DESIGNING FOR TRANSPARENT INTENTIONS IN AI POWERED ENERGY SYSTEMS

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MSc Design for Interaction
Master thesis report

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EXECUTIVE SUMMARY

This master thesis explores the domain of energy consumption at households through the lens of multi-intentionality. The project proposes a digital system that can help capture user intentions and communicate system intention in order to create transparency and trust in the system.

Chapter 1 explores the domain of energy to understand the technical aspects involved in the context like the functioning of smart meters, smart grids and how data is processed and used in these systems.

Chapter 2 involves literature review on the concept of interactive machine intelligence, and designing for intelligent systems. This sets a foundation and even some intital design directions to consider in the design phase.

Chapter 3 dissects multi-intentionality by using 'intentions' as a unit of analysis and explores three perspectives of interpreting intentions. Later, multi-intentionality is introduced in the domain of energy use and the intentionality gap is identified.

Chapter 4 constitutes narrowing down the research focus, identifying and defining the five intention profiles and framing the research questions to be explored in the design phase.

Chapter 5 covers a brief exploration of the features that other companies provide through their digital systems to users.

Chapter 6 involves performing user research to understand real life experiences of users with their energy provider. In addition to this, interviews with experts were conducted to get further insights on AI in energy, interactive machine intelligence and values.

Chapter 7 takes up a major part of the thesis. It contains all the design iterations performed along with the conclusions and decisions made for the design that leads upto to the final design recommendations of Chapter 8. The design through research methodology was followed to explore the concept of multi-intentionality and how it will be perceived by end users. Chapter 8 also discusses how the intentionality gap is addressed.

Chapter 9 concludes the thesis by revisiting the concept of mult-intentionality with the insights gathered through out the journey of the thesis research.

The thesis makes multi-intentionality more concrete and creates a means of communicating or presenting the required information to users to improve transparency and trust in complex digital systems. Presenting tradeoffs and negotiating with the system along with transparent representation of what the systems learns about the user, strong data visualisations and explainable recommendatios become a core part of solving for intentionality gaps.

ABSTRACT

The development of intelligent systems has created enormous opportunities to improve and change human lives. These systems are heavily reliant and driven by data and algorithms to achieve optimal user experiences for myriad users. However, these data-driven products/services are multi-dimensional and multifaceted and do not necessarily have the same meaning and value to all its users. Different users may have different intentions of use for the system. Each user could also define different goals that may want to achieve using the system. Additionally, what goals the organization have for the users might not align with what the end users want for themselves. These differences in intentions are called as multi-intentionality.

In such scenarios, traditional design enforces the idea of simplifying interfaces that frame or dictate certain intentions of use for people. But this can be considered a sensitive issue because the end-users are unaware of these other potentially conflicting intentions. This creates an increase in tension between intelligent systems and the needs of end-users but also a sense of mistrust. Hence, there is a need to create a sense of legibility to the users on the behavior of these systems and the other intentions of use in order to enable trust.

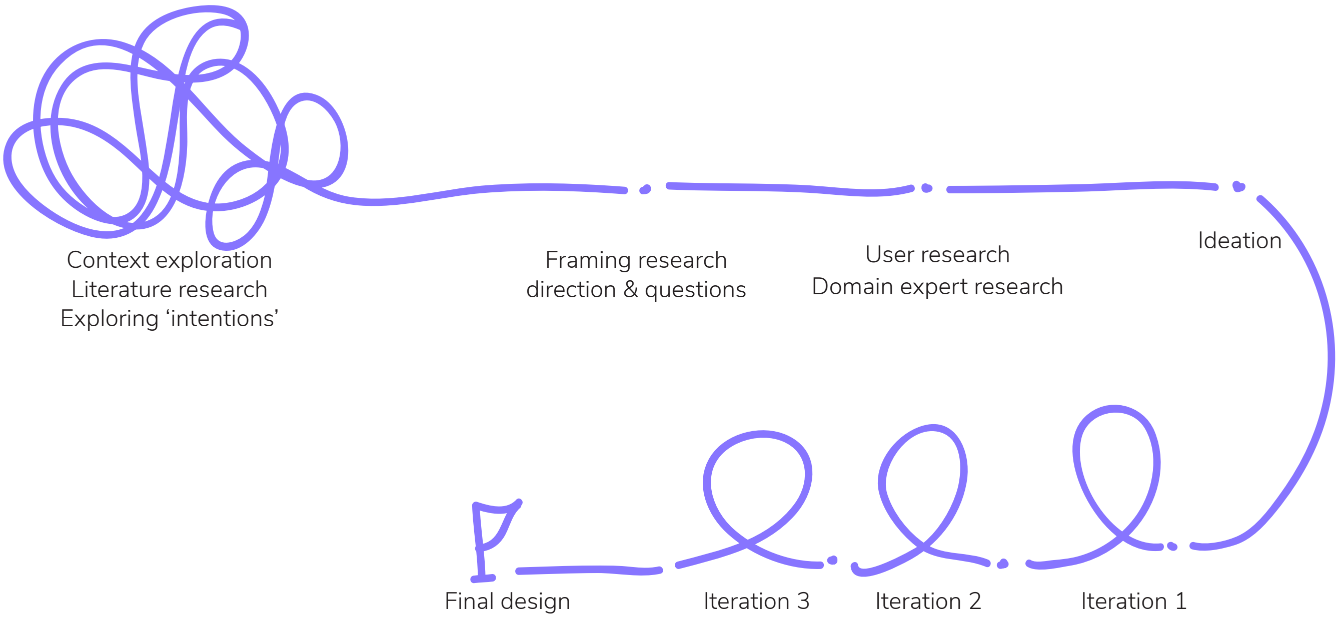
In this project, a way to help users sustainably consume energy is explored through the lens of multi-intentionality. The main aim of the research is to explore the meaning of intentions and multi-intentionality in the given context. Following this, the goal becomes to concretely represent the multi-intentionality into something more tangible for the users and applicable to the real world context.

The initial research resulted in identifying intention profiles for users, the intentionality gap and the need to capture intentions that is required in order to bring more legibility and transparency to a system that the user might interact with. Through multiple iterations, a digital interface is created, that through various communication data, data visualistaions and recommendation designs try to bridge the gap of intentionality between the two stakeholders (user and energy provider).
By capturing intentions, portraying the tradeoffs of user choices , showcasing their energy use, presenting their energy profile with respect to their goals, designing transparent recommendations, an effective proposal to bridge the gap between intentions is made. The designs were made with concrete thinking on how it could be applied to a real world problem and were validated through tests with users.

PROJECT CONTEXT AND DESIGN PROCESS

This project is in association with Deus (http://deus.ai)" and the "Connected Everyday Lab (CEL)" at TUDelft.
Deus is a company/design organization that focuses on human(ity) centered AI. They study and build AI services that will have a beneficial impact on future. They try to combine data, design, and artificial intelligence to ethically and efficiently tackle difficult challenges.
CEL (Connected Everyday Lab) research group is focused on researching and designing thoughtful interventions for modern complex technologies that are increasingly becoming interconnected.
Deus supported the project by providing a client to apply the problem and solution to. This helped ground the problem statement in a real-world context and additionally provide a sound business perspective to the project. The energy provider Vattenfall acts as the context for the application of multi-intentionality in the project.

The project follows a RtD research methodolgy. RtD stands for Research through Design methodolgy in which the design activties play a crucial role in the generation of knowledge. These design activities could involve any activity such as understanding a complex context, reframing a problem or iteratively developing prototypes (Stappers and Giaccardi, 2017). In this project, since multi-intentionality is a new and unexplored concept, RtD was the appropriate methodology to follow to help explore it. Here, prototypes in the form of digital interfaces are used as a means to explore the interpretation and presentation of multi-intentionality.
The image below shows a rough structure of the process followed throughout the project.



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01

UNDERSTANDING ENERGY DATA

This section sets the context of project by introducing the domain of energy and energy data. It also reviews some of the issues that come with maintaining energy data.

1.1 Introduction

The Netherlands, albeit historically popular for its windmills, has been quite slow at adopting renewable sources of energy. A large proportion of its energy production is still fueled by traditional fossil fuels like natural gas and coal. In 2018, the Netherlands produced 7.4% of its energy from renewables which grew to 8.6% in 2019. This is low in comparison to other EU countries, and a long way from reaching the goal of 14% share of renewable sources by the end of 2020.

According to the 2019 Climate Act, the Netherlands has set targets to reduce GHG (Green House Gas) emissions by 49% by 2030 and 95% by 2050 (versus 1990 levels). To address these challenges, the government is focusing on digitalized energy systems that enable more variable renewable generation and innovative new energy services. A new Energy Law is planned for 2022 that focuses on supporting demand-side response, energy aggregators, and services. This also means creating flexible and efficient energy systems. In order to facilitate this, the Netherlands has aimed to have 80% of households have a smart meter installed in their homes by the end of 2020. By 2018, about 1 million households had already installed a smart meter allowed energy providers to better manage electricity consumption. Moreover, with the increase in EVs (Electric Vehicles), further research is being done to understand how smart charging can limit the impact of EVs on the grid (IEA, n.d.-a).

1.2 Smart grids

A smart grid or a smart electrical/power grid is a power grid that uses a two-way flow of electricity and information to automate and distribute energy through a network. As opposed to traditional power grids that carry power from a few central generators to a large number of customers, smart grids act in a more adaptive, responsive, distributed and efficient way to deliver power in a reliant manner.

For example, a smart grid may automatically recover from a transformer failure event by redirecting power flow to recover power delivery. (Fang et al., 2011). Image 1 and 2 shares some of the differences between a traditional grid and smart grid.

Existing Grid	Smart Grid
Electromechanical	Digital
One-way communication	Two-way communication
Centralized generation	Distributed generation
Few sensors	Sensors throughout
Manual monitoring	Self-monitoring
Manual restoration	Self-healing
Failures and blackouts	Adaptive and islanding
Limited control	Pervasive control
Few customer choices	Many customer choices

Image 1: Comparison of a traditional grid vs smart grid (Fang et al., 2011)

Significant advantages of smart grids include: (Wikipedia contributors, 2021a,b)

Reliability: The smart grid makes use of state estimation to improve fault detection and to allow self-healing of the network by rerouting power through the grid.

Bi-directional energy flows: Smart grids allow for more distributed generation of power which can happen through contribution from PV panels on buildings/houses or even from EV(Electric Vehicles) and other sources.

Efficiency: Smart grids are better equipped to handle load adjustment and balancing to inform consumers about their consumption patterns to make demand more uniform but also storing more energy

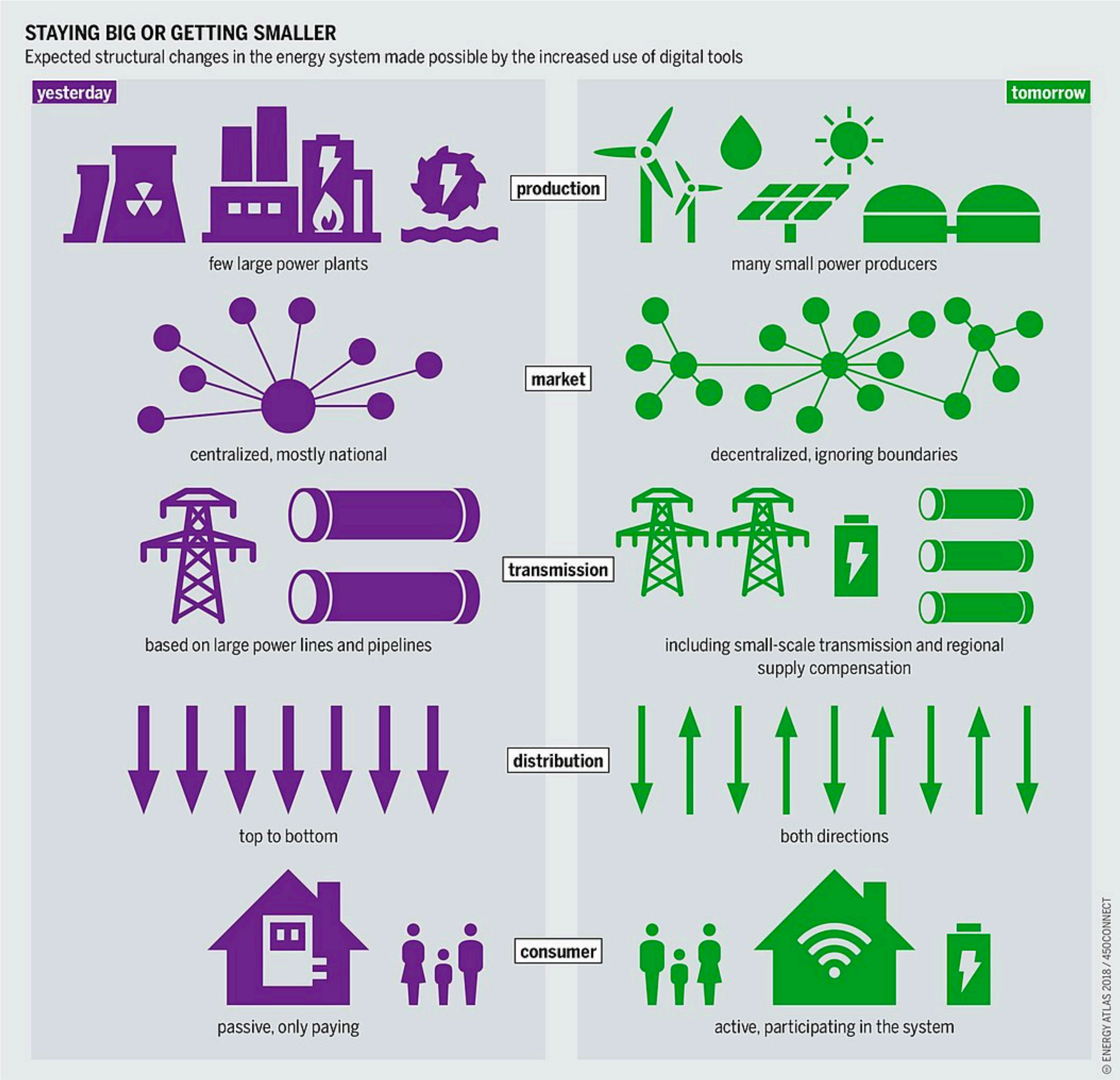

Image 2: Pictorial representation of what a smart grid could achieve (Bartz Stockmar)

during off peak hours to supply during high peak hours.

Dynamic pricing: To motivate people to cut back on use perform peak leveling, prices of electricity can be dynamically varied to be higher during high peak hours and lower during low demand hours.
Enabling sustainability: The flexibility of smart grids allows the integration of highly variable renewable energy sources such as solar power and wind power.

Demand response: Smart grids can enable demand response ie. allow information to be relayed to customers so that they can adjust their use facilitating adjustments in demand for power instead of adjusting the supply. This may include postponing certain activities in a day or switching to their on-site solar panels and batteries.

1.3 Smart meters

A vital component of smart power grids is the smart metering infrastructure. Smart metering is used to obtain information about the appliances and devices used by end users. The goal is to automatically collect and transfer diagnostic, consumption and status data to a central database for billing, troubleshooting and analyses of energy use.(Fang et al., 2011) In general , a smart meter is an electronic device that collects real time data like the voltage levels, current and power factor. Image 3 shows an example of a smart metering structure.

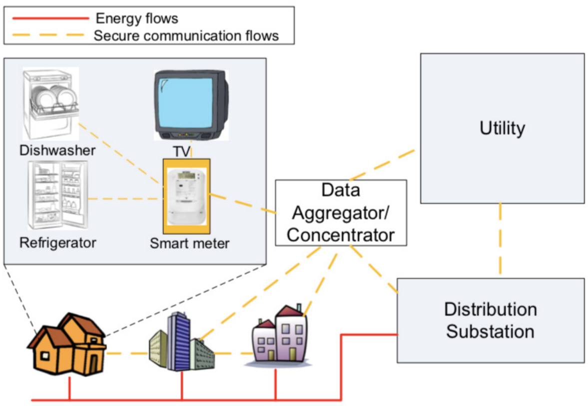

Image 3: An example of how data flows from a home through a smart meter to an energy aggregator/provider.(Fang et al., 2011)

Smart meters can communicate back to the consumers with real time data and insights into energy use to empower a more sustainable use of energy. Image 4 shows an example of a smart meter and an in-home display that communicates information to the customers. The same data is used by data aggregators (commonly called energy providers) to understand energy consumption patterns so that they can better understand the energy needs and predict the amount of energy they will have to buy from the energy markets.

Smart meters are likely to become a norm in every household in the Netherlands by the end of 2020. The Dutch government had planned to roll out 15 million smart gas and electricity meters as part of a national plan (Smart Energy International, 2014).

Image 4: A model of a smart meter (above) and in-home display

1.4 Digitalization of energy

Digital technologies will promote the growth and an increased number of connected, intelligent, efficient and sustainable devices/appliances that can help contribute to energy systems. This is also largely supported by the growing power and the use of data in data analytic and artificial intelligence. Everyday objects like home appliances, cars, smart wearables are connected to intelligent communication networks and provide a range of services like home automation, intelligent transport, personalised healthcare etc. The future anticipates digitalized energy systems, where it will be possible to identify who needs how much energy, at what time and where, at the lowest cost possible. Digitalization is already creating positive waves in being able to provide energy in a safer, more productive and sustainable and most importantly in an accessible way (IEA, n.d.-b)

The expected contribution of digitalizing energy is that it will help improve the responsiveness of energy services by using more sensors at home, allowing the prediction of user behavior, so that services (eg. heating and cooling) can also be automated more easily with learning algorithms. This allows new practices for managing peak loads through behavioural changes, such as asking users to carry out EV charging during non-peak hours, and shedding loads by for instance optimising temperature settings to reduce energy demand during certain times. Digital data and analytics can benefit customers in monitoring their energy behavior, reducing their energy bills and making more sustainable energy choices. For energy providers or aggregators, predicting and monitoring real time energy data can help them identify and predict downtimes, maintenance times or better optimization of energy load.

Digitalization will also blur the distinction between consumption and generation through 4 main factors:

1. smart demand response
2. integration of variable energy sources
3. implementation of smart charging for EVs
4. small-scale electricity resources like household solar PVs(photovoltaics)

However, digitalization often comes with the two most obvious dilemmas like new security policies and privacy risks. To continue progress and support of energy consumption through the grid, it becomes essential to develop a clear approach to how data ownership is maintained in this sector. This includes being able to access the essential data required for optimization without compromising on concerns like privacy and cybersecurity.

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1.5 Security and privacy of energy data

Privacy , security and data ownership plays a big role in the movement towards safe digitalisation of technology. As the granularity and the variety of data collected from various resources like connected devices and smart energy meters continue to grow, it becomes easier to predict every day user activities and behaviors at home. The smaller the measurement intervals of the meter readings the more detailed information is revealed about the various energy behaviors exhibited in the house. For instance, a 15-minute interval smart meter can read and make a lot of conclusions about a household and its members. Some of the data that an aggregator can understand from user data can be viewed in image 5.

Since power usage patterns derived from smart meters can reveal a lot about human behavioral patterns it could potentially be used to even identify individuals(Riemann, 2019). This implies power data being considered a part of personal data and the processing of such data should comply with the EU's General Data Protection Regulation (GDPR).

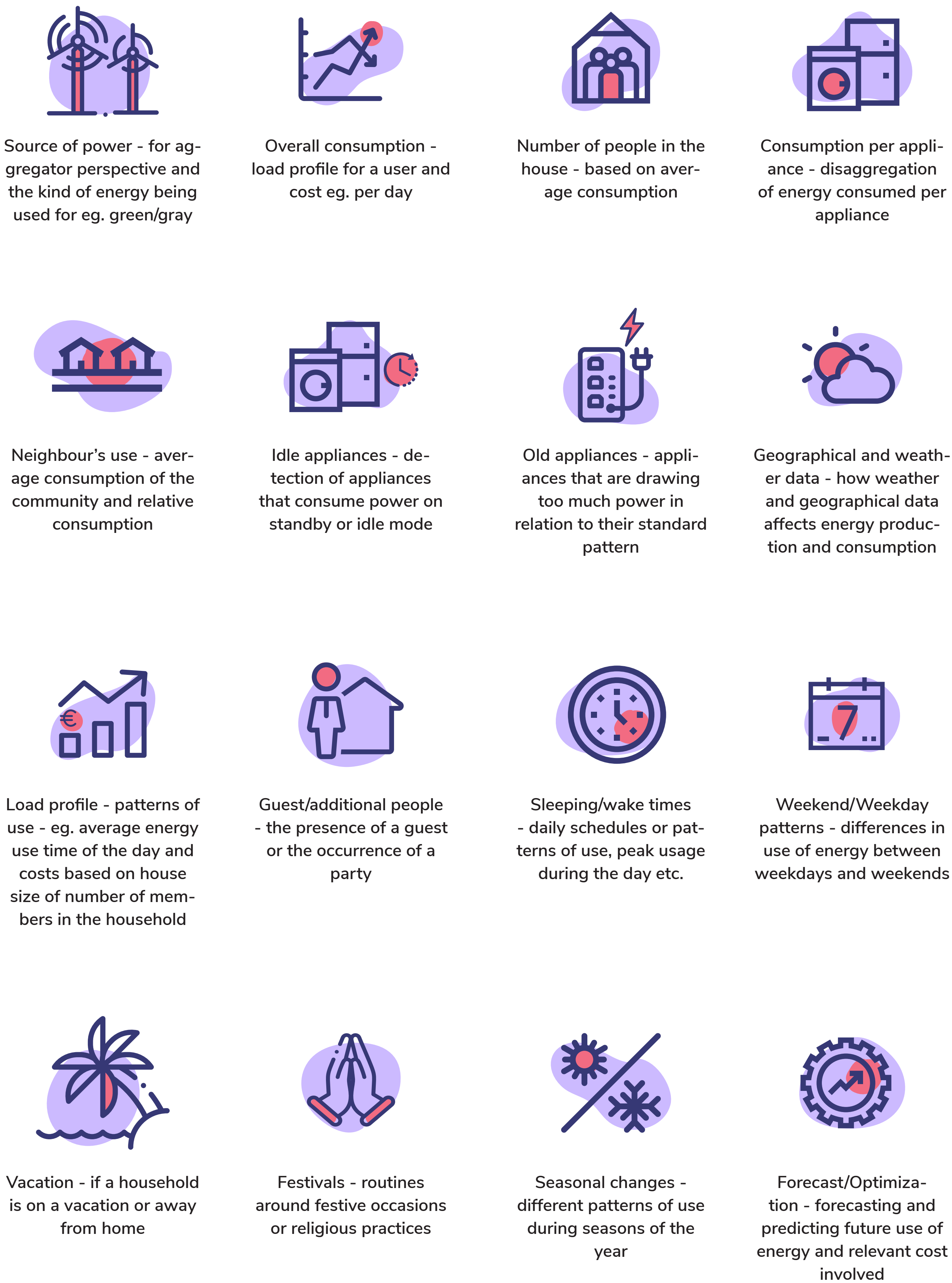


Image 5: Data that an aggregator can derive from smart meter readings

1.6 Control and Transparency of energy data

As mentioned, smart meters data gives rise to complex issues around data handling and the kind of processing performed on it. Most customers are unaware about the kind of data and the amount of patterns that can be learnt through energy meter data. Most importantly, customers are also unaware how the data is being used by the company and for what purposes. It therefore becomes imperative to inform users about the data is used, where it is used, how it benefits them and why they need to share/not share their data. Users should be provided with the knowledge of what risks are involved in sharing their data.With this awareness users can make informed decisions about how much energy data and how often they would want to share this data with their energy providers.

02

DESIGNING FOR INTERACTION WITH INTELLIGENT SYSTEMS

An essential part of designing for intelligent and connected systems is understanding how users would interact with these systems. This exploration was done to understand elements or aspects of design that needed to be considered for a better user experience and effect on behavior change. It also acted as a source of inspiration for the conceptualisation phase.

2.1 Rethinking eco-feedback systems

Pierce and Paulos (May, 2012) propose features or new alternate ways to make ECF (energy consumption feedback) more contextually relevant and useful for users. Displaying new and interesting forms of visualisation and datasets apart from their overall household consumption could contribute like source of power, critical peak loads on the grid, dynamic pricing information can be effective in communicating not just energy consumption but energy demand. The general notion of forcing consumers to reduce their consumption often is not sustainable, instead users need to be encouraged to shift their consumption behavior ie. move high demand activities like laundry to non-peak hours to reduce load on the grid. Possibly automatizing some of these activities through smart appliances by designing them to be responsive to the grid's needs is an interesting area of focus. This could also mean offering advice of better home improvements like an efficient hot water heater instead of curtailing hot water consumption and encouraging adoption of new technologies like PV (photovoltaic) panels. Another interesting option is to consider Geelen et al. 's (2013) recommendation for goal-driven interfaces than mere displays of energy consumption and production. This can enable users to make trade-offs and interact with smart energy systems (Geelen and Keyson, 2012) by encouraging them to achieve goals through necessary behavioral adaptations.

2.2 Accounting for the messy social lives

Snow at al. (2017, May) discussed the variability in social factors that come with interaction with systems like smart thermostats e.g Nest. Often intelligent systems require some form of input in the form of user engagement/interaction to learn their preferences and schedules. However, it might be difficult to get regular and unbiased engagement with users at all times. As highlighted by Strengers (2014), there is a tendency for designers to assume that every user will be a "Resource Man" ie. a technical, rational-minded and consistent consumer that would be willing to understand data and make informed choices about their energy consumption. But, often life is unpredictable and messy for people and it is essential to keep in mind how everyday life can influence use of such systems. This would mean designing systems that not just act as reminders but also clearly incentivise, provide reason for action and most importantly flexibility to adapt to the unpredictabilities of life. However, it is important to keep in mind that it is common to see a decline in interaction with eco feedback systems with time (Yang et al., 2014).

2.3 Interactive machine intelligence

2.3.1 The interactive machine learning process

In order to create a more bi-directional sense of human machine interaction, it is essential for users to have moments where they can give feedback to better learn their preferences. Interactive machine learning process (image 6) is a growing area of study where the machine learning algorithm is rapidly iterated in small increments (with a single update, the model does not alter dramatically) instead of large increments in periodic intervals. This allows users to analyze the impact of their actions in real time and adjust subsequent inputs to achieve desired results. Even users with little or no machine-learning knowledge can control machine-learning behaviors through low-cost trial and error inputs (Amershi et al.,2014). The most commonly applied form of such a process in the real world domain are recommender systems in Amazon (product recommendations), Netflix (movie

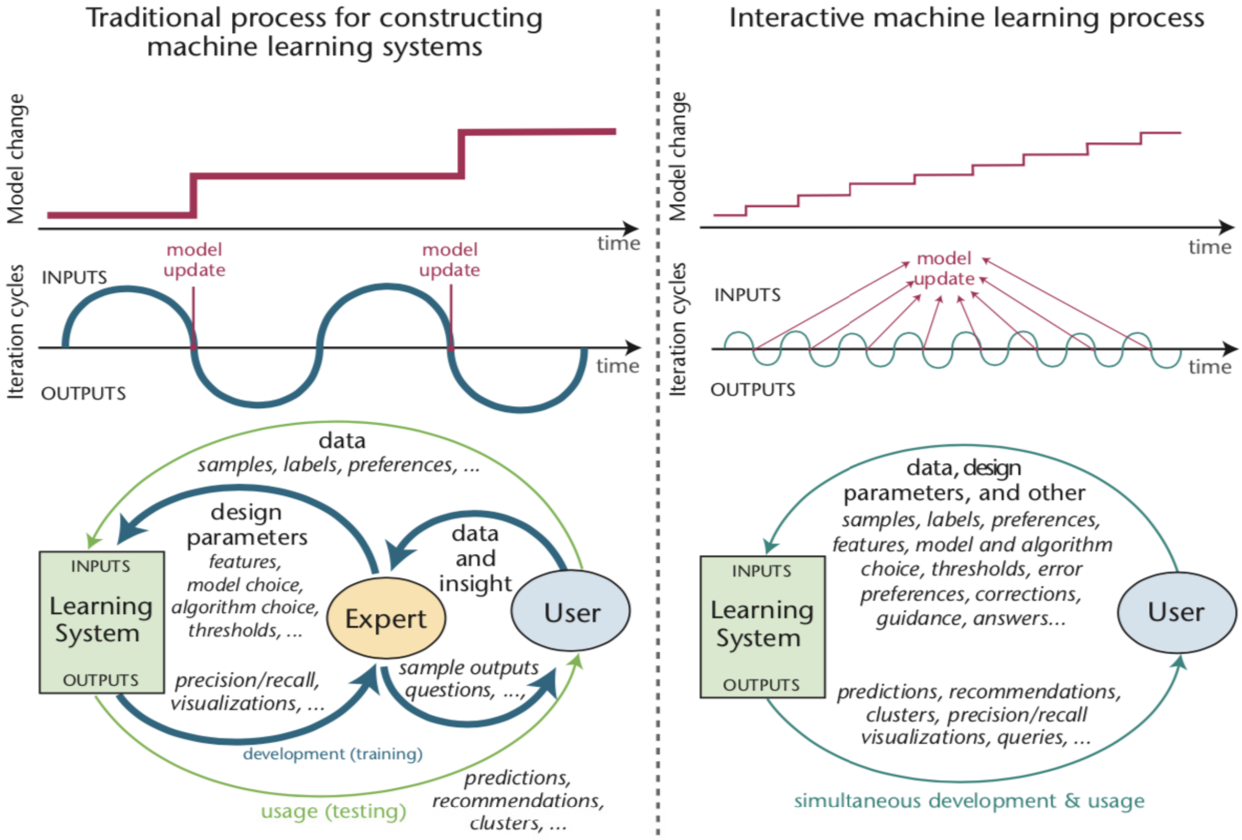


Image 6: Traditional Applied and Interactive Machine Learning. (Amershi et al.,2014)

recommendations) and Spotify (music recommendations). Users in such platforms are frequently questioned about their preferences for specific items (for instance, which they state by liking or disliking them), following which, these choices are quickly incorporated into the underlying learning system for future recommendations. This is an iterative process that happens again when the user might encounter an undesirable recommendation. Amershi et al. (2014) discusses through case studies the elements of interactive machine learning that need to be considered when designing for such systems.

2.3.2 How the feedback interaction could be

Cakmak et al. (2010), for instance discovered that a continuous stream of inquiries from a system during interaction could be perceived as annoying and a decline in the user's mental model of what the system has actually learned. This was also seen in Guillory and Bilmes's (2011) findings on Netflix recommendation systems where users dislike acting as oracles (repeatedly telling a system whether it is right or wrong) and experiential aspects of interaction like interruptibility and frustration need to be accounted for while incorporating active learning in such systems. There needs to be a sufficient balance of getting input vs learning while users are actively interacting/ engaging with a digital program. Moreover, people also want to provide feedback not just in binary formats (like yes/no, like/dislike, pick from existing options) but also in more open-ended formats. In Stumpf et al. 's (2017) study, when unrestricted by an interface, users would provide multiple ways to improve an algorithm, for example suggesting alternative features, adjusting the importance of weights given to certain features, changing the information extracted from texts, etc. This might imply a need to understand if allowing users to state their preferences (intenions) in a more open-ended feedback might be useful in helping the system learn very specific needs of the users.

2.3.3 Building transparency in intelligent systems

A very pertinent aspect of intelligent systems involves showing users how their machine learning systems work and users generally value a certain level of transparency for the same (Amershi et al., 2014). Adding contextual information and reducing uncertainty information (Rosenthal and Dey, 2010) to user input can help users give more accurate feedback to the system and are also better incentivised to do so because the information appears more relevant to the users. In addition to this, from a cost-benefit trade-off perspective, users are more willing to invest in being involved in complex tasks if they are perceived to benefit from them than the amount of effort put in (Blackwell, 2002).

According to research, traditional interfaces that support understandability and actionability are generally more usable than interfaces that do not support these principles (Amershi et al.,2014) and often interactive machine learning systems often violate many of those existing user interface design principles. As suggested by Norman (1994), trust and safety are the primary factors to keep in mind while designing intelligent systems. That would mean creating a good balance for users to contribute to the system by timing such suggestions, allowing direct control under uncertain situations and maintaining a log of recent interactions (Horvitz, 1999). Although, here it is important to note that users can often get bored or can show inconsistent task behavior with time or might not be as invested in expressing themselves as they initially did. It is also possible for the user's perception of a concept to shift with repeated interaction with the system. (Dudley and Kristensson, 2018).

2.3.4 Axies - an example of human-ai collaboration for value alignment

To expand on an example, a recent study done by Liscio et al. (2021) showcases how interactive machine intelligence through a platform was used to generate value alignment. It is commonly understood that values are abstract motivations that guide people's opinions and actions (Schwartz, 2012). So, they created "Axies", a methodology supported by a digital platform that requires human annotators to collaborate (perform high-level cognitive tasks). It uses natural language processing (NLP) to guide the annotation. In essence, Axies supports human annotators (who may not have expertise in AI) by AI in value identification. Since value identification is difficult, the platform employs an AI technique where annotators are provided with an opinion corpus composed of textual opinions that are value-laden for a specific context. The annotators are expected to annotate values based on their own opinions. The interface allows the annotators to add or delete values and their associated keywords at any moment. This example is an interesting case study for interactive machine learning especially in the context of something as subjective as values which is closely related to what drives intentions as well.

2.3.5 Capture intent

A more implicit way for the system to learn what the users want is suggested by Yang (2017, March), where the interface adapts with time (adaptive user interfaces) to improve interface navigation which can be supported as the machine learning algorithm accumulates traces of user data and make better predictions of what user intent might be. Dudley and Kristensson (2018) also suggested that the design of the interface may help extract intent from other input actions that the user provides. However, there is always an uncertainty in user intent vs user input which Fogarty et al. (2008, April) says algorithms can help identify or distinguish from the relevant inputs when there are only minor inconsistencies.

Another example of implicitly understanding user intent is often employed in social network platforms where if a user skips a certain recommended contact/profile it is deemed as a negative sample or undesirable contact. But in a more practical setting as in a smart home, most devices are still programmed on somewhat simplistic rules. As a result, a meaningful smart-home behavior is broken down and described in a series of fragmented simple rules related to various physical sensors and behaviors wherein the connection with the original intention is missing (Funk et al.,2018). Mennicken and Huang (2012, June) for instance identified that people have specific motivations when they install home automation systems, but also that people could have conflicting values or interests depending on the context, time and even members of a household. But, it is well recognized that it is not easy for smart-home systems to automatically understand the intentions of users (Norman, 2009). A possible way to resolve this is to explicitly include humans in the loop (Rogers,2006) and to also avoid leaving users in the dark about what the system knows about them, how the system knows and what it is doing about it (Bellotti and Edwards, 2001). This would also mean being able to facilitate active involvement of users by providing an appropriate interface where users can indicate their intentions (Rogers, 2006). This input can be used by intelligent systems to internally resolve conflicts and prioritise certain actions or settings that the user might want over others in certain contexts based on the intentions they had provided. Hence, explicitly capturing intentions can be useful for automated systems to make decisions on what trade-offs are suitable for the users (Funk et al.,2018).

03

MULTI-INTENTIONALITY AS A LENS

The primary focus of the project involves exploring the concept of multi-intentionality. This section tries to set the focus for the research by exploring the meaning of 'intentions' and identifying the gaps in intentions in the context of energy systems.

3.1 Conceptualizing multi-intentionality

The development of intelligent systems has created enormous opportunities to improve and change human lives. These systems are heavily reliant and driven by data and algorithms to achieve optimal user experiences for myriad users. Moreover, these technologies can often be considered as "fluid assemblages" (Redström and Wiltse , 2015). Such modern technological interventions often are considered fluid because of how their form and function can change with the way users interact/use them and also when introduced in different contexts (Wiltse, 2020). They can also be considered as assemblages as most data-driven systems are a complex network of several interconnected and diverse components that work independently and together to be presented with a certain stable identity(ies) or purpose(s) of use (Wiltse, 2020). Fluid assemblages continuously evolve/change when in use, customize themselves to different users and do not necessarily retain their initial form of release. Furthermore, from a postphenomenological (Ihde, 1995) notion, complex and multi-component systems possess the quality of multi-stability i.e that humans can potentially establish multiple relations to the systems they interact with through the way they use (or appropriate) them or where and when they decide to use them (Rosenberger, 2014).

Although multi-stability accounts for the variation in use, it however doesn't consider the variation in perspectives of use from various users (Redström and Wiltse, 2018). This introduces the possibility of a system having multiple intentions of use. For example, an end-user could use a product/service as a tool to accomplish a task, whereas the same tool could be used by a developer to understand and track a user's interests/behavior and in turn optimise services further. This phenomena of multi-intentionality (Redström and Wiltse, 2018) is quite common in modern data-driven digital systems. As Redstrom and Wiltse put it : "this is about an assemblage becoming present as fundamentally different 'things' framed by different intentions." It has also become increasingly common for interfaces of such digital systems to define how these intentions are communicated to these multiple users and their intention of use. In such scenarios, traditional design enforces the idea of simplifying interfaces that frame or dictate certain intentions of use for people. However, multiple users (end users, developers, analysts, owners) have conflicting needs especially when a product/service is used with different intentions. On a more abstract level, the goals that the organization has for their customers(users) might not align with what the end users want for themselves. This can be considered a sensitive issue because the end-users are unaware of these other potentially conflicting intentions. In turn, this could create an increase in tension between intelligent systems and the needs of end-users, but also a sense of mistrust. Hence, there is a need to create a sense of legibility to the users on the behavior of these systems and the other intentions of use in order to enable trust.

Such data-driven and intelligent systems are gaining popularity in nearly every industry. One such industry is the sustainable/renewable energy domain where automation is being used to effectively optimise and control energy consumption. Most data-driven products/services are multidimensional and multifaceted and do not necessarily have the same meaning and value to all its users. Different users could use it with different intentions and assign their own purpose of use.

3.2 Exploring ‘intentions’ as a unit of analysis/design

In this section, the idea of ‘intentions’ is explored from three perspectives. The goal is to unpack what ‘intentions’ mean and what role it could play in the context of the project.

3.2.1 A consumer psychology perspective

Morwitz & Munz (2021) stated that “intentions are assumed to capture the motivational factors that influence a behavior; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior”. Based on the model (Image 7) , intention is a predecessor to a certain behavior which is often driven by existing attitudes or beliefs that an individual may possess.. Intentions are also related to goals , which are desired outcomes or states that people try to achieve (Albarracín et al., 2019; Baumgartner & Pieters, 2008; Kopetz et al., 2012). Often there is a hierarchy in goals (Pieters, et al., 1995), i.e. the focal goal of, for instance, being more sustainable which can be achieved by subordinate goals like deciding to reduce energy consumption or actively using public transport. These could be further divided into actions such as reducing heating usage or deciding to use the bike more often. As stated previously as well, Fishbein and Ajzen (1975) proposed that it is the behavioral intention of a person that was a strong indicator of whether an action or certain behavior was likely to be exhibited.

Although attitudes and beliefs play a major role in how people decide to behave in a particular situation and moreover decide whether a certain behavior is desirable. In this project, the attitudes and beliefs are not explored in depth, instead it is assumed that in general there is an increasing trend in people having a positive and participative attitude towards sustainable behavior (Statistics Netherlands, 2021).

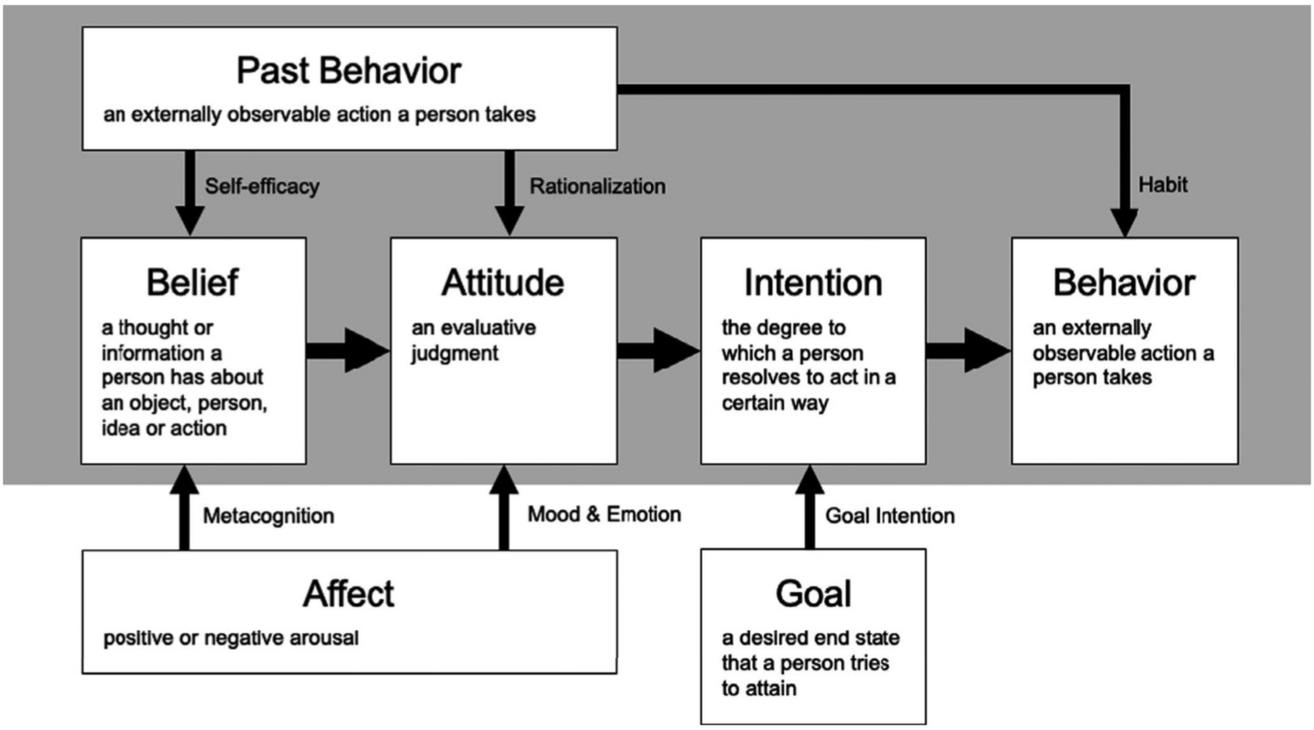


Image 7: The hypothetical relationship between the various constructs that affects intention (Morwitz & Munz (2021)

3.2.2 A mental model and interface perspective

From a human-computer interaction perspective, Colman and Leung (2000) talk about the different intentional models (image 8) that people have while using complex multi-layered systems. There is a strong emphasis on the interpretation of the various representations that the users can hold for a system. It suggests a better way to match what a system represents to the different mental models that users may have without breaking down the coherency of the integrated version of such a system. From a philosophical notion, Searle (1984) states that "the feature by which our mental states are directed at, or about, or refer to, or are of objects and states of the world other than themselves". The most effective and common way of reasoning about human behavior, according to Searle, is to explain human behavior in terms of the behavior's intention. He proposed two essential components to intentional states : 1. 'content' could be objects, actors and actions in a person's mental representation, 2. The 'psychological' mode depicts whether the person holding the representation wants, fears, intends, or believes the action. For instance, two people may have a shared understanding of structural model (expert understanding of the system) and functional model (behavior and interaction of the system) but the intentional context can vary for the same two people. This is better explained by the idea of an intentional model (image) that a user generally has about a system i.e it constitutes an individual's perception of the purpose of the system driven by the user's goals and intentions in a given context. Colmon and Leung also go on to emphasize that the interface designed for such a system can heavily influence how they perceive the goals of the system including their own. Hence, understanding the likely intentional models that users may have can also aid in developing "compatible explanations" of the behavior of the system.

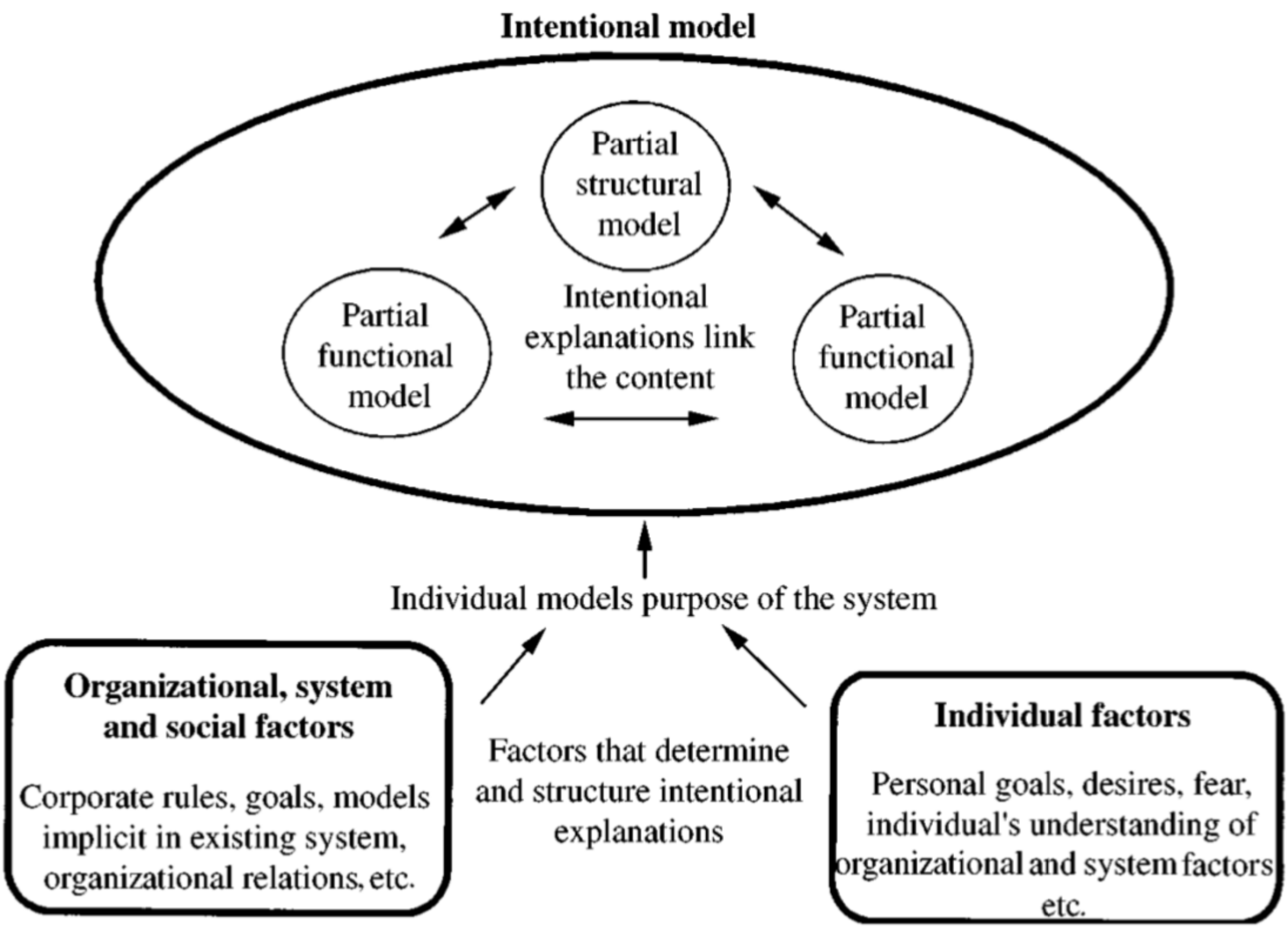


Image 8: Relationship between intentional models and structural/functional models.

3.2.3 A postphenomenology perspective

Postphenomenology is the study of relationships between technological artifacts and human beings and it focuses on the different ways that technologies can form the relations between people and the world. In this perspective, technological artifacts are not just seen as serving a functional purpose but as something that mediates human experiences and practices (Rosenberger and Verbeek, 2015). As mentioned earlier, most technological artifacts these days are complex systems that have the quality of multi-stability ie. the variation in use (Ihde, 1995) that an artifact can go through. Humans often form their own relations to the systems around them by interacting with them in different contexts and moments in different ways (Rosenberger, 2014). However, it is in multi-intentionality that perspectives of use from humans are accounted for i.e. humans can have multiple intentions of use for a system.

According to Rosenberger(2014), intentions could be both a user's individual intentions as well as habitual inclinations towards technology. A user might use an artifact to achieve their own specific goals associated with it, and may also materially customize it to suit their own needs. In addition to this, habitual inclinations that a user might have towards other technologies or activities in everyday life will also affect the way a system is used. For this project, both individual, deliberate intentions and habitual inclination that a user might have are considered as factors in determining the use of the system.

3.2.4 Discussion on the three perspectives

For this project, a mixed perspective of intentions is taken into account. From a consumer psychology perspective, intention is more centred around the idea of behavior change towards sustainable behavior. The user would have certain intentions and goals associated with certain actions that they might want to take and this would in turn dictate the preferences they will have for the system. In the human computer interaction perspective, the intentions are driven by the mental models that the users can have about the purpose of the system. This can include how the interface communicates the intention of the system at a certain point but also how the user can communicate theirs to the system. An additional aspect would include how the system interprets implicit user intent through their interactions with the system. From a postphenomenological perspective, intentions are translated into deliberate intentions of use that the user might have while being introduced to the system and on continuous interaction with the system. However, the system should also be able to identify patterns in use or habitual inclinations that users might have in order to promote more sustainable behavior.

3.3 Understanding and mapping intentionality gaps in energy consumption

Currently, most energy systems are driven by the intentions of the company. It could be considered as the specific ways in which energy companies would materially customize the technology(that users interact with) to suit their own purposes. Their intentions are often translated in the form of some algorithm that proposes/showcases personalised services or products or recommendations and analytics data that help customers become more aware about their energy behavior. Recommendations for modifying energy behavior are often made to help energy providers better optimise load, provide a consistent supply and prevent outages.

However, what the user's intentions are while using a system is not often captured. A gap that was discovered while researching various providers and their approach to helping customers become energy conscious was the lack of understanding of user intentions.

The systems act very efficiently as information sources, however do not satisfy more concrete user goals. Most energy companies don't necessarily capture what the user's intentions might be with respect to their energy behavior(image 9). It is uncertain how willing they are to participate in moving towards being more sustainable. The assumption is that by capturing what the users want to achieve through the system better and more relevant recommendations can be given which could lead to possibly better chances of behavioral change. This would possibly also elicit the feeling that both the user and the system is working towards a common goal and that the system has a shared understanding of what the user wants.

As discussed earlier, intentions in general are considered powerful predictors of behavior [Morwitz & Munz, 2021]. This not just helps the system understand what the users prioritise, but would also mean making the intentions of the system as clear as possible so that the users can predict how the system would behave.

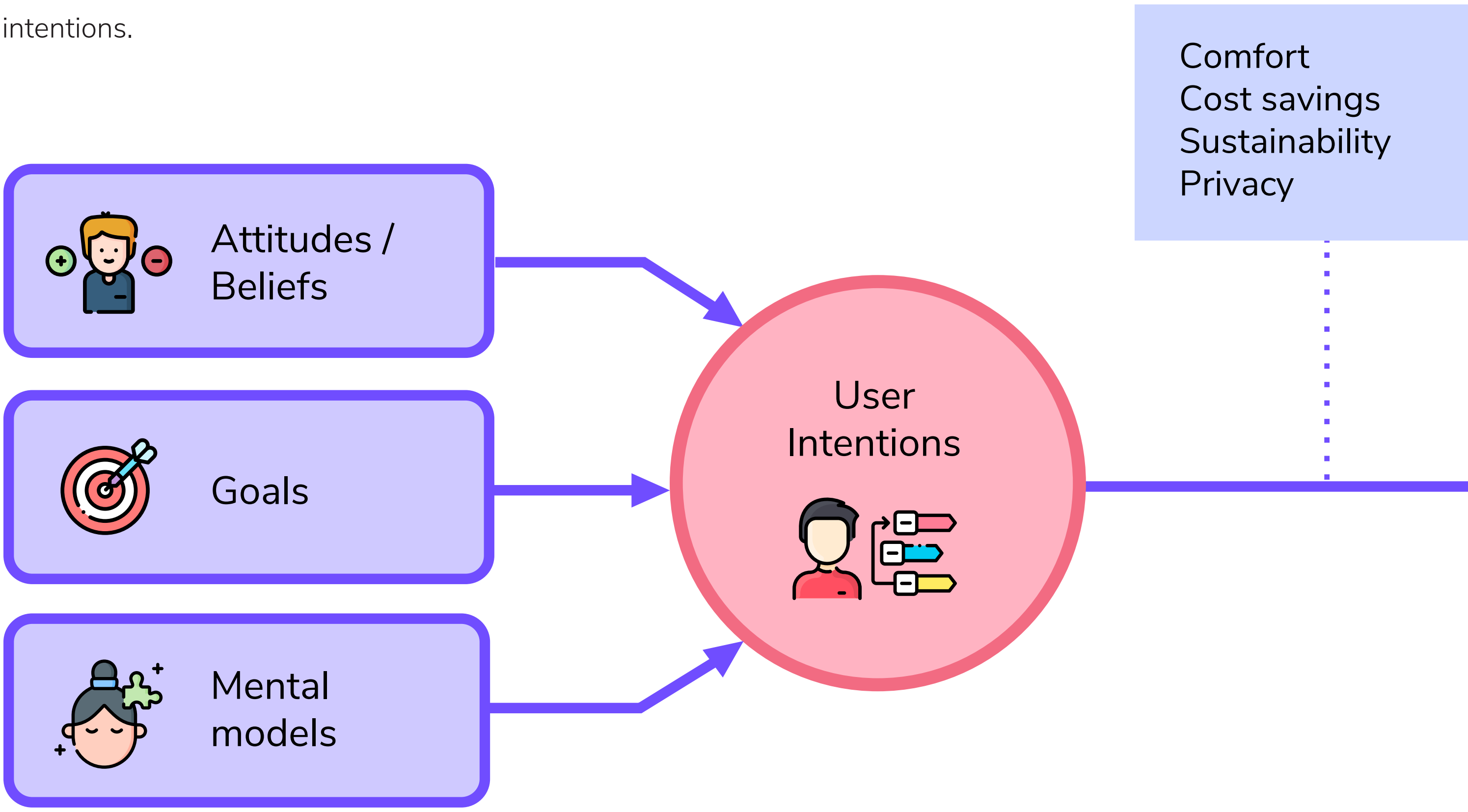
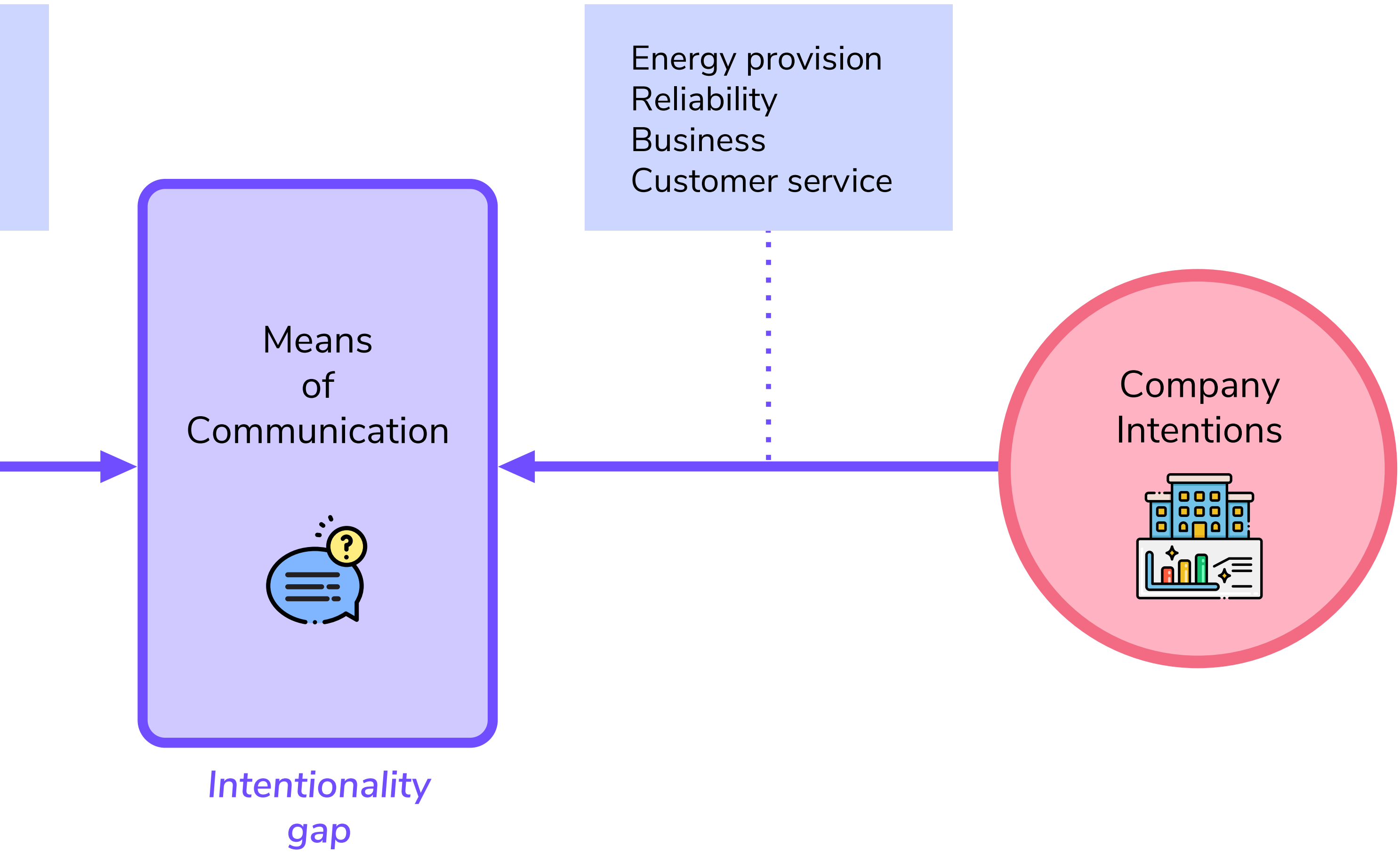


Image 9 : A graphical representation of the various components identified between user and company intentions.

This should be accompanied by enough information about why the system made a certain decision or recommendation so that trust and transparency can be enabled. However it is important to note that capturing intentions and providing personalised recommendations alone don't necessarily facilitate behavior change. As Nyborg and Nyborg (2013) suggests "willingness to flexibility : the participants' willingness and motivation to move consumption is dependent on their general interests, attitudes, values and indoor and comfort habits, as well as their relationship to technology, economy and the environment" which are multiple variables that come into play when considering behavioral change in energy consumption.



04

RESEARCH DIRECTION

This section defines the focus for the project. Based on the initial reserach activities performed, intentional profiles are identified and the major research questions are defined.

4.1 Narrowing the research focus

Intention can be considered as something that precedes a future event or action exhibited by a user. As mentioned earlier, there is a need to collect the intentions or goals of a system. So, collecting intentions here means collecting the tendencies or willingness to exhibit or prioritise certain behavior, most importantly sustainable behavior. Here, intentions more specifically means 'intention of use' i.e with respect to how users would want to use the system for themselves to achieve their goals. The intentions can be stated in statements as " *I want to save as much money as possible from my energy bills*" "*I want my family's comfort to stay as a priority*" " *I want a warm comfortable home and wouldn't want the slightest discomfort*".

These intentions are often driven by underlying values, attitudes and beliefs. The idea is to not collect their current or beliefs but elucidate their values/ beliefs based on their intentions of use. ie. their willingness and the degree to which they prioritise the often reported goals when using an energy recommendation system. ie (sustainability goals, comfort/convenience goals, economy goals, privacy goals, no goals/default user). According to Vattenfall, most users fall in the category of comfort and economical goals. A handful are sustainability-focused and only few users even find privacy a relevant concern . But this is primarily because of a lack of awareness of what smart metering capabilities are, although there has been an emerging trend of anti- smart meter groups all over the world.

The driving factor is to understand their intention to use an energy recommendation system and where they stand in attaining these goals. It is important to note as mentioned earlier the perception towards technology is dependent on both the user's individual intentions and the habitual inclinations (Rosenberger, 2014).

Every individual user would have existing habitual inclinations towards the idea of energy consumption. The project would focus on capturing the deliberate intentions of the user to enable the system to align it's function to helping users attain these goals. The habitual inclinations are expected to be processed by the system with time as it learns the tendencies, patterns and the behaviors that the users exhibit. This is expected to contribute to the way the system will adapt and personalise itself for the user. Because the core element of personalisation is making recommendations relevant to the user, personalising recommendations based on their intention of use can be highly beneficial in making recommendations more relevant to their goals, in turn resulting in possibly a higher chance of behavior change.

The goal in the project is to give users a sense of being able to make their intentions (by prioritization of their goals) clear to the system. The interaction should ideally facilitate a collaborative feeling of the system and user (keeping both intentions users and systems in mind) to move towards a more sustainable behavior in the long run. It can be considered as easing the users into more sustainable behavior or building a path towards it.

It is anticipated that when given immediate and strong recommendations eg. "Here is your solar panel installation plan" when a user is not habituated to smaller levels of sustainable behavior it becomes a huge lifestyle change and the user is likely to ignore them. But now one could considerably systematize and create a much more step by step approach i.e provide easy to harder sustainable advice/recommendation with time.

It is important to keep in mind that intentions often self reported are not entirely reliable. This is where the system learns what the user actually does (habitual inclinations and other activities) or changes in his/her habits to adapt the profiling that the system has of the user. This is likely to change the intentions or underlying goals the system elucidates about the user.

The user however should still be able to control how the system behaves eventually as well. An interesting research made by Kroesen et al. (2017), more recently questions how attitudes and behaviors are co-related. They claimed that the behavior of an individual affects their attitude more than vice versa. This will form an interesting case for the system to understand and adjust the priorities that drive the user, which in turn can be a good predictor of intentions. In general, people would always want to be sustainable or claim to want to be sustainable, but may not exhibit the appropriate/associated behavior or even attempt to change their behavior. When this happens the system should be able to identify that certain users are not as sustainable as they claim and would most likely require more simpler recommendations as a start for behavioral change i.e the system should be able to adapt to better fit the lifestyle behavior of the users.

4.2 Identifying intention profiles

Since there is already sufficient research involved in identifying user groups in the use of energy monitoring systems or HEMS (home energy management system), the existing literature research was used as a foundation to elucidate possible user groups relevant from the perspective of user intentions. Van Dam, S. (2017) for instance, identified 5 user groups (image 10) based on how people use HEMS in their homes, their expectations and motivations to use such a system and their feeling of responsibility towards energy consumption.

On the other hand, Straub & Volmer (2018) classified users based on their perception, attitudes and behaviors in the use associated with HEMS. They identified 5 user groups 1. optimists 2. privacy-conscious citizens 3.technicians 4.scpetics 5. indifferent. Another research [Nyborg & Røpke, 2013] identified users based on the use of the home automation energy management system, their backgrounds, values and their relationship with energy. Here, they categorize users into categories as shown in image 11.

	'techie'	'one-off user'	'manager'	'thrifty spender'	'joie de vivre'
Key characteristics	Data geek, energy conscious, tech-nical, interested in gadgets, maintai-ner (and installer) of appliances and equipment	Goal-oriented, technical, inte-rested in gadgets, maintainer (and installer) of appliances and equipment	Controlling, strict parenting, managing family members (and administration/ money), energy conscious	Frugal, sober upbringing, does administration, keeps track of money. Want to economize, though not sure how to.	Enjoys life, laid-back, relaxed parenting style, likes new designs, keeps overview of money. Unmindful of energy
Technical back-ground	++	++	+/-	--	--
Interest in gadgets	++	++	+/-	+/-	+
Kept track of meter readings	++	+/-	+/-	+/-	--
Motivation to participate	Fun/sport, gadget appeal	Looking for saving opportunities, fun	Check on other family members	Free, find ways to save money	Gain insight, Suspi-cion checker
Underlying motives	Predominantly environmental, also economic	Predominantly environ-mental and fire safety	Environ-mental or economic, both strong	Economic, strong	Environ-mental or economic but not very dominant
Goals	Discovering con-sumption (of appli-ances), reducing as much as possible, keeping track of consumption	Discovering consumption pre-ferably of individual appliances. Find (technical) reducti-on measures	Discover energy consumption, keep track of whether applian-ces are left on unneces-sarily and who is responsible	Save money	Find phantom loads, global over-view/ indication for bill at the end of the year
Short-term or lon-ger-term (goal-re-lated) interest in HEMS	Discovering and reducing: mainly initial use. Keeping track: lon-ger-term (frequent)	Short term	Discovering: mainly initial use Keeping track: Lon-ger-term (frequent)		Phantom loads: short-term over-view: Longer term (infrequent)
Behavioural or technical soluti-ons/ control	Technical	Mainly technical	Mainly behavioural	Behavioural	Neither
Desires	Raw, exportable, detailed data, prognosis, shower use data	Raw, detailed data	Control mecha-nism, baseline check, shower use data	Information, perso-na-lized advice, insights	Certainty, referen-ce, overview

Image 10: User group classification by Van Dam, S.(2017).

Enthusiastic

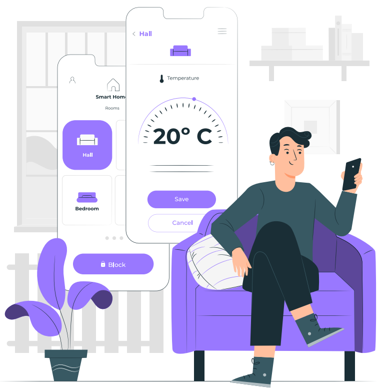
- **The technical:** technique-enthusiasts who are engaged in the 'electricity world'; they have joined eFlex to contribute to technological and societal development
- **The economical:** system-thinkers who have joined eFlex to control and optimise the family's energy consumption
- **The curious:** people with an inquiring attitude toward life; for them, eFlex is an opportunity to learn new things about energy and electricity

Interested

- **The participating:** humanists who want to do something good for others; they are primarily in the eFlex project for the sake of the environment and the project's greater cause
- **The comfortable:** appreciate comfort and convenience in their homes; for them, eFlex is an opportunity to save money and do a good deed without compromising comfort or time for other things.

Image 11: User group classification by Nyborg & Røpke (2013).

Based on the above research, possible user profiles from the perspective of intentions were generated. The main profiles would be :



Comfort-driven

A comfort driven user would prioritise convenience and comfort over other factors. They are probably more resistant to adapt to sudden changes in their schedules and saving money is a good-to-have but not a primary motivator.

Cost-driven

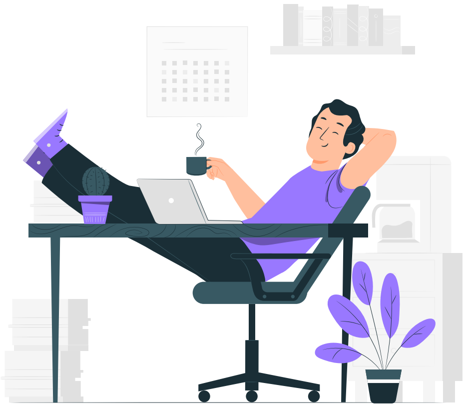
The cost-driven user's main priority would be to save money wherever possible. They wouldn't mind shifting their activities around a little if it means they save on their energy bills. They don't necessarily compromise comfort, instead they are more cautious in their use.

Sustainability-driven

The sustainability focused users are people that care for the environment and the consequences of their actions towards it. Although they need not necessarily be already sustainable in their behavior, they have the intention and willingness to try to be and for instance might be concerned about environmental impact in other areas like waste or pollution. This user group has the intention to move towards becoming energy independent and want to invest in solar and wind related energy sources.

Privacy-corncerned

The privacy-concerned are the sceptics among these user groups. They don't trust organizations to do the right thing with the data in general and are quite aware about how data is used in various ways. They are not necessarily against the idea of sharing data, rather they want assurance that data is shared for the right purposes only when necessary and protected to avoid breach of personal information.



Indifferent/default

The final user group are people who don't have any particular opinion about energy. They have a rather nonchalant attitude towards their energy behavior and don't see themselves playing a significant role in contributing towards environmental well-being. A HEMS(home energy management system) is in general not considered appealing or necessary for them. They are more likely to go with the default or standard settings of a system and might not make an extra effort to learn or adjust their behavior.

A "technology driven" user group was also considered as a profile but was not included as technology is anyway anticipated to be a part of the design solution and "being technology-driven" could be translated more as being a behavioral trait rather than an intention/goal.

Here, ***it is important to note that most users fall into a profile of mixed intentions but with different levels of priorities for each.*** For instance, most users wouldn't want to miss the chance of wanting to save money but the amount of priority they decide to give to their comfort would change how it affects the amount they save on their energy bill. Similarly, sustainability is often a secondary goal that users might have, but not necessarily at the cost of comfort. This is obviously subjective, contextual and most importantly is likely to also change with time. For instance, the user might prioritize comfort when he/she has guests over even if it contradicts his/her priorities for the household.

4.3 Defining research questions

Based on the literature research, the major areas of focus were defined :

RQ1 How can we capture the intentions, goals and preferences of users of home energy systems ?

The goal here is to explore how interfaces can capture the intentions of what people would need and how they intend to use the system.

RQ2 How can a home energy system communicate how the system will potentially behave based on user intentions ?

This research question would involve trying to understand how users could be presented with consequences (good and bad) of their choices. The idea is to communicate the tradeoffs of their intentions so that users understand how the system would potentially behave and in turn why it indeed would behave in a certain way.

RQ3 How can a home energy system explain its actions and recommendations to users ?

This exploration will involve trying to understand what elements in the interface could contribute to the explainability of the system's functioning, especially the personalised recommendations that will be provided to the users.

RQ4 How do end-users perceive the intentions behind a smart energy management system ?

In this question, the goal is to understand if users identify that the system has an intention of its own and if so, how they interpret the intention.

RQ5 What are the aspects affecting users' trust and perception of transparency with smart home energy systems ?

Here, the aim is to explore ways to improve the transparency of the working of the system, how it makes its decisions so that users understand why the system behaves a certain way. It should ideally contribute to reducing the number of surprises the user might feel while interacting with the system.

RQ6 How can users be supported in developing a sense of control with smart home energy systems?

This question tries to explore ways to provide users enough flexibility and control over choices in how the system could work for them. The users should be able to fully understand that they can override the system's settings or recommendations anytime they choose to.

05

FEATURE EXPLORATION AND BENCHMARKING

In this section, a brief exploration of the features that other energy companies provide through their digital systems was done. The activity was also to gain an understanding of what additional features could prove to be useful in the user's context.

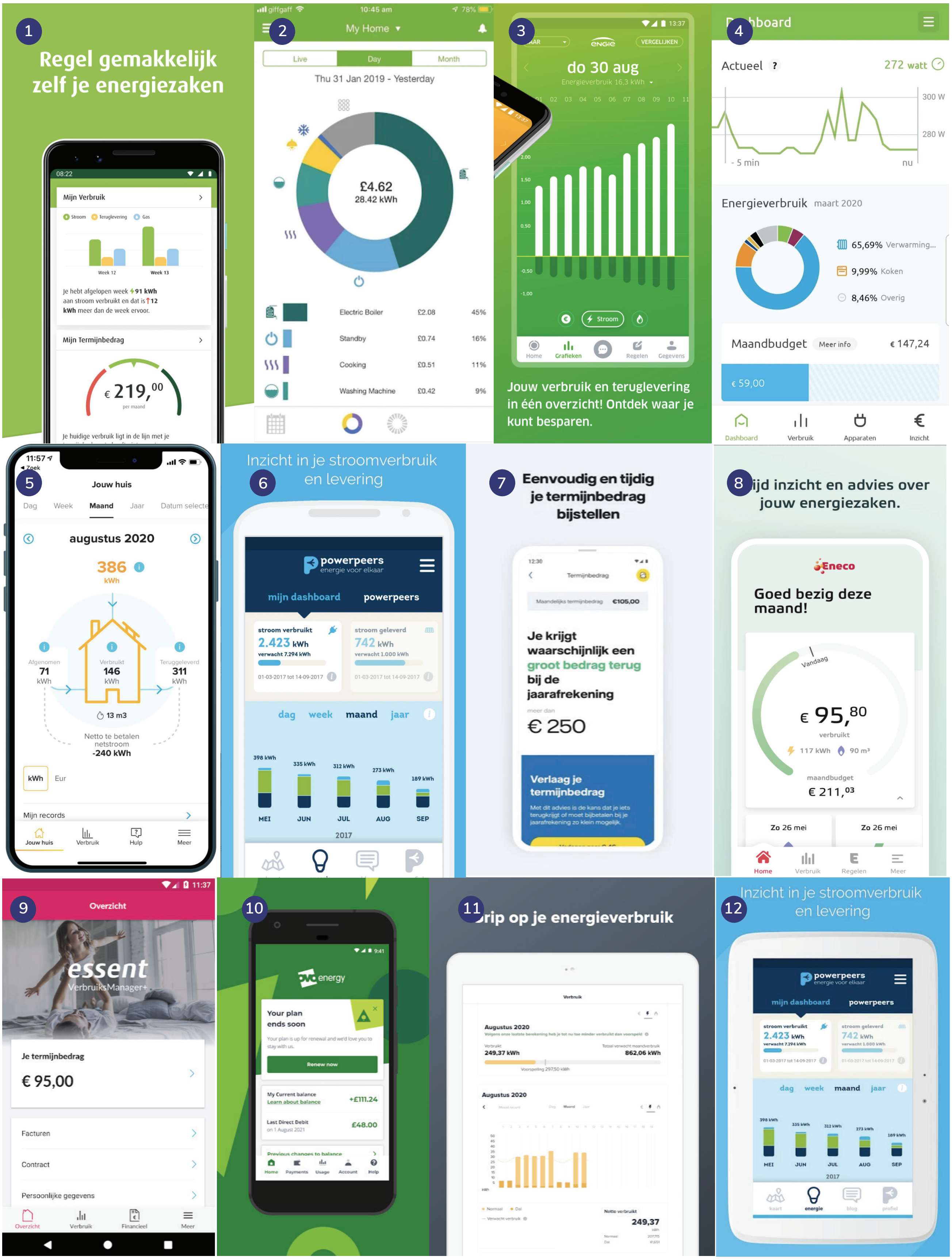


Image 12: 1. Greenchoice, 2. Voltaware, 3. Engie, 4. Pure Energie, 5. Zelfstroom, 6. Powerpeers, 7. Vattenfall, 8. Eneco, 9. Essent, 9. Ovo Energy, 10. Vandebron, 11. Powerpeers

5.1 Feature analysis

Before the conceptualisation phase, there was a need to understand what facilities the existing energy providers gave to their customers. It was necessary to avoid redundancy in design ideas and to also understand what further features could complement the existing ones keeping future developments in mind. A brief exploration of energy monitoring apps (image 12)provided by various energy companies/aggregators within the Netherlands and a few outside were performed. It helped to make a note of the current trends of features that the companies provide to their customers.

Some of the common features noted were :

Overall consumption : hourly, dayly, monthly, yearly; along with comparisons
Energy bill updates and notification
Comparison of consumption to similar households
Appliance disaggregation
Changing data, privacy, payment settings
Informing about moving
Power contributed through PVs

It was interesting to note that most advice is somewhat generic and not necessarily personalised or relevant enough to be actionable for customers. More interesting information and recommendations are provided by third party energy monitoring companies like Sense, Sampee,(image 13) etc like time-of-use tracking, smart recommendations and warnings.

Moreover, most applications do not capture user goals or priorities to tailor recommendations/advice to better fit their lifestyles. This in turn becomes one of the focuses of exploration in the project to understand: how users view capturing of intentions and how personalisation based on this can help them become more energy conscious.

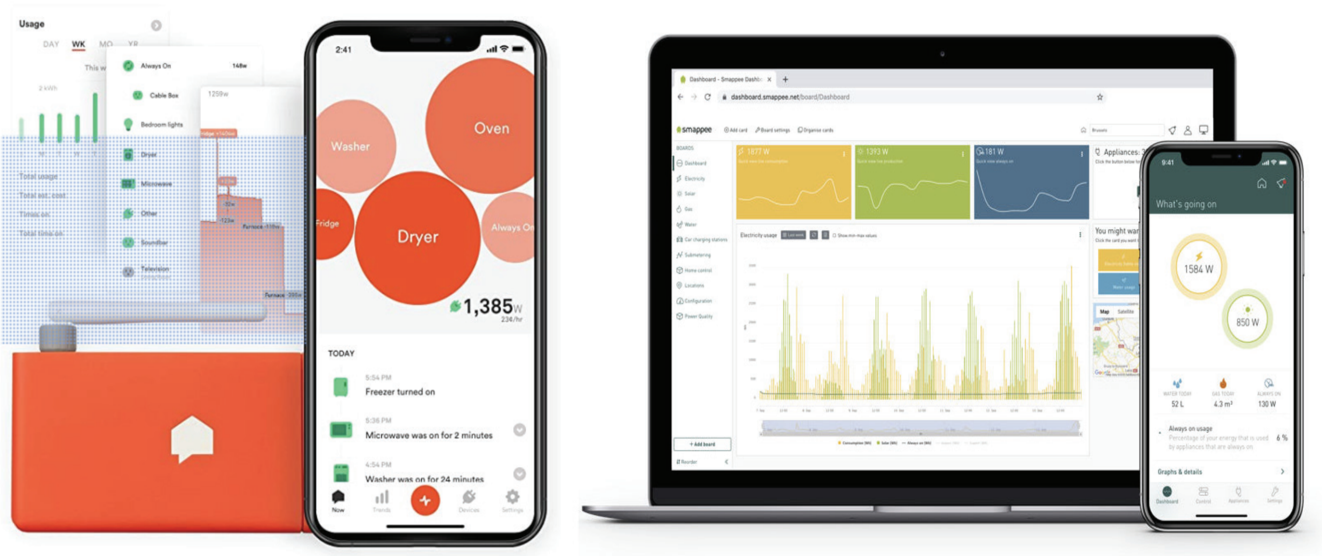


Image 13: 1. Sense (left) and Sampee (right)

06

USER AND DOMAIN EXPERT RESEARCH

To better understand the user's context and experiences with energy use, a survey and user research was conducted. In order to further explore the energy domain, interactive machine learning and the concept of values, experts were contacted for interviews to gather opinions and ideas.

6.1 Survey

A survey was created to validate the identification of the various user groups. The survey was quite short and it was released across various social media platforms like facebook, linkedin, whatsapp, slack and discord to also recruit participants for interviews and user tests.
The survey received 34 responses. This was expected due to the limited extent of the researcher's circle. Other interesting factors could be that most people don't engage with the concept of energy and so couldn't relate to the first question("Do you have a smart meter at home?"). i.e possibly was not fully aware if they had a smart meter at home and what it could do for them.

6.1.1 Result of survey

The general trend lean towards most participants prioritising comfort first (41%), followed by saving money (29%) after which sustainability (35%) is the focus. Privacy was one of the last priorities for majority participants. The "other" option is invalid for most participants.

Interestingly, there were no new intentions/priorities mentioned and most participants were able to communicate their needs through the 4 groups identified. Even if other priorities were mentioned, there were largely feature requests like 'real time data', 'insight into use', 'automation', and 'uninterrupted power supply'(which comes under comfort as a priority). 8 participants wanted to give an equal but secondary priority to being sustainable and saving money(23%). 2 participants wanted to give an equal first priority to being comfortable and being sustainable. 3 participants wanted to give an equal first priority to being comfortable as well as saving money. There was only 1 participant each that wanted to prioritise comfort/privacy and saving money/privacy equally.

6.1.2 Discussion

The assumption that comfort and saving money would be of the highest priority was validated through the survey. It also matches with what Vattenfall said most of their user groups lie. It was also evident that people had multiple intentions of use with different priorities for each.

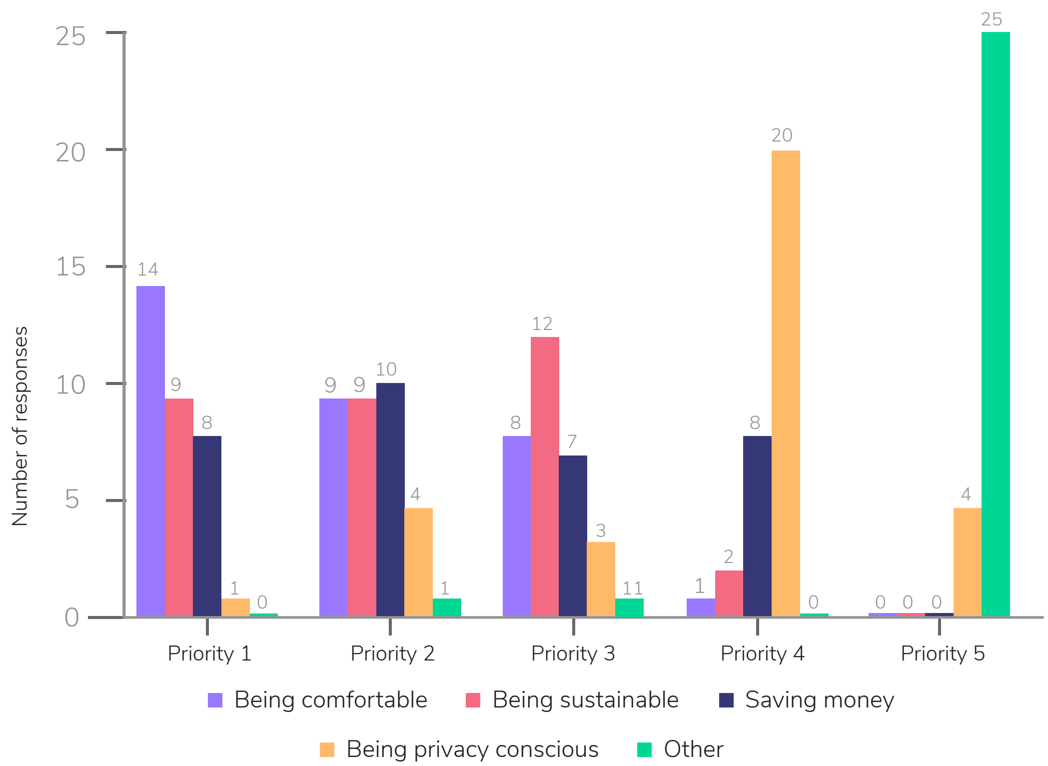


Figure 1 : Survey results

It was also interesting to note that some users did not even consider privacy an issue. This implied a lack of knowledge in how smart meters work and how much information can be inferred from energy meter data. In addition to that, no participant stated any other intention or priority while monitoring their energy use. Few participants (6 - 17%) reported having used apps like Eneco(toon), Fronius, Greenchoice to monitor their energy use. Even here, the data that was tracked was very basic, for instance, overall consumption. Others (3) relied on emails from the energy company to understand their energy use. Some participants were not aware that this was even possible. This implied there was a need for people to really engage with energy data and to also design a system with enough information that could be relevant and actionable for them.

6.2 User interviews

6.2.1 Setting and participants

To better understand the energy behavior and awareness of users, a short interview was conducted. The goal of the interview was to understand their experiences with their energy provider which includes the service provided by the company and the perceived intention.

It also involved exploring their goals and intentions and what steps they take to be more sustainable and how they currently access the data of their energy use.

The interviews were conducted online through the Zoom meeting application. The interviews were held for 20-30 mins each. Participants(table 1) were recruited through both convenience sampling and from the survey form. Interview questions were prepared in a semi-structured manner.

6.2.2 Insights

Actions on bills is not common

Currently it appears that most users don't necessarily take a lot of active steps to monitor energy use or stay on top of their consumption. They are often reminded of 'energy' only on the arrival of their monthly bill/report. By then it is usually too late to take any corrective measures to adjust their consumption. Another, common theme is the lack of detailed information and real time data that the users could use to infer insights about their energy use. This lack of detail results in a lack of awareness of what activities most of their energy is spent on.

Participant	Age	Profession	Family info	Type of house	Energy provider/ bill per month	Smart meter	Energy tracking means
P1	40	UX Designer	Wife, young child	Apartment (3 room)	Vattenfall/ 80 Eur	Yes	Bills, emails
P2	57	Entrepreneur	-	Canal house (5 room)	Energiedirect/ 180 Eur	Yes	Bills, emails, app
P3	34	Advisor	Wife, infant	Dutch house (5 room)	Budgetenergie/ 180 Eur	Yes	Bills, emails
P4	38	Operations Lead	Wife	Combined Dutch house (>5 rooms)	Eneco/ 250 Eur	Yes	Bills, emails, app
P5	34	Program Manager	Wife, toddler	Apartment (5 room)	BESCOM - Indian/ 50 Eur	No	Bills, app
P6	23	Student	Girlfriend	Dutch house (5 room)	Vandebron/ 110 Eur	No	Bills, emails

Table 1 : Participant information from user interviews

Currently it appears that most users don't necessarily take a lot of active steps to monitor energy use or stay on top of their consumption. They are often reminded of 'energy' only on the arrival of their monthly bill/report. By then it is usually too late to take any corrective measures to adjust their consumption. Another, common theme is the lack of detailed information and real time data that the users could use to infer insights about their energy use. This lack of detail results in a lack of awareness of what activities most of their energy is spent on.

Relevance of the recommendations

Most providers provide broad and generic textbook advice/recommendations like " change your bulbs to LEDs". Such advice, although informative, is somewhat redundant in the modern world where most people are already aware of the obvious ways to save energy. There is a lack of personalised, time-relevant and actionable advice that can inform and motivate people to adjust their energy behavior.

Common intentions of users

Being comfortable becomes rationally and quite obviously the most important intention of every family. This is also largely determined by the economic status of the household. Most participants interviewed were financially sound. Only one household's first focus was saving money. Sustainability is often a secondary or tertiary objective for most participants.

"We cook on electricity so it's important we have a very reliable supplier, also with heating when it's cold, my priority is that it works, especially with a baby, comfort becomes very important."

Communication of intention

A company's intention is often strongly perceived and understood through their PR (public relations) or marketing campaigns (image 14). Most companies are driven by a specific proposition of saving costs(Image) or even being fully green. When there is a mismatch between what intentions the companies communicated and what happens in reality, people are faced with unpleasant experiences and as a result loss of trust. When the claims made to help users achieve a certain goal (for eg. low costs) is not met with support to actually help them reach it, users are met with surprises at the end of the year with huge bills. This in turn also results in users switching providers and a loss of loyal customers for the providers.

Need for interactive data and usage information

Most of the information relayed to users about their energy use is through monthly reports, and few providers also provide data through apps in the form of comparison graphs. There appears to be a lack of interactive and engaging ways to represent energy data. Representing complex information in

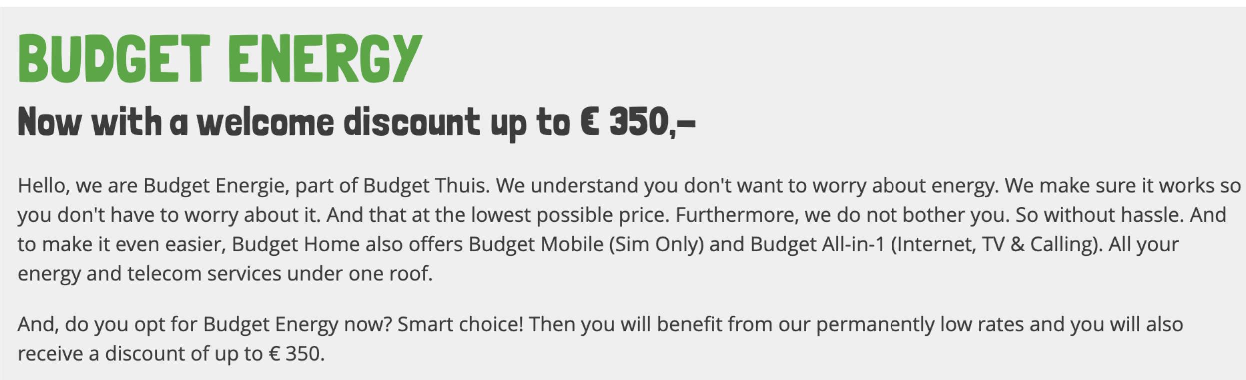


Image 14: Example of proposition by Budget Energie

interesting ways could possibly be more engaging and motivating for users to participate in energy saving behavior.

“I would like to see my actual usage, my actual data, why am I not charged on the actuals? Why give me a surprise at the end of the year?”

How loyalty is affected with time

Two users reported moving energy providers often to save on costs. This came out as an interesting insight because ideally a customer should feel like being loyal would come with the benefits of more savings, but they felt on the contrary. As soon as the promotional offer given to a new customer has expired, the real costs come as a surprise to the users and they soon intend to switch providers. This creates an interesting question of how reframing the intentions of the company could affect the loyalty of their customers.

“I think the consumer has to choose by picking the right provider if they want to make an impact.”

Generating energy - a challenge

Installing solar panels is seen as a somewhat taxing process for consumers. Some of the reasons stated were that they were unsure of the costs involved and were also unfamiliar with the process of installing PV. For others, it was the issue of ruining the aesthetics of their house. Smoothening the process of adopting solar panels or more importantly inching the users slowly towards adopting such sustainable options is necessary. It might be necessary to provide users with sufficient information to ensure that they feel prepared to take such steps.

Energy - more as an invisible utility

Overall, most participants exhibited the feeling that energy is purely viewed as utility. It is apparent that it is largely taken for granted until their energy bill arrives. Viewing energy as a basic commodity is not necessarily a bad thing since it’s a sign of modern development. But it has led to people becoming desensitised or less aware about the sources and value of the energy they use. As van Dam, S. (2017) stated “Energy flows in households are mostly invisible.”. Dobbyn and Thomas (2005) also noted that gas and electricity operate more on a subconscious level within people’s homes i.e people have little awareness of how , when and where the energy is produced. There is also little emotional connection or sentiment around the idea of energy. These factors make it even harder for users to feel motivated enough to actively participate in modifying their energy behavior.

“For me energy - it just needs to work, if it is cold then I should be able to turn on the heat and my wife likes using the sauna and I don't want to stop her.”

“I should be able to use whatever I use whenever I want to use it.”

6.3 Expert interviews

6.3.1 Setting and participants

To further explore and gather insights on the domain of energy, interactive machine learning and values associated with sustainable behavior, experts were interviewed. The goal of the interview was to clarify some of the understandings gathered through the literature review and get opinions on possible design directions. Each interview was conducted online through the Zoom meeting application and took a time span of 30 mins to 1 hour each. Semi-structured questions were prepared for each of the interviews.
The experts were recruited through email and all of them work in various faculties at the Delft University of Technology.

6.3.2 Insights

The perception of sustainability from an energy perspective

For different experts, being sustainable meant different things. It could be perceived as the reduction in carbon emission or to minimise the overall carbon intensity of the energy system.

On the other hand, sustainability could also be viewed as something that can be sustained and could be built infrastructure-wise and supported with the right kind of energy sources so that they last several years.

What the grid tries to do

The goal of the grid is to often ensure there are no instabilities and that there is also a reliable infrastructure at all times to avoid black outs. It is very important that sufficient data is communicated to the energy aggregators so that they know how much energy is anticipated to be consumed soon. This would also mean constant information communication between the DSO (Distribution System Operators) and the energy aggregator to deal with immediate energy demands and network congestion . One of the primary focuses is monitoring the behaviors of the network to ensure safe and reliable energy distribution.

Expectations from a user to contribute to sustainable energy use

There needs to be a better connection built between energy and the individuals. An essential part is being able to balance comfort and the energy consumed. The idea of energy conservation is however tricky, as sometimes users are in fact encouraged to consume more as there is so much

Expert	Profession	Expertise
E1	Assistant Professor	Smart grid, data analytics, power systems, risk analysis, monte carlo methods
E2	Assistant Professor	Machine learning in electrical power grids, electric power grid generation
E3	Assistant Professor	Power systems operation, machine learning, mathematical optimisation
E4	Associate Professor	Socio-technical algorithmics, machine learning, data analytics, agent-based modelling
E5	Assistant Professor	Responsible artificial intelligence, AI agents and socio-technical systems
E6	Phd candidate	Design ethics, changing values in design, design strategies for sociotechnical systems

Table 2 : Participant information from user interviews

energy for instance generated through wind and it is more beneficial to use it than to try and store it. Apparently, previous studies on demand response did not yield much effect on an individual scale however, it is believed that if a larger population of people decide to modify their behavior to be more sustainable, it can have an impact. But it is quite common for people to not change their behavior as it is not clearly visible to the user what indeed happens in the grid.

Moreover, energy conservation is not made as interesting and appealing to the masses through advertising as much as it is done for plastic packaging or pollution. It is also not incentivised enough for people to invest time into. So there is a serious lack of connection and understanding towards energy from a people's perspective. But it is well understood that changes in contexts and social situations often put users in a situation where they end up consuming more power. This also created a need for a good communication model that can inform users about what impact every energy consumption activity has. This could also possibly help reduce carbon emissions in a collective manner.

Interesting parameters to measure to understand user intentions

A number of correlations are interesting to consider for eg. capturing their behavior in the supermarket depending on the kind of products that they buy or based on their choice of transport on an everyday basis. One could also try to extract social media data and analyse the data to understand what inclinations the users could have. Exploring various lifestyle parameters could be used to understand where a user stands on a sustainability scale when compared to other people. People could also be presented with multiple choices and further questions on why they performed a certain action. Although it is important to note that often in AI, the connection between input and output is somewhat vague and it can be hard to ascertain whether the system is being fair about what it learns.

Introducing transparency and control into system

It might be overwhelming for a user to see the intricate details of how the system works. But a simplified version of the model can help users understand how inputs and outputs are co-related and possibly what factors affected certain decisions made by the system. On the other hand, users could be told what data is used and there is permission and ownership provided for the data that will be shared. From the perspective of intentions, it would be important to maintain that that both the system and the user has a similar understanding of what sustainability means, else it would lead to a decline in confidence towards the system. With respect to control, it is quite common for users to view having a sense of control as effective as having control itself. It is also known to contribute positively to the user experience of the system.

The intentions that the system should have

The goal should be to reduce carbon intensity as much as possible and ensure reliability. It should also ensure a good balance in the energy market. This would include maintaining costs i.e providing energy at affordable costs to consumers. It is also possible that the system has a certain set of values that end users are not aware of and it is translated through strategies or nudging that eventually benefit sustainability.

Addressing privacy concerns of consumers

Data anonymization techniques can be used by avoiding pinpointing to a particular household. For instance, the data could be randomised and an artificial similar version of it can be generated from the original data. So one can still compute the average consumption of a neighborhood but not the lead to any specific household. It is also possible to use AI to estimate what is most important data to have and how it could be randomized and aggregated to ensure privacy. Another possibility is using edge computing to ensure most data used for computation is stored locally with the owners of the data and only the most essential details regarding load profiles are shared with the energy company.

Adopting the value of sustainability

When designing for sustainable behavior although it might be good to consider whether people indeed value sustainability or the reward associated with it. Each person might want to realise their values differently and will also have different norms associated with it. The system should ideally be able to influence people to start adopting sustainability as a value. Hence, the system indeed can in some ways also create or change values in people based on the way it is designed.

Relationship between values and intentions

In the case of designing systems of people, ie. from the perspective of designing one's life, it has to be intentional. Hence, the only way to realize a value is by initially having the intention to do so. These intentions are often based on a certain set of beliefs about the world. This intention then gets modified into a set of norms about what kind of behavior is necessary for the realization of this value. This could be both from a person's personal history of acting, or from a more theoretical deliberation about behavior. The resulting action will or will not lead to the realization of the value which acts as a feedback loop about their beliefs, intentions and the norms resulting from that. However, it is important to remember that values are not perfect predictors of behavior because a person might believe in sustainability but might still be exhibiting some unsustainable behaviors either due to lack of awareness or other personal reasons.

Attributing human qualities to an AI system

Experts feel that AI lacks the intuition that humans have. It is unable to abstract or detect new situations beyond what it is trained for and so in general they aren't as adaptable as people assume. It would be interesting to design an AI to be more curious ie. explore curious states if possible, to encourage it to ask questions and learn. One expert even compared it to a baby that is sensing and learning different things, however it is still immature and one would never allow a baby to make important decisions. Another expert, believed that the AI system could be compassionate, that everything shouldn't be reduced to maximization and minimization and that there should be room for people to make mistakes.

What future energy scenario could look like

The ideal scenario would be that future energy systems are made more flexible and adaptable and most non-renewable sources of power are phased out. Carbon neutralization becomes an important goal in this scenario. More people may become energy producers and energy might become a passive source of income. Energy production may become hyperlocal to save on distribution and infrastructure. The recommendation systems should ideally become more intuitive about user schedules and be able to understand what users might do on a certain day and time so that certain activities can be automated. It is also anticipated that all homes will become fully smart and systems including appliances might communicate with the grid to manage and respond to grid management. This however, will create some privacy issues.

07

ITERATIVE DESIGN

This section constitutes a major part of the thesis project. Here, the research questions are explored through various iterations starting from ideation to different phases of tests with users and designers generating various insights that lead to the final design.

7.1 Introduction

An iterative design approach (Image 15) was followed for the entirety of the project., followed by six weeks of literature research and expert interviews. Based on the gap identified, the ideation was performed. The foundation for the ideation was derived from the literature review and interview data collected. As mentioned previously, the research through design approach was followed as a means to explore further the interpretation in intentionality within digital systems in the energy context. The ideas explored multiple aspects including the capturing intention, providing tradeoffs, showing transparency, portraying negotiation, exploring value elicitation and representation and gamification for sustainable behavior change

7.2 Ideation

The concepts are explorations of ways to capture intentions, represent tradeoffs of the choices that the users make when they state their intentions, showcasing how the system understands the user and how the system makes decisions and creates recommendations. It was decided that the interface would be designed for an in-home display device. Elburg(2014) for instance stated that sophisticated HEMS with real-time data on a smartphone or tablet can be very attractive to already technology minded users, but for the less committed or interested user group, a visually appealing in-home display can be more effective. Along with that, the intention was to also create the opportunity to have a better involvement in contributing towards energy behavior from a family/household perspective. Having an application that everyone can interact with would probably bring better awareness in energy consumption as opposed to a monthly energy bill or an app that usually only one person in the household engages with.

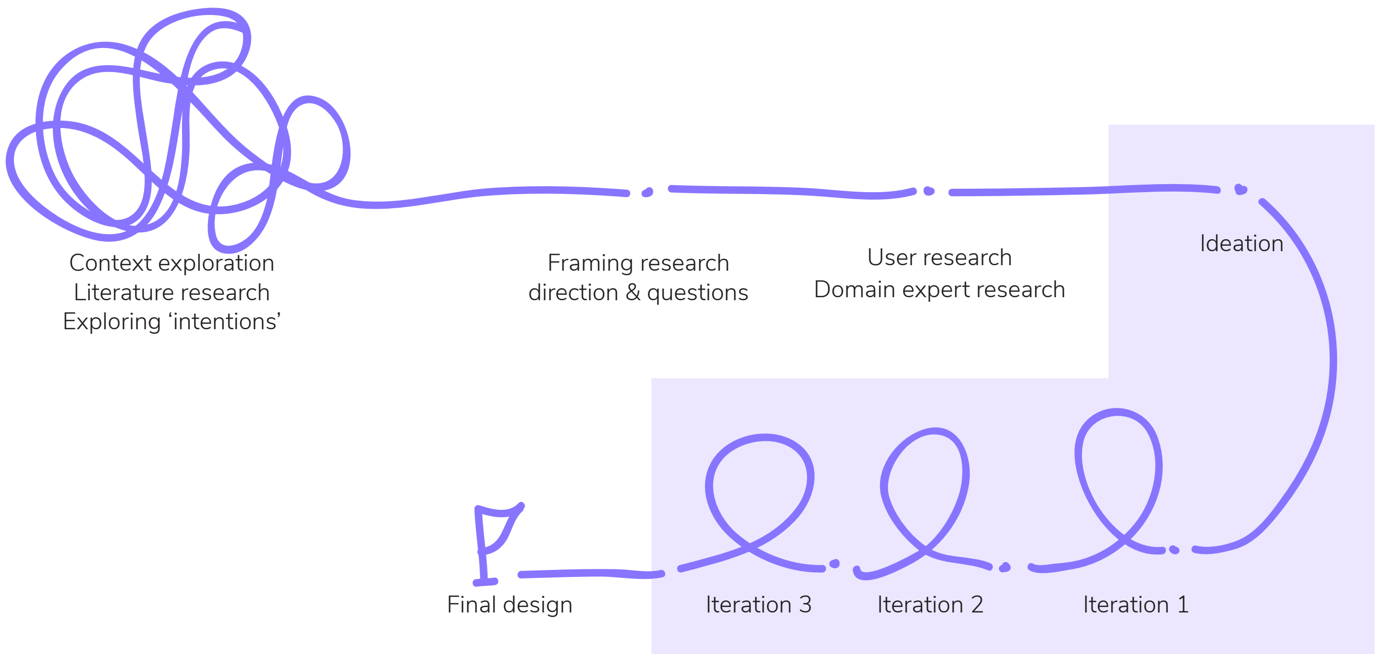


Image 15 : Design process highlighting RtD

Concept 1

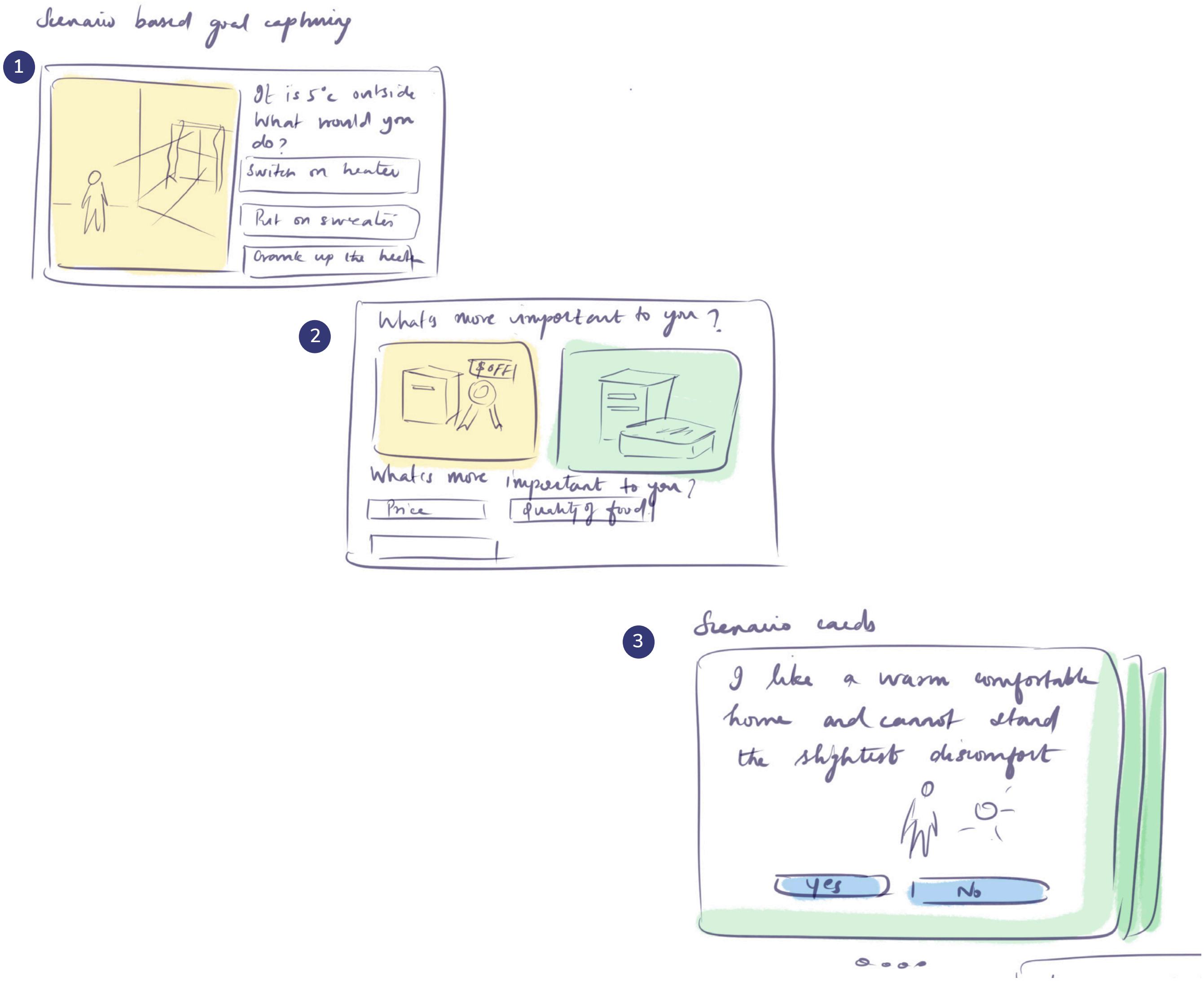


Image 16 : 1. Scenario based goal capturing (1&2) and scenario cards (3).

The first part of the design concept involved being able to capture the intentions or goals of the users (image 16).

i) For instance, scenario based goal capturing involves being able to collect user preferences based on the choices they would make when in a certain situation/circumstances. E.g. If the temperature was hot outside, what would the user prefer to do? The user will be provided with possible ways they would respond to the situation. Another way to do the same would be to understand their values based on their interests in other parts/areas of their life. For instance, how does the user make choices in a supermarket? Do they prioritise price over quality? The idea was inspired from interactive machine intelligence and Geelen et al. 's (2013) proposition of goal-driven interfaces.

ii) Another option was to consider scenario cards that people can agree or disagree with easily to indicate if they would be comfortable with certain situations or not.

Concept 2

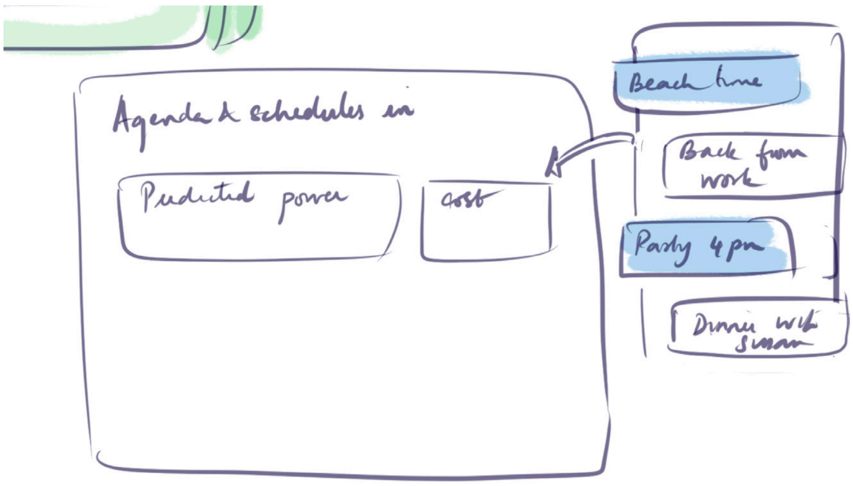


Image 17 : Calendar integration tro account for social lives

Another part of the concept exploration was to create a family hub and calendar feature where every activity of the family or time spent together could be integrated with the energy company so that they could better predict specific events or moments of additional energy consumption. Based on experts' vision of what future energy management systems could look like, the idea was meant to act as means to create more integration of the varying social lives of the people into the system. It was also meant to create a moment where family members could engage in conversations about their energy behavior. (Image 17)

Concept 3

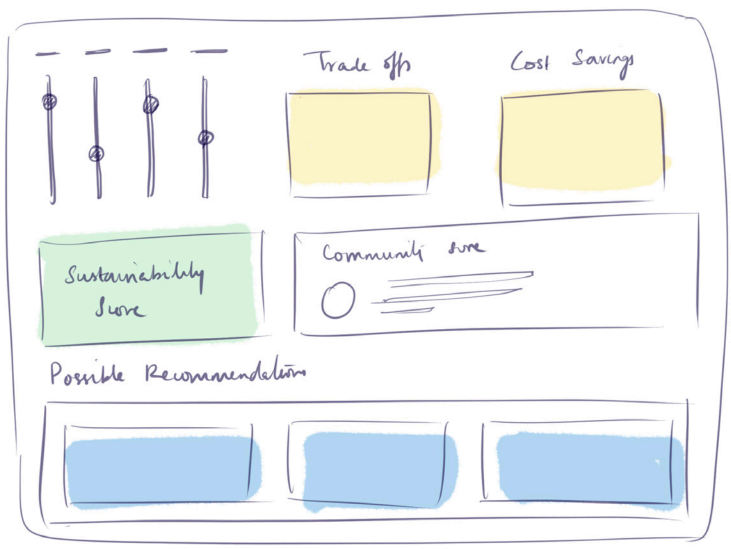


Image 18 : Presenting tradeoffs as a means to understand how the system would behave based on their priorities.

The third part of the concept was being able to display the trade-offs of the choices or priorities that the users give. The idea is to give users a clear indication or sufficient information about how the system would adapt based on their intentions/goals and what results they could/would achieve with the save. For example, how the recommendation would work if comfort is prioritised and how it would affect the cost, their sustainability score and carbon footprint. Users would still be given a chance to change the settings if they still wanted to.(Image 18)

Concept 4

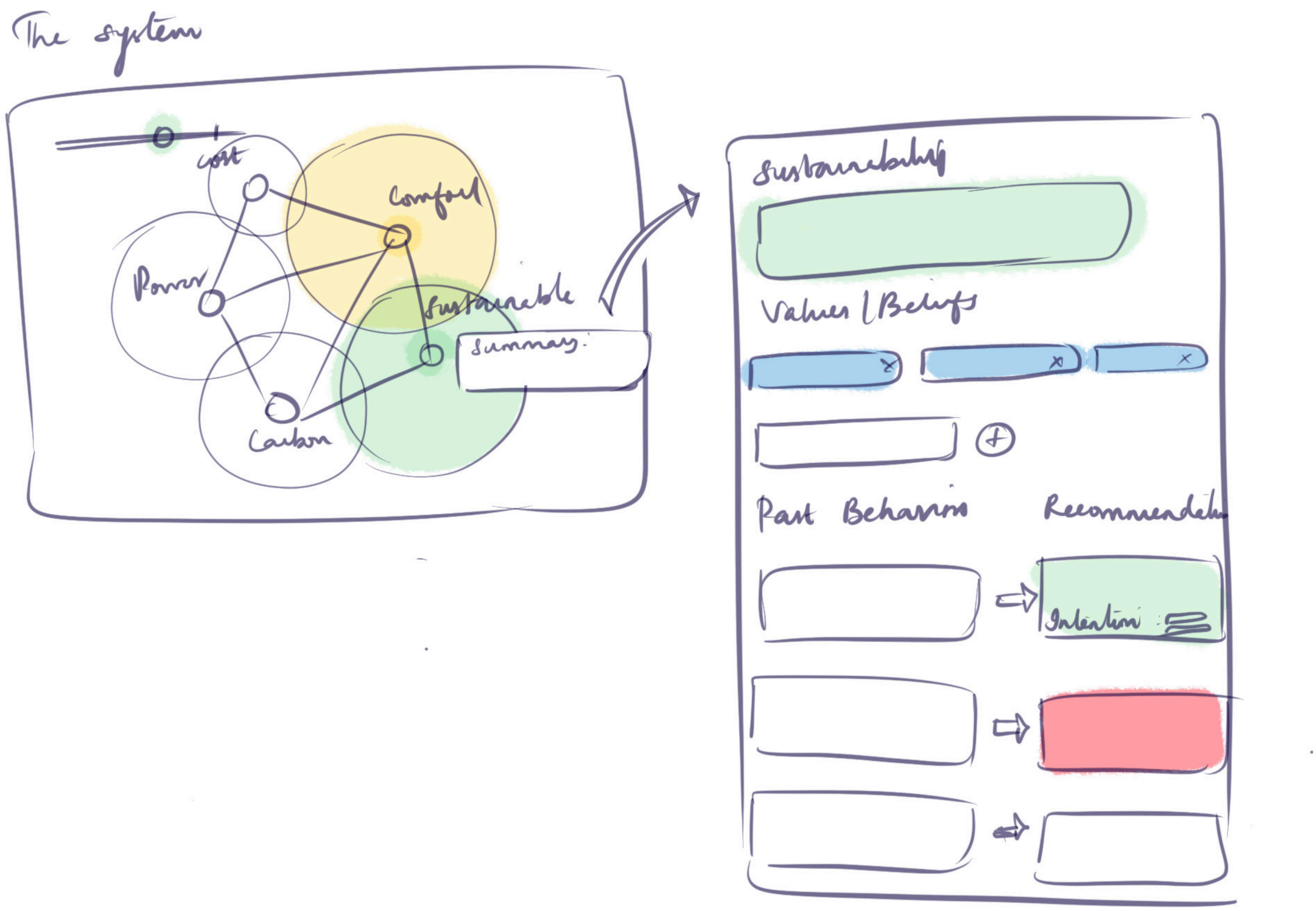


Image 19 : Calendar integration tro account for social lives

The next part of the concept involved giving users a transparent image of what the system understood about the users and how well they were performing in their goals. It was meant to give users a clear idea of what the system interpreted their actions and a form of feedback for them to work towards. It involved displaying a network of nodes that were connected and showed the relationship between the data. The nodes could further be explored to understand what values the system associated them with and their previously stated priorities. The "Axies" case study (Liscio et al., 2021) inspired adding the value element to the design. It also would show their past behaviors and the recommendations that the system recommended to them (Image 19).

Concept 5

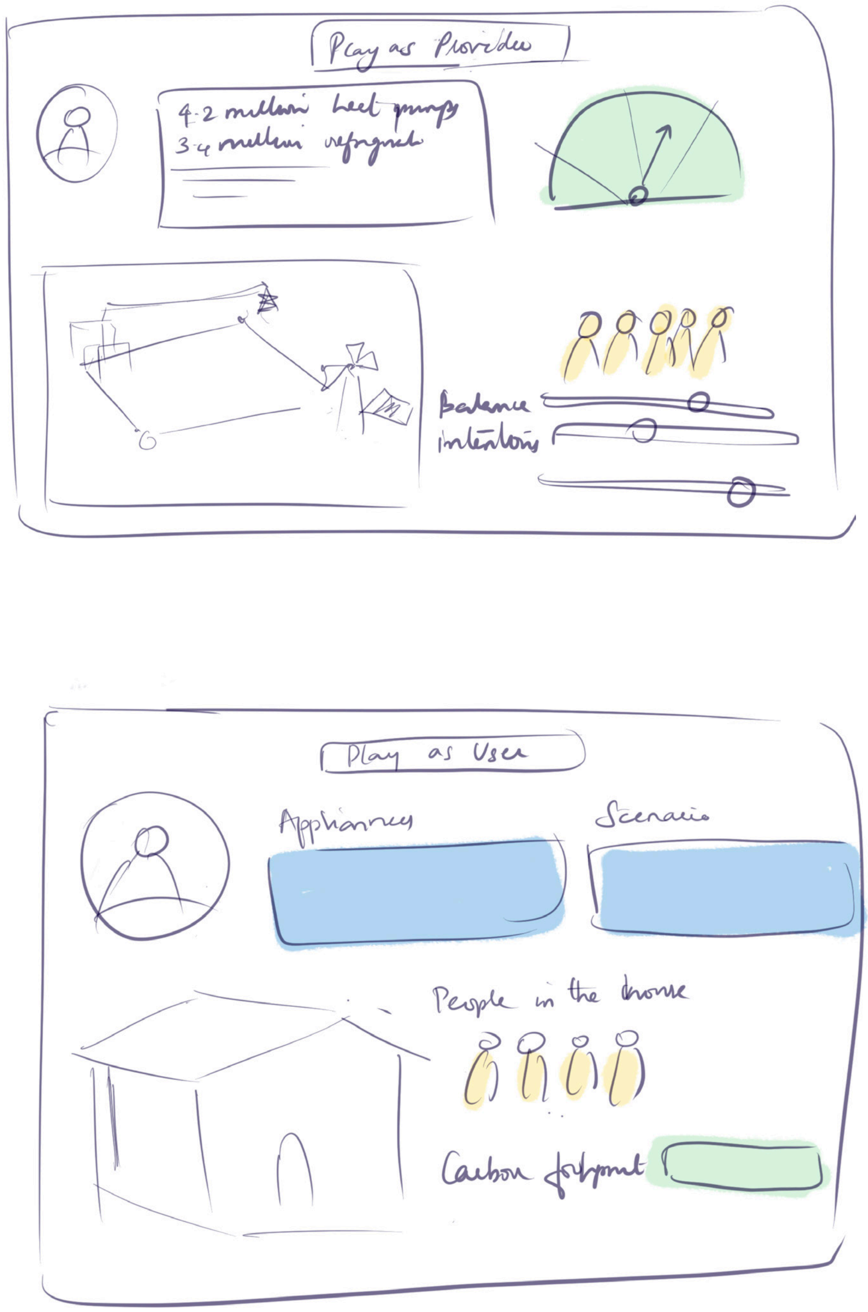


Image 20 : Game of intentions

A more game based simulation speculative concept was also explored. Here, users could act as an energy provider or user. As an energy provider, the player has to manage the grid and energy consumption of the people, convince or send advice to consumers to improve their energy behavior. As a user, the player will have to manage and maintain a sustainable home and reduce their carbon footprint by managing the appliances at home and yet keep the members of the household happy. This idea is focused on creating more awareness to people on the control and intention from the perspective of both sides ie. as an energy provider and as a customer. (Image 20)

Concept 6

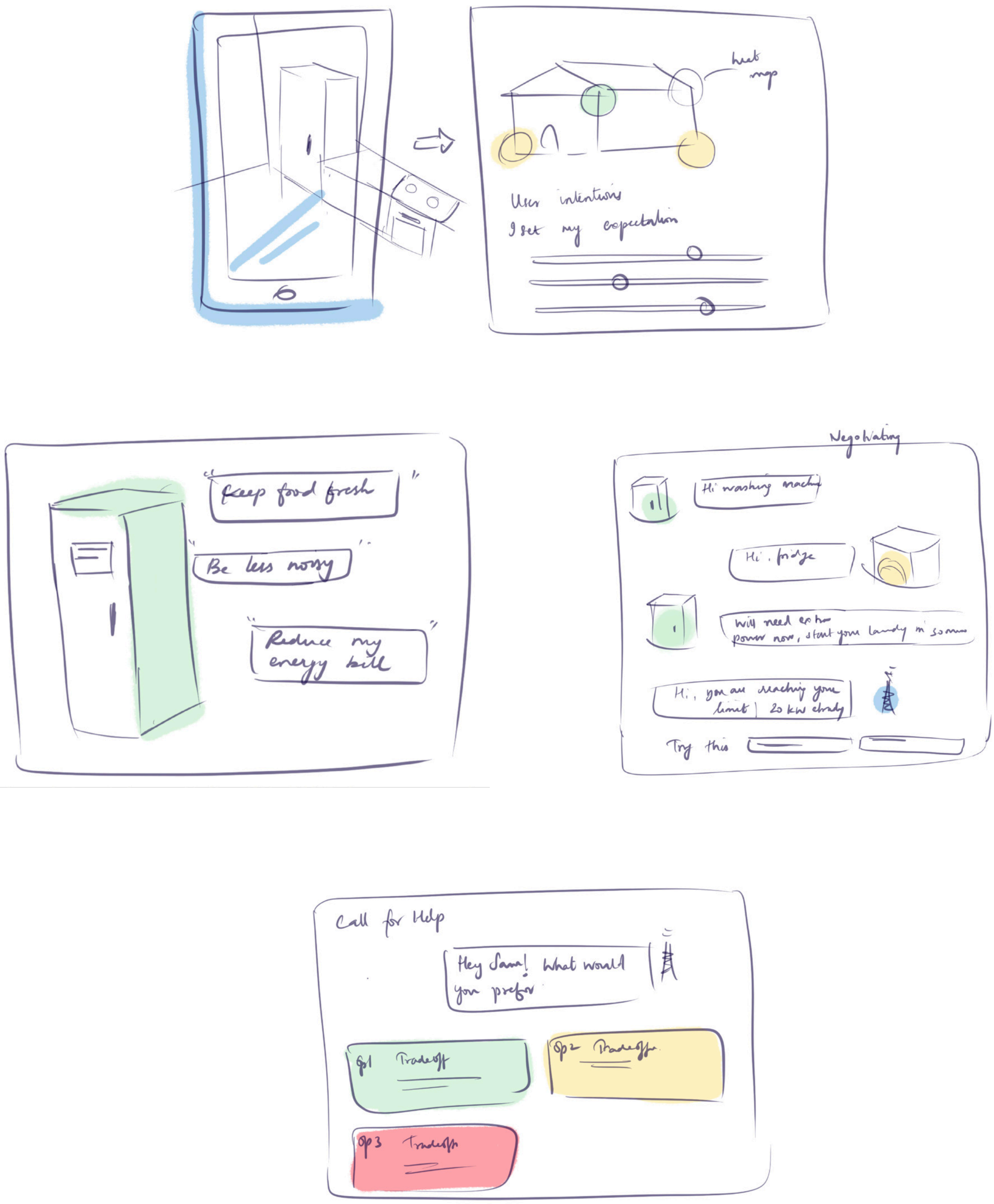


Image 21: Digita twin and internal negotiation of appliances

The next concept was allowing users to scan their entire house and create a digital twin of their house to monitor every energy consumption point in the house. Here, every appliance has their own intention/goals and can negotiate with each other on how to plan their energy requirements to fit a certain budget. When any conflict arises, the user is asked to state their preference. Here, the tradeoffs of every choice is made clear by the system so that they know the effects of the decision they make. The idea of making negotiation more human was inspired from the more-than-human design methodology (Giaccardi, 2020).(Image 21)

Iteration 1

Validating concept direction with users

7.3 Iteration I

From the conceptualisation, some parts which leaned towards a more practical application in achieving the goals towards the research questions were elaborated on. The four main areas that were focused on were :

1. Understanding how intentions could be captured and how users will perceive the idea of intentions from a user and system perspective. (RQ1)
2. Representation of trade offs and potential behavior of the system based on the choice of user intentions.(RQ2, RQ4)
3. Exploring the portrayal of transparency and presenting the values the system elicits about the users. (RQ2, RQ4, RQ5)
4. Showing how the system negotiated, made decisions on a recommendation and when users could be involved in negotiation. (RQ3,RQ6)

7.3.1 Prototyping

The prototype consisted of three scenarios that were presented to the users. Since it was the initial iteration, the wireframes were kept abstract but also had a certain level of high-fidelity in terms of content. Some parts of the information was deliberately left open-ended to elicit creative responses from the test participant.
The three scenario were :

i) capturing intentions and showing the effects of actions
ii) letting the user know what model the system has of their intentions
iii) exploring potential interactions between the home devices

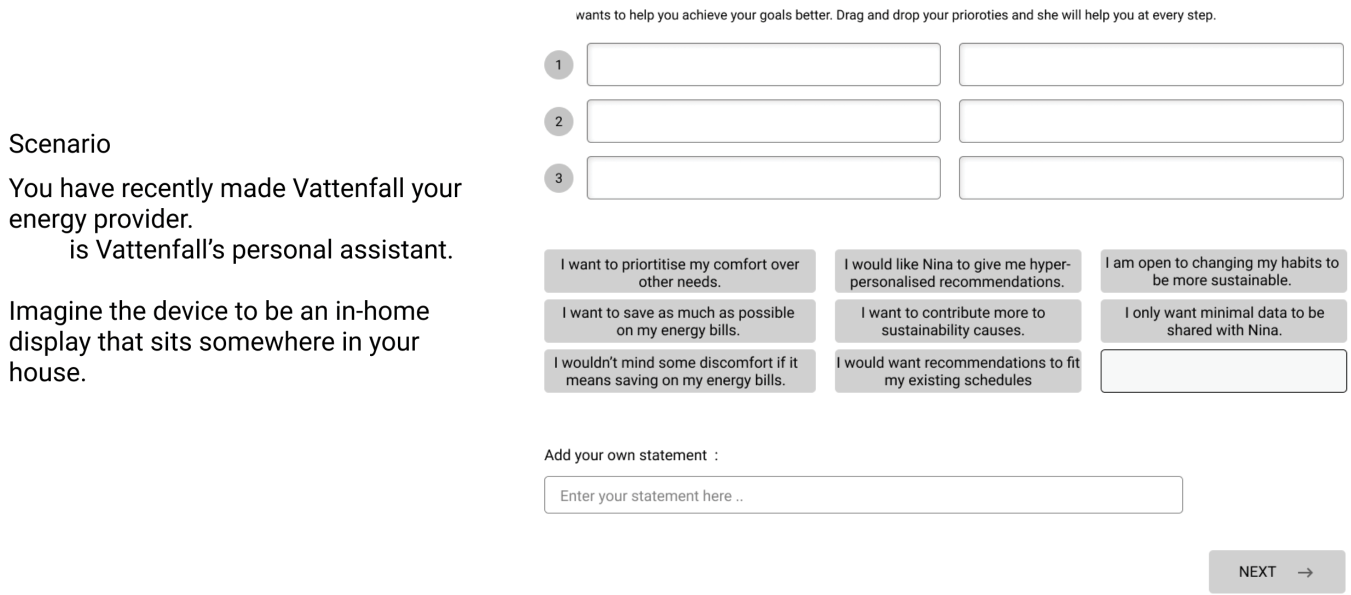


Image 22: Capturing intentions through statements

Scenario 1: The users are expected to state (drag and drop) what they prioritise among the 4 factors - comfort, cost, sustainability or privacy. The screen consisted of 8 statements - 2 for each factor. Users were also allowed to provide equal priority to certain statements if required. They were also allowed to add their own statements if required. (Image 22)

The statements involved the following :
One factor had opposing range like privacy, whereas every other factor had a varying degree of how much the user might want to prioritise their goals(Image 23).

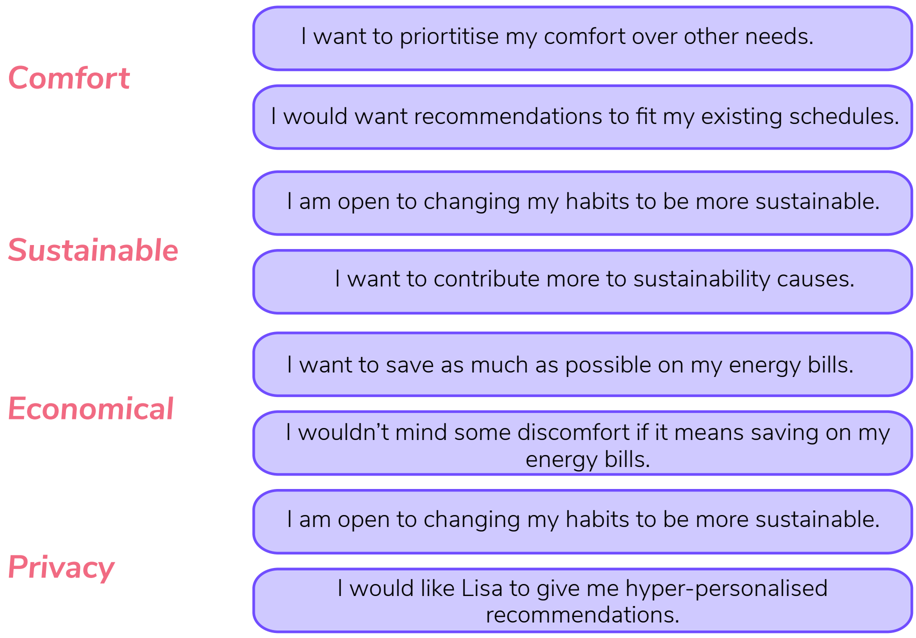


Image 23: Statements designed for each of the factors

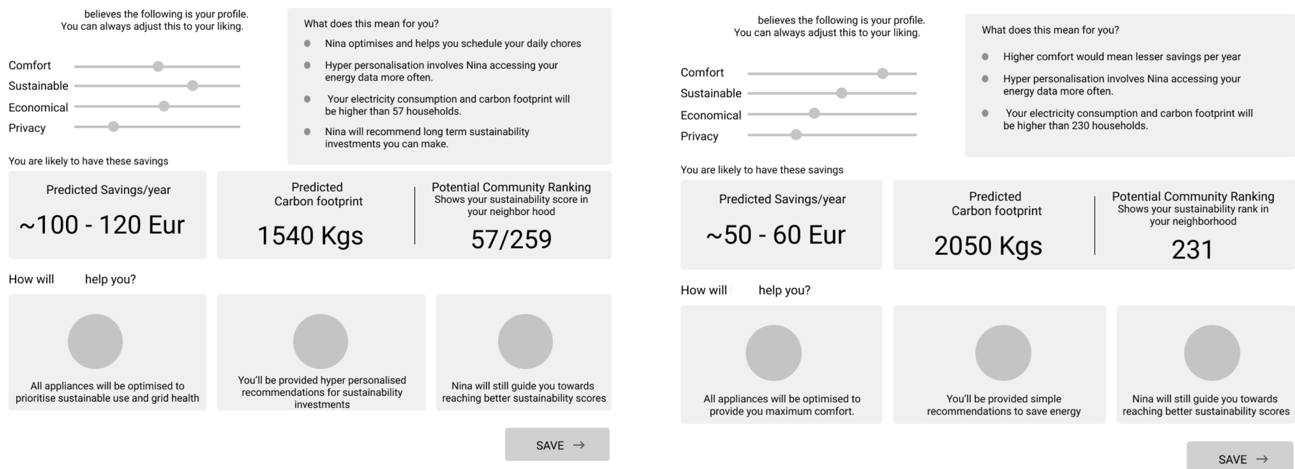


Image 24: Two profiles for presenting tradeoffs : sustainability focused(left), comfort focused(right)

Following this, the user is presented with an understanding of their profile and what they can expect the system to do for them based on their priorities. It basically presents the user with the trade-offs that they are making if they choose to prioritise certain factors. The idea lets users know the benefit/costs of the choices they are making and how the systems would respond to them and why it would behave a certain way. The goal is to transparently communicate to the users the resulting behavior of the system due to their choices. The user can still play around by moving the sliders and exploring how the tradeoffs would change so they can still flexibly choose the system's behavior. Two versions were made, one for a user that prioritizes comfort and another for a user that prioritizes sustainability (Image 24)

Scenario 2: The next scenario explored showing the user what the system's understanding of the user. This acts as a confrontational screen where users get to see what understanding the system has about their behavior over a period of use. The system here tries to profile the user based on how they are doing with respect to comfort, cost, economy and privacy. The node-like representation was kept purposely abstract to see if users could relate to what was represented and to also elicit their creative responses. Often, privacy is likely to be a constant factor that might not change with time. The user can see how their profile has changed over the months to understand their behavior better. The user could further explore the node to see the conclusions the system has made on the user.

For instance, on clicking on the node for sustainability, the user sees their initial priorities, the values that the system has identified for the user based on their past behavior and associated recommendations which led to the profiling of the user. The goal here was to share a transparent view of what the system understands about the user. (Image 25)

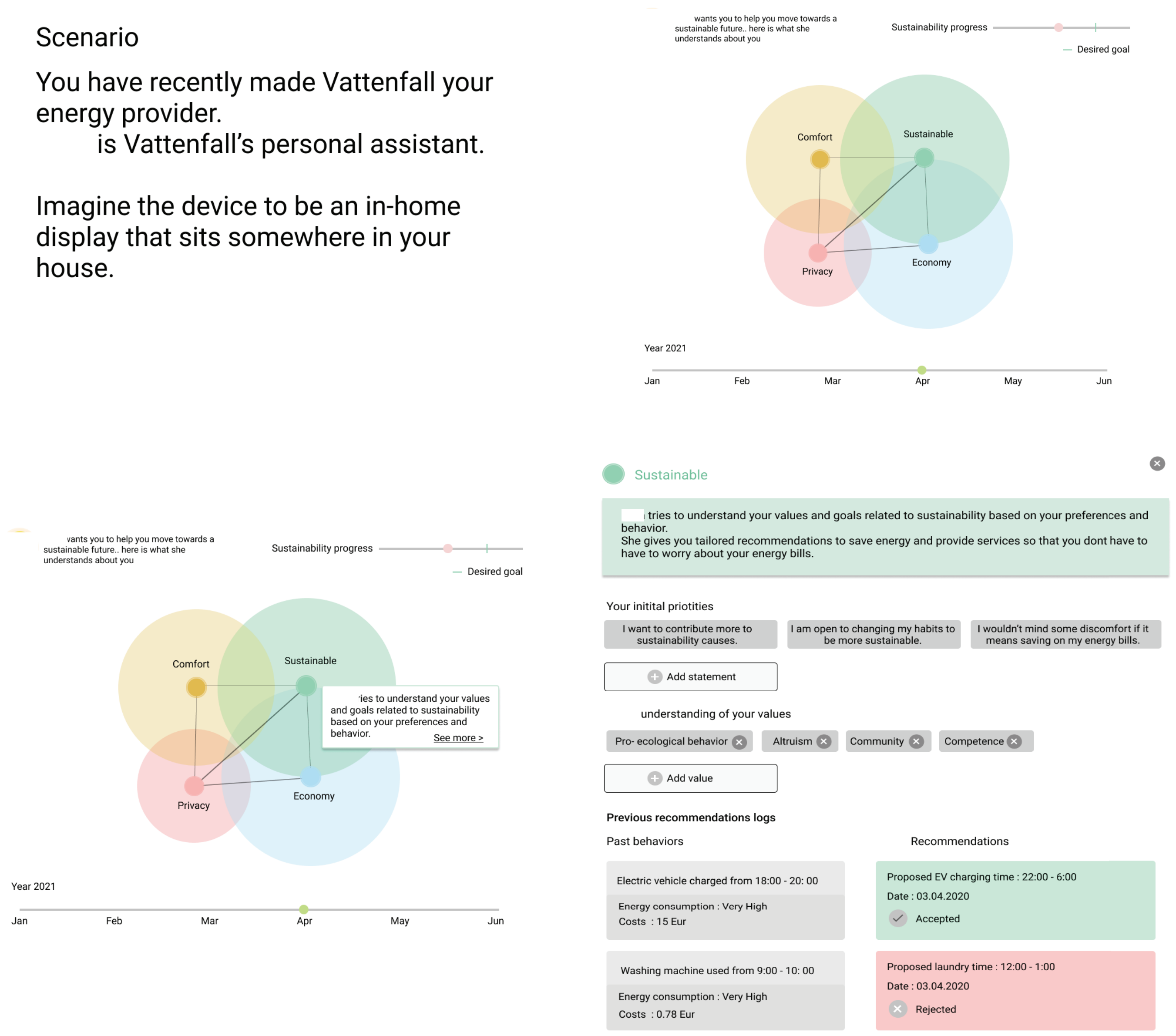
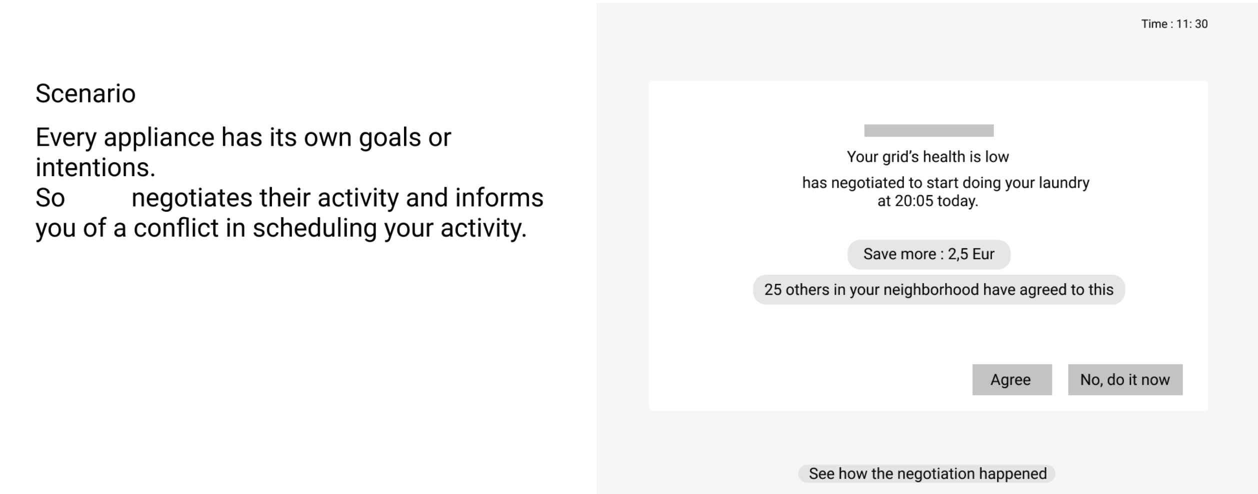


Image 25: A node like representation of how the 4 factors are connected and influence each other and a detailed look into what the sustainability node constitutes(bottom right).

Scenario 2: In the third scenario, every appliance has their own intention/goals. Each appliance works towards its own responsibilities of doing their own tasks for e.g, keeping food fresh as a refrigerator. But here, the appliances all work together to negotiate between achieving a certain energy budget goal. The user is showcased a sample recommendation made by the system after a negotiation was attempted by the appliances. The recommendation asks the user to make a choice when a conflict occurs between the appliances and the requirements of the user. The user can further explore how the negotiation between the appliances happened to understand how the system responded to a set of events.



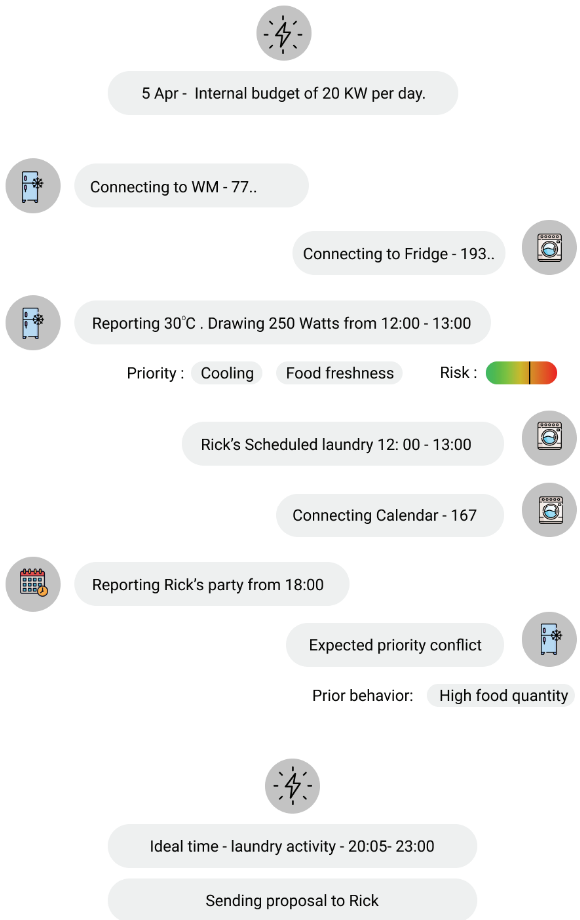


Image 26: Recommendation design and the negotiation between the appliances

7.3.2 User Test

Test Setup

Due to the Covid-19 rules, tests were conducted remotely through the Zoom application(Image 27). The researcher shared the screen of the prototype on Figma application and remote control was given to the participants so that they could directly interact with the prototype. The prototype was displayed in the model of an IPad-mini to mimic the idea of an in-home display. (add images). Six user tests were conducted which consumed about 45 mins - 1.5 hrs each. A semi-structured interview was prepared. They were asked to "think out loud" for each screen they viewed and based on their responses, follow up questions were asked.

Objectives

The goal of the test was to explore the idea of capturing intentions, presenting tradeoffs of their choices, modelling transparency in the form of a graph and showcasing the concept of internal negotiation within appliances. All the scenarios were presented in a somewhat high fidelity yet abstract manner to elicit creative responses from the participants.

Participant	Age	Profession
P1	40	UX Designer
P2	57	Entrepreneur
P3	34	Advisor
P4	38	Operations Lead
P5	34	Program Manager
P6	23	Student

Table 3 : Participant information from user test - iteration 1

Participants

Three participants were recruited through convenience sampling and three of them through the survey form.(Table 3)

Tools

- Zoom(Video, audio recording, remote control)
- Otter.ai (Audio transcription)
- Note taking
- Figma

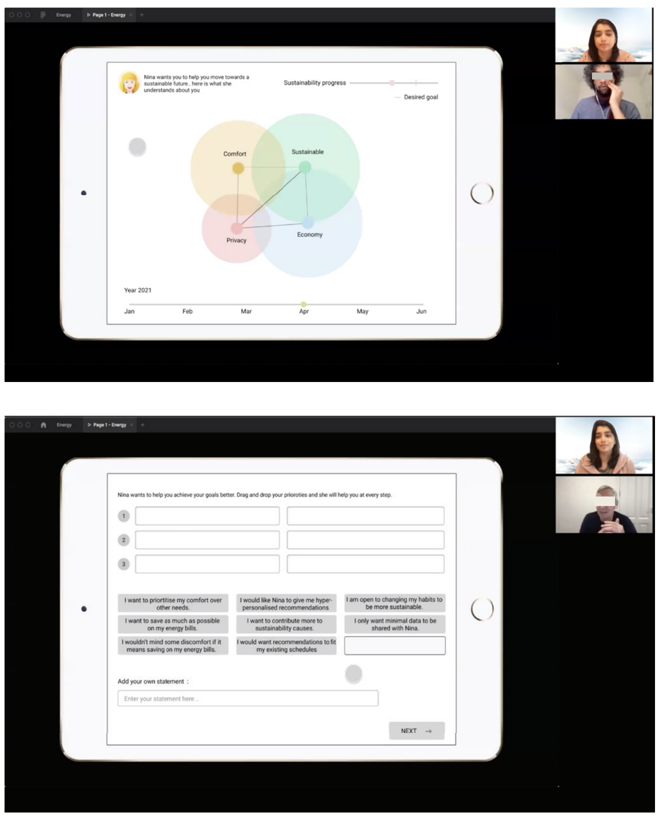


Image 27: Online user testing

7.3.3 Insights

Scenario 1

Choosing intentions

- Understanding users' choices in intentions

The main insights here involved learning about how people interpreted and picked their priorities. It was interesting to find that 4/6 participants' first priority was "I am open to changing my habits to be more sustainable" and was within the top three priorities for the two other participants. Following this, 4/6 participants also preferred having hyper personalised recommendations as part of the preference within the top three. 3/6 users also considered "I want to prioritise my comfort over other needs" as part of their top three choices. This was a positive indication than most participants were willing to make efforts to be more sustainable which could indeed be supported by personalisation from the system.

-Clarity in interface and cognitive load

From a UI perspective, it wasn't apparent or clear enough that people could give equal priorities to two statements and most users didn't have any additional statements of their own to make. If they did add any it was to emphasise on giving equal importance to or more factors for e.g I want a good balance between sustainability, cost and comfort. 2/6 participants felt it was a lot of reading to do and was cognitively bit difficult to make choices between the statements.

-Need to simplify means to pick intentions

Allowing users to pick their intentions needs to be made much simpler and possibly more interactive through images and scenarios. One way could be to make it scenario based and relevant to other everyday choices and other is to simplify them to be made as yes/no questions.

Presenting tradeoffs

- Interpretation of tradeoffs and intentionality

The main positive insight is that the users did interpret the screen as a representation of the system profiling the user and that the system is setting itself up to behave the way the user intended in the future. They also found the data on the page relevant to the choices that they made and that the overall intention of the system is to make the user sustainable eventually. The ranking creates a sense of competition and fun in the users and they feel like they want to work towards being ranked better. A predicted value of their savings and their carbon footprint was also valuable for them to see. However, the carbon footprint value as expected when represented by "kgs" often remains unrelatable or is difficult for users to visualise how it really affects the environment.

-Interface ambiguity and customization

In the interface, two users felt that the screen was wordy. The slider needed reference points to understand the level to which they belonged to a certain priority. One of the users expected flexibility in being able to customize the recommendations even further for instance, being able to set the comfort level for each device individually.

-Increasing appeal and readability

The tradeoffs could be represented in a more visually appealing way with more icons and lesser text and the information provided needs to be made further relatable for e.g carbon footprint and the community ranking. Further thought needs to be put into how the tradeoff changes with changes in the sliders.

Scenario 2

Nodal representation

- Representation considered too abstract

As expected the representation of the nodes were too abstract for most users to understand although 5/6 were able to identify it as being related to their own energy behavior. They could associate with the idea that there was still room for improvement in their energy consumption/sustainability goal. However, the circles, connected lines and overlapping sections were not easily interpreted.

-Need for quantification and clarity

The representation of their performance needs to be simplified and made more readable at first glance. Since the circle and lines don't show quantitative values it becomes difficult for participants to interpret what the real impact of their behavior is. The slider that acts as an indication towards intended sustainability goals need to be made more concrete as well.

Exploration of the node

-Perception of values

In general, the information feels heavy for users to read since it's a lot of text. The display of values had mixed responses. 2/6 users found it interesting and rewarding to understand what the system would think about them. On the other hand , the rest found it too personal , somewhat subjective and even creepy/judgemental.

-Interpretation of recommendation logs

The recommendation log was found to be useful as a way to remind oneself of previous activities and participants found this useful as a feature. However, some users were not clear whether these recommendations were real time or indeed logs of the past activities.

- Boundaries in transparency

There needs to be a fine balance in trying to achieve transparency vs being overly transparent to the users. Users don't want to feel judged by an energy provider about their behavior. Since sustainability was the only node explored here the values used were in the positive context, but the node that denotes comfort could possibly host values like hedonism which will be offensive to the users. Here, the possibility is to still identify these positive values and use them as rewards and badges as a form of recognition for energy conscious users. One user also stated the need for the system to sound more friendly and less like a machine which is an interesting point to consider.

Scenario 3

Notification design

- Feeling of control

Users like the fact that the recommendations are straightforward and find it useful to know clear benefits of the action/behavior recommended by the system. The idea of being able to say "no" or disagree with the system is appreciated i.e they have the power to influence the system. However, they also wanted to see the effect on sustainability for e.g the carbon footprint. One participant fe lt the need to have multiple choices of recommendations based on the intentions they picked.

"In essence it sounds very good and you can directly influence it."

- Social pressure and data sharing

Two participants assumed that the neighbours are aware of their activities and it created a sense of obligation to listen to the system. This was not well received as it added a sense of pressure/stress to the participant.

> *"Looks like neighbors know your party - feels like adding a bit of peer pressure."*

- Recognition of risk/conflict

Most participants took quite some time to interpret that there was a conflict that occured between two machines. It was not fully clear that there was a negotiation occurring between the devices and the grid to maintain their budget. Hence, the representation was ambiguous and required high cognitive effort to interpret.

- Information overload

Although the negotiation is more a choice for the users to see what happens behind the scenes of a recommendation made by the system, most of them felt it was too much information to process. Two participants who had a larger inclination towards data and programming of machines were more interested in reading and interpreting the conflict and liked viewing the decision making process of the system. Two participants were also not interested in viewing the negotiation at all.

> *"I want things to be fast and simple and not spend too much time on it."*

- Making system information friendly

Although the negotiation was presented in a conversational format (chat like), it still appeared too formal. The language was still not friendly or intuitive enough to process immediately.

7.3.4 Discussion and implication - Iteration 1

The idea of intentionality is not an apparent concept to most users and is not necessarily an intuitive idea that occurs to most users while interacting with a system. When interviewed about the section on capturing intentions, users had their own interpretation or generic language to interpret them. Intentions were perceived instead merely as personalisation, customization, stating preferences or declaring their needs or goals. Most users also struggled to come up with their own statement that could represent their needs. Hence capturing scenarios needed to be made less intensive and segmented based on the focus of goals.

In the prototype, there were two levels/layers of transparency(about how the system sees people): one the graphical and the other value based interpretation. As mentioned earlier, most participants like one level of transparency with respect to what the system understands about the user. Beyond that, it is perceived as overly personal and makes users feel uneasy and judged. Hence, the concept of displaying values explicitly will be removed and instead positive values could be presented as badges or rewards to appreciate sustainable behavior/actions. Users also requested for more real time data supported by the predictive data and recommendations so that they can make self-informed decisions about the use of their energy.

The negotiation scenario, although found interesting, was too detailed or technical for most users. People expected more higher level information and less systems like language for easier interpretation. The conversational negotiation scenario will hence be removed and simplified in the following iterations.

Overall the concept and direction was well received. The intention of the system was perceived as being guiding towards sustainable behavior. Even for a somewhat abstract prototype,participants had feelings of trust and a sense of transparency towards the system. While providing a sample recommendation, users perceived a sense of having control over the system's behavior.

Iteration 2

Ideation with designers

7.4 Iteration 2

This iteration involved taking the learnings from the previous iteration and further exploring ways to represent the user's intentions, visualising tradeoffs and real time energy consumption.The second iteration was performed with product designers as a means to test the concept and co-create parts of the design. The main areas of focus were:

1. Exploring different versions of capturing scenarios. (RQ1)

2. Presentation of tradeoffs and providing forecast information of system behavior.(RQ2, RQ4, RQ6)

3. Focus on brainstorming effective and engaging ways to show real time data visualisations to users. (RQ2, RQ4, RQ5)

4. Identifying less intrusive ways to show the system's perspective of user's behavior.(RQ4, RQ5, RQ6)

5. Trying to portray energy from an anthropomorphic angle.(RQ5)

4. Overall aesthetic exploration for the design.

7.4.1 Prototyping

The prototype consisted of five scenarios that were presented to the users. This iteration had a higher fidelity and the visual design for the interfaces was explored as well. Some parts of the interfaces were not fully finished or finalised and were instead kept open as a point of discussion with the designers. The five scenario were :

i) variations of capturing intentions and showing the effects of actions
ii) showing the effects of their intentions in a detailed and friendly manner
iii) exporing energy disaggregation
iv) presenting the energy profile of users in a graphical manner
v) Aesthtics and emotion exploration for the homescreen

Exploration 1 : Capturing intentions

The first exploration was in ways to capture intentions as a means to personalise the behavior of the system.

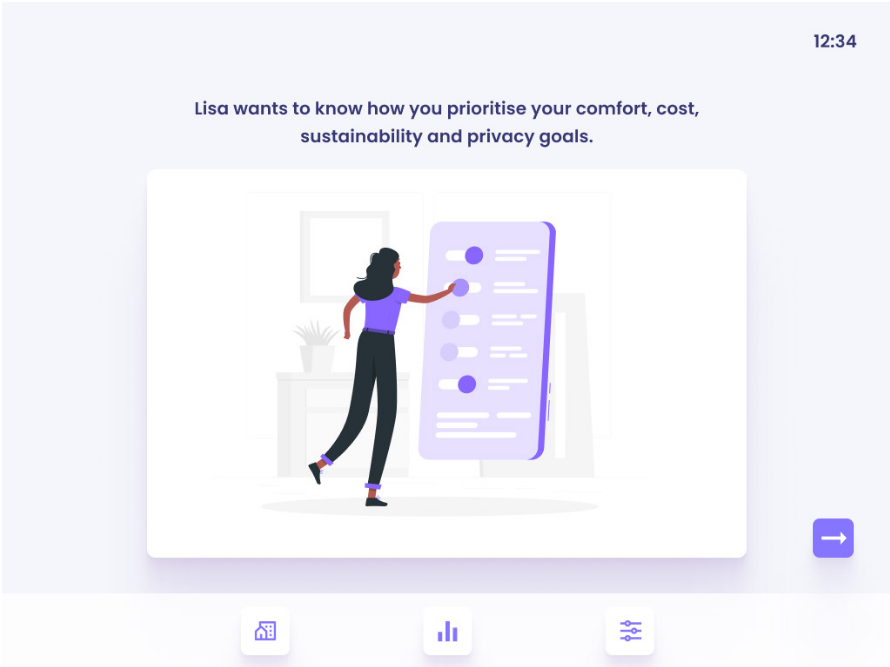


Image 28: Introduction screen of the setup for capturing intentions

Option 1: The first option was to put the question in context of a situation and capture their response to understand how they would act in the particular situation. Here, the response will try to elicit what their priorities are through their choice of action.The goal was to avoid asking intentions directly so that people could stay true to their likely natural behavior(Image 29).

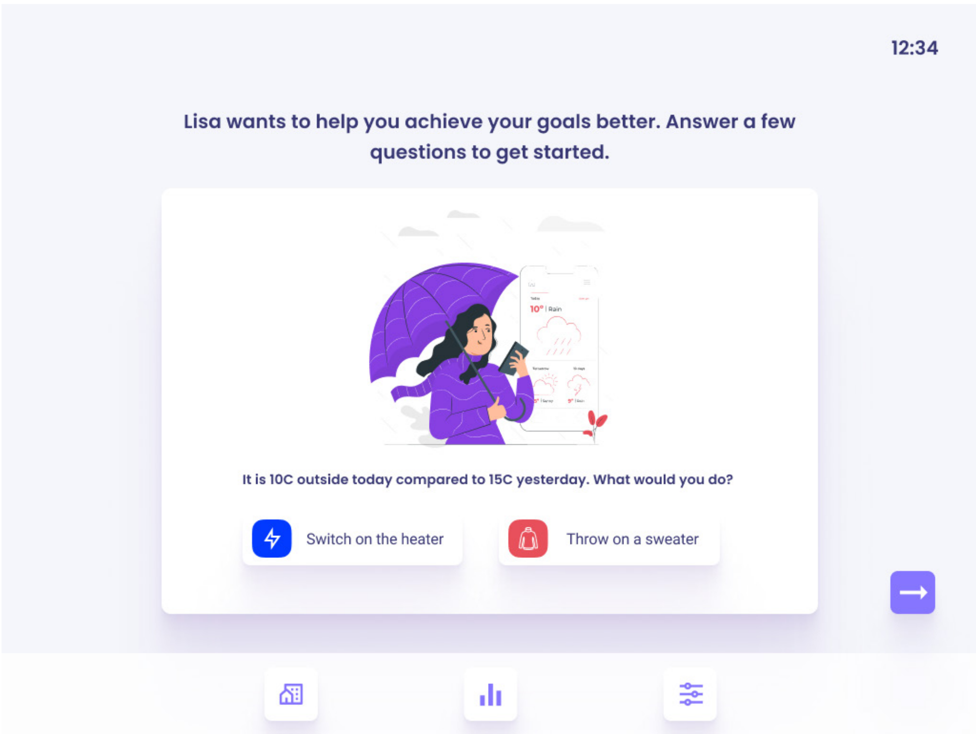


Image 29: Using a real world scenario to capture intention.

Option 2: The second option was to explicitly provide the statements and allow users to easily disagree or agree with the statement. This came from the need to reduce the cognitive load on users when exploring the statements. It was also made with the anticipation that making it a simple interaction would also prompt users to respond more intuitively(Image 30).

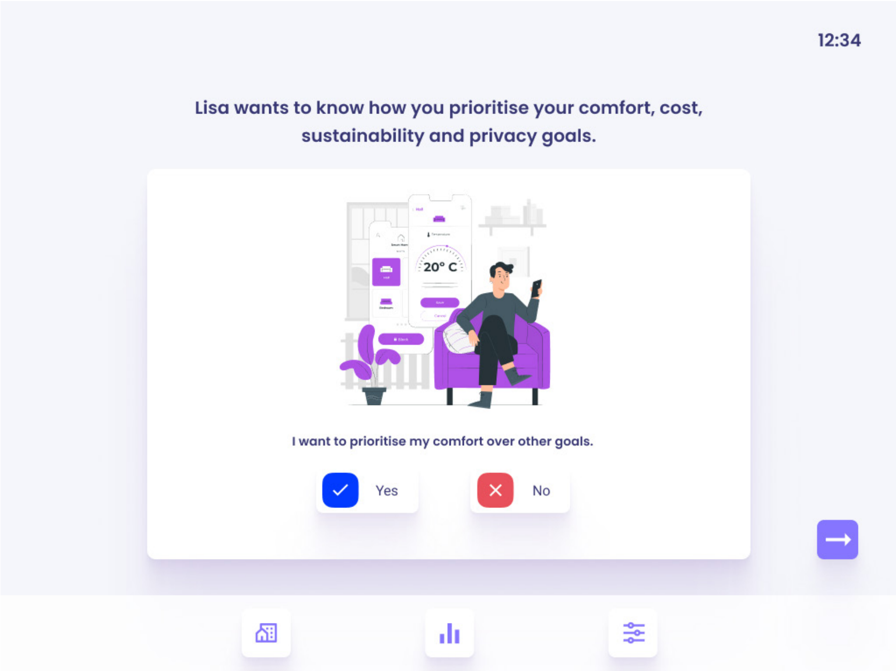


Image 30: Providing statements straight away with the option to agree or disagree.

Option 3: This version borrows from the previous iteration of using statements as a way to capture intentions. This time the statements are split into the 4 factors each (comfort, economic, sustainability, privacy). Each statement is designed to have a varying degree of priority. This version does require a bit of additional thinking/effort from the user to weigh the statements and consider what fits them best (Image 31).

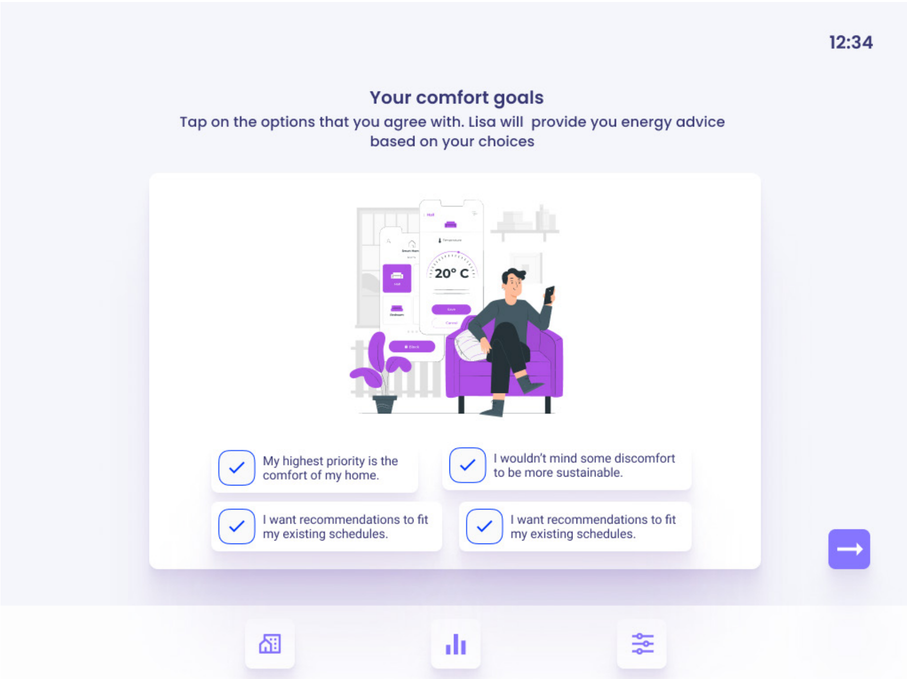


Image 31: Providing multiple statement options for each factor.

Option 4: The simplest version was to offer a slider option to directly indicate their priorities. This was one of the requested styles in the previous iteration. Although this version did not contain the nuance or context as much as the other options. (Image 32)

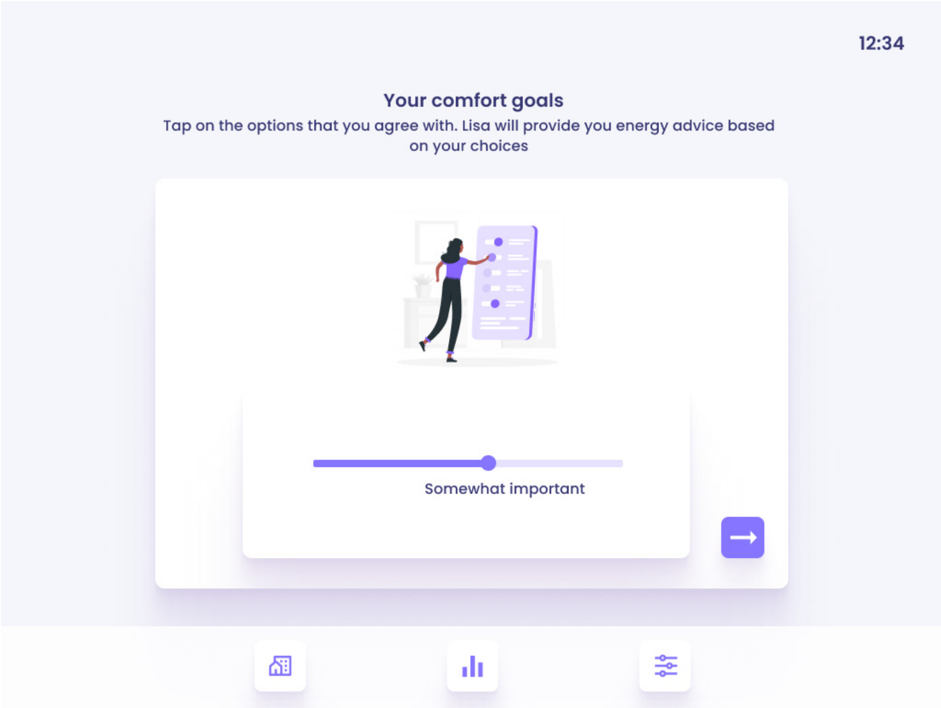


Image 32: Using a simple slider for each factor.

Exploration 2 : Presenting tradeoffs

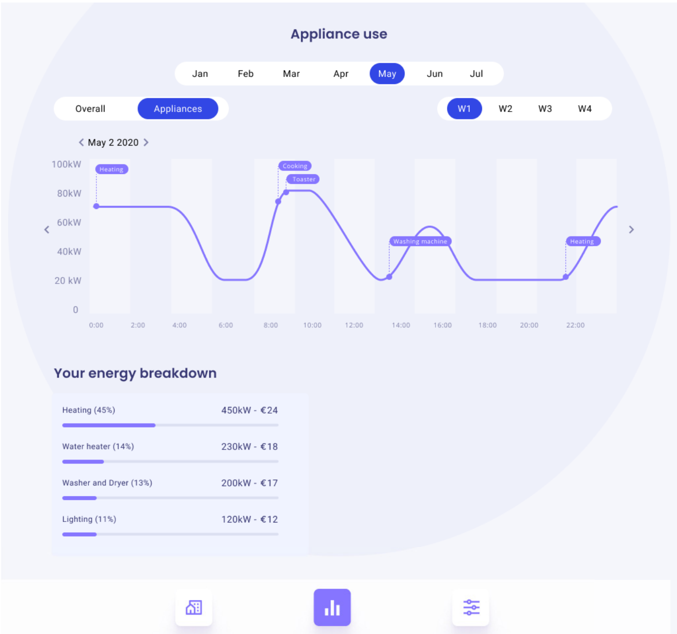
Here, as opposed to the previous iteration, the data was presented in much smaller pieces and split into clear sections. The priorities that could be more dynamically controlled were limited to the three main parts which are: Comfort, Cost and Sustainability. Control over privacy was separated for the sake of better awareness and clarity in understanding the implications of sharing data. Moreover, privacy was a component that was not meant to be changed too often or in a fluid way as it would hinder the efficient working of the system.

Users were provided with quick statements of how their choices would impact them with respect to the four factors. These factors were exclusively color coded to help users better associate with the 4 factors when exposed to them in other parts of the prototype. They could still adjust their comfort, cost, sustainability preferences through the sliders provided and moreover explore the privacy settings through another dedicated link. The rest of the profile showed users their forecasted data and how Lisa would make recommendations/ help the users achieve their goal (Image 33).

Image 33: Presenting tradeoffs and a forecast of their savings, carbon footprint etc.

Exploration 3 : Showing energy breakdowns

Ways to present the energy consumption of a household was explored. The goal was also to explore unconventional ways of presenting the data with the intention to make it more captivating/engaging.
For the energy breakdown, a bubble graph and line graph with annotations was used to present per appliance use, time of use and the amount of consumption. The cost breakdown per day was also provided. The graphs were meant to help users understand their patterns in consumption and moreover a complete breakdown of appliances adds to transparency of the system by helping users know what contributes to their energy bill. (Image 34)



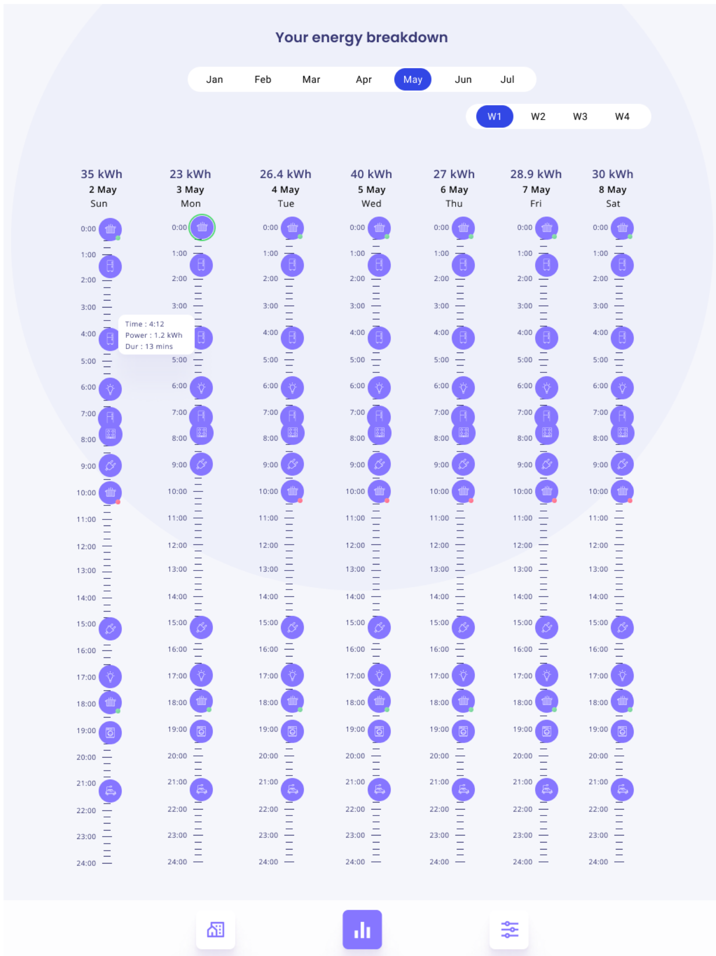
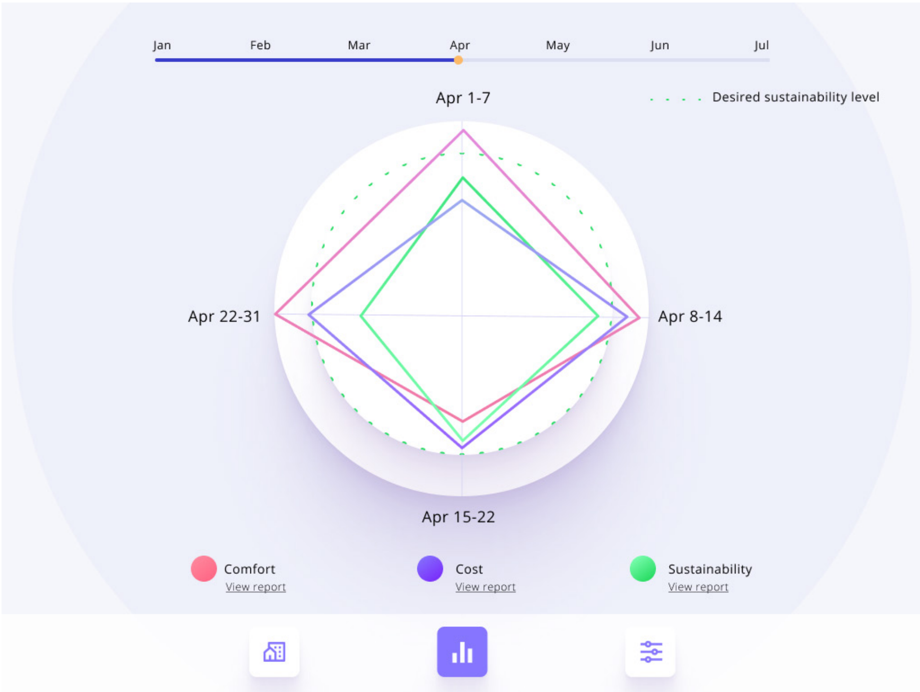


Image 34: Consumption breakdown per appliance (top) weekly patterns of consumption (bottom)

Exploration 4: Showing energy profile

The energy profile is a way to represent a user's performance with respect to their 3 factor goals: comfort, sustainability and cost. The goal was to preview a monthly representation of how users were keeping up with the goals they set for themselves. It is meant as a moment of reflection for the users to understand their behavior and usage behavior. It is meant as a transparent way to represent the system's interpretation of how the user is performing. It provides users the opportunity to also recognize if they need to rethink their goals/ priorities and in turn change how the system could behave for them in the future.(Image 35)



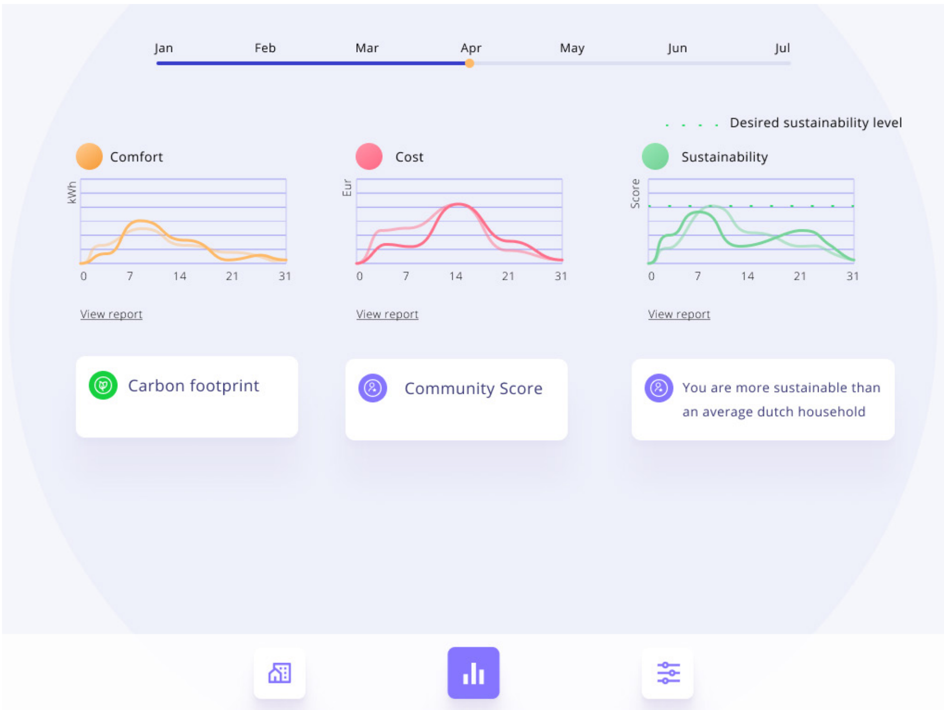
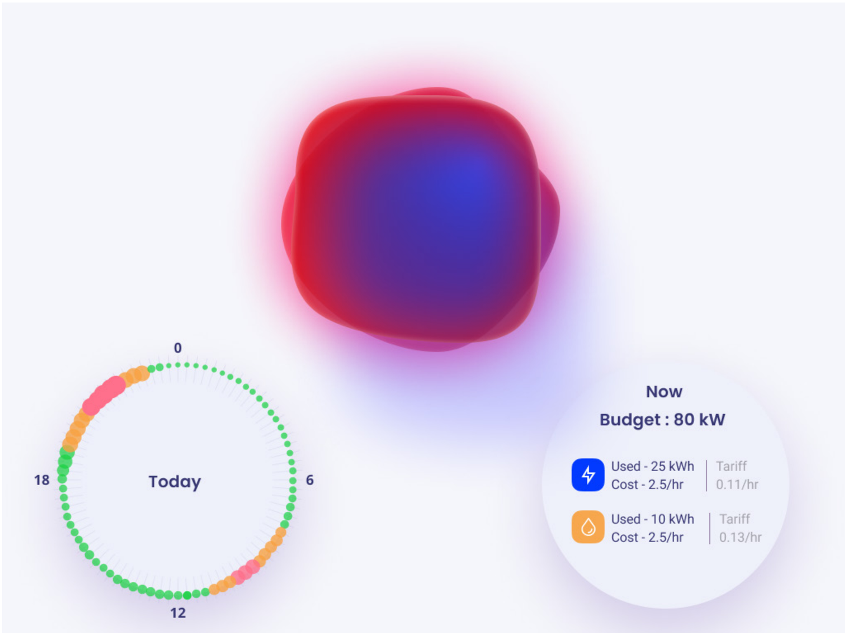


Image 35: Representation of how users are doing with respect to their goals

Exploration 5 : Homescreen exploration

The screens were meant as an aesthetic exploration of visualising data in an engaging way to help people associate or interact with their energy use for often. One involved a more practical data-driven visualisation over a 24 hour clock and the other a more emotive heartbeat like representation for real time energy.(Image 36)



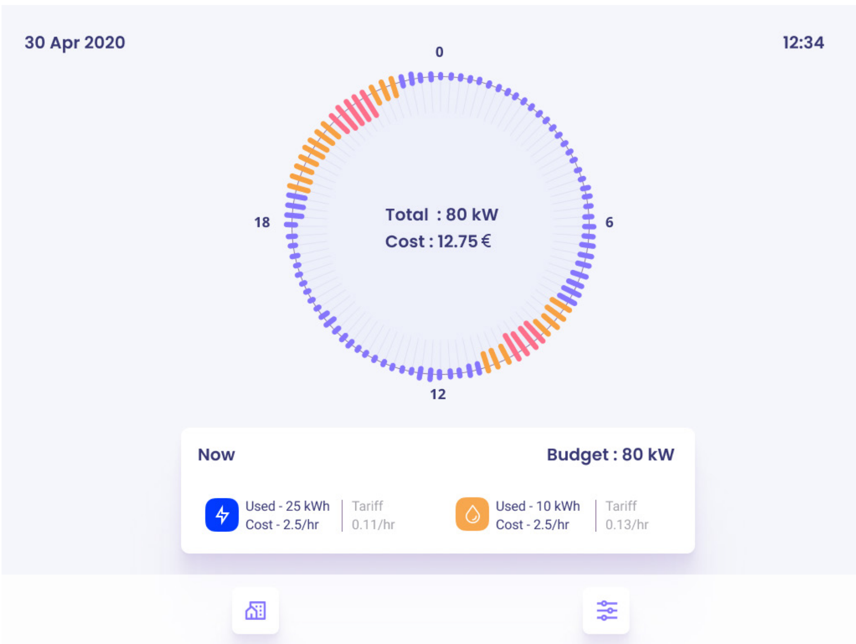


Image 36: Homescreen exploration

7.4.2 Co-creation

Setup

Due to the Covid-19 rules, tests were conducted remotely through the Zoom application. The researcher shared the screen of the prototype on Figma application and remote control was given to the participants so that they could directly interact with the prototype. The prototype was displayed in the model of an IPad-mini to mimic the idea of an in-home display. (add images). Four individual brainstorm sessions were conducted which consumed about 1 hour - 1.5 hrs each. The first part involved asking for interpretation of the prototype, followed by a discussion on their opinions and expectations. The possible alternatives for further iterations were then explored through an open discussion with the participants.

Objectives

The goal of the co-creation was to explore the different versions/ways of idea of capturing intentions, presenting tradeoffs of their choices and modelling transparency in the form of a graph. The idea was to iterate with fellow designers on which version would work best and how it could be further improved to be presented for the next iteration of user tests.

Participant/ Gender	Age	Background experience
P1(F)	27	Negotiation with AI in autonomous vehicles
P2 (F)	28	AI experience in autonomous vehicles, gaming design
P3 (F)	27	AI for well being
P4 (M)	26	Machine learning, data design, coding

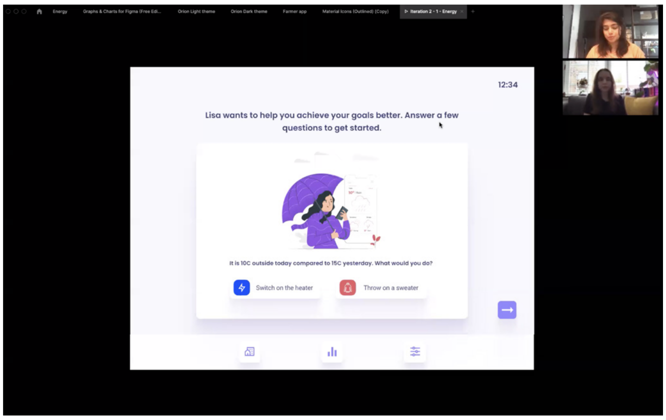
Table 4 : Participant information from co-creation - iteration 2

Participants

Four participants were recruited through convenience sampling. All participants were from the Design for Interaction masters program and have some form of experience working on the theme of artificial intelligence. (Table 4)

Tools

- Zoom(Video, audio recording, remote control)
- Otter.ai (Audio transcription)
- Note taking
- Figma



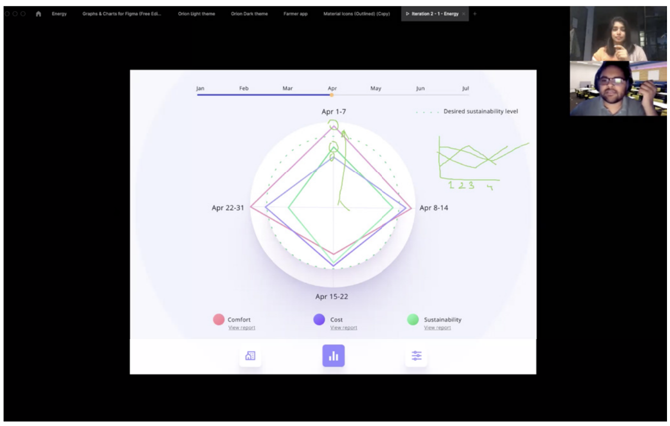
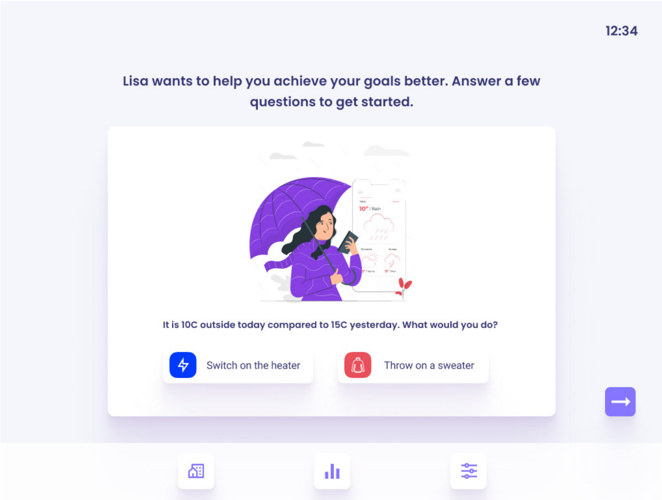
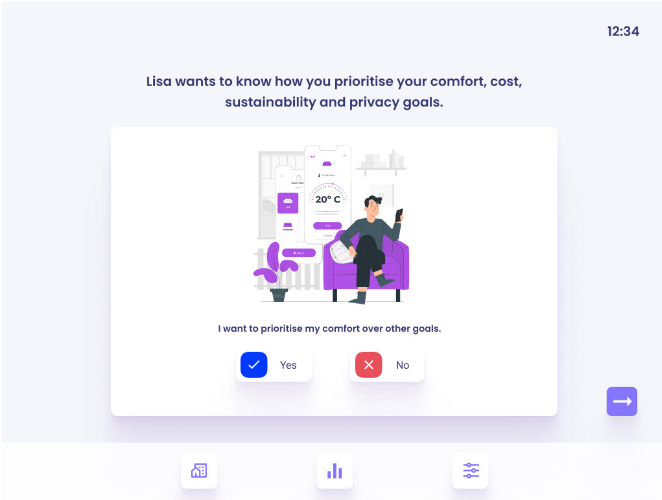


Image 37: Co-creation with designers

7.4.3 Insights

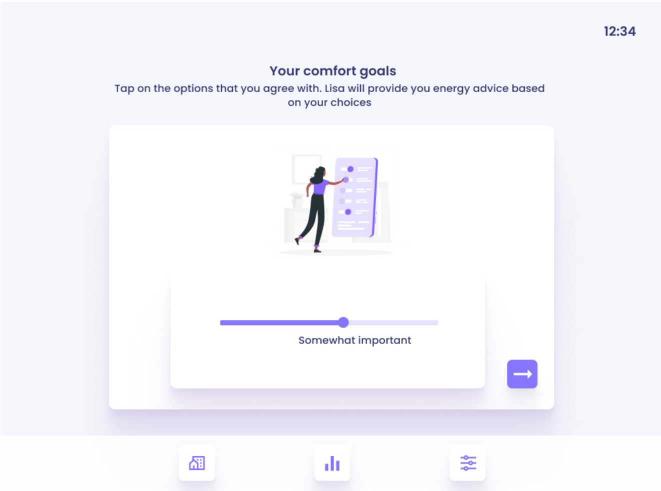
Exploration 1: Capturing intentions



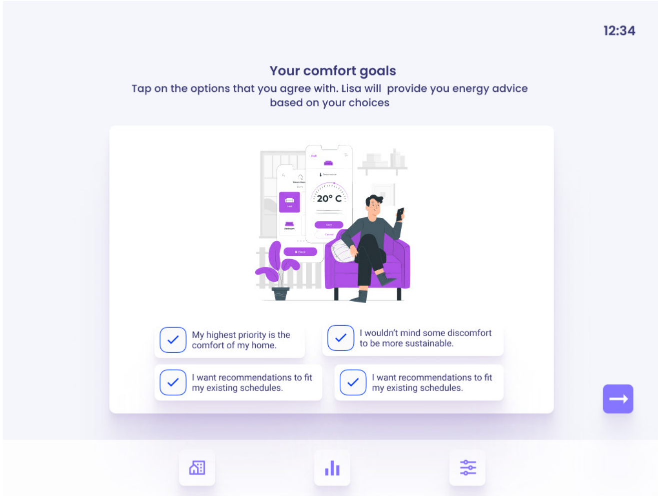


The context based questions are effective in making people give a hint on the alternate solution they could consider i.e in this case choosing to wear a sweater as opposed to turning up the heat in not too cold weather. However, the need/purpose of these contextual questions weren't immediately clear to the participants. The value of the context is lost and the question appears abstract when the purpose is not made clear. Also, there is a likelihood that people would choose a more socially acceptable answer as opposed to their actual behavior in the given context.

Here, it was more evident that Lisa was trying to learn the preferences of the users when compared to option a. However, this presentation, although much simplified, would severely limit the number of questions one could ask. There would be too many screens to click through which users would get frustrated with and in turn delay setting up the system. Moreover, there was a chance that users might click through the questions in a rather frivolous/ speedy fashion without much thought into the question asked.



The statement style presentation was most preferred among the four. The statements appeared concrete and nuanced. It gave participants to weigh what they wanted more explicitly and felt nudged towards considered sustainability. Two participants stated that they were more likely to sacrifice discomfort and attempt to be sustainable when confronted with such statements.



The statement style presentation was most preferred among the four. The statements appeared concrete and nuanced. It gave participants to weigh what they wanted more explicitly and felt nudged towards considered sustainability. Two participants stated that they were more likely to sacrifice discomfort and attempt to be sustainable when confronted with such statements.

Exploration 2: Presenting system

- *Tradeoffs*

Overall the tradeoffs act as a starting point for participants to learn the impact of the choices made by choosing one's priorities, although it lacks enough specificity. There is better clarity in its impact if there are pointers that show how each of the three factors influence each other. There is also some ambiguity in what the resolution of privacy means and it is important to educate users about the impact it has on the behavior of the system. Although 2/4 designers felt that privacy need not take such a high priority in the content architecture and that a high emphasis on privacy may elicit negative emotions in people by implying that it is something to be concerned about.

"I can learn the consequences of my choices."

"I see that the system is also trying to be persuasive to steer towards lowering energy use."

- *Forecast data and recommendations*

The forecast data was helpful in quantifying the intentions into a more tangible result. The participants also felt that this section of information needed to take precedence on the page. There was also curiosity to understand how these numbers were actually predicted. The participants felt that the ranking would incentivise/motivate people to try to change their energy consumption behavior. The word "recommendations" was misleading in representing how Lisa would help the users achieve their goal. It was also rather ambiguous in giving a picture of what it would mean in the actual context of use.

"Good to see the numbers and the impact because you become more accountable."

"I am curious about the community score- has a potential for a lot of competitiveness between people."

Exploration 3: Energy breakdown

- Understanding behavior/usage patterns

The energy breakdown has a good potential in helping people understand their patterns of use on a daily basis. The bubble graph was interpreted as a way to understand one's routine better, whereas the line graph gave a better overview of the overall consumption. An ideal representation would be to combine both ways of data visualization. Additional elements like a side menu to control the appliances that one wants to see, a calendar entry point and a legend were recommended by the participants.

- UI and interaction

There was quite some ambiguity in the representation of the start and end of each appliance. More exploration was needed in presenting the appliances with more clarity, for instance with different colors and bigger icons.

"It feels like a lot of value is added to energy by just visualising it."

- Energy profile

One participant raised a concern on the level of detail of the data and that it was getting quite personal. She was also willing to compromise on the efficiency of the system if she could maintain some privacy. This might suggest that disaggregation for appliances can be data that people can choose to have the system generate rather than it be a default feature provided by Lisa..

"I am a bit terrified about how much Lisa knows about me."

Exploration 4: Energy profile

The energy profile with the spider graph proved to be difficult to interpret and somewhat abstract. The relationship between the different factors was not apparent. Two participants interpreted it as being only related to the monitoring of sustainability goals. The resolution of the graph was also suggested to be low. The circular regions were also intercepted as boundaries and hence the shadows were confusing to the participants.

The line graph however was more approachable and readable and appeared to provide more information on the factors. The insights at the bottom could also act as a way to communicate quick conclusions or information about one's performance with respect to their goals.

Overall, it still remained a challenge on how this representation could be better visualised. A combination of line graphs was the most commonly suggested.

Exploration 5: Energy profile

The hour-wise line representation was clearly viewed as the energy consumption for the day, although the yellow and the purple colors were misinterpreted as gas and electricity consumption respectively. It would be useful to add how much a purple, yellow or red would mean in kWh. The participants suggested that the heartbeat for the energy could instead act as screensaver for people who have an interest in the aesthetic appeal of an in-home display as opposed to real time data. Although one participant said that they would personally not connect with something abstract and would prefer to have practical information upfront instead or rather have a functional home screen.

7.4.4 Discussion and implication - Iteration 2

The second iteration helped make some concrete decisions on what the possibilities towards final design could look like. The main takeaways were in understanding what parts of the design worked and what could be made better. Capturing intentions were made best contextual, nuanced and effective in the format of statements. It had a more persuasive effect compared to other ways of presentation. The presentation of trade offs were effective in creating tension among the participants about the potential consequences of their priorities or goals in using the system. It was also well effective in communicating the impact of their actions in a quantified manner. Some pointers on the trade-off still needed to be made more concrete and possibly explained through examples to help users understand how a trade off would translate into real life.

The data visualization of the energy breakdown was found to be insightful and useful in understanding one's energy patterns. However, some parts appeared somewhat complex or overwhelming to read. A more practical version of combining energy breakdown and overall consumption was co-created which was used in the next iteration. The energy profile for the users needed to be simplified as much as possible and it was decided to make the representation into simple line graphs. The exploration of the heartbeat for energy had a somewhat mixed response and it was agreed upon that it was best suited for users who had an inclination for aesthetic appeal.

Overall, the design was also heading towards the right direction with respect to capturing user intent, presenting what the system knows about user behavior and in communicating transparency by providing the right information.

Iteration 3

Final iteration with users

7.5 Iteration 3

The third iteration moves towards the finalisation of several parts of the design. Based on iteration 2, there were clear preferences or design proposals that were drawn. There were concrete decisions made on how the data visualisation could be presented to the users. The third iteration was also tested with real users with a wide range of demographics in order to validate the design.
The main areas of focus were:

1. Designing all variations of the statements to include all profiles of users. (RQ1)

2. Presentation of tradeoffs and providing forecast information of system behavior. Supporting these tradeoffs with tangible examples.(RQ2, RQ4, RQ6)

3. Finalising effective and engaging ways to show real time data visualisations to users. (RQ2, RQ4, RQ5)

4. Presenting the system's perspective of user's behavior in a simplistic manner.(RQ4, RQ5, RQ6)

5. Testing the portrayal of energy from an anthropomorphic angle with users.(RQ5)

.

7.5.1 Prototyping

The prototype consisted of six scenarios that were presented to the users. All parts of the prototypes were high-fidelity and supported with visual design elements as well.
The six scenario were :

i) capturing intentions through statements
ii) communicating to users the effects of their choices in a tangible manner
iii) empowering users with detailed data visualisations of their energy use
iv) letting the user know what model the system has of their intentions - energy profile
v) presenting variations of what recommendations the system could make
vi) homescreen preferences of the users

Scenario 1 : Capturing intentions

Based on the previous iteration, it was clearly concluded that statements were preferred in adding nuance and context in helping capture intentions better. In addition to that, it added a persuasiveness that helped people consider sustainability as an influencing factor among more common factors like comfort or cost. Moreover, the number of statements were increased from 2 for each factor to four each and split into sections so that people can focus on each priority separately. This also helped define the statements in a more detailed manner. Each statement was carefully constructed to help categorize users' priorities as uniquely as possible. They are allowed to choose at most two statements to state their preference. (Image 38,39)

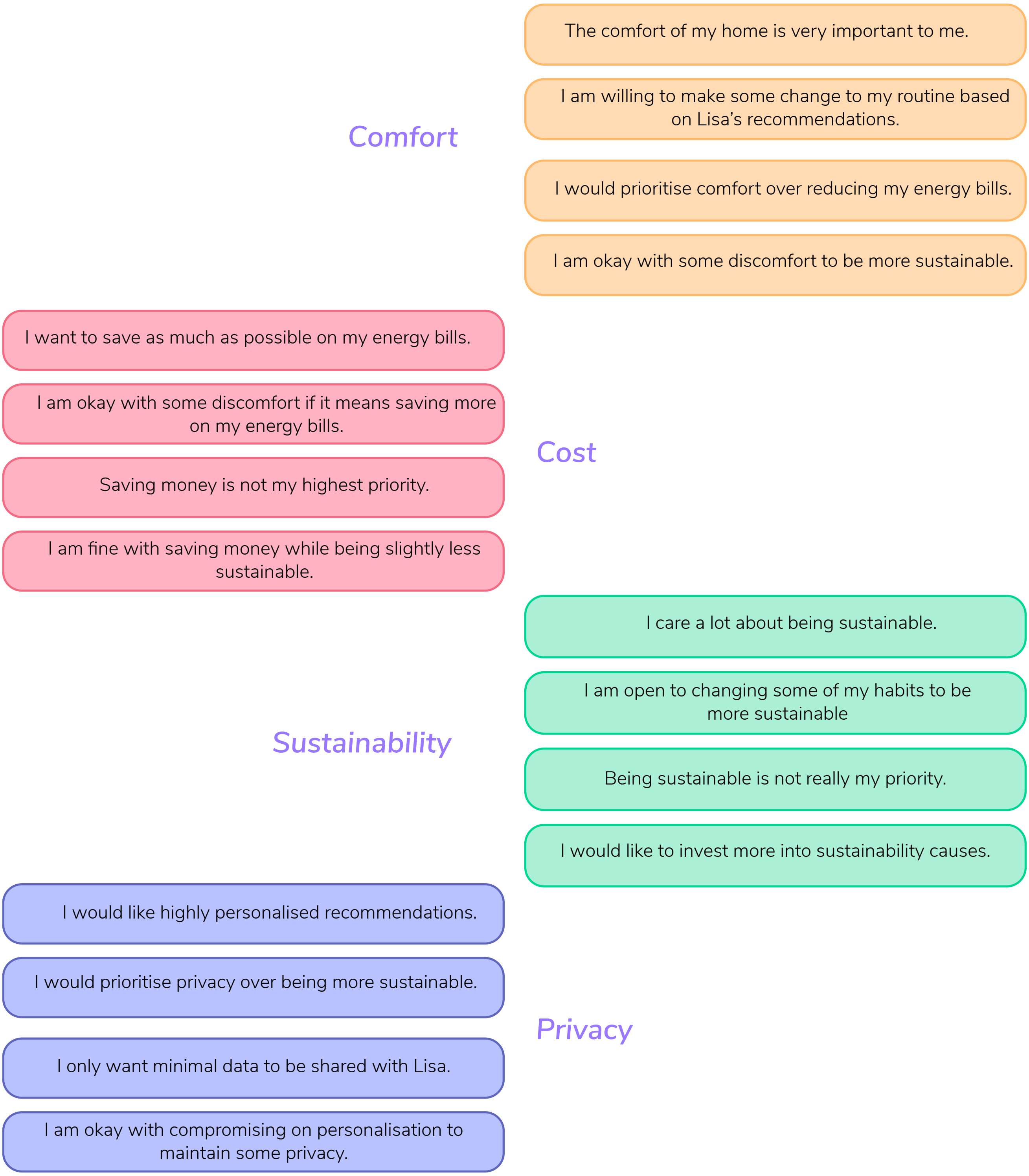


Image 38: Statements designed to capture user intentions

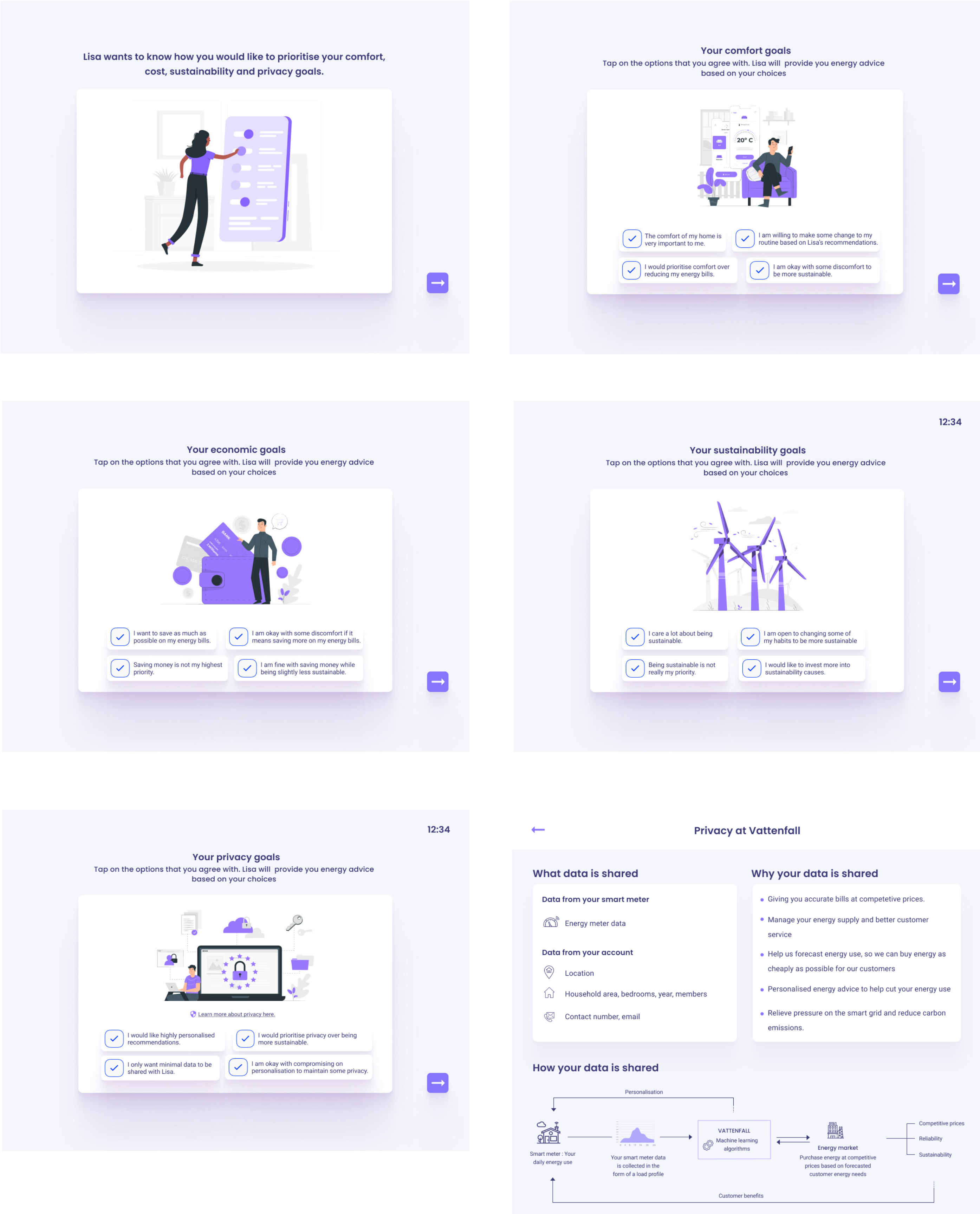


Image 39: Interfaces of the 4 factors with statments and information regarding how data is shared with the energy provider

For instance, if John chooses :

"I am willing to make some change to my routine based on Lisa's recommendations" and
"The comfort of my home is very important to me"
"I want to save as much as possible on my energy bills"
"I am open to changing some of my habits to be more sustainable."

If Jane chooses :
"I am willing to make some change to my routine based on Lisa's recommendations"
"I am okay with some discomfort to be more sustainable"
"Saving money is not my highest priority"
"I am open to changing some of my habits to be more sustainable"

John is going to be higher on the comfort profile and cost saving priority and lower on the sustainability scale compared to Jane who will score higher priority for sustainability, lower on the scale of cost saving and slightly lower on comfort as well.

All statements cover a spectrum of choices in combination with each of other factors (sustainability, cost, comfort). However, for sustainability three out of four choices are leaning towards nudging users to consider sustainable behavior as part of their plan. For privacy , an additional link is introduced to help users understand how smart meter data is used and how the data collected is used to help the system or company's functioning and in turn how that benefits the user.

Scenario 2: Presenting tradeoffs

Most parts of the tradeoff presentation were kept the same. Except in this iteration, the section of "how priorities impact you" was made more precise and involved a combination of how each factor influences the other based on users' choices were also elaborated. Two profiles were created to illustrate an example of how the system would behave when different intentions were stated.
The two profiles were:
Comfort and sustainability as a high priority with high personalisation (Image 40)
Comfort and cost as a high priority with low personalisation(Image 41)

To make the tradeoffs of users' choices more relatable and concrete an example of a real life situation of how the system would respond was provided for each tradeoff. This was meant to help users better visualise how the system might behave as opposed to keeping statements on an abstract level.

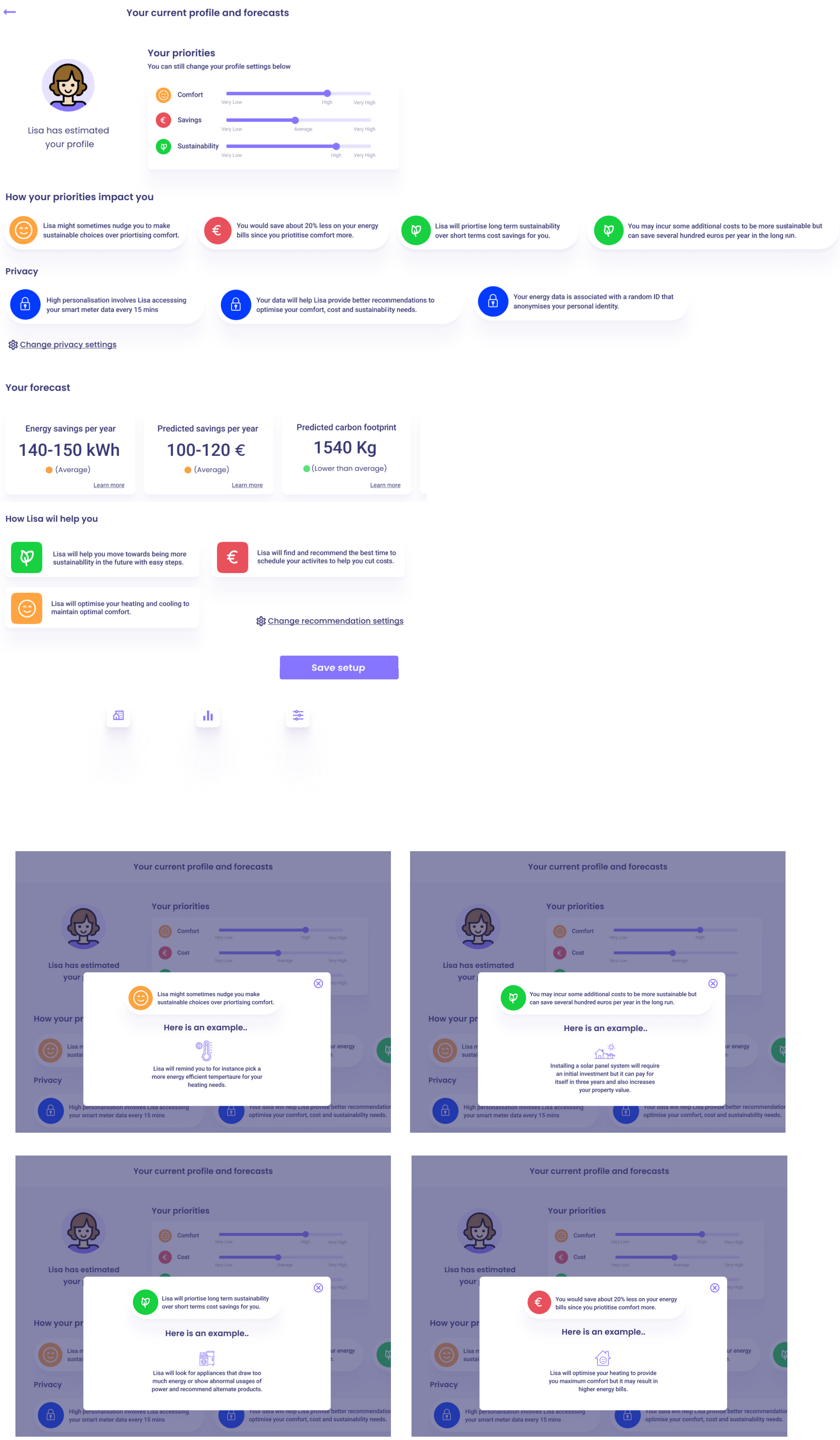
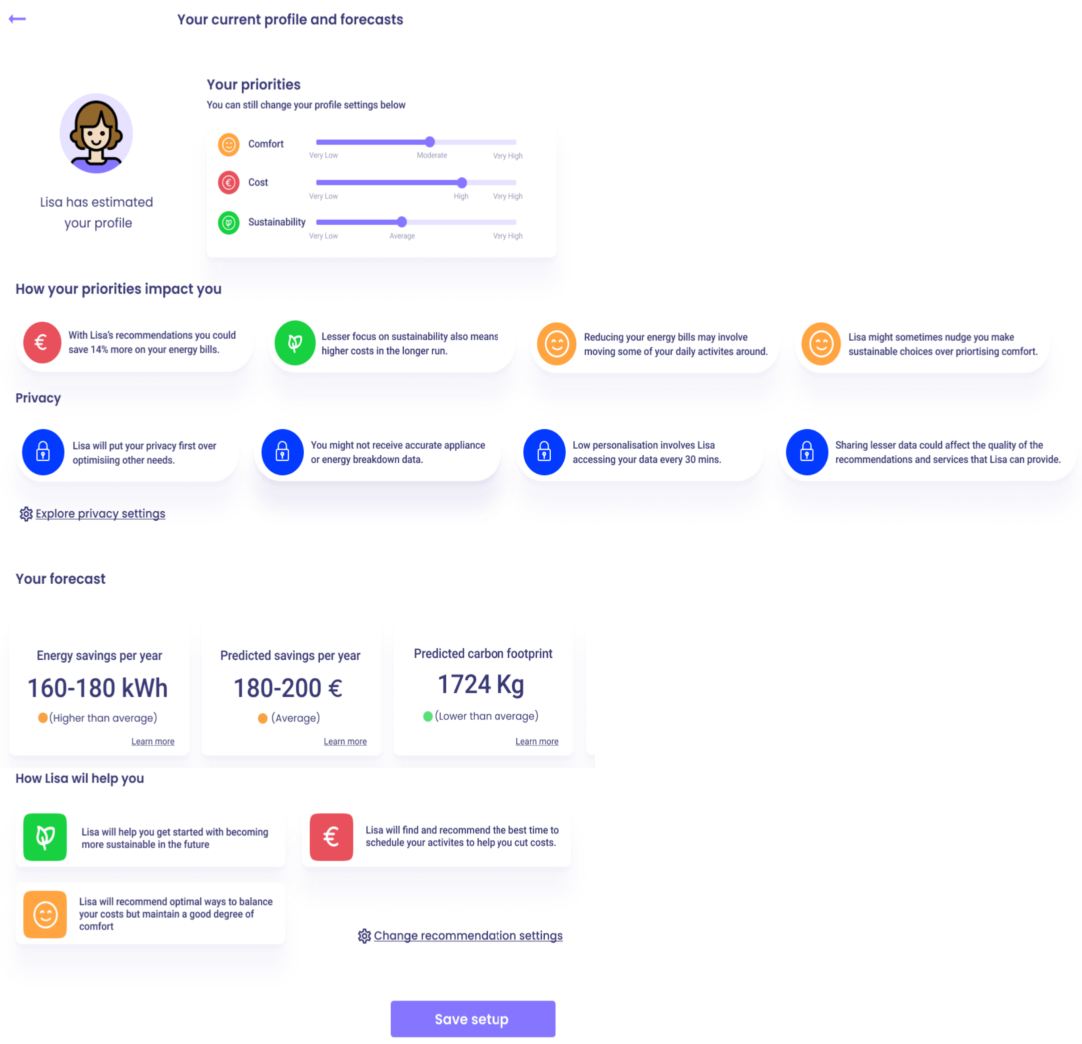


Image 40: Presenting tradeoffs (top) and showing examples of how the system would act Comfort and sustainability as a high priority with high personalisation



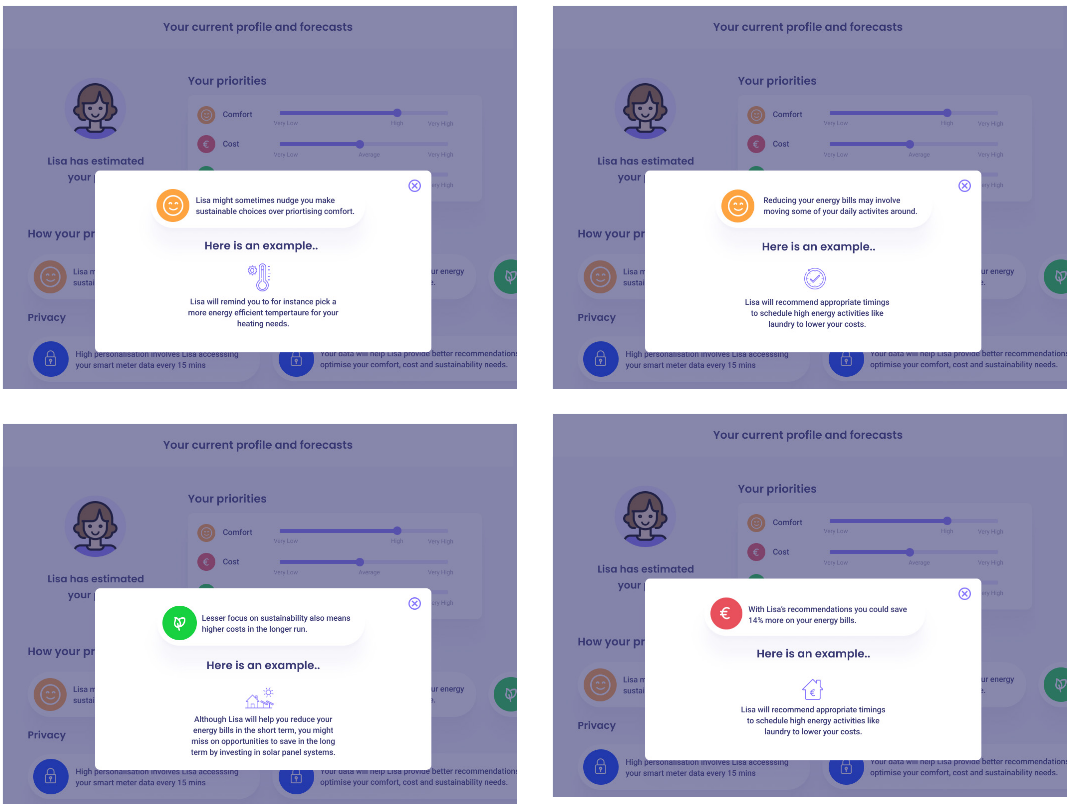


Image 41: Presenting tradeoffs (top) and showing examples of how the system would act Comfort and cost as a high priority with low personalisation

The users are still provided with an option to change their privacy settings and understand how smart meter data resolution works. Similar information about how the data is used by the system and company is shared here as well, in case the user did not view it while stating their intentions.

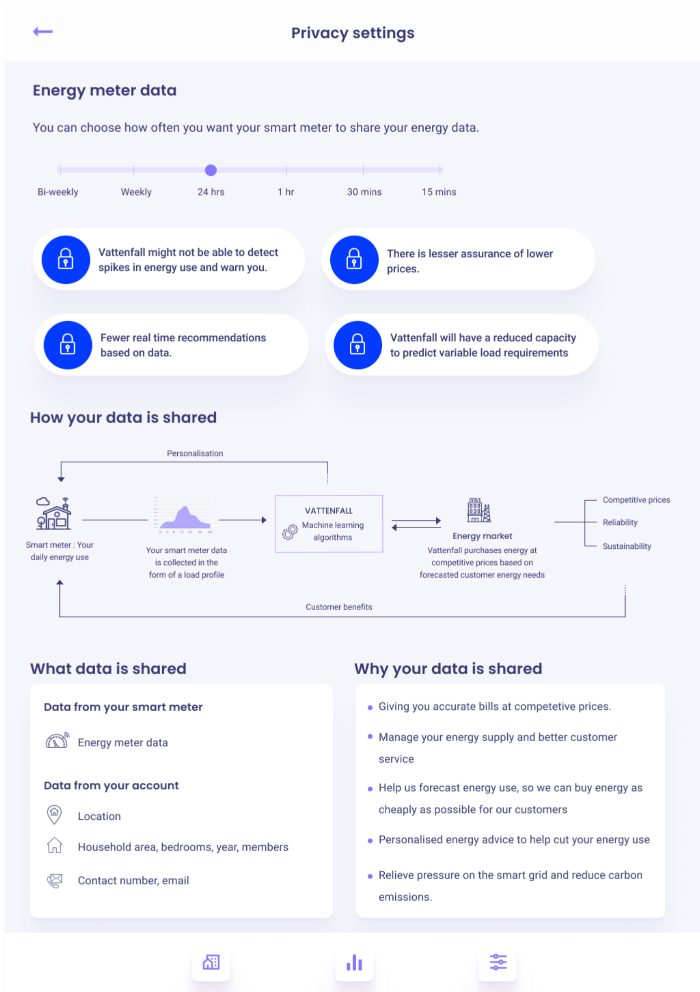


Image 42: Presentation of privacy control and smart meter data resolution

Scenario 3: Data visualisation of energy use

The energy breakdown of the appliances are meant to provide real time data of overall energy consumption as well as per appliance usage (Image 43). The appliance use is elaborated further with a visual timeline representation of when and what the appliance is in use throughout the day. Consumption and cost will provide a percentage wise breakdown along with costs to help users understand what activities or devices consume the most energy in a day. Long with this , insights or advice is given based on interesting patterns e.g. an unhealthy practice or a malfunctioning appliance the system might detect. The real time data by itself can allow users to make self- informed decisions to change their activities or consumption. A major focus here was presenting the data in a possibly interesting or engaging data visualisation format to encourage users to interact with the system and take action towards more sustainable behavior.

Image 43 : Participant information from user test - iteration 1

Image 43: Energy breakdown representation

The consumption pattern (Image 44) was meant to help users see their weekly use or long term use to help change habits that they might be missing out from the perspective of daily activities. The previous illustration was a more detailed approach that could aid in identifying anomalies and view cost related implications associated with it whereas the consumption patterns aims to look at behavior patterns over a longer period of time.

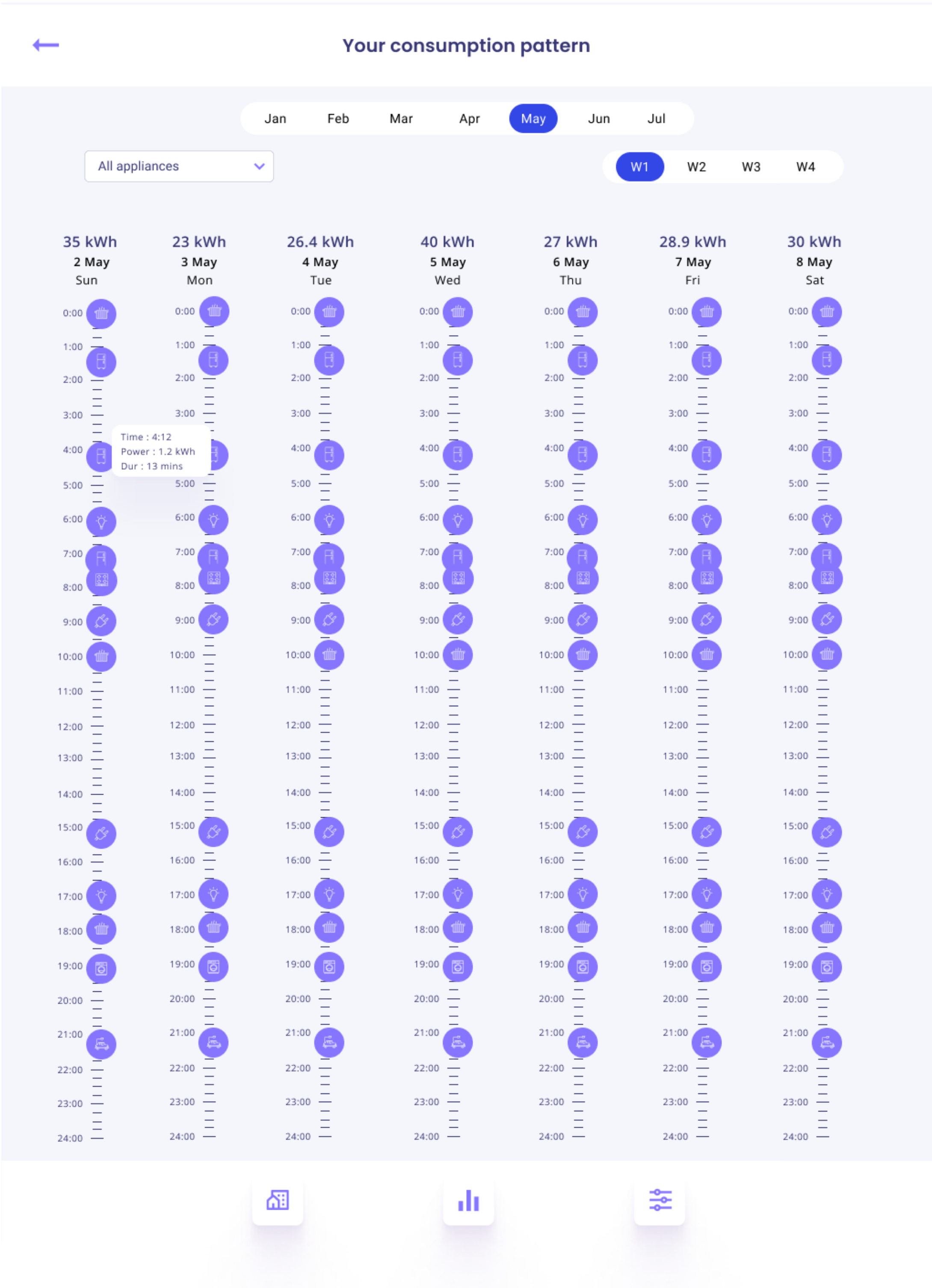


Image 44: Weekly pattern of energy consumption

Scenario 4: Energy profile

Based on feedback from the previous iteration, the graph was simplified and made into line graphs of the three factors : comfort, sustainability and cost. The comfort was quantified in terms of the amount of energy consumed, cost in terms of bill expense, and sustainability, a score between 0-100. Each of these factors also have a budget or goal to adhere to to reach the intentional goals they set for themselves while setting up the system behavior. Stats about their consumption and how they compare to their previous month is also included along with their carbon footprint. They are also provided with community data to help understand how they are performing in their neighborhood. Some positive and negative trends are also pointed out by the system to help encourage or inform users about their existing behavior.

Users can further investigate how they are doing on each factor by exploring the “Reports” section. Here they can see a history of their priorities which they are allowed to change to reset their goals. They are also provided a log of the recommendations provided by the system and the ones that the users had accepted or rejected along with the impact the action had. The values of their behavior are captured through badges that the users received when exhibiting positive behavior. As mentioned in the first iteration, negative values are no longer stated as users feel judged or patronized by the system.

The energy profile is overall aimed to help users reflect on their goals. It is meant to be somewhat confrontational and by providing a transparent view of how the user is doing with respect to their goals, they can modify their behavior or instead choose to modify their goals. The system however continues to adapt itself based on the behavioral patterns of the users to continue providing appropriate and actionable insights/recommendations.

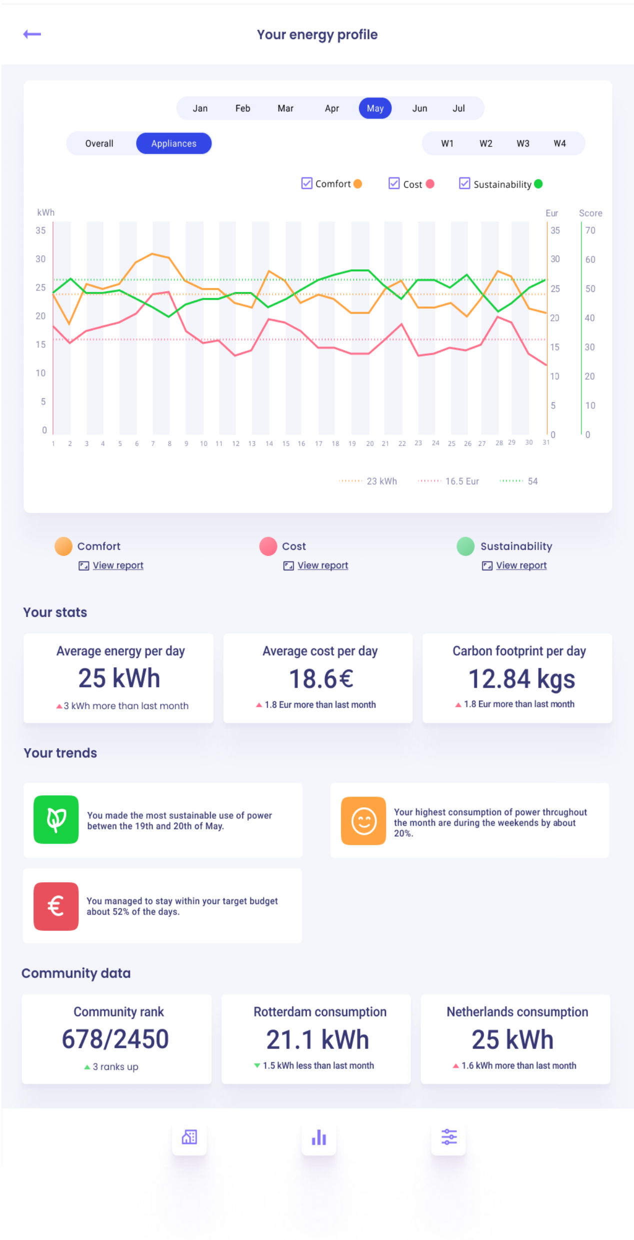


Image 45: Energy profile of the users and the sustainability report.

Scenario 5: Designing recommendations

Three different recommendation types were designed : A scheduling update, usage alert, recommendation time. They were designed to support users in understanding why/how the decision was made and recommended by the system. Each advice is also supported by concrete benefits that the user can have in adhering to the recommendations. However, there is full control for the user to ignore or decline the recommendation or even reschedule activities to suit them better. Here, the recommendations are also designed with the assumption that some appliances are smart and connected to the system so that they can be remotely scheduled and managed. The system should be able to learn what the users prefer with time and help auto-schedule or even adjust recommendations based on the likelihood of it actually leading to sustainable behavior.

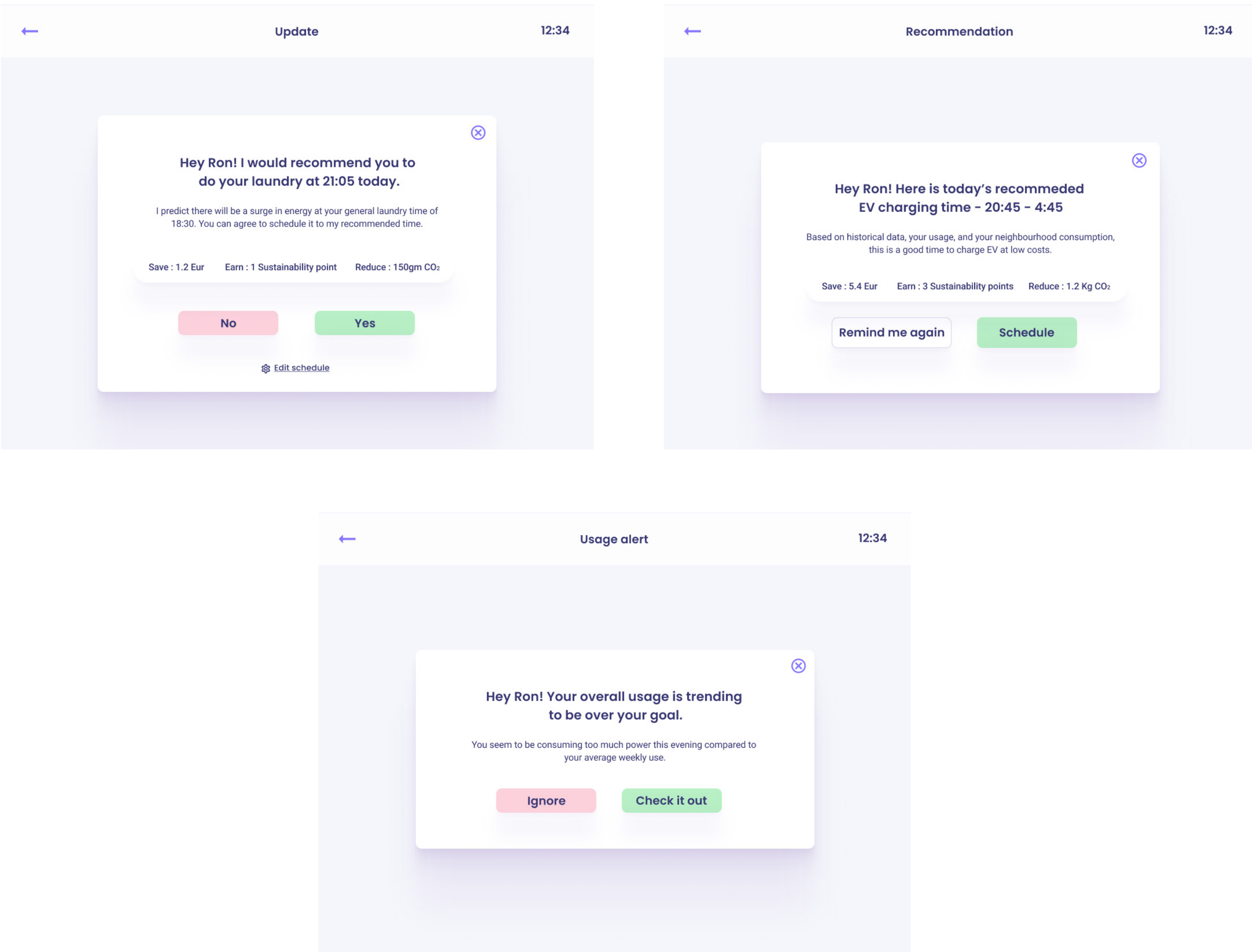


Image 46: Variations of recommendation design

Scenario 6: Homescreen exploration

This scenario involves two options for users to see on their display device when the user is not actively interacting with it. The first option was a more practical real time data visualization of energy consumption during every hour of the day. The idea is to keep users aware of their overall consumption and provide a visual sense of their consumption pattern in a day. From the user interviews, it was apparent that people had no connection to energy beyond it being a mere utility. The second option was more to appeal to the emotional side of users by providing energy a "heartbeat". The visualisation would turn darker and beat faster when consumption is high or would be green and calmer when the consumption is low. It is assumed that humanizing energy could help users connect and empathize with it better. It is also meant for users who prefer an additional aesthetic appeal to a rather data-driven system to better suit their household.

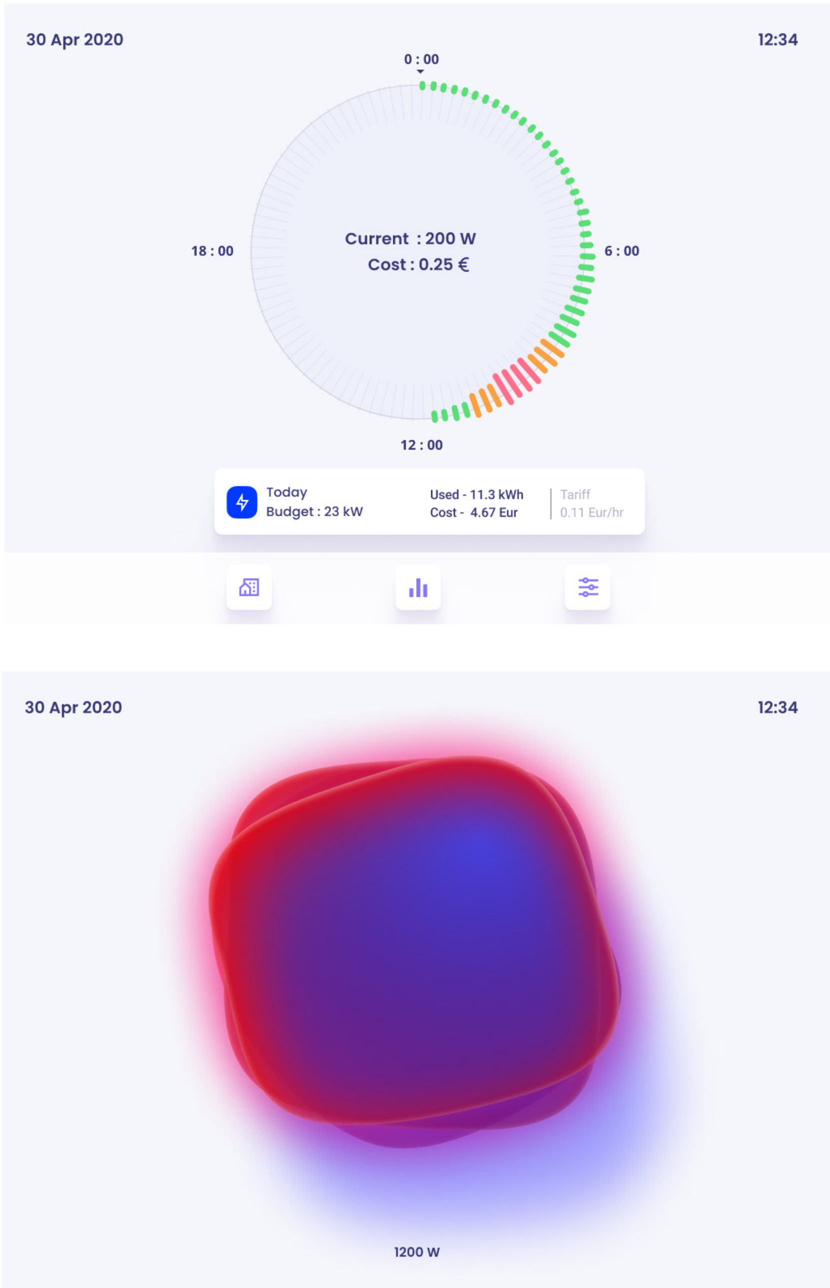


Image 47: Homescreen design for the system.

7.5.2 User test

Setup

Due to the Covid-19 rules, tests were conducted remotely through the Zoom application. The researcher shared the screen of the prototype on Figma application and remote control was given to the participants so that they could directly interact with the prototype. The prototype was displayed in the model of an IPad-mini to mimic the idea of an in-home display. (add images). Seven user tests were conducted which lasted from a range of 50 mins - 1 hour 20 mins. Semi - structured interview questions were prepared. Participants were asked to “think out loud” while interacting with the prototype and relevant questions were asked based on their response. At the end of the test, all participants were asked to fill in a questionnaire and rate the overall design on an AttrakDiff scale.

Objectives

This was the final user test for the project. The goal was to move towards the final design based on the feedback received. The design overall had taken a very practical, high fidelity and more concrete turn through the previous iterations. Hence, this was the final user evaluation that would be performed.

Participant	Age	Background experience
P1(M)	40	UX Designer
P2(M)	57	Entrepreneur
P3(M)	34	Advisor
P4(F)	28	Software Developer
P4(F)	47	Project Manager
P6(F)	32	Laser Specialist
P7(M)	23	Student

Table 5 : Participant information from user test - iteration 3

Participants

Seven participants were recruited through convenience sampling. Participants ranged from different backgrounds, age groups, living situations and energy providers. All participants were however residing in the Netherlands and were paying their own energy bills.(Table 5)

Tools

Zoom(Video, audio recording, remote control)

Otter.ai (Audio transcription)

Note taking

Figma

Survey

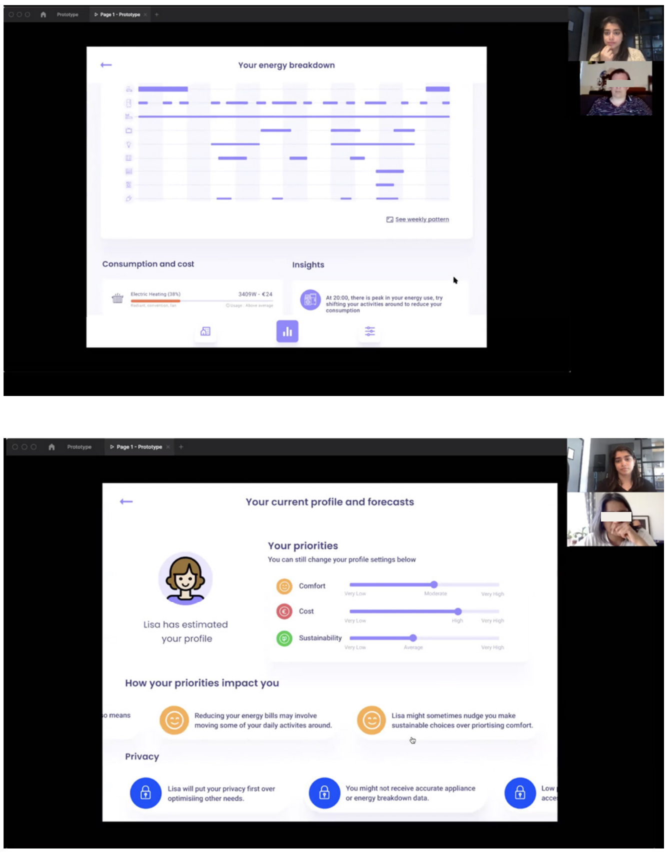


Image 48: Online user testing - iteration 3

7.5.3 Insights

Scenario 1: Capturing intentions

- The effectiveness of the statements

Users felt that they were able to communicate what they wanted with the system through the statements. It was interesting to note that every statement was picked by at least one participant except for one of the statements "Being sustainable is not really my priority." This however can be considered a positive result. However, three statements felt very absolute for the users. For instance, in the statement "The comfort of my home is very important to me" , 'very' could be removed , in "I care a lot about being sustainable", 'a lot' could be removed and in "I would like highly personalised recommendations.", 'highly' could be removed.

- Creating tension and discussion

The slight cognitive effort involved to choose the statements forces people to actually weigh their options and effects of their action. Users often start recalling some of their past behaviors and sometimes justify already being sustainable or sacrificing comfort in certain situations.

"I am ok with some discomfort if it means saving more on my energy bills, because I used to leave my bathroom heating and my bill used to go through the roof, so I am willing to sacrifice that.."

"I think I am already doing a lot in my lifestyle to support sustainability, for e.g I use the bike, I walk, I am vegan, I don't take long showers. for e.g my brother could be there for an hour.. "

- Relationship between personalisation and privacy

Some of the users could not directly correlate with how personalisation could be associated with privacy, while others were left in the dilemma of whether they wanted to share their data to benefit from the systems. However, three users were quite aware of how data sharing works and did not mind sharing data as long as they were not used for advertising purposes.

"It's always a dilemma - do you want real privacy or do you want the system to help you to make your life easier? "

Exploration 2: Presenting tradeoffs

- Providing overview through data

The tradeoff page provides a good overview for users to understand how the user's intentions are translated into system behavior. Participants feel like they understand the impact of their choices and how the system would help them achieve the deliberate goals they have set for themselves. The examples make the trade offs more relatable for the user. They are also able to associate with the colors and identify the tradeoffs as being associated with a category. They favor the fact that the system reports back in simple and short textual format which supports comprehension of system behavior.

"It is summarising what my priorities are and how they will help me with everything."

"It actually shows you very clearly what the consequences of your choices are - in a no-nonsense way."

- Feeling a sense of control

Users have a sense of control over the system. They appreciate the fact that they can see which profile they lie in and can in turn change these priorities further if needed. However, one user felt like they had a high need to commit and was not willing to do that. He would rather have a more flexible trial period where he can try the system's setting and reset if needed.

"So maybe i would want to try it.. maybe see what my comfort is, and or be like maybe I reduce my comfort a little bit more and see what the impact of that is.."

- Control over privacy still unclear

Since most users still don't understand the entire functioning of a smart meter, sometimes they are unwilling to give up their information. There needs to be more education provided on why and how the data is used to help maintain energy reliability. They also feel like they need more control over which specific data they could share.

- Influencing factor of quantified stats

Users like the fact that the stats provide forecasts and concrete information on how their choices affect them in terms of costs for instance. Providing a sustainability ranking was perceived as a way to encourage competition in a neighbourhood. Although two users expressed scepticism over whether the forecasts will hold true after use.

"Normally these forecasts never materialise this way.."

- Transparency

All users felt that the information presented provided a sense of transparency towards the system. It reduces ambiguity of what the system intends to do. Users don't feel like any information is hidden and the simplified, concise way the data is presented help them develop trust in the system.

"I think if the data is used to help you and the environment, the forecast is based on my answers so I think its correct, so I will trust the system because it is a system."

Exploration 3: Data visualisation of energy use

- Practicality of real time data

Participants feel they receive an efficient overview of their consumption. They like specific and actionable advice(for eg. the information on a malfunctioning refrigerator) and feel that it helps especially to track when multiple members are in the house for instance, when kids/teenagers consume power carelessly. It also provides a big picture view of how much energy is consumed throughout the day. Participants felt it created awareness on where the money is most spent and they could make appropriate changes to their usage. For the weekly representation of the consumption data, the apparent benefit was not noted by the users. However, 3 users stated that they would prefer the insights to be provided first followed by the more detailed information.

"It will definitely help me, I like the fact that it becomes transparent what appliances are used when and what the financial impact of that is."

- Perception of technological capabilities

Participants were impressed that it was possible to compute some detailed information of appliance use. 6/7 participants were unaware that smart meter data can be used for disaggregation. One of the users was visibly surprised and even slightly uneasy about the level of detail the system could learn about his consumption.

"My god this is detailed - now this makes me think they know when I watch TV and when I charge my car."

- Overload of data

One of the participants expressed that she felt overwhelmed looking at the data and would not want to interact with it or view it very often. Another participant also agreed that all people, for instance, his partner would not want to look at complex data. Two participants stated that men are more likely to engage in data intensive visualisations like these. Overall, for some participants the data could feel cognitive overwhelming at first, but it is anticipated that it will not be so with repeated use.

-UI and interaction

The graphs although appeared complex, most users were able to comprehend what it communicated eventually. However, some icons appear too small or ambiguous. Users also expected quantified values of the cost of Kw available for the breakdown of appliances ie. see data in an interactive fashion.

Exploration 4: Energy profile

- Interpretation of the graph

Overall most users perceived this to be a somewhat difficult graph to read primarily because it has multiple Y axises. However, they did understand that it was communicating how they performed with respect to the three factors that they had prioritised. The lack of clarity came from the missing legends, prior education on the budgets set by the system and multiple axises. There was also a lack of context to the graph as it was only presented as a separate scenario rather than as part of an entire digital application. Participants were also curious about the math behind the graph. Overall, there needed to be additional information provided to support the readability of the graph.

Another issue that cropped up with the use of extensive data visualisation is the possibility of the novelty wearing out. Users might eventually stop viewing this data or find it less interesting with repeated use.

“For a hobbyist you likes this it's nice, for me if the novelty wears off I don't think I'll be looking at this a lot.”

“If the goal is to just give transparency then it is fine, it is always nice to have it.. if there is a problem, or something you really want to improve you could do that.”

- Provision of comparative data

Peer data and other household data can again act as a good source of healthy competition and prompt people to try harder to achieve their sustainability goals. It added context to their performance and helped them reflect on whether they need to make more active changes. The comparison data with respect to previous months could also be useful in keeping track of how users progress or digress towards/from their goals. Although they would like data like the carbon footprint to be made more tangible and also be able to view what factors affected those trends.

“I like the community ranking - so it's nice to be competitive and have a comparison- it gives a kind of reference frame, how much is a normal usage in a day etc.”

- Feeling of positive reinforcement

Providing factual patterns/insights like “ You have stayed within your budget 52% of the days” gives people a sense of achievement and progress. It becomes imperative for users to feel that they are doing well in the goals they have set for themselves. Participants provided affirmation that they would like to continue to receive such positive trends from the system. The badges (values) on the sustainability report add to the positive feeling as well.

“People like to know they have done well - so I like the kind of language you use.”

-Sense of control and transparency

In the sustainability report, the ability to view the priorities that affect their goals and to make changes to it adds to their feeling of transparency and control. The recommendation logs that track which advisory contributed to their score also help them reflect on which activities affected their overall consumption and performance.

Exploration 5: Designing recommendations

- Positive perception towards recommendations

Participants appreciate that the recommendations are designed to be short, precise and clear. They feel motivated to consider the advice given since it clearly gives the participant an idea of what they gain/lose from the action/activity. Visualising impact proves to be a convincing way to motivate people to shift their energy consumption behavior. They feel that they have a sense of control or have a choice in whether they want to accept the recommendations or not.

> *"It's nice to very clearly have the benefit.. that would give a concrete reason to do it."*

- Controlling the frequency and type of recommendations

A general concern raised by three participants was about the frequency of the recommendations. They feel that it might be getting too frequent and do not want to add to the myriad of other notifications they receive from other devices. Participants however like that the ability to control/reschedule activities provide flexibility to adapt their needs vs the advice provided by the system. However, some users wanted to have control over how the recommendations are received in terms of frequency, the type of recommendation and for what situations the recommendations are provided. For instance, users should be able to pick which appliances they want updates on, be able to choose the preferred timings to receive advice, or possibly decide they would want a report every three days instead of notifications.

> *"I feel it can get intrusive because I don't want another appliance in my house sending notifications."*

> *"So maybe they give priorities to certain appliances that use a lot of energy and they have a few that they feel they can influence the usage."*

- Transparency in recommendations

Participants found the recommendations convincing and understood why the recommendations were made. They also realize that the recommendations are derived based on the intentions that they picked while setting up the system. Participants also perceived that the system is trying to help them achieve their goals through the advice.

> *"It is convincing, because you have clearly mentioned historical data etc, and also mentioned the consequences.."*

- Issues with committing to tasks

An interesting insight that came from the test was also in how participants don't necessarily want to commit to scheduling some tasks because it might not necessarily fit well with other aspects of their unpredictable social lives. Users expect more freedom in terms of when they could do mundane activities for e.g doing laundry for one particular participant was more a matter of convenience when he would have put off doing the activity for a while.

Exploration 6: Homescreen exploration

- Perceived usefulness of each type of screen

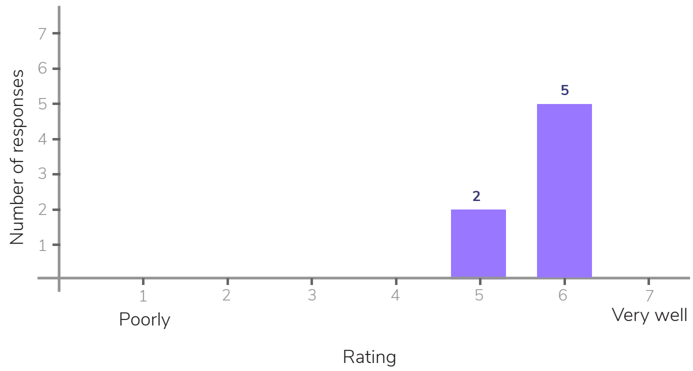
All users interpreted the data visualisation on the homescreen appropriately. It was, however, difficult to intuitively know what the 'heartbeat' could mean. Between the two, users that had an inclination towards data preferred the data visualization perceived it to be useful. However, the 'heartbeat' was appreciated for its aesthetic appeal. The ideal balance would be to have the 'heartbeat' as an option for users who like abstract representations of data and could choose between which screen they want to have

- More possible features that could be explored

The main purpose of the screen was to serve as an information panel that could communicate how much power the users were consuming throughout the day. However, users expected more features or controls from it. For instance, one participant wanted weather data to know if they would produce enough power through PV cells and possibly be able to control their heating, while another participant wanted to see their carbon footprint.

7.5.4 Survey Results

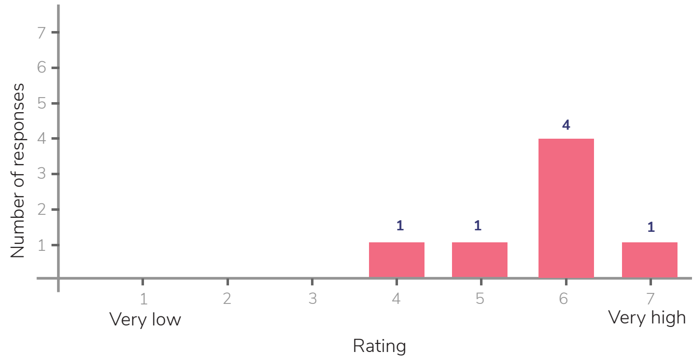
How well is the intention of the system communicated?



The intention of the system was quite clear to the users. They recognize that the system intends to help them with their goals and help them become more sustainable. Participants recognize that the questions are also a way to establish their intent to the system and that the system also tries to prioritise what the users need.

> "I think it's very well communicated because I understand what it wants to do and how it can help."

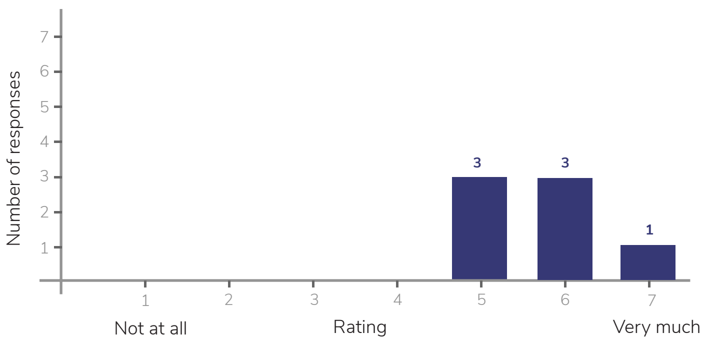
How transparent does the system feel?



Transparency was overall rated high as people felt that the system communicated efficiently what it was doing and why it was performing a certain action. However, two users were not entirely convinced of how and where the data was used by the company.

> "Because I am not sure what happens with the data, I don't know if the company is using data only for this.."

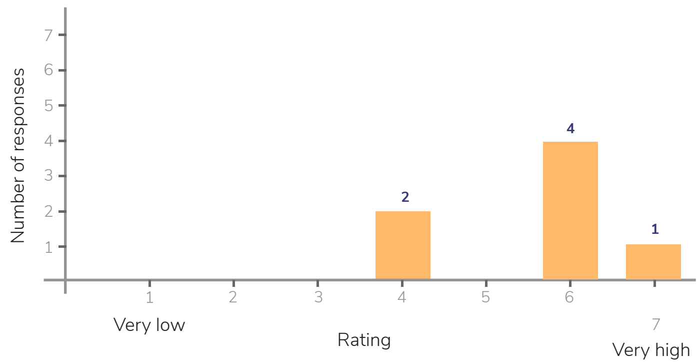
How much autonomy do you feel when using the system?



All users agreed that the system was flexible and allowed users to control most aspects of the functioning of the system. They continue to feel like they are the driver of the system and ask sufficient permission from the user to perform actions. However, one user suggested that they might want to give more control to the system.

> "Quite a lot you can do yourself, it shows the benefits , and because the information is clear it gives autonomy."

How much would you trust the advice given by the system?



Trust was also rated high by 5/7 participants. Participants felt that they could trust the technology because it is data driven and involves machine learning. Although two participants were a little sceptical and wanted to know how they could assure themselves that the system was indeed prioritising what they needed.

> "Yes I would trust it very much cause it's machine learning , probably trust it more than myself."

> "A little bit difficult to trust.. it says it priorities , but with a system like this it is difficult to know, and you can't trust the system that it would do it the right way, as a customer there is no good way to compare this."

7.5.5 Attrakdiff rating

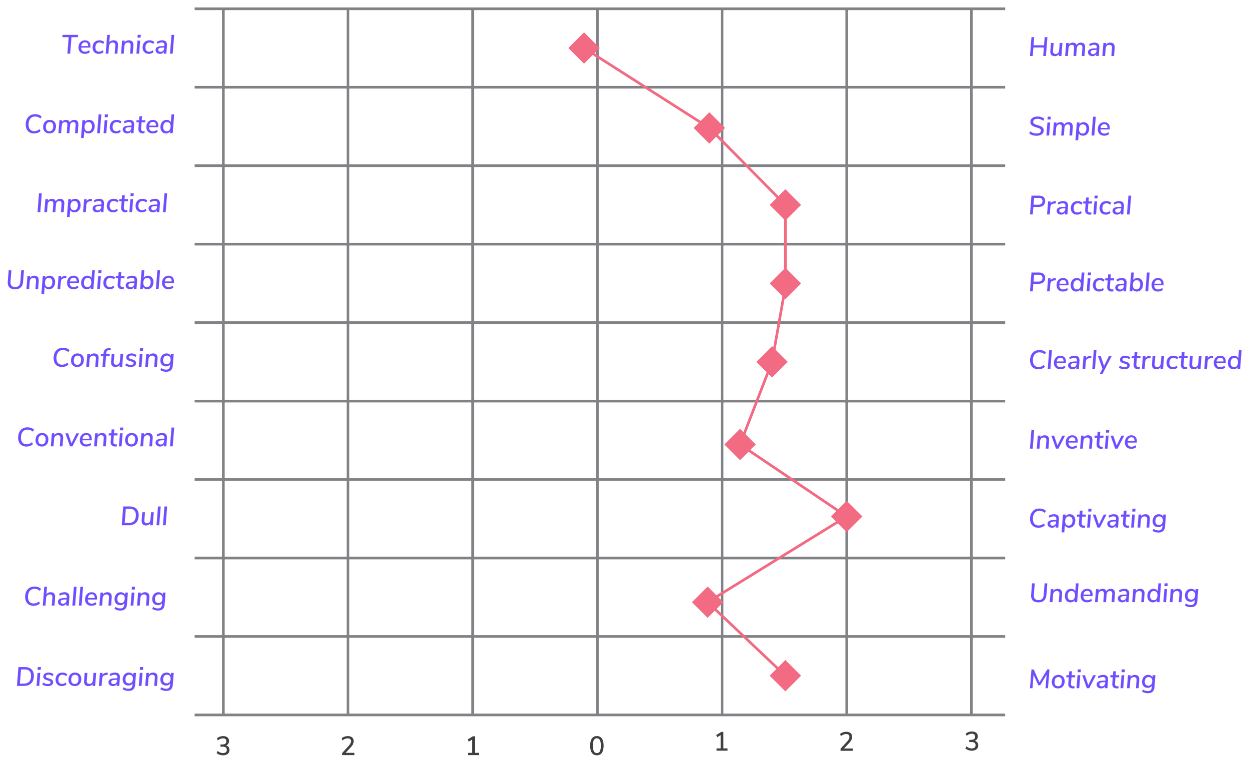


Figure 2 : Attrakdif results from iteration 3.

The attrakdiff surveyq was taken by all seven participants, they were also requested to explain why they provided the specific rating to get more insight into their thought process.

Most users felt the system was both technical and human, but leaned a bit more towards the technical side due to presentation of complex data. The sysytem seemed simple enough to use, but it was apparent that there would be a small learning curve, and people with technical backgrounds might need lesser effort to get acquainted with the system.

Participants also agreed that the system is practical in terms of helping them optimise their energy use and do good for the environment. They also felt the system would be predictable as long as it continues to do what it says and they understand what is happening with the system.

Additonally, the system was found to be inventive and captivating as most users havent seen a system as extensive and detailed for energy use as this.

However, participants did feel that it would be slightly challenging to get accustomed to the system's behavior and the data presented to them.
Finally, users felt that it was encouraging and would motivate them to reconsider their energy use although they did not want it to come in the way of convenience.

7.5.6 Discussion and implication - Iteration 3

The third iteration created the opportunity to generate some very rich insights on how people percieved and interacted with the system. The statements had the intended effect by helping users communicate how they wanted the system to work. The tradeoff page was found to be extremely practical and useful for users to gauge system behavior and enabled more trust towards the functioning of the system. The energy disaggregation and consumption data also added to the credibility of how and what contributes to the consumption and the costs. However, the weekly pattern of the system needed some additional elements to make it more intuitive.

Most particpants needed extra effort to understand the visualisation presented to users for how they were performing with respect to their goals. This scenario ideally would require more iterations in order to make it more intuitive or simple for interpretation. However, the comparison data and badges designed add a sense of gamification so that users are motivated to continue reaching their targets. The recommendations give users a good sense of control and they get a concrete idea of why they need to follow the advise from the system.

Overall, the final design would constitute some changes based on the above insights and some additional recommendation of suggestions that would be included as part of the design.

Moreover, the third iteration has lead to some interesting overall insights that lead to the connecting several data that was collected from the literature review, user interviews, expert interviews and previous interations. These insights will be discussed in section 7.6.

Overall insights

7.6 Overall insights and discussion

The intention of the system was quite clear to the users. They recognize that the system intends to help them with their goals and help them become more sustainable. Participants recognize that the questions are also a way to establish their intent to the system and that the system also tries to prioritise what the users need.

- Capturing intentions

Using statements to capture intentions has been successful in getting an insight into what expectations people have when using a system to monitor their energy needs. The slight cognitive effort involved in reading through the statements is effective in putting users into a dilemma about what they truly want. It encourages users to consider what they would like to prioritise against other factors. An adding effect of the statements, is the implicit likelihood of users considering sacrificing or trading off one factor for another. For example, users without given the choice might not explicitly consider sacrificing a little comfort unless nudged to do so. Although it is still debatable whether these statements are indeed fully sufficient to capture every every spectrum of intention there is.

- Redefining presentation of privacy

The intention of what a company would do with user's data becomes an essential part of an important insight gathered through the tests was a demand or need to make complicated privacy related matters less complex and more accessible for users. There is a need to present users with a simplified version of how privacy looks like within the company and how/when/where/why the data is used for any purpose. This simplified version is only expected to co-exist complex legal documents and not meant to replace them. Instead, making privacy more accessible and interactive can be extremely beneficial in helping users feel a sense of trust towards the company image.

- Tradeoffs for transparency

The presentation of tradeoffs becomes a strong point in contributing towards the system's transparency. It achieves in communicating the future intentions of the system clearly to the user. Users are plainly presented with the consequences (gain and lose) of their choices. It could prove to be useful in reducing unexpected surprises that the users might face during system use and provide a sense of comfort. The trade offs are a means to present how users' intentions could be translated into system behavior.

- Effects of mood/emotions on intentions and use

Emotions have not been given explicit focus throughout the iterations. However, the tests revealed how moods or emotional aspects of a user's life might affect the way users might interact with the system. A user, for instance, stated that they might be more willing to sacrifice their comfort if they were in an overall positive mood. This includes the effect on the system behavior during user setup (state intentions or priorities) and also the effect on daily activities. The effect on mood during the setup could have considerable implications. This also brings to attention that intelligent systems need to be built to be more forgiving and compassionate towards humans. As stated by a participant: "After a long day, you sometimes just want to come home, cook, have dinner and sleep and don't want to be told that I shouldn't be doing something then", there is a need to consider the imperfections of being human and the unpredictability in their lives. This includes how a user might feel(emotionally) at a certain moment where they may not have the motivation to act sustainably or might just want to enjoy the comforts of their home without having to worry about acting responsibly. AI systems should then be able to avoid over penalising humans for being humans, adjust to possible anomalies and not constantly point out the shortcomings of the user behavior to avoid frustration of users. This includes how hyper personalisation should not be designed to always be about crude recommendations or facts.tem behavior.

- Balancing the sense of autonomy and control

The design currently provides several touch points during the scenarios to modify settings or change their mind about how the system should function for them. This includes both a chance to change their initial priorities during setup or after several months of use, or even their privacy setting if they find the system to be too intrusive. Providing a sense of control also contributes to the feeling of transparency and flexibility towards the system and the company's intention. It moves away from the common dark UX patterns that loop users into an endless array of settings to modify even the simplest things.

"It feels like I am still the driver, it has recommendations and can opt not to follow it."

However, it did bring up the concern of too much control or autonomy. Providing too much control can make users feel overwhelmed. Users started to feel that they might have to interact with the system too often.This is especially common among novice users of smart systems who might have difficulties deciding for themselves what best works for them. In such cases, there needs to be a good balance of providing autonomy, but also possible defaults that the user can pick when unsure about their choices. In addition to this. Moreover, with long term use, giving more control to the system becomes a logical step especially when users begin to trust the system.

"Quite a lot of autonomy cause at different instances it gives me more chance to change things , frankly would like to give the system more autonomy."

- Power of data

Providing real time data to users has been a powerful way to empower users in understanding their own behaviors or patterns. It makes the concept of everyday energy use more approachable and accessible. In addition to this, users felt a sense of autonomy i.e when equipped with real time data, they can make data-informed decisions to move to more sustainable behavior. In addition to this, data can act as a source for conflict resolution. When users are faced with confusing or unexpected energy bills (from interview data), now they can fully understand what contributed to their costs, resolve/negotiate with the company or even prevent the entire situation.

- Education about energy

As observed throughout the user tests, energy is not a very tangible concept for most people. It is an invisible utility most often taken for granted. Also, the lack of advertising or appealing information about energy doesn't help users connect with energy as an essential part towards sustainability. There needs to be a more systematic way to help users understand how energy is produced, how smart grids function and how smart meters work. They need to know how their energy use can impact the entire system and hence why they need to adopt more sustainable practices. This could either by introducing small informative pieces into the energy recommendation systems itself or could be through better advertising or education provided by the company

- *Leveraging data visualizations*

Throughout the design process, frequent exploration of data visualizations was performed. It was apparent that data visualisations are a powerful and effective way to represent otherwise boring numerical data. The data visualizations were often found to be engaging and interesting for users to explore. However, they can be overwhelming to users who are not familiar with reading graphs. Overall, there is still a need to simplify some of the visualisations to improve readability. In addition to that, there is always a possibility that the interactivity of the visualisation can lose its novelty with long term use.

- *Designing for adaptive interfaces*

Different people required different resolutions of data. Although detailed data representations can be insightful and actionable for some people, most people preferred direct trends/insights or recommendations that they could quickly act on. However, it is the very presence of the detailed data that supports and adds trustworthiness to the insight/recommendation provided by the system. For most users, as the novelty of interactive data wears out, they would just want the important information relayed quickly. An additional element to explore here is to see how adaptive interfaces could be used to provide different views of data to different people(as in fluid assemblages) i.e users could potentially decide what kind of data they want the system to process for them and in turn the interface that is presented to the users.

- *Volatility of intentions*

Different people required different resolutions of data. Although detailed data representations can be insightful and actionable for some people, most people preferred direct trends/insights or recommendations that they could quickly act on. However, it is the very presence of the detailed data that supports and adds trustworthiness to the insight/recommendation provided by the system. For most users, as the novelty of interactive data wears out, they would just want the important information relayed quickly. An additional element to explore here is to see how adaptive interfaces could be used to provide different views of data to different people(as in fluid assemblages) i.e users could potentially decide what kind of data they want the system to process for them and in turn the interface that is presented to the users.

For example, one user who had participated both in Iteration 1 and 3 had picked "I want to save as much as possible on my energy bills" as a top priority in Iteration 1 but chose " Saving money is not my highest priorty" in Iteration 3.

- *Trust in AI*

A dilemma that arose through the design tests was also the fundamental perception towards AI with respect to trust. There were polarities in how people reacted towards the system and how it affected trust.

There were two areas of trust that came up - do AI systems function correctly, and do the participants trust the intentions behind the system.

For instance, there were users who trusted the intelligent system because it was driven by machine learning and data e.g "I would trust it very much cause its machine learning , probably trust it more than myself" . Trust in system functionality is also heavily affected when a system does even the smallest mistake or misinterprets user needs i.e the system gets over penalised/criticised when it does not meet user expectations. This related to the level of familiarity people had with the AI domain: participants who were more aware of how AI worked seemed to feel more in control of the system, however also knows that what the system suggests may not be entirely true.

At the same time, it terrifies them when they know that the system can learn so much about their behavior hence creating a negative emotion (reducing trust) towards AI based systems.It then becomes imperative to understand how one could balance the effect that well performing intelligent systems can have on users.

30 Apr 2020
12:34
0 : 00
18 : 00
6 : 00
12 : 00
Current : 200 W
Cost : 0.25 €
CO_2 : 1.5 kg
Today
Budget : 23 kW
Used - 11.3 kWh
Cost - 4.67 Eur
Tariff
0.11 Eur/hr

08

FINAL DESIGN AND RECOMMENDATIONS

The final design section creates another version of the design protptype based on the feedback recieved along with possible addition features or sections of the interface based on user need and feedback.

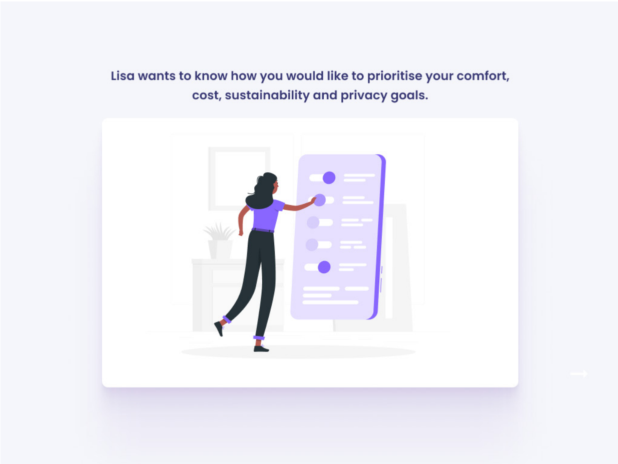
8.1 Final design interfaces

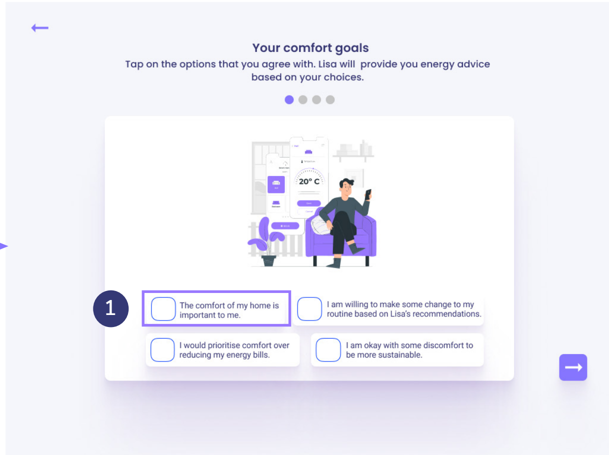
8.2 Bridging the intentionality gap

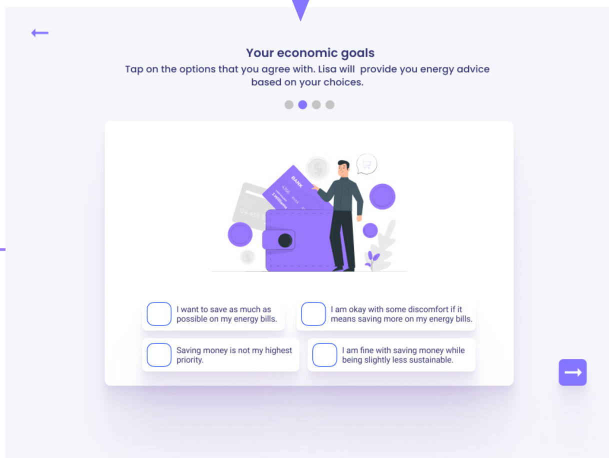
8.1 Final design interfaces

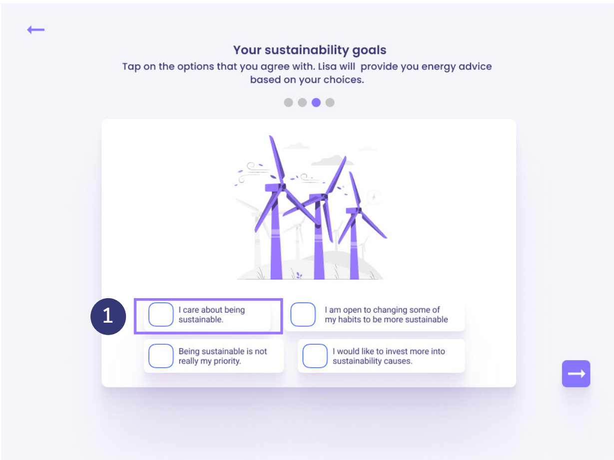
Access to link of prototype : https://www.figma.com/file/EqsxuVxHLtUfVDsIPYxz8g/Prototype?node-id=0%3A1

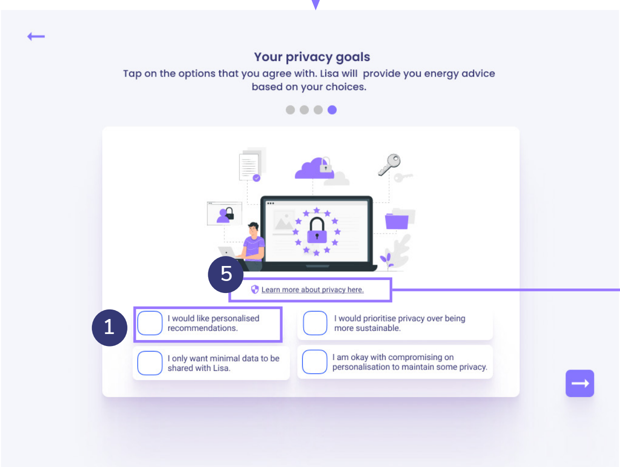
Scenario 1 : Capturing intentions



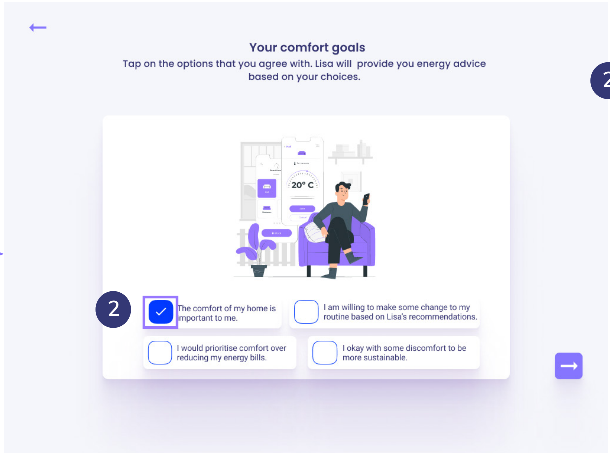






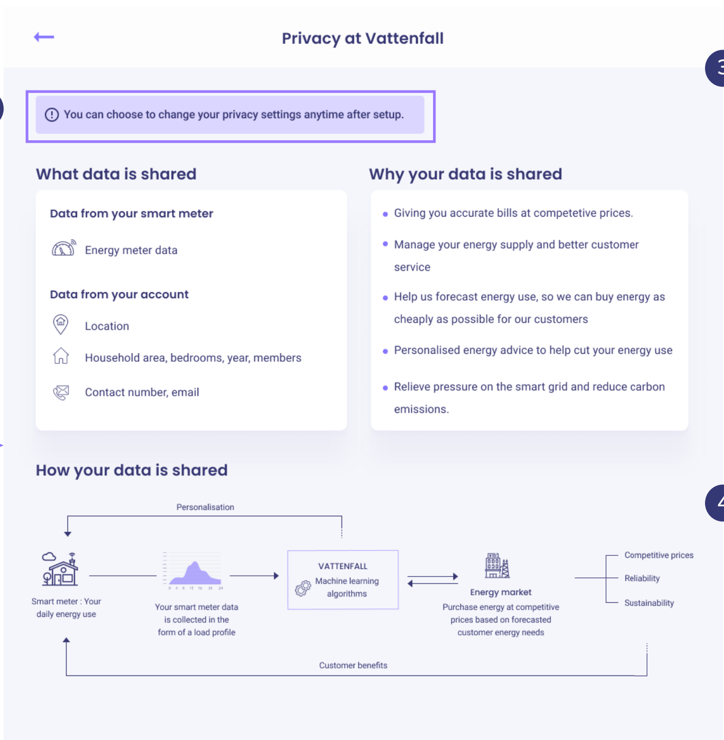


5 User can access privacy related information to educate themselves on how data is used.



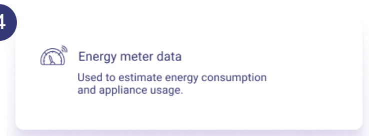
2 The interaction of selecting the options is made more apparent.

1 The absoluteness in the statements have been removed and in the following statements : "The comfort of my home is important to", "I care about being sustainable", "I would like personalised recommendations", 2



3 User is informed that he/she can always change aspects of the privacy settings anytime later.

4

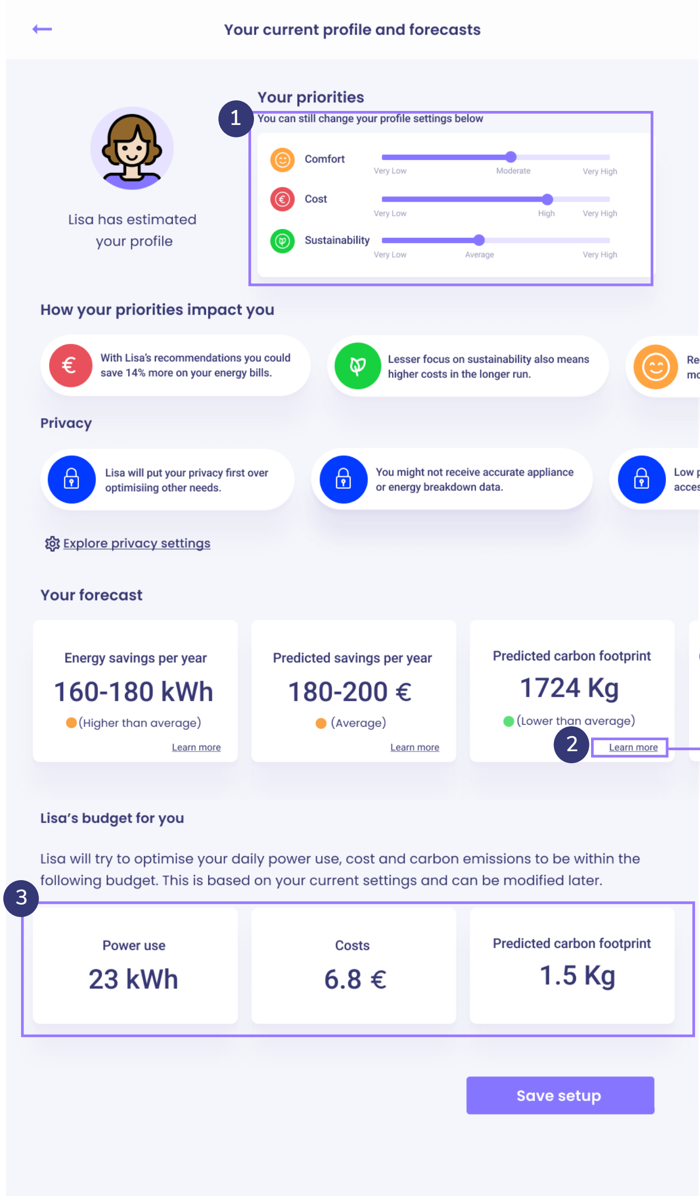


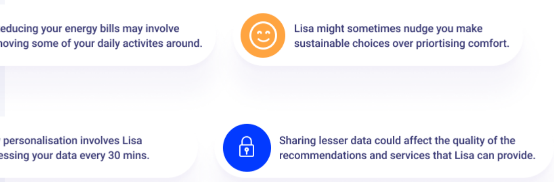
4 User would need to be provided additional information on what the specific data is used for, as shown in above example.

Scenario 2 : Presenting tradeoffs

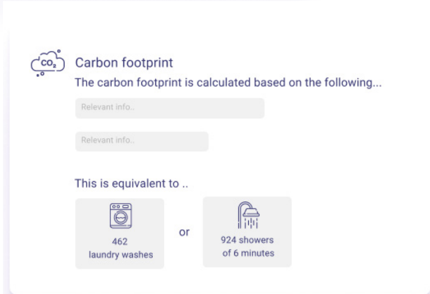
This page is followed by the setup from scenario 1.

The profile of a user that prioritizes cost and comfort, but has a lower focus on sustainability with low personalisation needs.



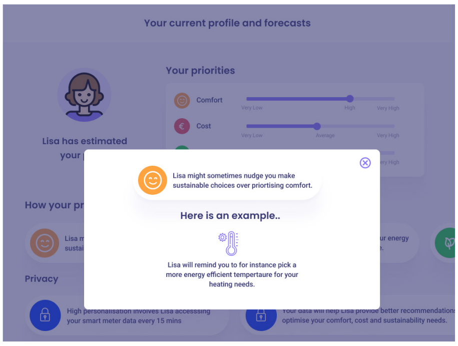


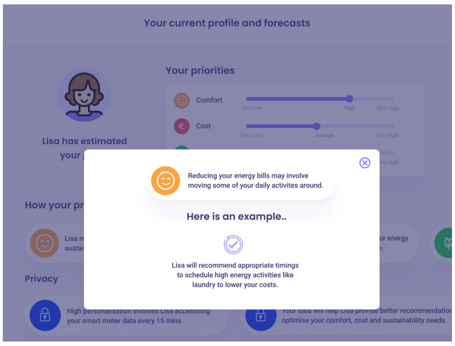
1 Users can still finalise how they want the system to work for them. The impact will change according to the changes.

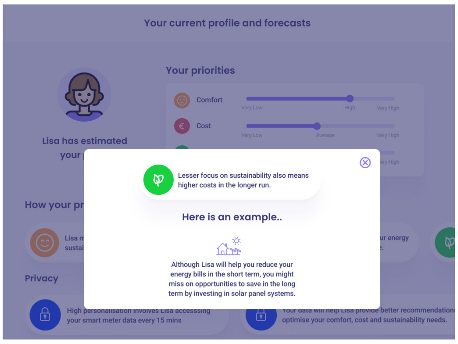


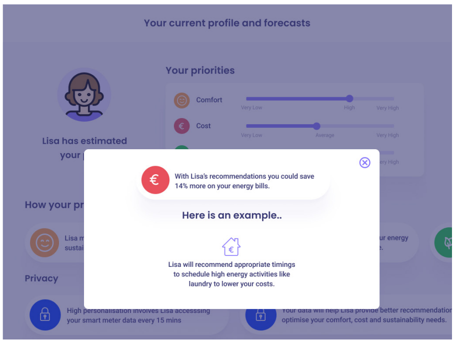
2 The 'Learn more' feature would provide details on how the system calculates the quanitified values.

3 The Lisa's(personal assistant) recommendation sections were replaced with the budget that the system would try to adhere to for user to act as goals for their intentions.

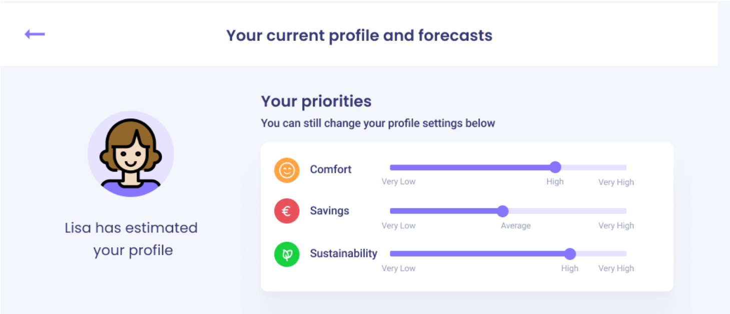


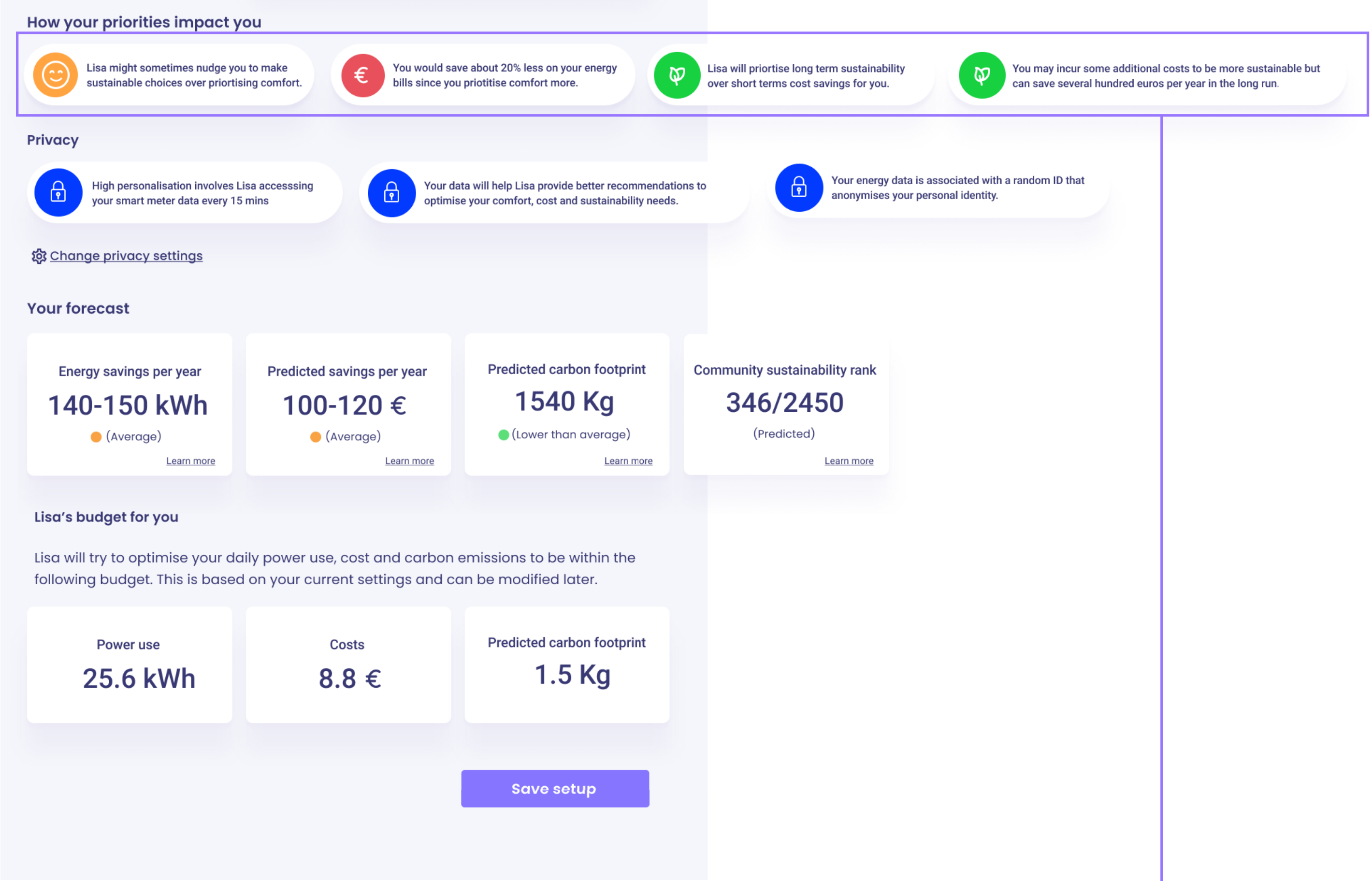


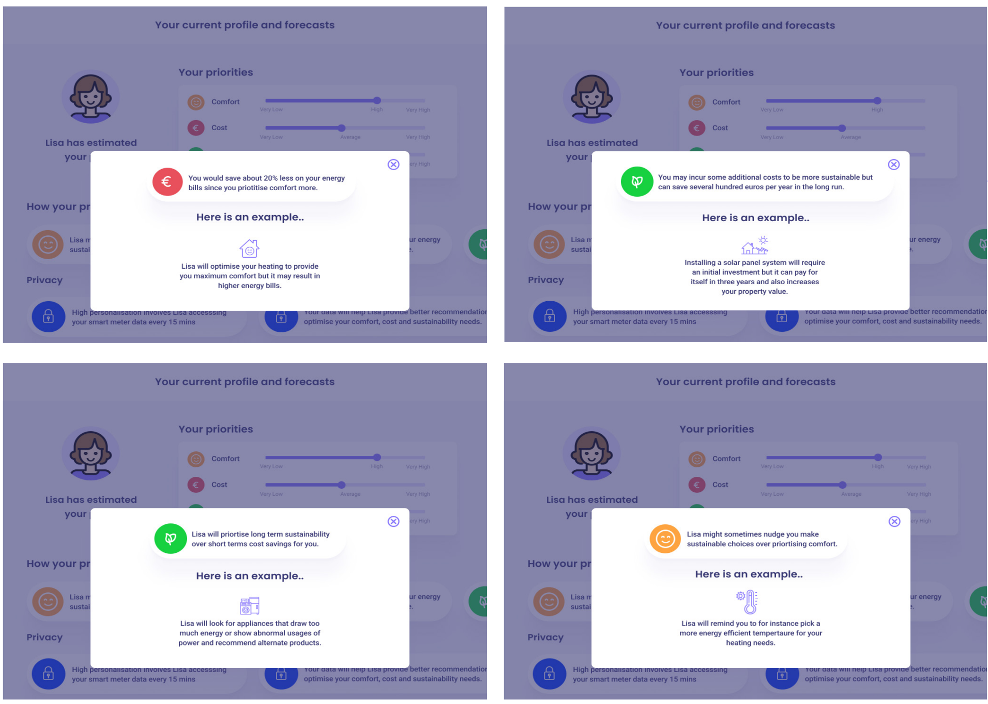




The profile of a user that prioritizes comfort and sustainability, but has a lower focus on saving money with very high personalisation needs.



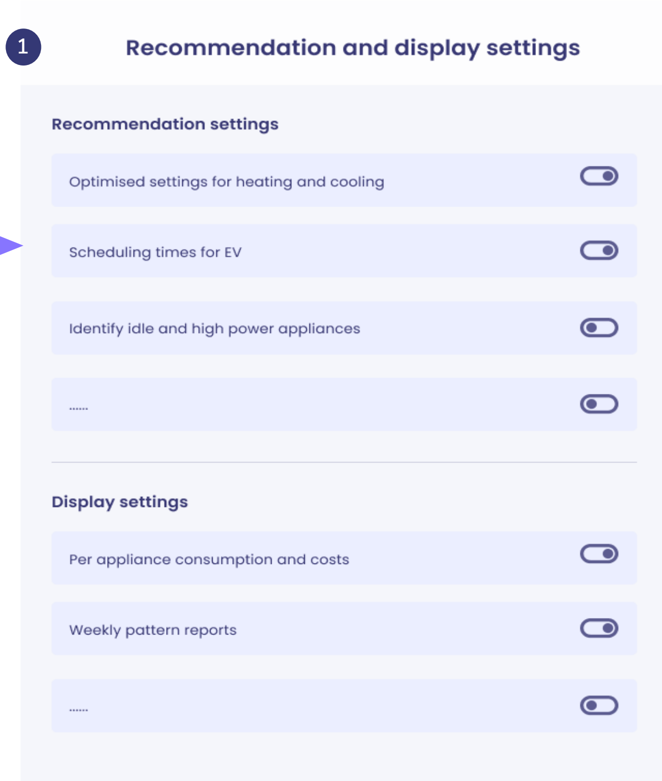




4 Each priority impact is supported by an example of how Lisa would act in a given situation to help users visualise what it would mean in reality.

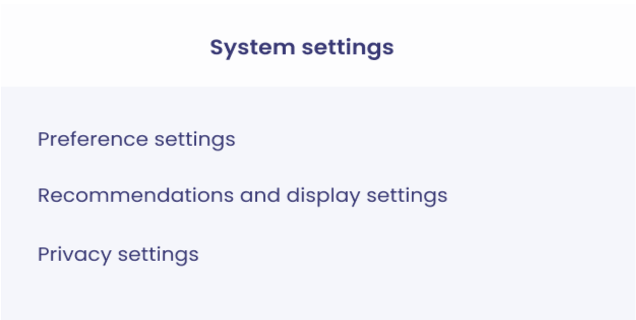
Scenario 3: Controlling privacy and recommendation settings

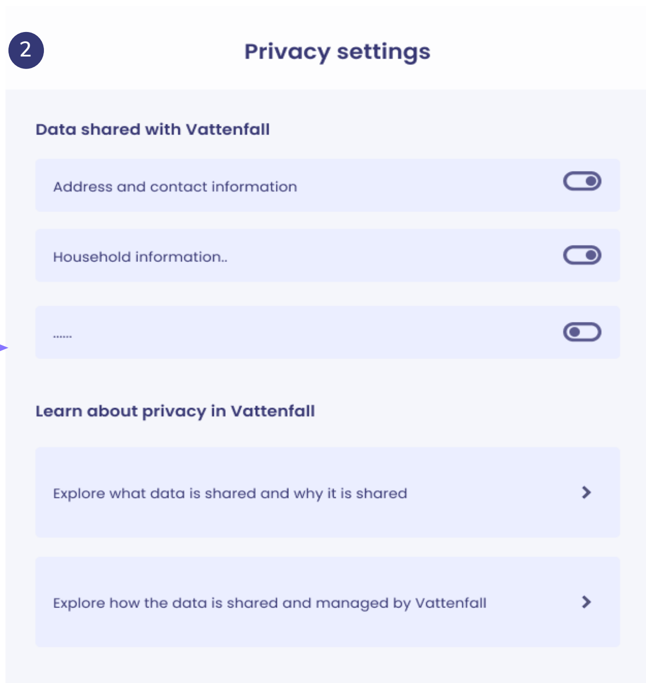
The system settings is a possible way to provide more nuanced control to the system for the users who need it. It includes a dedicated section for recommendations and privacy related data.



1

Users can decide to chose what kind of advise they want so that they are not interrupted with too many notifications hence reducing the burden of interaction. They can also choose to decide what kind of data the system processes and proceeds to provide as information or insights.

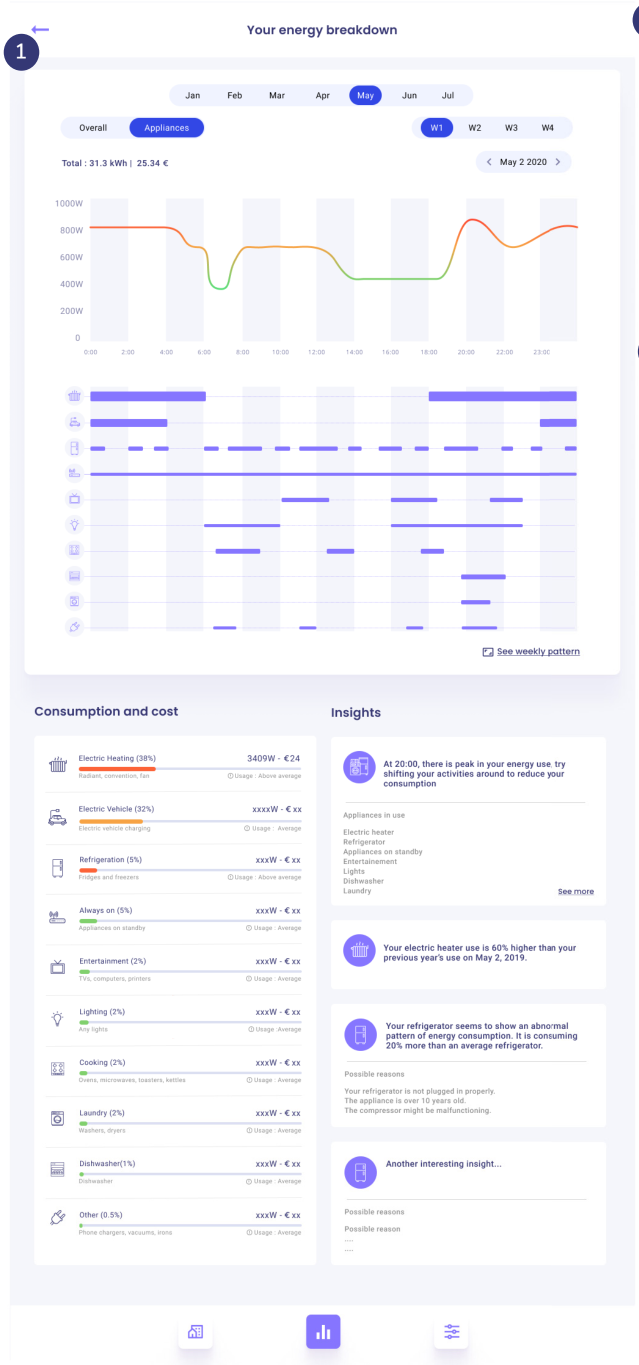




2

The privacy settings is a way for users to control what data is shared with their energy provider. They can also explore information on how the data is share and managed by the company.

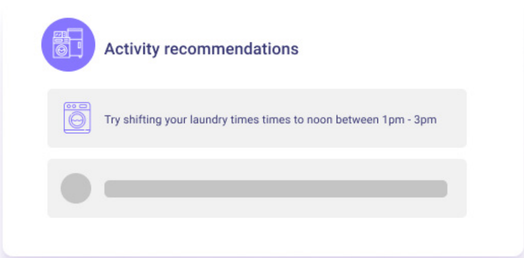
Scenario 4: Energy consumption and disaggregation

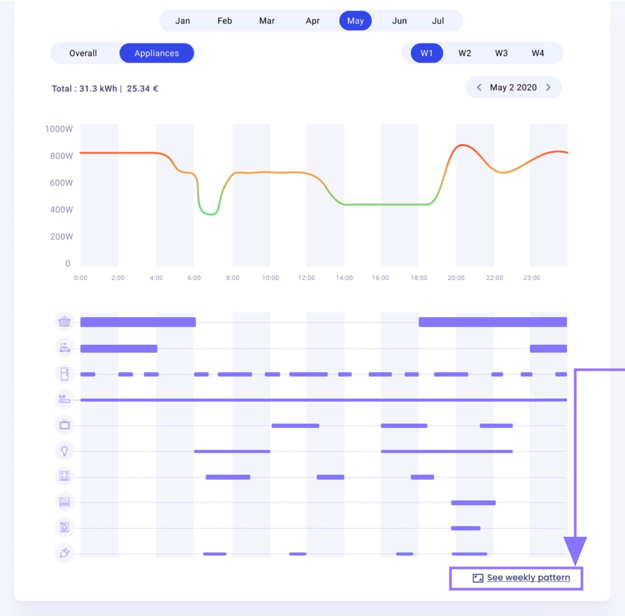


1 Consumption data and appliance disaggregation play a big role in showing how the users are doing on a daily basis and can track their daily activities. Consumption and cost breakdown is clearly provided to give users a sense of transparency on what contributes to their bills. This is then supported by actionable insights on what they can improve.

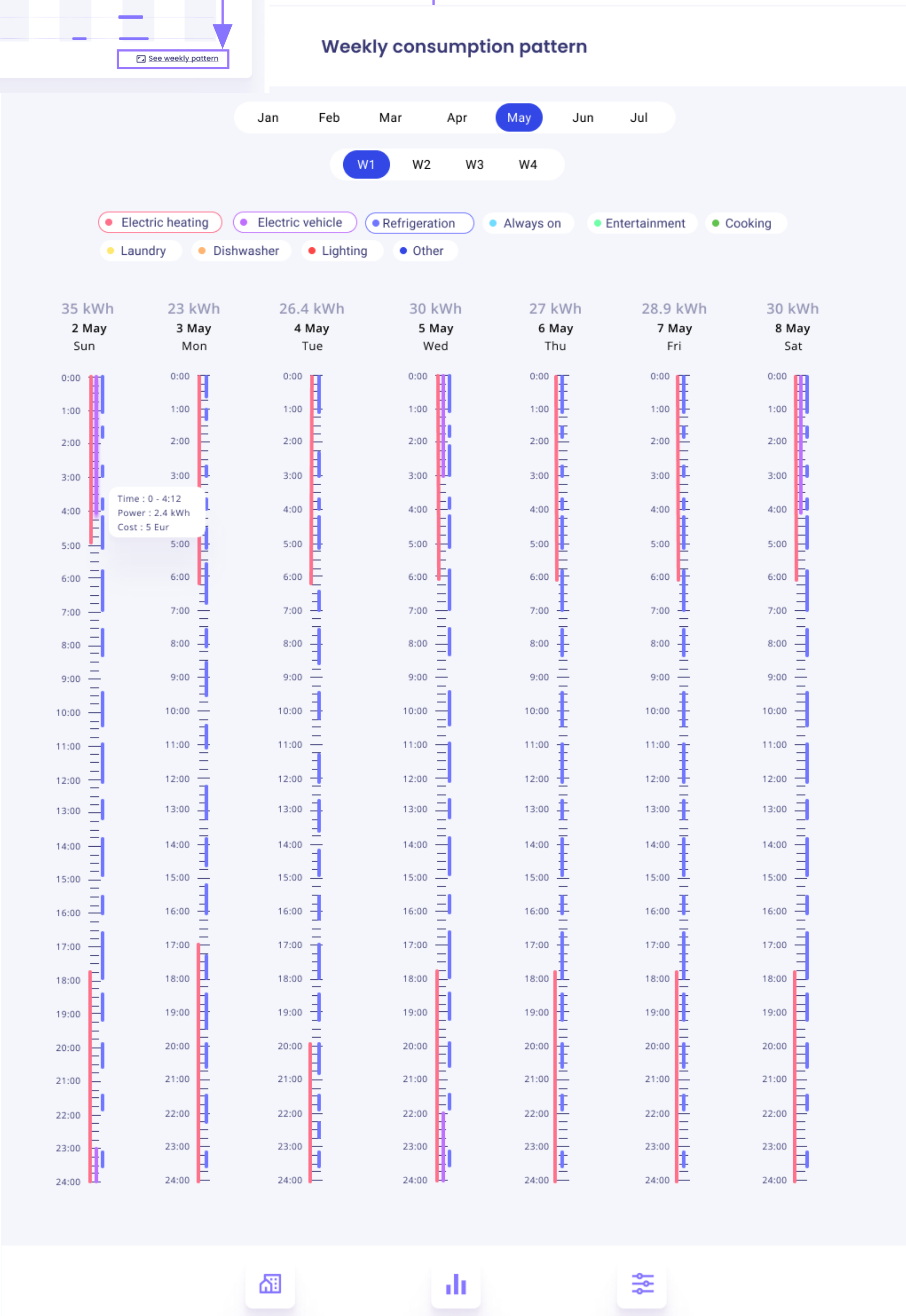
2 Users can explore further by interacting with the graphs to see a more detailed/ quantified data associated with their consumption.

3 Users are informed that their appliances are fighting for energy at certain times during the day and recommend specific activites to be shifted around to reduce the load on the grid.

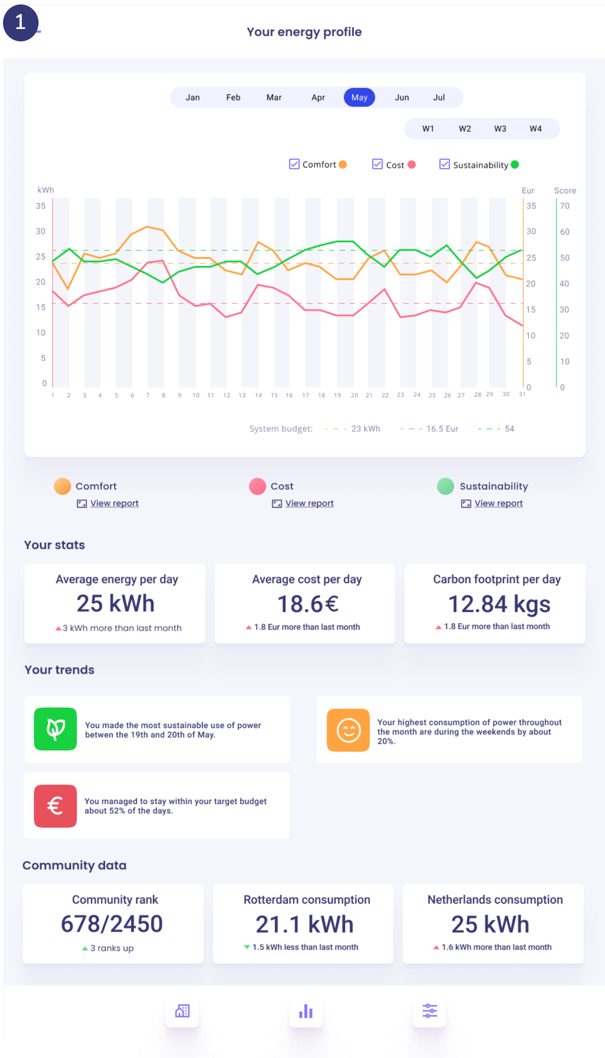




A redesigned weekly disaggregation representation. The icons were removed and instead converted to similar timelines where users can click through appliances to active the timeline. This, however might still require further testing to validate the visualisation.



Scenario 5: Energy profile

1


1 Users can reflect on how they are performing with respect to their goals by comparing their comfort, cost and sustainability factors with the budget goal/budget set by the system based on the intentions captured. They can also viewed detailed reports for each factor, see positive or negative trends in their consumption and see community information for comparison.

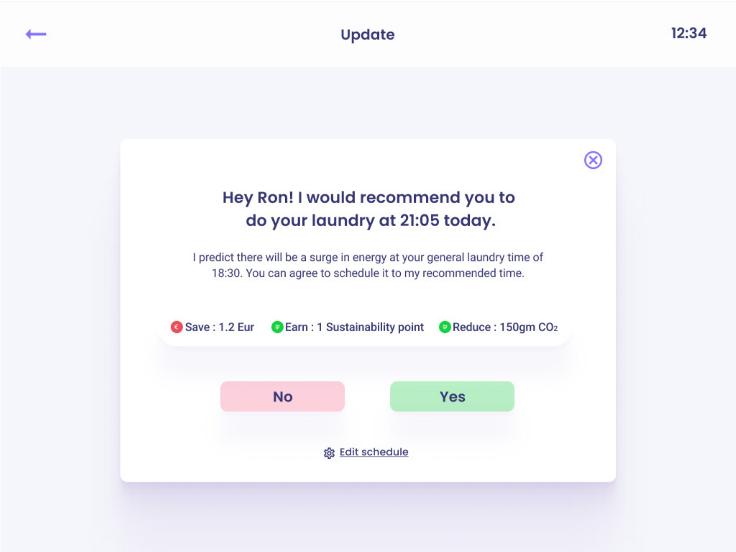
2 Users wanted to also see more quantified comparison data on how they were doing with respect to other people.

2


3

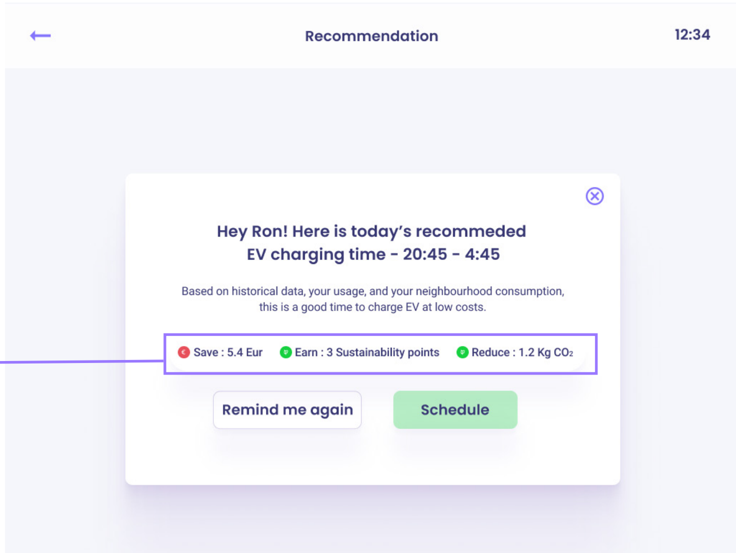

3 Users can read detailed reports of each factor, explore the badges they earned and see which priorties contribute to the current setup/behavior of the system. They can further also decide to adjust these if they feel the current behavior does not fit their needs. In addition to this, they can track all the associated recommendation that they system had made for the user, if they followed/ignored the advice and what contributed to their sustainability score.

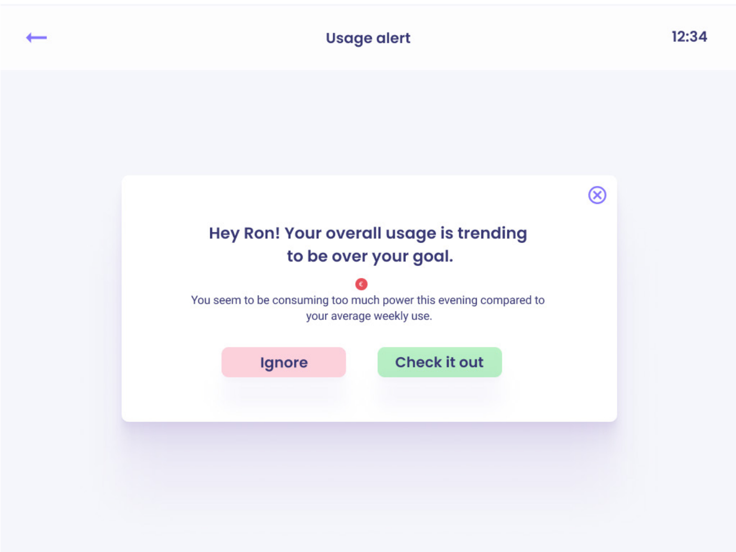
Scenario 6: Recommendations



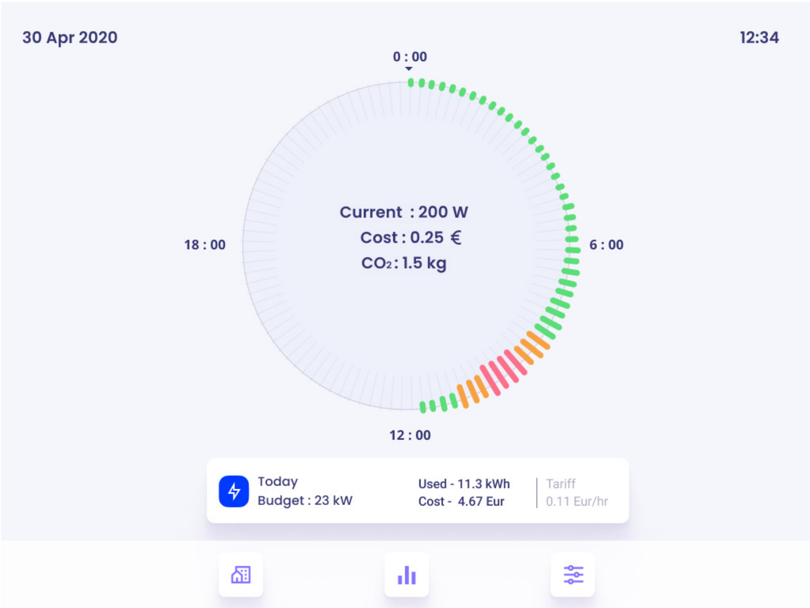
Three types of recommenadtions were designed : update, recommendation, usage alert. Each serves it's own purpose in informing users about a situation.
It is supported with concrete reasons on why the recommendation was made and how it benefits the user.

Icons are added to each benefit so that users can better associate what intention or priority was considered while the system provides the advice.

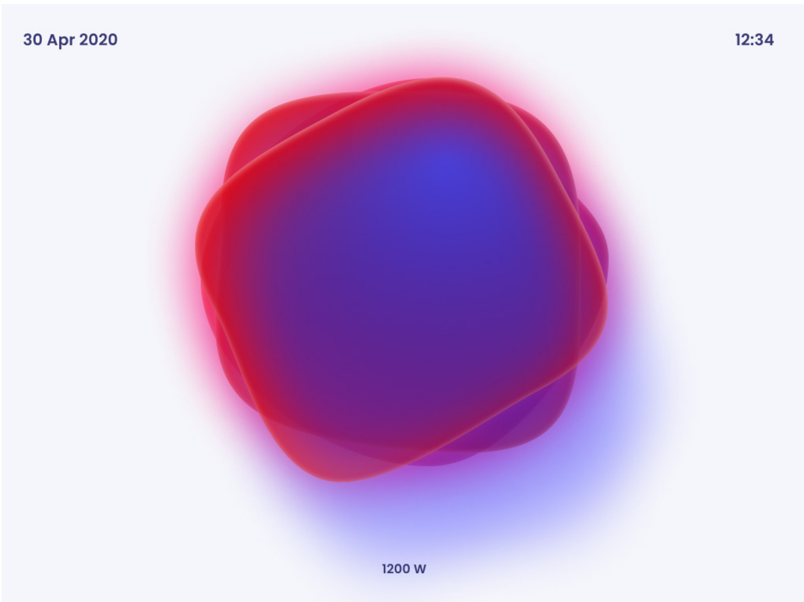




Scenario 7: Homescreen design



The homescreen acts a real time data visualiser of the energy consumption and gives users a picture of their peak usages for an entire day.



Since users had divided opinions about this abstract representation of power it is still kept a choice for users to set as screensaver.

8.2 Bridging the intentionality gap

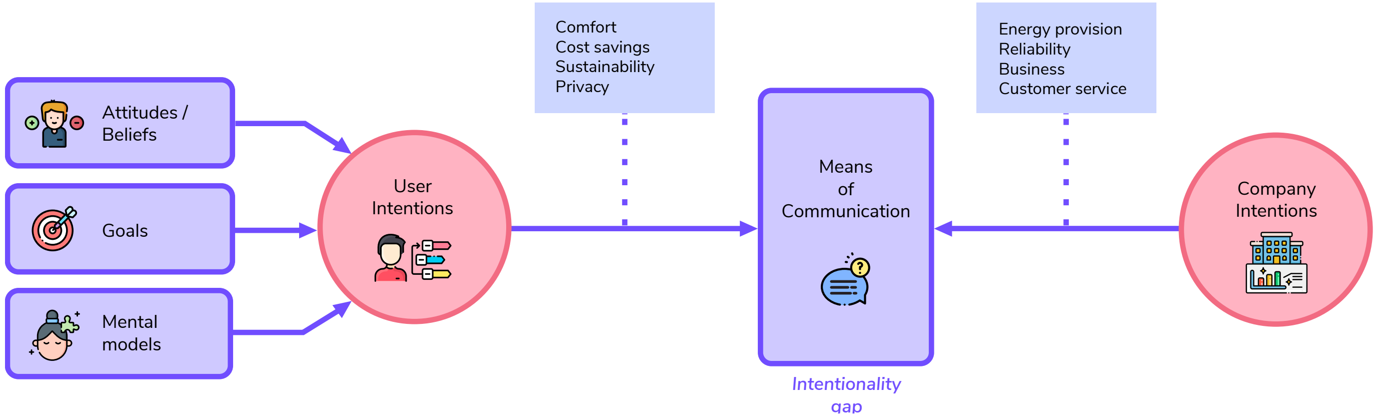


Image 49: The initial model of the various components identified between user and company intentions.

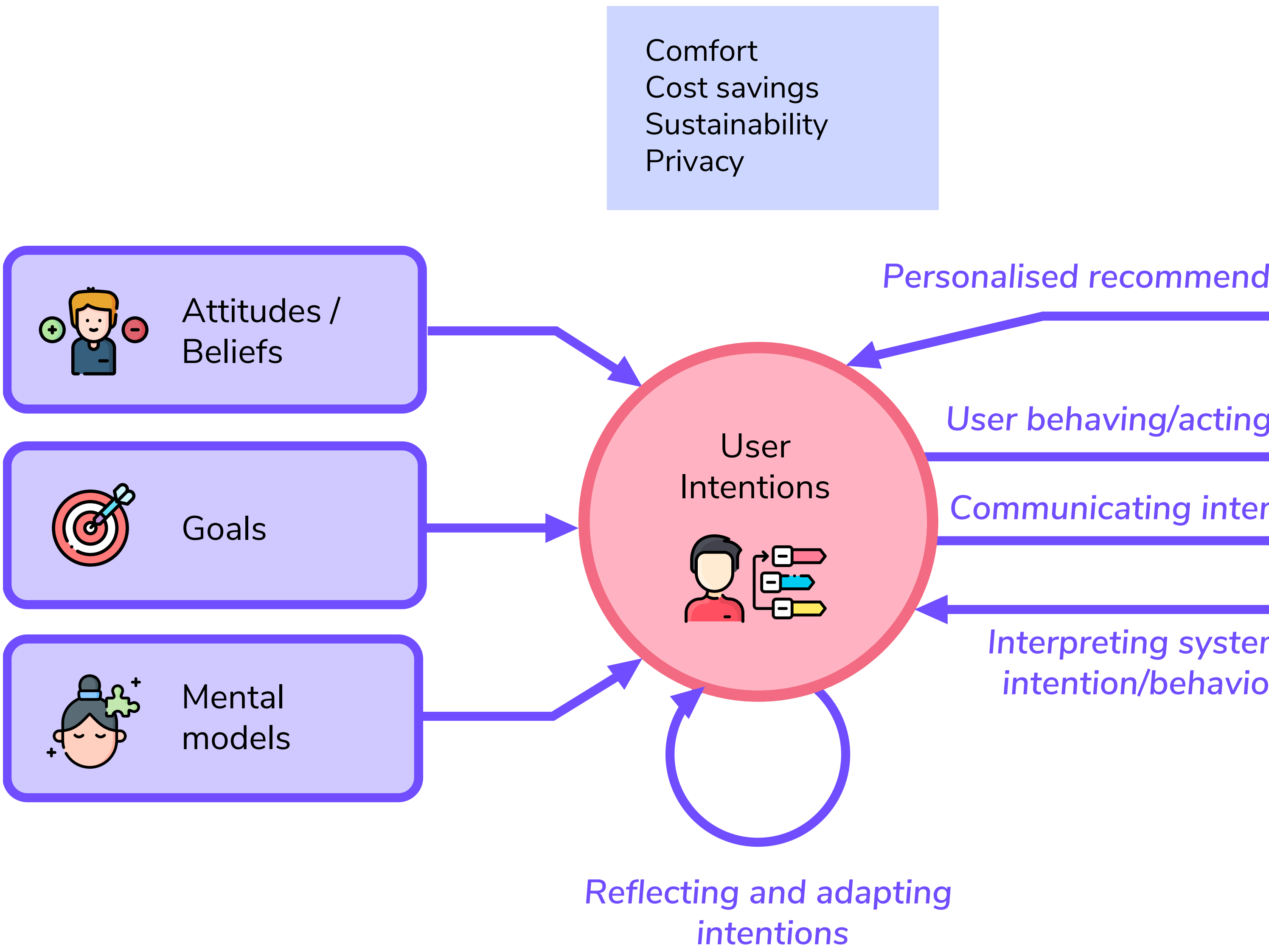
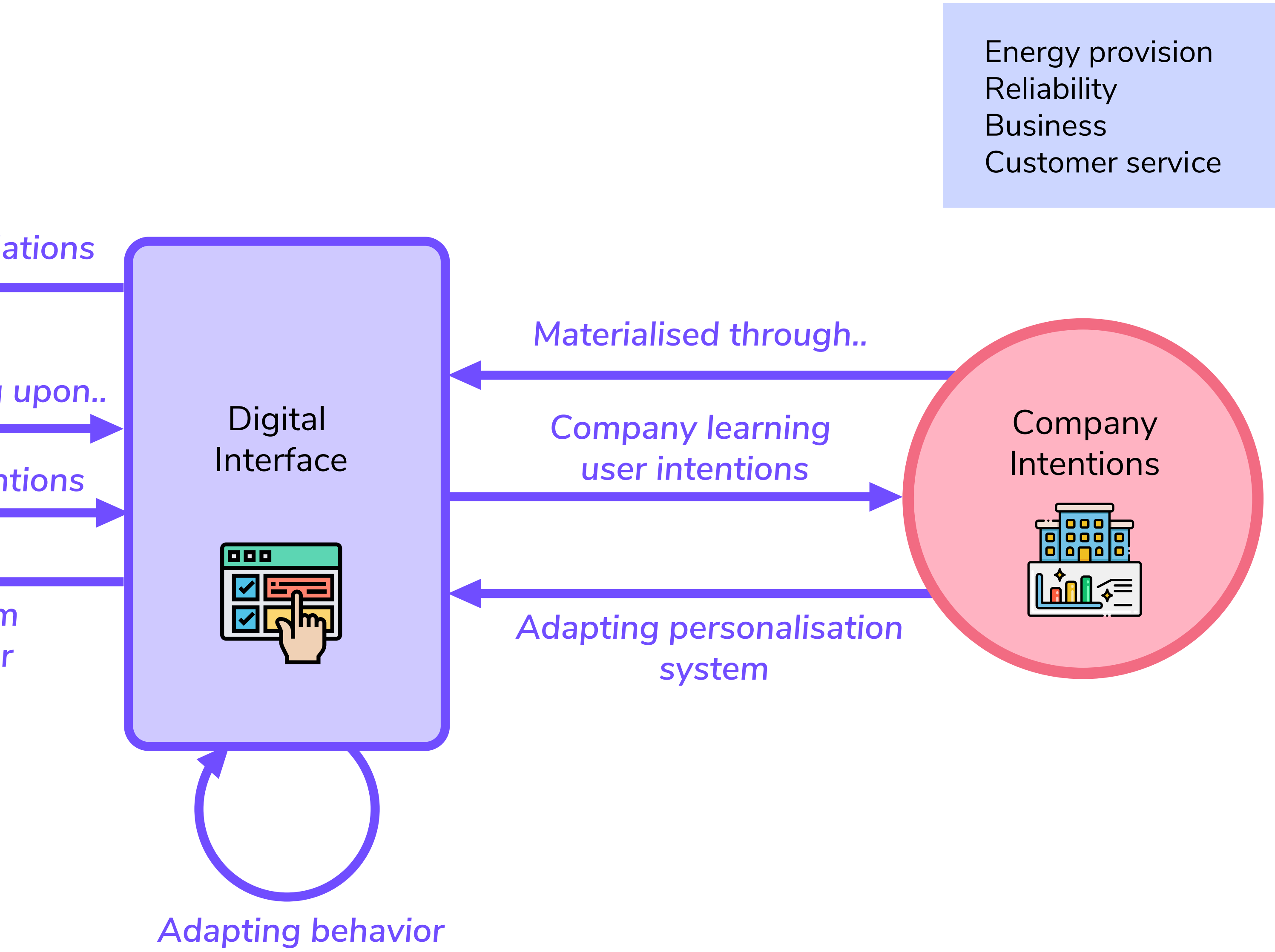


Image 50: Revisiting the model based on the insights gathered through design.

As seen in image 49, there is an intentionality gap that was identified between users and the company. Through the design process that gap is addressed by building a digital system that captures user intentions and in turn adapts to user needs.

In image 50, one can see that a user's intention is influenced by their **attitudes/beliefs, goals and mental models**. Through the digital interface which is a **materialisation of company intentions**, users can **communicate their intentions**. The company and and the system itself can **learn about user intentions** which can help to **provide personalised recomendations** but also **adapt the system depending on how the user behaves/acts upon these** recommendations. The users always percieves and **interprets the system intentions/behavior** and can use the information provided by the system to **reflect on their behavior**. Further, they can **adapt their intentions** if they feel like the system behavior is not appropriate enough for them.



REVISITING MULTI-INTENTIONALITY FOR DESIGNERS

This section finalises the thoughts around the reserach questions, states the contributions to design practicen and academic knowledge. It also discusses some of the limitations and unexplored aspects of the project. It then concludes on a personal reflection about the project.

9.1 Addressing research questions

This section revisits the research questions that were framed for the project and discusses the outcomes for each.

RQ1 How can we capture the intentions, goals and preferences of users of home energy systems ?

In this system, we used statements act as the medium for users to communicate their intentions through an interface to the system. The focus here is again on communicating the intention of use for the system rather than general intentions or overall goals. We explored intentions in four directions - comfort, cost, sustainability and privacy. This worked well with our participants - it gave them a framework for starting to think about complex questions, while keeping it concrete enough to relate to real behavioural change. From this perspective, the four profiles of intentions effectively can help indicate what the user might want to achieve with an home energy system and how they could modify the behavior to better fit their needs.

RQ2 How can a home energy system communicate how the system will potentially behave based on user intentions ?

Explaining the consequences of user intentions and preference is a vital part of the design. A screen is solely dedicated to explaining the tradeoffs of the profile that they belong to by providing both quantified data as well as examples of how the system would balance the three factors of comfort, cost and sustainability for the user. It provides an option to negotiate with the system what users would really like for themselves and what they are willing to accommodate in order to achieve their goals. Hence, presenting trade-offs become an important part of communicating to users how the system would behave after setup.

RQ3 How can a home energy system explain its actions and recommendations to users ?

Recommendations and advice are designed with enough communicative data to explain to users why the specific advice is provided by the system. Users are made aware why they need to for instance schedule an energy intensive activity for later. It also incentivises the users by providing a concrete idea of how they could benefit from the recommendation. In the privacy sections, the system also tries to explain why they need to share specific data to the system and the company and how the data is processed by the company to benefit their customers.

RQ4 How do end-users perceive the intentions behind a smart energy management system ?

The goal was to ensure that the system is perceived to have an intention of nudging users towards sustainability. This was achieved, as most users identified that the system was trying to help them become sustainable but at the same time prioritise their personal goals. However, it is also normal for users to perceive that the system has no intentions at all. Overall, the system was indeed perceived to have some form of positive intention and users did not feel uncomfortable about using the system.

RQ5 What are the aspects affecting users' trust and perception of transparency with smart home energy systems ?

Data and concise communication information about system behavior proved to be very useful in building trust among users. Real-time data can be very powerful in helping users understand their own behavior and patterns of energy use. In addition to that, communicating information in simple, accessible ways and providing enough touch points for users to see what the system tracks and how it makes decisions proved to help increase the perception of transparency in the system.

RQ6 How can users be supported in developing a sense of control with smart home energy systems?

Providing multiple touch points for users to adjust their needs and establishing that the users can always override the system' recommendations is an effective way to provide more autonomy to users. The design gives sufficient touch points and opportunities across multiple scenarios so that the system appears flexible/less rigid to the users. Users feel that they have a choice in how the system behaves and are not forced into rigid settings that might make them feel like the system overtakes the user's preferences/decisions.

9.2 Contribution to new knowledge

This project set out to investigate ways to present multi-intentionality in a real context. This involved taking new perspectives into account, understanding the meaning of intentions in the context of energy and exploring ways to present them to users.

- Intentions - the three perspectives

The three perspectives of intentions - psychology, human-computer interaction (HCI) and postphenomenology brings a unique dimension to how intentions could take different meanings during different times during different parts of the interaction. To elaborate, the postphenomenology perspective becomes the highest level of abstraction taken with respect to multi-intentionality. Here, intention is perceived as 'intention of use' for the system as a whole. This is a primary focus while setting up the system and while negotiating trade offs with the system. The HCI perspective comes in when the system is more in use on an everyday basis. It examines whether the system indeed fits the mental model and the perception of use that the user intends. The psychology perspective of intentions is employed to create behavioral change in users towards a more sustainable behavior.

- Intentionality gaps

Identifying intentionality gaps is an essential part in bridging the gap of possible misinterpretation of intentions when multiple stakeholders are involved as participants in a system. Identifying these gaps and knowing what parts of the system needs legibility in order to create transparency and trust in the system acts as a starting point for designers to start exploring ways to clarify intentions of the system to potential end users.

- Perception of intentions from users

As explored through the iterations, the meaning of intentions often take a more simplified stance for users. Intentions are not implicitly associated with systems or even explicitly perceived by users on interaction. Intentions are rather perceived through the brand image that the company stands for in their advertising platforms as well as through the service they provide. However, systems can still be designed to include the perception of having intent by using the right communicative language, presenting the right information, and designing recommendations which are materialised through the interface.

- Negotiation and tradeoff as a means to represent system transparency

Creating a means to negotiate tradeoffs and presenting tradeoffs for various intention profiles have a major positive effect in contributing towards system transparency. Modern digital systems often don't facilitate or help users understand how system preferences would affect the various parameters that interest users. Laying out these tradeoffs or consequences for choices and providing an opportunity for them to still negotiate the behavior of the system contributes to the sense of control in users. In addition to that, it also contributes positively to the brand image of the company and its intentions.

9.3 Contribution to design practice

The project also outlines some practical applications and insights that could be used by designers in projects as a source of inspiration or starting point for further exploration.

- Hyper personalisation for designing recommendations

The project aims to move away from abstract recommendations to concrete ones designed to convince people to act in more sustainable ways. It explored ways to represent tangible benefits and explain why a certain recommendation is made, making it relevant and actionable for users. It is also suggested that recommendations should be designed and adapted to fit the level of an intention profile i.e based on willingness and the likelihood of user action and previous patterns of use.

- Data visualizations in energy domain

Data has proven to be a powerful source of information in the energy context. This is primarily because most energy providers don't provide enough real time data about energy consumption patterns. The project aims to provide not just overall consumption but also breakdown or pattern use in an engaging and unique way so that users can analyse their consumption behavior.

- Ways to add transparency, trust and control

The project explored some very practical ways to improve transparency, trust and provide a sense of control to the users. Introducing multiple touch points across the system to adjust or modify system actions can contribute to the sense of control to the users. Transparency and trust are largely driven by explaining system behavior, making consequences and benefits of user choice apparent, supporting the same with real time data and using the appropriate communicative language. In addition to that, making privacy related information accessible and coherent adds to the feeling of user trust.

9.4 Limitations/Unexplored aspects

This discussion provides briefly a look into some of the limitations of the project and some areas that remained unexplored.

- Long term and real world use

Due to limitations in timeline, it is unclear how a system built around intentions would perform in the long run. The prototypes were also only tested online and could not be deployed in the field due to Covid-19 restrictions.

- Data visualization

Although three iterations were performed, it is important to note that the data visualizations cannot be considered as the absolute solution or form of representation for the content intended. The representation of the three factors - comfort, sustainability and cost still requires multiple iterations and even more ideation to improve its readability and intuitiveness.

- Could mult-intentional interaction be physical?

There was no exploration performed on what multi-intentionality could be like in physical form. The digital interface was primarily chosen as it was the best way to represent complex data.

- Programming logic

The design was always developed on the underlying thought of how intentionality could be programmed or made into an algorithm. Therefore, some parts of how this could be made more tangible is clear, however there still needs more exploration/research on how well subjective aspects like comfort could be programmed into a system. There is also the risk of the system having a bias and hence an uncertainty of whether the system really is prioritizing what the users want.

- Completeness of the digital system

The project explores the digital interface through multiple scenarios. However, the entire digital system is not built due to time constraints. Ideally, the entire navigational flow and information architecture (along with supporting interfaces) of the energy management system would be designed in a non-academic setting.

9.5 Personal reflection

The project has been an interesting journey right from the start to end. There are plenty lessons and some 'goals' which I was able to 'intentionally' achieve through the constraints of the project.

- Multi-intentionality?
I was initially somewhat apprehensive about exploring a completely new topic that did not have a lot of prior research or projects on. It was sometimes hard to wrap my head around some of the very philosophical angles that multi-intentionality took. Moreover, it being an abstract subject, the main challenge was trying to make it as concrete as possible and most importantly trying to simplify it to users. However, this proved to be increasingly exciting as I went about the intial research phase and I felt confident that it could be shaped into something more tangible. It could also be luck that I got the right insights or the right ideas at the right time, but I'm glad it did indeed all fall into place.

- Research through design
When Elisa suggested that I try the research through design methodolgy, I was worried. My previous experiences with the methodology was not all that pleasant. But, I am glad that I decided to trust her and give the research method another try. I happened to enjoy the process and now feel more confident in it. Although there was uncertainity associated with the process, it proved the most appropriate and helpful in tackling the design challenge I had.

- Love for designing for AI
A main reason for picking this topic was my interest in AI technology and designing responsibly for it. Working with Deus and exploring human-centrerd AI and multi-intentionality has only strengthened my interest and drive to continue working in the field. I feel there is huge potential to make positive impact by designing for artificial intelligence effectively.

- Decision making and thinking
Often I can get indecisive, confused or fearful of missing out things or details or the need to find answers right away. This also includes a very high expectation from myself in delivering and pushing for more in little time. I tried to control this personal obsession a little more in the project journey and tried to make more solid descions during each iterations. That involved letting go of some ideas and

willing to rework or rethink things and accept feedback. This, of course was only possible due to my kind supervisors who were very positive throughout the discovery and design stages and did not in the slightest way add any mental stress to me. This project has helped me gain more conviction over my process and skills as a designer.

- Growth in analysis

I felt that the biggest leap I had in terms of my skillset was in my analysis process. When I reflect back on some of the other projects at TUDelft, I realise that my thesis provided a great opportunity for me rethink and relearn my way of analysis. For the first time, I found myself being able to beautifully connect insights right from the literature research to the various iterations and uncover more insights through those connections. I am certainly proud that I was able to add richness to the insights gained.

- Management skills

The thesis was done at a time when things were personally very difficult for me. I wasn't at my best or productive self. There were several days or moments when I couldn't make any progress or get any work done. Inspite of all that, I made it. This was a great reminder of my resilience, persistence dedication and sense of committment.

- Wishes

I wish I had more time to further several angles about the research. It felt like the thesis had opened up more questions and possible areas of research. I would have loved to find answers to all those questions. I had also hoped for a chance to do some physical prototyping but the interfaces themselves consumed so much time because of the complexity of the domain and topic itself.

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