needed to be defined in order to continue with the prototype and conduct a user test.

6.2.1 Functionality

The booking system is a service that the users can access through the web. The decision was made to purposely move away from the mobile phone, where much of the current interaction occurs today. The system could be viewed as having a couple of main functionalities, which are described below.

Matching function
As a booking system designed for solar panels with different personalities, the panels are allocated according to the features of the user. Thus the system starts with a quiz, where the user matches with the solar panel depending on their answers. The quiz is short with three questions including their opinion about solar panels, personality attributes, and amount of people living in the household. The form of the quiz is multiple-choice questions. The purpose of the quiz is also to reverse the role of users often questioning solar panel systems by introducing a way for the system to question the user instead.

Communication.
This is against the norm that the presence of solar panels is barely felt within the household. By requiring input from the user, this feature allows the system to become less passive and invisible After matching, the panels and users would interact

occasionally through a chatting function. The interaction is designed as conversation, similarly to chatbots, which presents the panels' personality and allows for efficient communication. The character is represented by the shape of a sound wave, which is less fixed and avoids possible misinterpretation that can come from designing a graphical figure.

Monitoring.
This function twists the norm where the solar energy production data is always satisfying, sufficient, and highly quantitative. It does so through the personality, how the information is presented as well as the need to schedule in the monitoring sessions.

The character is designed around the idea of a piece of solar panel that works during the day to maintain the harvest of sunshine. This personality serves users by giving feedback on the monitoring information which is presented as the data of production. Meanwhile, this character chats with the user according to its personality and can have a say in the amount of information that is shared.

As the core of the interaction, the design of the monitoring emphasizes playfulness and challenges by twisting the satisfaction of service into a level of uncertainty. When considering different ways of doing so, the concept of flipping cards in order to receive monitoring information was developed. The idea is that the user can choose between a couple of different cards, each containing different information with technical data or , with the less useful, random weather forecasts. These 'insufficient' or 'unsatisfying' information pieces are also supposed to provoke reflection from the users around their monitoring behavior.

To put distance from the monitoring activity being done without thought, the scheduling of the monitoring sessions was also included. The solar panels will ask the user for the date for the next monitoring session and prepare for it. However, there is still a chance that the users get some monitoring information outside of the scheduled day, although it is up to the solar panel's willingness to do so and it may set some terms that needs to be fulfilled.

Household dynamic.
To even out the distribution of monitoring interaction within the household and creating an inclusive household dynamic, the idea of having different household members monitoring on different days was also developed. This function requires another household member to monitor for a certain period of time, such as a week or a day, to guarantee that the ability of monitoring is not overtaken by only one household member. However, the other members should also not be forced to monitor because of the requirement, therefore, the household members can also decline to monitor.

Conflict.
To create more challenges, highlight the existence of solar panels, and emphasize a more transactional relationship between the panels and users, the ability of conflicts arising was included. The conflict occurs in the form of complaints from the solar panels (or the user) if they do not get along. For example, it can be based on the frequency of monitoring. If the user does not show up according to the schedule or continuously asks for additional information outside of the schedule, the panel will complain. If the

problem is not solved, it might escalate to the panel deciding to 'divorce' from the user over time. From the user's perspective, if a conflict arises which cannot be solved, they can submit an application to eventually unmatch with the panel.

6.2.2 Overview

The development of the concept was aided by creating a user flow diagram of the panel booking system (figure 15) showing the different points of interaction between the solar panel system and the user.

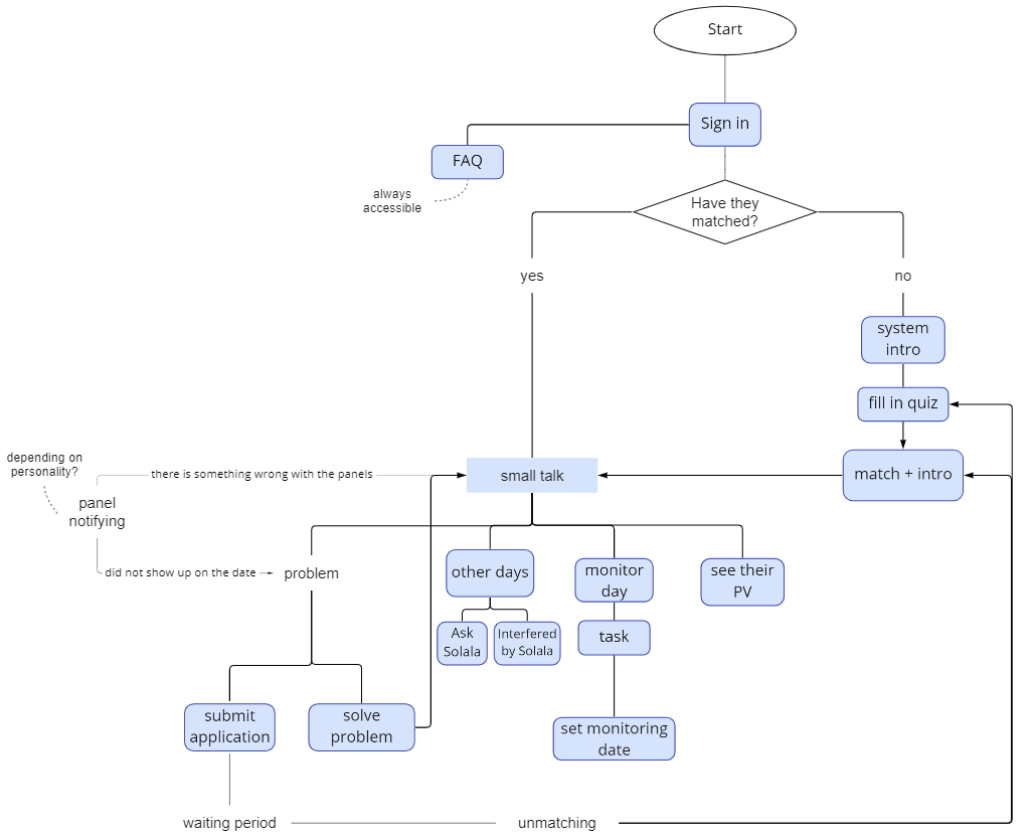


Figure15. user flow diagram of the panel booking system

Other than the three themes of communication with panels: matching, monitoring, and problem-solving, a new theme was added at the end: visual communication. The idea was to bring the user closer to the artifact that they booked. Therefore, the ability of the users seeing an image of the solar panel is added as a new function. The users would be able to see their panel through live footage that the booking system is connected to.

6.3 User Test

The following sections explains the structure of the user test in more detail. The results are then presented.

6.3.1 User test structure

To examine the work result of the concept development, a scenario-based digital user test was planned and conducted. This evaluation displays the challenges of living with

solar panels by selecting four scenarios that could represent the most challenging part of the concept in a serial experience. Concerning choosing scenarios, a list of goals to achieve was discussed and settled as below.

- connect with everyday life
- provoke reflection
- challenge the monitoring habit
- present the solar panel's personality

The idea of having a personality within the solar panel booking system requires the system to react to the user's replies. In this concept, to help participants better understand the process of the system, the interaction was achieved through a chat conversation with a couple of pre-prepared replies that the users could choose from.

To avoid bias from the participants, the norm-related background information of the concept was not disclosed. In the advertisement, the user test plan was illustrated in three sections: initiation, interaction, and closure. The concept was presented as a futuristic solar panel booking system similar to the laundry booking system in apartment buildings. The user test background presented was for the participants to experience living with solar panels booked from this system during a one-week trial. The test was realized by a low-fidelity prototype created in Figma, in the form of a chat-based interaction. To show a complete experience with possible emotional fluctuation as possible, a couple of scenarios were designed with the challenges and functions blended into them.

The three sections were planned as below:

- Section 1 - Initiation
  - Explain the process of the test, the background of the concept, and hand over the materials: instruction and question sheet.
  - Go through the panel matching scenario with the users (figure 16).
  In the scenario, users will take a quiz with three multiple choice questions about their personality, household composition, and opinion toward solar panels (figure 17). Based on the result, they get allocated with a solar panel personality. To reduce the variables in this test, all the participants were arranged with the same personality – Solala, who will set up a date as the monitoring day.

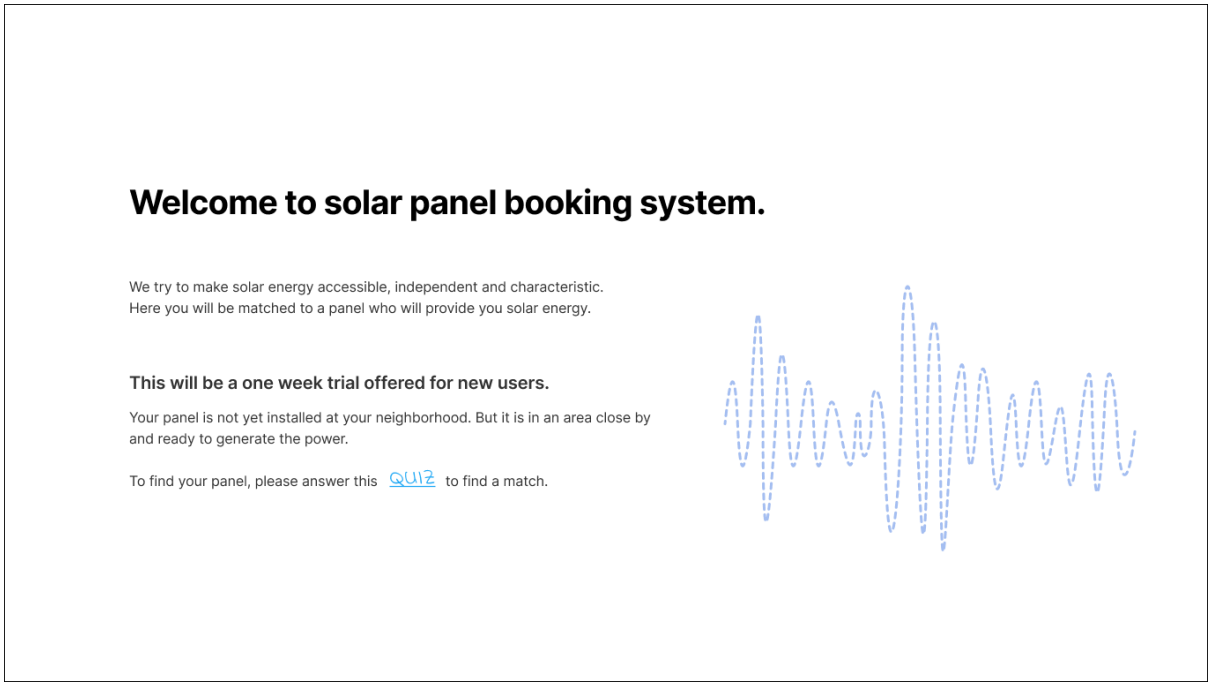


Figure 16. First page of the interaction

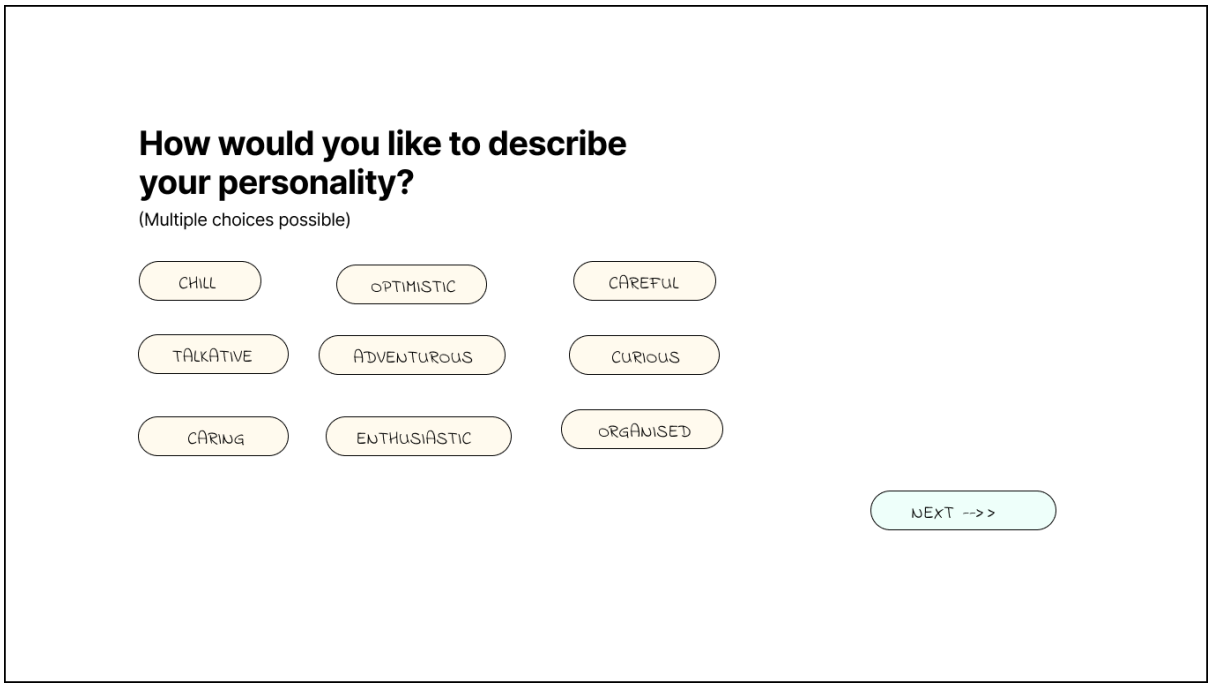


Figure 17. One of the quiz-questions

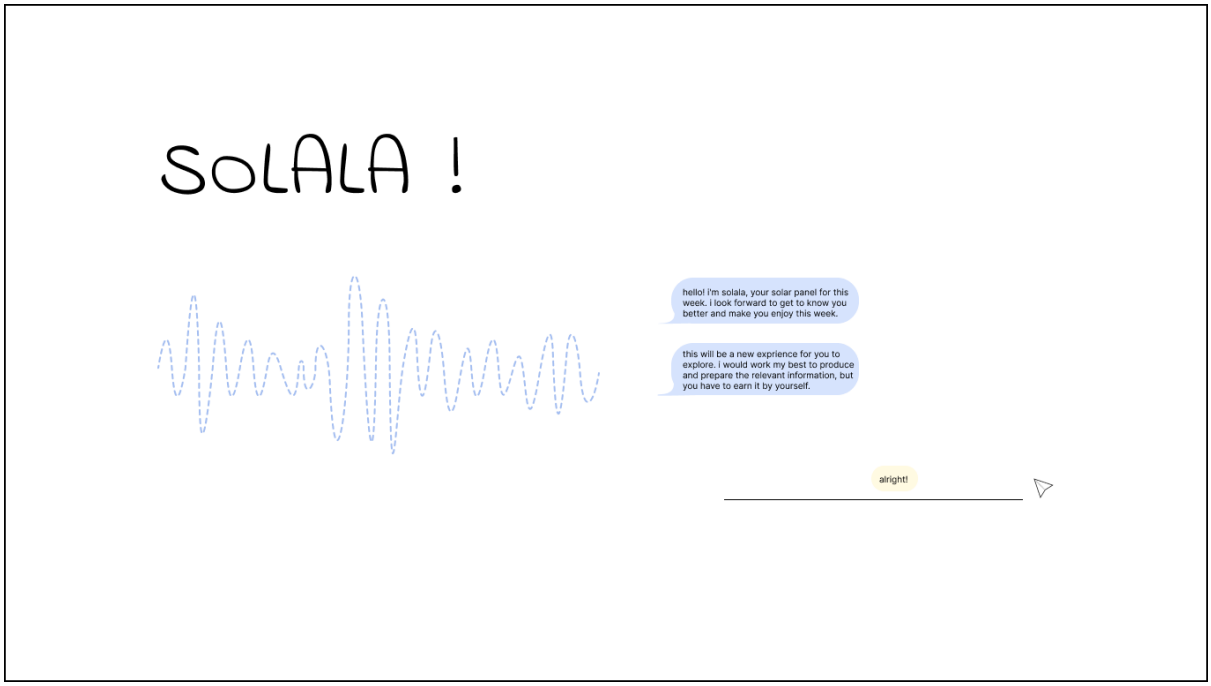


Figure 18. First messages in the chat

- Section 2- Interaction
  This section offers three scenarios of living with solar panels

  Scenario 1- Monitoring day.
  As scheduled, on the monitor day, Solala offers three cards with monitoring information, but the participant can only choose one of them. The chosen card will then be flipped over, giving them access to a piece of monitoring information.

  Scenario 2 - Attempted behavior steering
  Solala bet on the participant's solar energy usage and lost to a neighbor. In this scenario, Solala will tell the participant that the bet was lost, and that the product from the whole day will be given away to the neighbor who is doing "better", which refers to using more electricity during the time when their solar panels are still working. Solala goes silent after explanation.

  Scenario 3 - Last message with condition for final monitoring
  Solala decides to offer the participant a chance to know more information about the production of their solar panels, but there are conditions. The participant has to ask another person to help them. The original idea in the concept was to encourage the user to invite a household member, but in the user test, this was broadened to inviting anyone. This choice was made in order to make it easier for the users to participate. If they decline asking a friend, they can also pay one kWh of electricity to Solala in exchange for the information. The participants can also refuse this deal. As this is the last interaction, Solala will then offer a selfie as a souvenir.

- Section 3 - Closure

Participants were interviewed shortly regarding their understanding, interaction, and reflection about the concept. At the later part of the user test, the norm-creative aspect was disclosed.

Above all, in light of a concept which challenges the physical and financial barrier of using solar energy, this plan makes it unpredictable and uncomfortable for participants to interact with. Additionally, the aim was to inspire comprehension and reflection from this user test.

6.3.2 User test results

The purpose of the user test was to receive feedback from reflective activities within the concept to support iteration. The prototype was therefore made similar to how the final concept was imagined to be. Since there were challenging elements incorporated within it, the user test also came to show some similarities to using a provotype, which is an exaggerated and provocative prototype that triggers discussion (Boer, Laurens & Donovan, Jared 2012). However, since the aim of the user test was to obtain reactions to a realistically prototyped concept, provotype as a method was not implicated.

None of the participants had experience with residential solar panel systems although they all expressed having an interest in it. Reasons for not installing it were for example inability to install panels at the residence, whereupon a booking system was of interest for the participant.

The quiz from section 1 revealed that all the participants lived in a household with at least one other member, and they all viewed solar panels as an investment and regarded it as interesting. For the most part, participants share a personality as optimistic, enthusiastic, and talkative according to themselves.

From the first matching, the participants found the prototype easy to use. They also found it to be unlike anything they had seen before, especially when the full intent of the concept and its norm-creative aspect was not disclosed. The participants were asked if they had any expectations prior to the first interaction, however, they did not know what to express.

During the second section, the participants got to interact with the system through the three scenarios. For the monitoring scenario, the majority expected to receive more information. They also found it confusing as to why they had to choose only one card. “I probably expected more detailed information.” one participant wrote. Some also mentioned that the information was not relatable, “I’m not even sure what it means that a solar panel “has worked” for a certain amount of time.”.

The second scenario was not appreciated by the participants. They expressed dissatisfaction with the unpleasant feeling of being controlled by having their energy being betted on. “ If it had related to real money, I might have felt that it’s a bit too unreliable for me to invest in” one participant explained. Another participant wished for the system to suggest how it could be solved. “I would have also liked to receive some quantitative info - like you are using half of the energy in comparison with them or maybe a recommendation on how to fix that.”

The final scenario, where the participants were encouraged to get a friend to monitor, received fewer negative reactions than the previous scenario. Although the participants did not express enjoying it. Some described the interaction as greedy and needy, others found it impractical by being hard to understand. A few of the participants also did not know that the link presented by Solala was a functional link that they could share with their friends. Furthermore, one of the friends did not interact with the system due to failing to either receive or understand the information. Adjusting the challenge was therefore necessary.

At the end of the weekly trial, the final meeting with the participants was held to know more about their opinions on this concept. To start with, incorporating a personality into the system was perceived as a possible way to reach another target group. However, the participants themselves did not see it as a necessity to have a personality if they would acquire solar panels. The functionality was more important for them. Additionally, some indicated that it makes a difference if the service with personality was paid for or a free service. They explained that having a free service could lead to a higher tolerance of the personality's behavior. Meanwhile paying for a service would mean an expectation that the system is reliable and that it functions as expected.

Secondly, the interaction was not integrated well enough. Participants said that the information received during monitoring was difficult to comprehend and do something with. "I got to know what is produced but I can't relate to the info. It would be much helpful to say something along the lines like 'it is enough to power your laundry machine for 3 hours", one participant wrote after the first scenario. Although the purpose was to challenge the users, the lack of information, in this case, could work against new users that need more time to understand and adapt to the system.

An interesting finding was that although none of the participants had solar panels, they all wished for more detailed and quantitative information when monitoring. This could hint at them having similar monitoring behavior as current solar panel users. This could also imply a risk of over-monitoring. One participant also highlighted that living in an apartment can mean less possibility to control some parts of the energy consumption. Since the major consumption, such as heating, could be set up the same in the whole building and they use a public laundry machine. Meanwhile, for a house owner, there is a possibility to have more influence on energy consumption.

7.

FINAL ITERATIVE DESIGN

This chapter presents the final design solution that corresponds to the feedback from user test results.

After discussion and interactive concept development, the final design was settled. The target user group and scenario of the concept were not changed, nor did the concept of a booking system. The service is still accessible through a website. However, the ability to book the panels through a physical monitor in the apartment building was also included, similarly to current laundry booking systems (figure 19). The physical monitor could be beneficial from the perspective of being accessible and having the ability to attract additional users.

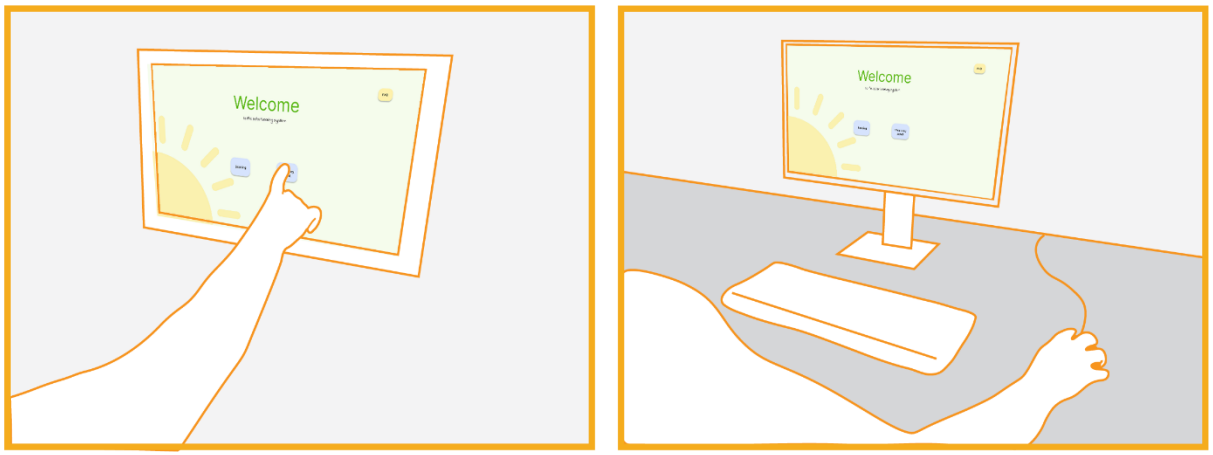


Figure 19. The booking system through the public monitor and as a website

From the user test result, it was intriguing that the new potential users showed the same demand as current residential solar panel users in Sweden. Thus the functions and behavior of users were reflected upon and the concept was iterated by reorganizing the interaction. The user flow for the final solution can be seen in the figure below. The solution is meant to highlight the norms of living with solar panels by reversing them and showing the users an alternative way of living with solar panels. Over time, by interacting with the panel, the users can reflect and find the way they want to live with solar panels.

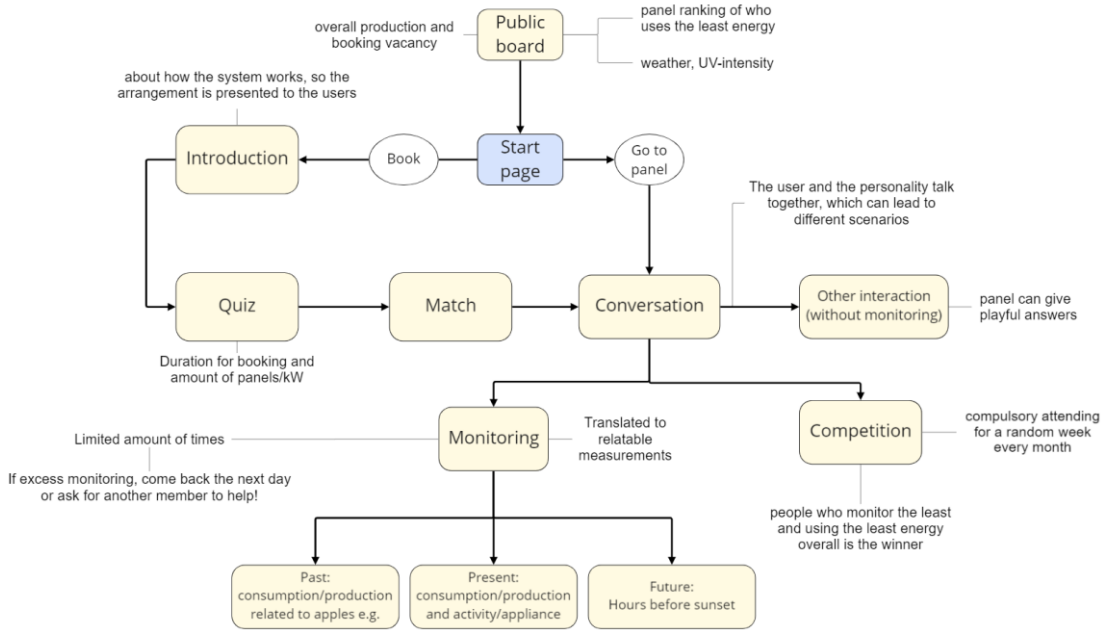


Figure 20. User flow of the improved concept

The improvements that have been made to the final solution are presented through the main elements of the system: public board, introduction, matching, conversation, monitoring and competition. The public board is a new feature, while the introduction and matching have been further developed from the previous concept. The three pages: matching, monitoring and competition are remade and updated from the scenarios in the previous concept.

Public board

To create an interactive dynamic for the users, emphasize the existence of solar panels, and attract potential users, a new page was added to the concept. This page works as a public board in the entrance floor of the building.

The interface (figure 21) works as a wallpaper and through one click on the screen, users will be led to the booking system.

Figure 21. Public board

The public board contains information as follows:

- Ranking of users: the one who is using the least energy will be ranked as number one, and the name of the user's panel will be displayed alongside it instead of the user's name. This prevents personal information from being disclosed. With the public board, a family heading out could shut down all their appliances in the house, get downstairs, and notice their panel being listed as the first position in the board.
- The booking situation of the whole building: shows the vacancy of the solar panel plant and the people who booked the panels.
- Information: weather and UV-intensity is displayed. This information brings the solar panel to the personal daily life and connects the daily behavior with the board. For example, users seeing the UV-intensity might be reminded to use sunscreen or the weather can remind them to bring an umbrella.

Introduction
From the user test result, a need to improve the introduction of the system was revealed. The introduction page was therefore defined (figure 22). In the final concept, this system introduces and explains how the booking system works by showing the booking journey with three parts. It displays to the users that by going through the quiz, matching and then having conversation with the panel personality, they will be able to book solar panels and interact with them.

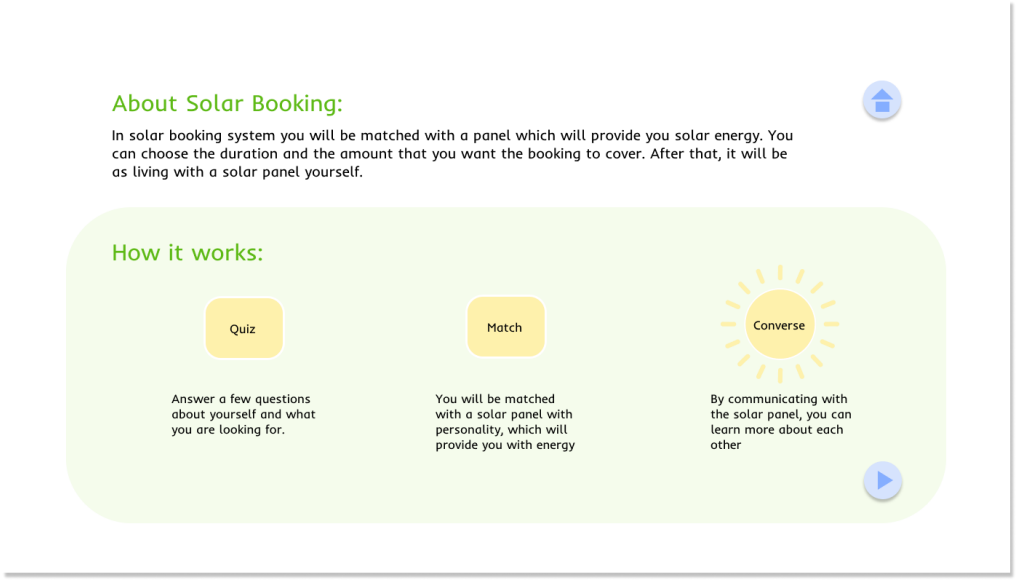


Figure 22. Format for the introduction page

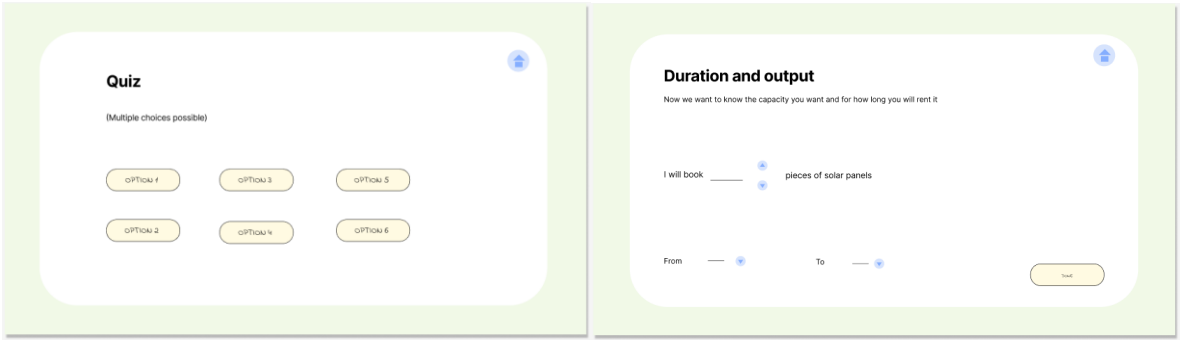
Matching:
The matching function is still based on the quiz result, but the appearance of the interface was updated to keep the consistency with the other pages (figure 23).

Figure 23. Format for the matching page

The quiz (figure 24, a) is the same as in the user test and will still begin with personal questions, which reverses the norm that users always question the panels by giving the solar panel the opportunity to ask the users. In the final design, the quiz will end with a

page where users can select the time and the amount of panels they want to book (figure 24, b).

Concerning the customized personality and the various users it will interact with, the personality related data needs to be handled once the user stops booking. Thus there are several models of basic personality, which will be allocated based on the answer of the quiz and grows based on the conversation it has with the users. Once the booking is ended, the data will be cleared, unless the user extends their booking.



(a) (b)

Figure 24. Format for the quiz

Conversation

The personality of the solar panel is dependent on the quiz and will be conveyed through the conversation (figure 25). It is through conversation that the user can access information. Access to monitoring information if one example of an outcome of the conversation, but there is a possibility to interact beyond that as well. However, to avoid unnecessary subjects from being brought up, the conversation is limited to being related to solar energy. Upon being asked a question, the personality can give a playful reply.

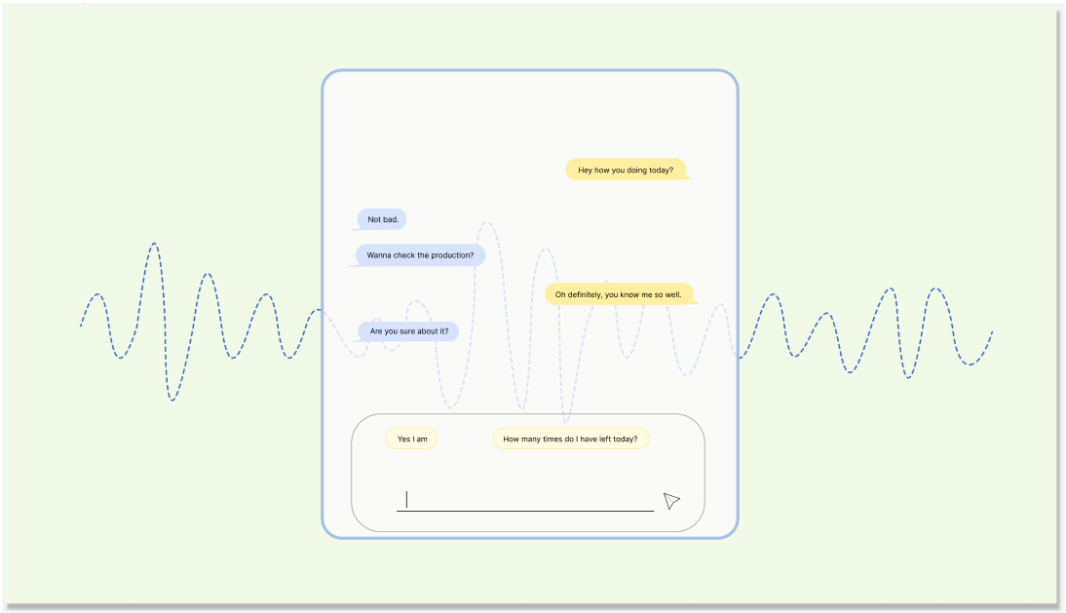


Figure 25. Format for the conversation

Monitoring
The monitoring function was redesigned with a new way of presenting information regarding the solar panel production, highlighting its connection to users' everyday life. Aiming to reverse the norm of unbalanced household monitoring dynamic and over-monitoring, rules of the monitoring frequency within the household are also specified.

Compared to the previous concept, there is no longer a schedule that has to be set beforehand for the monitoring. However, the monitoring frequency does have its limitations. To balance the household dynamic related to monitoring, each household member has a limited number of times that they can monitor each week. If they monitor more than the given time in a day, their solar panel will tell them to come back the next day or that the user asks another family member to join the monitoring.

What is kept from the previous concept is that the monitoring is presented through three cards containing different pieces of information. However, all of them are available to the user during the monitoring session. In contrast to the previous concept, all the information on the cards is translated into more relatable information, without the typical measurements, such as kWh. A larger group of users has therefore the ability to understand the information presented. Additionally, this has the potential to help with raising the energy awareness and enabling the users to steer their consumption.

The three cards are presented in relation to time, meaning that they showcase the production and consumption relationship to the past, present and future (figure 26). This is to provoke the reflection from users to understand the reasoning of the content.

Figure 26. Monitoring and the various measurements

The monitoring information from the past expresses what has been produced as well as consumed in the recent week. The energy production and consumption will be translated to other relatable concepts in daily life. For example, the amount of apples that are needed to be digested in order to reach the equal amount of energy, which provides a new perspective as well as it increases awareness of the energy.

The monitoring information from the present hits at the current capability of the solar panel production related to activity. For example, that the solar panel is producing enough energy to supply the washing machine. It will also relate the current consumption in relation to the activity. For example, that the current consumption equals using two washing machines.

The monitoring information for the future indicates the time that is left for the solar energy to be produced. This is conveyed through displaying the amount of hours left until sunset, which can help the users relate the information to their electricity consumption plan in the near future.

Competition

Instead of the personality betting on the energy consumption, the challenge between users in different households was designed as a competition (figure 27). Its function is to convey the recommended lifestyle of not monitoring obsessively and aimlessly. During the analysis of users' behaviors, living with solar panels was rather easygoing. Additionally, frequent monitoring was not required and did not correspond to being good at utilizing more solar energy. Users were shown to barely try to steer their consumption to maximize their saving, even with sufficient data and frequent monitoring, since it was too troublesome to steer. The competition can therefore help users reflect on their monitoring behavior as well as their energy consumption.

Figure 27. Competition-page

This competition is designed as a compulsory activity that lasts for one random week each month, with a reward and a corresponding, yet gentle, punishment. The norm-related aim is to highlight the presence of solar panels, add playfulness and a challenging aspect. More importantly, to provoke reflection around their own way of living with solar panels.

The premise of the competition is that the participant who monitors the least while also consuming the least electricity in total wins. The winner will get one hour's production from each of the other competitors. This can be encouraging for the winners, while the punishment is a gentle consequence that can still cause some attention. Additionally, the competition is started at random, meaning a variation of users and energy consumption patterns that the participants will go against. There is therefore another intriguing and unpredictable element to the competition.

Apart from the competition encouraging less electricity consumption and attempting to prevent over-monitoring, it will also weaken the isolated feeling solar panel users can experience. Instead, the competition can give an opening to socialize.

The participants can follow the competition by visiting the competition-page. There, a game board will be displayed showing the number of competitors, the rank, their overall monitoring time, and overall energy consumption. However, checking the page frequently is regarded as monitoring, which can affect the ranking.

7.1 Connection to previous findings

As a way of connecting the final design to the previous findings, a new journey map was made for the concept (Figure 28). Compared to the previous customer journey map, the new one is simplified and shortened. The journey map starts with the user being curious about the solar booking system, which can have multiple entry points. Apart from having an interest in solar panels, the users can have additional motivations such as having an interest in the personality or that the system is accessible to the extent that they are interested in trying it out. The concept therefore lowers the threshold for users while attracting a broader group of users.

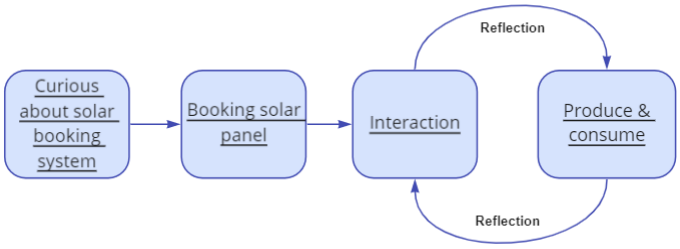
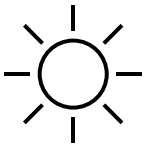


Figure 28. User journey map of the final concept

The distinction between users and customers was also diminished due to the process of acquiring solar panels being reduced. The user no longer has to undergo a lengthy process of reviewing offers from companies or installation. It can also contribute to less of a contrast within the household that can come from having some household members being very active in the acquisition of solar panels, where others are more passive users.

Additionally, the concept incorporates more reflective aspects since the user and the solar panel personality has to communicate with each other. The users therefore have to consider what to bring up in the conversation and they also have to interpret and reflect on the personalities' responses.

The target group for the concept could include potential users of all ages which brings more inclusiveness and more possibility into the design result. Interestingly, by eliminating the financial barrier of solar panels while also adapting the information in the system, the flexibility and accessibility made it possible for the features to be attractive. In terms of the persona, the booking system could be particularly fitting for the third persona, who lacks awareness of solar panels as well as the current means to install them.



8.

DISCUSSION

The following section presents the findings and their implications.

8.1 Final Results

The aim was to explore the relationship between solar panels and its stakeholders as well as how norm-creativity can be applied in this setting. During the research and user data collection, solar panels were found to have impacts through system monitoring, which related to many aspects such as family dynamic and control. Furthermore, living with panels had a positive influence on its users by being described as a good investment and an easy service. In addition to this leading to personal satisfaction, it also influenced how the topic was presented while socializing. Solar panels therefore also had an impact on social relationships. Rather than advertisements, life with solar panels was impacted by peer effect.

The findings show significance through presenting areas that can be addressed to encourage more people to become users. It also suggests areas that can be observed in order to move towards a more socially sustainable direction.

As the main interaction with solar panels, monitoring has appeared to be a significant part of the post-purchase process. Oftentimes as an interaction originating from economical aspects, through the monthly electricity bill. Monitoring impacts the norms within the household by creating a dynamic with uneven monitor distribution. It also establishes norms in how people interact with their system and knowledge that is expected from their users. By reasoning these impacts, the focus of user study and concept design was naturally anchored and unfolded to address monitoring.

The finding of monitoring being the main interaction, can point at the importance of considering how the activity is currently presented to the users. Especially with consideration to providing little value and a risk to be done excessively. Additionally, it can also be of interest to consider other ways of interacting with the solar panel system, to include a larger variety of users and increase the interest for solar panels.

Applying norm creativity in relation to solar panels could address various aspects of the post-purchase process. Among all the possibilities, the concept was planned in the long run for people who live in apartment buildings in the future. Which further was supported by the emergence of policies in Europe to accelerate the implementation of solar energy. One of the measures being to require new residential buildings to have solar panels installed e.g. (The European Commission, 2022). To challenge the norms of living with solar panels, the final concept was designed as a booking system without technical information where solar panels are endowed with personalities.

The findings present the potential and possibility to use norm-creativity in new settings, more specifically in relation to solar panels. Meanwhile, the solution also reveals the current monitoring frequency and dynamic within the households with solar panels. Allowing for an interaction that can be reflected upon and redesigned in a more socially sustainable way.

There are some limitations within this project which have an impact on the results and their generalizability. To start with, the participants recruited through the project might not be representative enough of everyday life with solar panels since they volunteered to participate out of interest in solar panels. Other stakeholders and people that have

never considered nor have any knowledge of solar panels could have also provided valuable insights.

Another limitation is the execution of the user test, which could have been done more extensively. The opinion of the participants can therefore have been impacted by their short interaction, lack of information about the concept or them not experiencing any economic repercussions.

The results have also been limited by a lack of consideration in the apartment household. Since the orientation was shifted from the findings, the target group the concept was designed for are different from the target of user study. In one of the user test closure interviews, it was mentioned that there is not much electricity control available in their apartment buildings. Again, the single feedback cannot represent the whole group, however, it is a reminder that there could be more thorough consideration in the concept development.

Finally, the findings can be related to environmental and ethical aspects. One phase of the customer journey was the end-of-life. Without proper handling, the waste from solar panels can harm the environment and threaten to be an apparent problem to handle in the future (Chowdhury, 2020, Daniela-Abigail et al.,2021). The concept can contribute to a wider spread of solar panels, which can increase the amount of waste. The end-of-life should therefore be of attention and handled properly.

Also, some studies have found a solar rebound effect, where users of solar panels increase their electricity usage following the installation (Qui et al., 2019, Beppler et al., 2021). The developed concept relates to this by not encouraging exchanging their grid electricity usage to solar energy. For example, through the competition in the booking system, the users are persuaded to decrease their energy consumption. The full extent of the consequence of this concept can however be further analyzed and considered.

8.2 A Provocative Approach

Following a norm-creative approach does not have a specific framework, which can complicate the design process. Formulating a criteria list for the solution was for example difficult as it may limit the norms that can be addressed or reinforce other norms that might not be preferred. Applying a norm-creative approach in industry settings can therefore become an obstacle.

Norm-creativity also posed unexpected and recurring challenges in finding a balance between being challenging and practical. To truly challenge the norms can be to find a solution that is more provocative. However, this can be less implementable. It can also cause discomfort to designers since it can go against the nature of finding solutions that pleases the users. Navigating the design process can also be difficult since it includes constantly questioning oneself and the direction of the solution.

Norm-creativity does however have great potential. There are strengths in highlighting norms, which can become lost in traditional design processes. For example it was possible to identify over-monitoring as a common behavior. To not challenge the norms could have been to provide even more information to the users. However, by taking a

norm-creative approach, it was encouraged to question whether it was the right direction to head towards or if there was an alternative.

Additionally, attention can be drawn towards the difference between a bad user experience and a challenging one. In this context, an example of a suboptimal user experience could be the first prototype of the concept since it to some extent lacked consistency and enough information to be understood. The final design had improved consistency in the information flow and connection between different functions, which can facilitate for the challenging aspect to take more space. The approach taken was therefore from an angle of reversing the norm while giving the users freedom to create their own way of living with solar panels. In the final design, it was realized that the challenge does not have to be achieved by sacrificing consistency. Rather, challenges can be addressed by twisting the interaction and information in an unpredictable way with playfulness.

Despite the difficulty in navigating between challenge and practicality or challenge and a bad experience, norm-creativity can find a middle ground. Examples found in NOVA (Alves et al., 2016) presents a large variety of norm-creative innovations, which have varying degrees of provocation. There is therefore a possibility to find a balance depending on the purpose of the particular design solution.

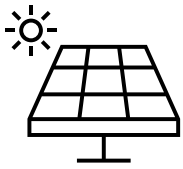
8.3 Future Implications

The findings have several implications for future research. The presented design solution is on a conceptual level, a future implication is therefore to further iterate on the concept with consideration to a broader variety of aspects, such as opinions from other potential users. With the newly updated policy in Europe that encourages apartment owners' access to solar energy, the concept is on a promising path towards contributing to future solutions. As the base of building a feasible concept for apartment building usage of solar panels, the concept offers a great reflection and critical thinking to build upon.

It is also possible to further explore certain aspects of the concepts. For example, the monitoring solution in the concept could be incorporated into current monitoring solutions for house owners with solar panels. Additionally, the customer journey map presents different phases, and some are yet to be explored. There is therefore a possibility to challenge even more aspects of living with solar panels.

Another part of this concept that can be developed is the gameplay design within the interaction. The mechanisms and feedback loop could be explored based on both solar panel products and the addition of more provoking elements. One interesting starting point is the consequence of the competition within the concept. The arrangement of the competition encourages minimum electricity consumption, but the one who achieved this would get more energy as a bonus. What this would lead to and how competitors perceive and are influenced by it could be intriguing to explore. The panel character with personality could also be developed enhanced with sound effects to build up more playfulness and attributes of communication. As for the monitoring and household dynamic, there are many aspects that could be built on such as the information chain offered from panels to different household members. Panels could cross feed the

information, then household members would need to exchange information, which leads to conversation and more possibilities. With the novelty of gamifying solar energy, this direction could have great potential to be developed.



9.

CONCLUSION

Solar panels have an influence on everyday life, especially during the post-purchase process, meaning after they have been installed. There are several stakeholders involved in the process, where the users are one of the most prevalent ones. The impact that solar panels have on the users include changes in their behavior, such as increased monitoring, and social interactions, such as them promoting the lifestyle to others. There were also aspects related to the household dynamic that were identified, since there was an uneven interest and interaction with the solar panel system within the household.

The project has also showcased the possibility to incorporate norm-creativity into a life with solar panels. After identifying norms from the collected data and undergoing an iterative design process, the final conceptual design was composed by reversing norms with balanced unpredictability, playfulness, and connection to daily life. Although the developed concept touches upon several norms, findings and earlier explored ideas present additional aspects that can be explored as well.

Following a norm-creative approach presented challenges throughout the design process and required a dedicated exploration of the user group as well as empathy and self-reflection in order to address it in a suitable manner. However, the norm-creative approach also highlighted its strength in addressing important aspects that can easily be overlooked and the possibility of finding unexpected solutions.

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Appendix

Appendix 1 - Questionnaire (English)

Everyday Life with Solar Panels

Hello!

We are two master students studying Industrial Design Engineering at Chalmers University of Technology. This survey is used for our ongoing master thesis about what it is like to live with solar panels and how more users can be included. We would ask you for a couple of minutes to answer some questions. It would be of great help for our thesis.

We respect your kindness to help and your privacy. The answers are anonymous and cannot be connected to you unless you decide to leave your email in the end. By the time the master thesis is completed, this survey will be deleted.

Thank you for your time!

Kind regards,
Jinhong and Yodit

*Obligatorisk

1. Age *

Markera endast en oval.

- ◯ 20 - 30
- ◯ 31 - 40
- ◯ 41 - 50
- ◯ 51 - 60
- ◯ 61 - 70
- ◯ 71 +

2. Gender *

Markera endast en oval.

- ◯ Male
- ◯ Female
- ◯ Prefer not to say
- ◯ Övrigt: _____

3. How many people are there in your household? *

Markera endast en oval.

- ◯ 1 - 2
- ◯ 3 - 5
- ◯ 6 and more

4. How long have you been living with solar panels installed? *

Markera endast en oval.

- ◯ Less than 6 months
- ◯ 6 - 12 months
- ◯ 1 - 3 years
- ◯ 3 years or more

5. What was your role in acquiring the solar panels? *

Markera endast en oval.

- ◯ I was the most active in the process
- ◯ Other members of my household were the most actively involved
- ◯ I was equally involved in the process as other household members
- ◯ I moved in to a house with existing solar panels
- ◯ Övrigt: _____

Installed Solar Panels

6. What is your reason for having solar panels? (You can choose more than one reason) *

Markera alla som gäller.

- [ ] It is sustainable and good for the environment
- [ ] I think the technology involved is interesting
- [ ] To earn or save money
- [ ] I like the independence from the conventional electrical grid
- [ ] Someone told me about it
- [ ] Övrigt: _____

7. Do you keep track of the electricity production? *

Markera endast en oval.

- ◯ Yes, I do.
- ◯ Yes, but someone else in the household does it
- ◯ No, I do not.

8. If yes. how frequently do you monitor the electricity production and why?

_____

_____

_____

_____

_____

9. How are you informed about your electricity production? (You can choose more than one alternative) *

Markera alla som gäller.

- [ ] Mobile application
- [ ] Website
- [ ] Screen attached to the solar panels
- [ ] Email
- [ ] Mail
- [ ] Övrigt: _____

10. How has your electricity consumption changed after living with solar panels? *

Markera endast en oval.

- ◯ Increased a lot
- ◯ Increased slightly
- ◯ Remained the same
- ◯ Decreased slightly
- ◯ Decreased a lot

11. If your electricity consumption changed. what do you think is the reason?

12. Have you bought other products/services as a result of having solar panels?

13. Has your lifestyle changed after living with solar panels?

14. Have you ever contacted the solar panel provider after living with solar panels? *

Markera endast en oval.

- ◯ Yes
- ◯ No

15. If yes. what was the reason that you contacted the solar panel provider?

16. What is the best part of living with solar panels? *

17. What is the worst part of living with solar panels? *

18. What about solar panels would you like to improve? *

19. What would you tell a friend that was thinking of getting solar panels? *

20. Do you think solar panels are for everyone?

21. Thank you for answering the survey! We would love to have a following interview where we can get better insight into the everyday life with solar panels. If you are interested in participating. please leave your email address below and we will contact you with more information. You are not obligated to participate further in the research if you leave us your email. We wish you lots of sunshine!

Appendix. 2 - Interview Questions (English)

Thank you for participating in our interview. Today we will ask you a couple of questions about living with solar panels.

We would love to record the audio of this interview so we can transcribe it later. But we will not share it with other people and we will delete it at the end of our thesis. Would that be okay?

Appropriation

- How long have you had your solar panels?
- What was the most important factor that made you decide to install solar panels? Were there any difficulties? Did something worry you? Is there something you dislike about having them?
- Did you have any contact with the solar panel company?
- For how long did you think about solar panels before installing them?
- Where did you find the information you needed? (About the system)
- When you just finished the installation, how was it to use or understand how the solar system works? How did having it installed make you feel? Did you have to get used to it/what did you do?
    - Did you have any expectations? Were they fulfilled?

Objectification

- Where are the panels located?
- How do you monitor the production? Which platform are you using?

Incorporation

- How frequently do you check the information?
- When do you check it? Is it usually before some activity? What are the other situations?
- (What do you do with the information? How does it make you feel?)
- Are there any other people in your household that checks the information?

(If they have other people in their household)

- *How frequently will he/ she check? Why do they think it's like that?*
- *Do the other members know as much about the solar panels? How do they feel about it?*

- Is there any other interaction between you and the solar panels?
- Do you have to do any maintenance?
- Has your electricity consumption changed after getting solar panels? Why? Is it as expected?
- Do the solar panels generate enough electricity for all your needs?
- What do you do with your excess electricity?
    - Do you sell it or use batteries to store excess electricity?

- Do you care about the financial return of your system? If so, have you done anything to maximize your savings?
- Do you feel you have all the knowledge you need about the solar panels installed at your place? Why? Do you think you have made full use of your system?
    - If so, how long did it take? If not, why?
- Did you learn something new about electricity (?) after installation? (Changed their identity)
- As we have understood it, the panels produce the most during the day, but that might be the time when you don't need or are not able to use the electricity, how do you balance that? Do you consider it a waste?
- Do you know how much electricity you need for different products in your home?

Conversion

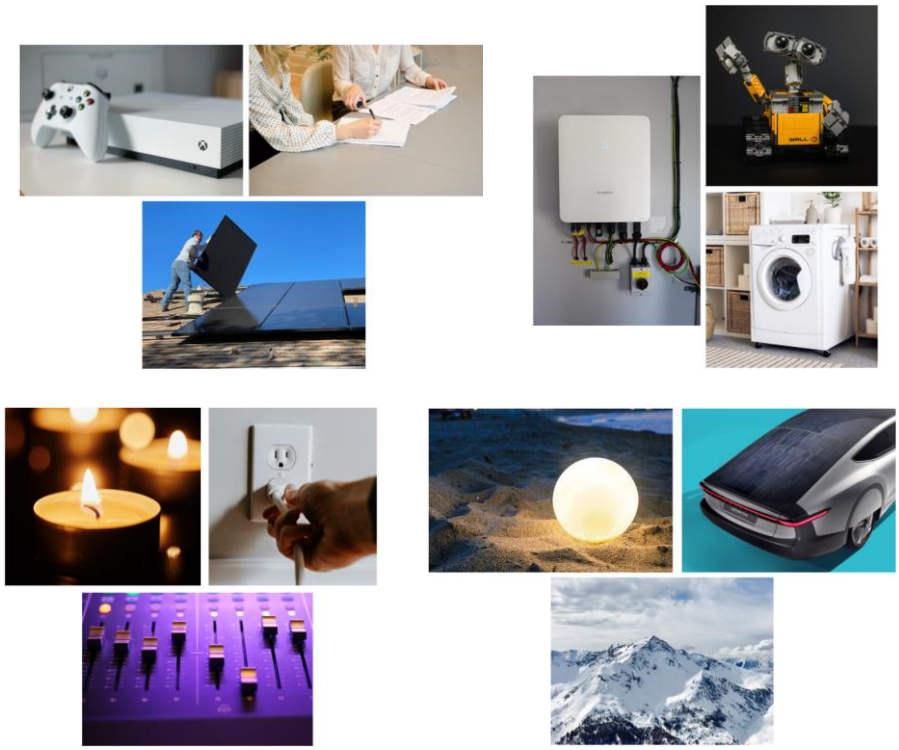
- Do you talk about solar panels with others (family, friends, neighbors, co-workers)? For what reason? What has been their reaction? Why? (Do they also have solar panels?)
- How can people become more interested in solar panels? Is something stopping them?

Wish and motivation

- What are the differences between using solar panels compared to the grid? (Other than economical aspect) (Usability/experience/ flexibility/autonomy)
    - How does it feel to produce your own electricity?
- Have you changed your perspective on something after you installed solar panels? (like care about environmental knowledge/activities more?)
- Any other differences about yourself after living with solar panels? why?
- Before you moved into the house with solar panels, did you ever think about installing it yourself? Why/why not?
- Now that you have experienced life with solar panels, would you still choose a house with solar panels if given another chance?
- What do you wish your solar system/ app could do? What else could they help with in the future?
- What do you think it would be in 20 years?

Repertory Grid Inspired activity

- As a final part of the interview, we would like to show you a couple of pictures.
  We are just interested in knowing your reflections and we think having some pictures can make it easier. But there is no right or wrong answer and we don't have anything we expect.
  We are going to show you a group of pictures and you get to decide if two of them have something in common, and why?
    - Which two pictures have something in common and why?
    - How is the third picture in comparison to the other two?



Ending

- We are planning to design some solutions during our thesis and we would love your opinion on it. You can of course say no if it doesn't suit you. But are we allowed to contact you with more information about future user tests?

Appendix 3 - Interview questions (Swedish)

Tack för att du deltar i vår intervju. Vi kommer att ställa dig frågor kring hur det är att leva med solpaneler.

Jag skulle uppskatta om jag fick lov att spela in ljudet, så att vi kan transkribera det senare. Vi kommer inte dela inspelning med någon annan och den kommer att raderas när vi är klara med vårt examensarbete. Går det bra?

Appropriation

- Hur länge har du haft solpaneler?
- Vad var den viktigaste faktorn som fick dig att besluta dig för solceller? Fanns det några svårigheter? Fanns det något som du oroade dig?
- Hur länge tänkte du på solceller innan du installerade dem?
- Var fann du den informationen du behövde? (om systemet)
- När installationen var färdig, hur var det att använda och förstå hur solcells systemet fungerade? Hur kändes det att ha det installerat? Behövde du vänja dig vid det? Vad gjorde du?
    - Hade du några förväntningar? Var de uppfyllda?

Objectification

- Var finns panelerna placerade?
- Hur håller du koll på produktionen (t.ex. mängden el)? Vilken plattform använder du? (app?)

Incorporation

- Har du fler personer i hushållet - vem brukar se över produktionen? Har de andra hushållsmedlemmarna tillgång till information om produktionen? (Om inte, hur bestämde ni vem som får informationen?)
- Hur ofta kollar du på informationen?
- När brukar du kolla på informationen? Är det vanligtvis före en viss aktivitet? Vad är de andra situationerna?
- Vad gör du med informationen? Hur får informationen dig att kännas?

Om de har andra personer i hushållet

- *Hur ofta kollar han/hon på informationen? Varför tror de att det är så?*
- Vet de andra hushålls medlemmarna lika mycket om solceller? Hur känner du kring det?

- Behöver du göra något underhåll på solcellerna?
- Har din elkonsumtion ändrats efter du installerade solceller? Varför? Är det som förväntat?
- Vad brukar du göra med överskotts elektriciteten?
    - Säljer du det eller använder du batterier för att lagra överskottet?

- Bryr du dig om den ekonomiska lönsamheten av ditt system? I så fall, har du gjort något för att öka mängden du sparar/tjänar?
- Känner du att du har all kunskap du behöver om solcellerna du har installerat? Varför? Tycker du att du att du tar full användning av ditt system?
    - I så fall, hur lång tid tog det? Om inte, varför?
- Har du lärt dig något nytt om elektricitet efter installationen?
- Som vi har förstått det producerar panelerna som mest under dagen, men det kan vara en tid då du inte behöver eller har möjligheten att använda elektricitet, hur gör du för att balansera det?
- Vet du om hur mycket elektricitet du behöver till olika produkter i hemmet?

Conversion

- Pratar du om solceller med andra personer (familj, vänner, grannar, arbetskamrater)? Vad är anledningen? Vad har deras reaktion varit? Varför? (Har de också solceller?)
- Hur kan folk bli mer intresserade av solpaneler? Finns det något som stoppar dem?

Wish and motivation

- Vad är skillnaden mellan solceller jämfört med det vanliga elektriska nätverket? (utöver den ekonomiska aspekten)
  (Användarvänlighet/upplevelse/flexibilitet/självständighet)
    - Hur känns det att producera sin egen elektricitet?
- Har du ändrat perspektiv på något efter att du installerade solcellerna? (bryr du dig mer om miljön t.ex.?)
- Finns det några andra skillnader kring dig själv efter att du har börjat leva med solceller? Varför?
- (Tror du att andra personer ser dig på ett annorlunda sätt efter att du installerade solpaneler?)
- Vad önskar du att ditt solcellssystem eller app kunde göra? Vilka andra saker kan de hjälpa till med i framtiden?
- Hur tror du att det kommer vara om 20 år?

Repertory grid inspirerad aktivitet

Som en avslutande del av intervjun så skulle jag vilja visa dig ett par bilder. Det kommer vara en grupp bilder och du får bestämma om två av de har något gemensamt. Du kan välja flera olika kombinationer. Och det finns inget rätt eller fel svar, utan vi vill bara veta din tolkning och tanken är att bilder kan bidra till intressanta reflektioner.

Vilka två bilder har något gemensamt och varför?
Hur tycker du att den tredje bilden står i förhållande till de andra två?

Avlsut
Vår plan är att designa någon lösning… får vi lov att kontakta dig längre fram för…

Appendix 4 - The PMI method

	Concept 1	Concept 2	Concept 3
Plus	Challenge the norm: -Panels represents huge investment -Panel ownership is fixed with the living space (limited interaction) -Reverse the situation where people are to judge of panels -Panels means technology with knowledge to learn and hard to understand -The data demand must be satisfied anytime	-Challenge the monitoring behavior in a new format -Socialize the monitoring behavior outside and within the household -Less technical info & less obsession with numbers -More intuitive feedback that doesn't require previous knowledge or learning technical terms -Reduces overall screen time for the users -Can be used by people with visual impairment -Encourages certain behavior by unlocking achievements -Educates about how the electricity flows in the house -Portable and movable -Decoration: the functions and the product itself are decorative -Can be functional in the wintertime	-makes the panels come alive and allows a way to interact with it -Offers give some emotional support/happiness -Invites more household members -Present physical product and interaction
	Creates new norm: flexible solar energy supply -Unpredictability: panels have full freewill of what and when to work on, and who to work for. -Accessibility: panels can be connected whenever there is a supply by anyone -Business driven industry: balanced demand and supply created by the accessibility and digitalized service -Customized lease: panels can be rented for 1 day or 20 years -No need to know and engage in the installation from the users' side -Panels are service instead of a sloppy payback investment		
Minus	-A business idea might not be a critical design idea -Future situations with widespread panels might need more considerate discussion (about how to challenge a common and accessible product?) -The fun will gradually lose its novelty and become boring or annoying -Need a baseline to balance the profit of panels and difficulty of experience. -Might be really difficult to use for elderly users. -Not adapted to people with visual impairment -Need to design something for the winter, maybe.	-Users might be bored with it and stop monitoring over time -Relies on monitoring interested users	-Questionable feasibility -The regulation of inverters might be against redesigning the physical appearance of it. -Position of the inverter is limited -This concept doesn't have much functionality

Interesting	-Creates new potential to interaction: -Solar park is a instabox to expect -Panels can be decorated -Social interaction with a virtual character, reimagining panels as a communicable species. -This concept could be translated back to house owners and create new services. -Potential to include kids in the household. -The panel can demand the whole family to join and stir the dynamic.	Can be developed into another shape or form of monitoring with foundation in the same idea - e.g. the artwork monitoring Can be displayed to visitors of the house e.g. friends, etc.	-Can connect neighbor's pet -The pet can be portable -Winter function and interaction are uncertain