The design of a new extension for Toon

Bachelor assignment -
Indsturial Design

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Summary

This report describes the design process of the of a new extension for Toon, the smart thermostat by Eneco. Since 2014 is has been possible to connect various smart devices to Toon, this extends the functionalities that Toon can offer. For Eneco, it is important that new extensions will be developed for Toon within the field of smart homes. The goal of this bachelor assignment was to develop a new extension for Toon.
The project took place at Eneco's headquarters in Rotterdam. It also simulated the Lean Startup process; the designed concepts would be pitched for the stakeholders and the chosen concept would be developed into a minimum viable product.

The design process started with analyzing which smart home products are currently found on the market and identifying which of these products are currently in demand. Based on this information it was determined which product functionalities could make the extension interesting for both Toon and non-Toon consumers. Besides that, the customer profile of the current Toon customers was also further analyzed. The Toon itself was also studied as a product focusing on its technical details.
Based on the insights of the analysis phase, ideas were generated in the ideation phase. Various methods were used to enhance the ideation process, examples of these methods include TRIZ and Disruptive Images.
With the feedback from the stakeholders and the findings from the analysis phase, ideas were selected to be taken to the next stage of the project; this resulted in the development of 4 concepts of new extensions for Toon. No concept was alike, and they showed new potential areas for new extensions. The concepts were pitched for the stakeholders at Eneco; they were all received very positively, and all of them were deemed interesting enough for further advancement. In the end, the concept that could be developed in the least amount of time was selected for further development.

The chosen concept uses data of the user, in order to help the user to save energy. To realize this, three different functionalities were developed further. Due to the short timeframe in which this assignment took place, it was not possible to develop it up to the point of a minimum viable product. Instead, a user interface was designed for each of the functions on a high level of fidelity, and a prototype was programmed that validated the concept on a functional level. Both of these parts can be used for the further development of the concept.

Samenvatting

Dit verslag beschrijft het ontwerp proces van een nieuwe uitbreiding voor Toon, de slimme thermostaat van Eneco. Sinds 2014 is het mogelijk om andere slimme apparaten te koppelen met Toon. Eneco heeft er belang bij dat er nieuwe slimme uitbreidingen voor Toon ontwikkeld worden op het gebied van smart homes. Het doel van de opdracht was om een nieuwe uitbreiding te ontwerpen voor dit platform.
De opdracht vond plaats bij Eneco en simuleerde hierbij tevens het Lean Startup proces gedurende de opdracht. Zo werden de concepten onder andere gepitcht voor verschillende stakeholders en het gekozen concept zou worden uitgewerkt tot een minimum viable product.

Het ontwerp proces zelf, begon met een analyse waarin werd gekeken welke slimme producten momenteel op de markt te vinden zijn en in welke producten consumenten het meeste interesse hebben. Op basis hiervan werd vastgesteld welke functies het meest geschikt zouden zijn voor een nieuwe uitbreiding. Dit werd zowel voor Toon als niet-Toon klanten vastgesteld. Daarnaast werd ook het krantenprofiel van de huidige Toon klanten onderzocht. Ook werd Toon verder geanalyseerd op technisch gebied.
De uitkomsten van de analysefase dienden als input voor het generen van ideeën. Hierbij werden ook verschillende methodes gebruikt om dit proces te versterken, denk hierbij aan methodes zoals TRIZ en Disruptive Images.
Mede op basis van de input van de stakeholders, en de conclusies uit de analyse fase zijn ideeën geselecteerd voor de volgende stap; dit leidde tot de ontwikkeling van vier concepten. Deze waren elk verschillend en brachten nieuwe uitbreidingsrichtingen in kaart. De concepten zijn zowel bij Eneco als Quby (de oorspronkelijke ontwikkelaar van Toon) gepitcht, waarbij ze erg positief zijn ontvangen. Elk concept werd geschikt geacht voor verdere uitwerking. Uiteindelijk, is er voor het concept gekozen dat het snelste ontwikkeld kan worden.

Het gekozen concept gebruikt data van de klant, om de klant zelf te helpen met het besparen van energie. Hiervoor zijn drie verschillende functies verder ontwikkeld. Gezien het korte tijdsbestek van de opdracht, is het niet gelukt het concept volledig te ontwikkelen tot een minimum viable product. In plaats daarvan is er voor het gekozen concept een interface op een high fidelity niveau uitwerkt, en een prototype geprogrammeerd die de validiteit van het concept heeft aangetoond op functioneel niveau. Beide onderdelen kunnen gebruikt worden voor de verdere ontwikkeling.

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Reading guide

This report presents the process of the design of a new extension for Toon. The events that took place during the bachelor assignment are presented in such way that it seems as if the entire process happened chronologically. This was done to present the report in a more readable format. In reality, however, some events happened simultaneously. Although these implications will be minor, it is only mentioned to be precise. More information on this will be given later in this introduction when the planning and approach are presented.

The report is segmented into various parts; each part covers a certain phase of the design process. To some degree, they can be read individually from one another. As each phase builds up on the conclusions of the previous one, it is advised to start read the parts in chronological order from the outset.
Each part of the report begins with its general introduction and a finalizing conclusion; a gray background can distinguish them. In between chapters, various topics can be found discussing matters related to the design phase.

Definitions

Two concepts used in this report have multiple accepted definitions. To avoid confusion, a definition of both of them will be given as they are not further defined in the report itself:

Extension

In this report, an extension can be considered as a black box that can fulfill a certain function that is not yet defined at this moment. This 'black box' should not necessarily be imagined as a physical object per se, it can also be digital, or both at the same time. However, it will always be used in the context of being able to fulfill or add a new function to Toon.

Smart home product

Smart home products are products that provide home owners comfort, security, energy efficiency and convenience. Smart home products are commonly used to define appliances such as smart- thermostats, lightning, heating, air conditioning, entertainment audio & video systems, security and camera systems, that can communicate with one another. Some of these products can also be controlled remotely by phone or by internet (while their non-smart variants cannot) [1]. Home energy management products were also included under the definition of smart home products within this project.

About Eneco

This bachelor assignment was commissioned by Eneco, which is the trading name of Eneco Holding N.V.. Eneco is one of the biggest producers and suppliers of natural gas, electricity, and heat in the Netherlands and has its headquarters located in Rotterdam.

As the market for energy is becoming more liberal and competitive, Eneco has seen a drop in revenue in selling its traditional products.
For this reason, Eneco is changing strategy and making a transition towards a service providing company.
This change encompasses significant investments in innovation and collaboration with technology startups. One of these initiatives eventually resulted in the release of Toon in 2012, a smart thermostat originally developed and brought to market by Quby, a startup (back then) located in Amsterdam in which Eneco had invested. In 2015 Eneco fully acquired Quby, making it part of Eneco. With combined forces, both companies are striving to make Toon more successful. Since its release, Toon has known an exponential growth in the number of sales. Currently, over 300,00 Toon's are installed in the Netherlands. Besides functioning as a smart thermostat, Toon is also a home energy management platform, and more recently Toon is also expanding itself towards becoming a smart home hub. This bachelor assignment will focus on the smart home aspects of Toon. In illustration 1 the Eneco is presented in an infographic (the infographic is from 2015).

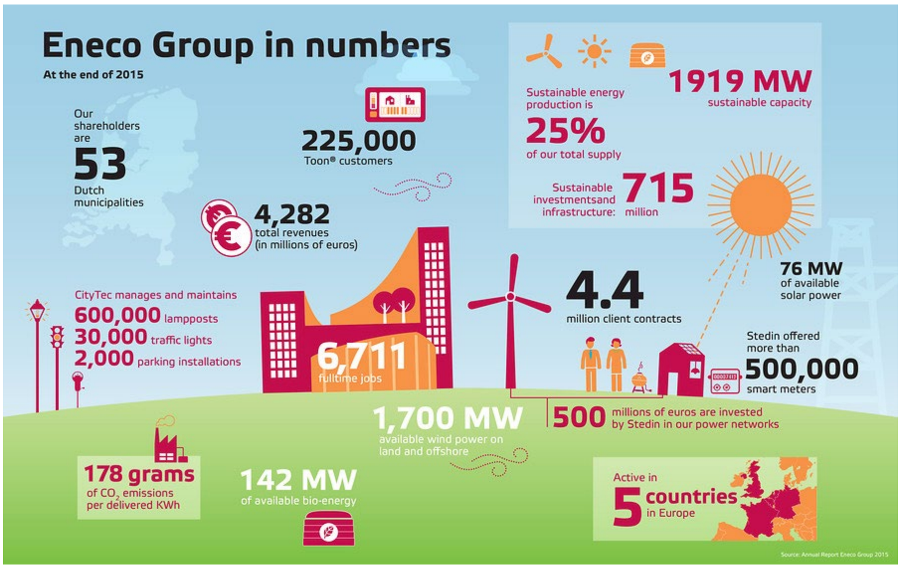


Illustration 1: the Eneco Group in numbers (image by Eneco)

The goal of the bachelor assigment

In 2014 Eneco released smart plugs for Toon, which was the first time another device could be paired with Toon. This was the first update for Toon that implemented smart home functionalities into Toon. By now, Toon can also be paired with Philips hue lighting bulbs and a smart smoke sensor.
Eneco wishes to speed up the process of adding new smart home related functionalities to Toon, either through software updates or by designing and pairing of new products. Therefore Eneco has taken the initiative to start an internal startup-simulating acceleration program, in which these new smart home extensions can be designed and developed. This bachelor assignment was completed within this program.

The goal of this bachelor assignment was to design a new extension for Toon within the smart home domain. Various concepts would be created including other facets such as a business model for each of the concepts. The concepts (including their business case) would be presented to Eneco. Based on this, one concept will be selected for further refinement. The design of the extension would be refined till the form of a minimum viable product, if the remaining time should allow for that.

Approach

As the assignment offered a lot of freedom but had to be carried out in a limited time span, the design process was planned out globally in advance. The foundation of this planning was based on the three steps of Design Thinking: immersion, design, and prototyping. To aid the design process, certain principles and techniques from the lean startup method [3] were also applied at the end of the concept phase and the prototyping phase.

The project started with an analysis of the current market and users of smart home products, followed by more research on Toon and its current users more specifically. The next steps in the project consist of an ideation and concept phase to design new extensions. At the end of the concept phase, a pitching session was held at Eneco with the aim to select a concept for further development. In the last stage of the project, the concept would be aimed to be developed towards the level of a minimum viable product.
Throughout the different stages of the project, experts from various disciplines within Eneco and Quby, were consulted for additional insights and feedback.

Part 2

Analysis phase

The case that Eneco has given can be interpreted in many different ways. As an ‘extension’ does not exclude anything specific, all the options were open. It was for this reason that the analysis aims to cover a wide scope of subjects in relation to smart home products.

Before delving straight into the reports and other intelligence on Toon Eneco was able to offer, information was sought outside of Eneco initially. This was done to create a framework about the smart home products in general, so it could be compared with the insights from Eneco. The analysis started with studying scientific papers and reports on smart home products. An overall distinction was made between market related topics, and user related topics. The market research in this part of the analysis focussed on smart home products in general. It also aimed to identify what smart home products are currently popular and in demand. The user research studied the relation humans have with the smart home technology and its products, how they experience it and what they expect from it.

The second part of the analysis phase focusses on Toon, the information in this part was provided by Eneco. It includes a detailed report on the user base of Toon and how the users of Toon currently interact with their product.

The analysis phase is split up into multiple chapters, each chapter has its focal point on a different aspect and presents its findings and conclusions. The first part of the analysis phase is a market research, followed up by a user research. Both of these chapters focus on smart home products in general, the parts that come after will focus more specifically on Toon more specifically. At the end of the analysis phase there will be a conclusion on the findings of the phase.

CHAPTER 2.1

Market Research

Introduction

This chapter provides a summary of the market research that was conducted. Its content will focus on the findings specifically. The goal of this research was to identify and analyze competitors and their products. Mainly to be updated with the current state of the smart home products, this part of the analysis phase was done first. Furthermore, it identifies areas of interest that were further analyzed in the user research. The scope of this research did not limit itself to the Netherlands alone, it included the international market as well.
Besides identifying competitors and their products, it looks into customer characteristics:

- For which reason are customers buying smart home products?
- When are new smart home products typically purchased?
- What is the customer profile of customers who purchase smart home products?

The findings, presented in this chapter, were mostly obtained from market research reports that were conducted by specialized market research firms. The reports were provided by Eneco's marketing department. They did not focus on Toon specifically, but on the market for smart home products itself. Moreover, two of Eneco's marketeers were interviewed to get additional information. To further ensure that the most recent information would be included, additional research was done into recent and upcoming product releases and announcements. This information was obtained using the internet, looking into sources such as CES 2016 (Consumer Electronics Show).

Illustration 3: A selection of various smart home product extensions from Toon's main competitors within the smart home domain. The displayed products are from Fibaro, SmartThings (Samsung) and Nest (Google).

What products are currently available on the market?

When analyzing what products are currently released by companies that offer a multitude of smart home products, something can be concluded straight away: most of these brands have a close to identical product portfolio. They all offer the same range of products with

similar features. Examples of these brands are SmartThings by Samsung, Nest by Google, HomeKit by Apple, Fibaro, Elgato and KPN Smartlife. Illustration 3 presents some of the product extensions from Toon's main competitors. The product portfolio consists in this case of a hub (illustration 4) and individual products or modules that can be connected to the hub according to the users preferences. Most of these hubs are physical products. Apple's Homekit is more or less an exception to this rule. In this particular case, the Apple products (iPhone and iPad) fulfills the functions of a hub through an app called HomeKit [4].
Most smart home hubs are compatible with a variety of products from different brands (especially when the product is not within their own portfolio obviously). However the product expansion options beyond the hub-brand are rather limited for most brands. The exceptions to this rule are Nest and SmartThings: their hubs allow the user to connect and control a wide selection of products beyond the hub-brand. Third party developers can connect their product to these brands using open-API's [5, 6]. Eneco is starting to deploy a similar strategy with their recently released open-API for Toon [7].

For a list of all products that were included in this research, please refer to appendix 1.
For each product, the following factors were taken into account: the brand that it currently belongs to, the main function(s) of the product, how the user can control them, how they report their status to the user, their market price, and their dominant tech specifications (which type of sensors are used, what communication protocol is used, and the range of operation).

Illustration 5: An air quality monitor made by Foobot (image by Foobot)

Illustration 4: A smarthome hub by Fibaro (image by Fibaro)

Further content

The further contents of this chapter are not included in the public version of this bachelor report due as it is to remain confidential. The original content presented the insights which aimed to answer the initial questions given during the introduction of this chapter. A summarizing conclusion is presented instead. The conclusion has been modified compared to the conclusion in the confidential version of the report. This was done to keep the said information secret.

Conclusion - public version

For the Dutch market, the main selling feature for a smart home product is the ability to aid with saving energy. Products that add safety, comfort or monitor health and wellbeing, are also trending products within the market. These functionalities provide interesting input on what a new Toon extension could focus on, as there is a market demand for these functions. People with a high income express the most interest in smart home products; they have a higher affinity with technology, and the price tag is less likely to be a barrier for purchase. Currently the high price tag, or an unclear added value of the product (especially when it replaces a already existing product) is something that keeps a lot of customers from purchasing smart home products.

Another finding based on the analysis of the products, is that it appeared that the way in which products from different brands can communicate with each other is limited by hardware. The product-connectivity features are essentially what makes a smart home product smart. Therefore this is an important factor to take into account. If the Toon-extension aims to become more widely adopted amongst other brands, then connectivity features should be taken into serious consideration. Products can only connect with each other if they share the same commutation hardware (Wi-Fi, BlueTooth, Z-Wave etc.).

Chapter 2.2

User Experience Research

Introduction

In order to gain a better understanding of current user needs, expectations and experiences of smart homes and products in this category, a desk-research on user experiences with smart home technology was conducted. This chapter describes what was researched, the findings, and the conclusion of the research. Some of the findings from the market research were input for the user research.
Most of the information was gathered through studying scientific papers on smart homes which were focused on the user-experience. The authors of these papers used focus groups or interviews to get information and opinions from the participants. To get more opinions on the overall user experience and satisfaction of certain products, on-line product reviews by consumers and specialized reviewers were analyzed for additional insights. The findings obtained through direct contact with the users of Toon and smart home products through semi-structured interviews is included in the next chapter of this report. For this part of the research, the primary goal was to identify generalities on the technology and the user experience of smart home products and their users.

User differences America and Europe

As was already concluded in the market research, the European and American consumers seek to fulfill different needs when it comes to smart home products. American consumers are really enthusiastic of the possibilities that Home Automation brings with regards to home security [9]. Their main motivation is a need for a feeling of safety against burglars, but also to remain feeling connected with their home [12]. For example when their children are home from school, but the parents still have to finish their shift at work, the parents receive a notification that their children made it home safe. The home security system can make them feel reassured that everything is ok.
European consumers, on the other hand, are strongly interested in their own activities and the impact of their behavior on their house [13]. Often in order to access their efforts towards achieving a specific goal such as reducing energy consumption [8, 14], or optimizing their resource use [15]. In other scientific reports, the same interest in this activity was observed for the European market [16].
Something that can be drawn from this, is that the needs, that European and American customers seek to fulfill, are different when it comes to these products. When plotting these needs on Maslow's Hierarchy of Needs [17] —in psychology used as a theory for human motivation, see illustration 6 — they belong to different hierarchies. According to the theory people will first realize the lower hierarchical needs before proceeding to the next. the need of safety (America's dominant market need) is placed under the need of esteem' and self actualization (European dominant market needs). By no means is this a 'one-size-fits all' conclusion when it comes to this market generalization. It gives an indication of which type of application would be more popular for each continent, and how the technology or product should be framed.

Another possible cause for this difference, that should not be underestimated, is that the price of electricity is higher in Europe than it is in America. However, the amount of electrical energy the average American consumes is also near double compared to the average European [18].

Illustration 6: Maslow's hierarchy of needs illustrated in its pyramid shape. [17]

Smart home products and family life

Before a new technology becomes adopted by masses, people often have their doubts or concerns about the impact of the technology on their lives. With technology within the smart home domain, this will be no different. People worry if they will get, or appear as, lazy by using Smart Home technology [19, 20]. Parents, for example, don't want their everyday tasks related to taking care of their children to be automated, as it makes them feel as ‘good parents'. Activities like these also enable them to spend some quality time with their children or teach them life skills [21]. However, parents are not hostile towards the combination of technology and family life. In fact, they even welcome it when it comes to certain applications, as was revealed in focus groups. In a variety of researches, parents expressed their wish for Smart Home products that assists them with their everyday tasks: mainly supporting them with their busy life with regards to them having children in a dual-income family. Be it through reminders on things they typically forget or help them with managing the activities of the children. Many of these families consist of dual-income households, adding additional challenges and chaos when it comes to raising children [19, 21].
Depending on the type of product, families with children act more beneficent to the adoption of a smart home technology. As was shown in research, children have a positive effect on the acceptation of the product [22]. This was an observation with the adoption of the robotic vacuum cleaner technology (such as the Roomba). Children liked the interaction with the product and got joy out of it, be it through chasing the Roomba or building obstacles for it.

Autonomous products versus controlled products

Completely autonomous technology often leaves users feeling out of control. Especially when they don't get the sufficient amount of feedback on the status of the device [23, 24]. If it is unclear how the technology reacts to their behavior, it might make them confused or annoyed by the product, as was also shown in research [25]. Moreover, users of smart home technology express the need to be able to turn their smart devices off, as they don't want to become completely dependent on the technology [26].

Users expressing their dissatisfaction with the way they currently control their Smart Home is frequently observed in on-line product reviews. This topic was also brought up during some of the interviews with users of smart home products [27], the same disappointment was expressed here (more on this in the next chapter). Users either have a lot of additional devices with each their own remote to control them due to incompatibility issues. Or they do not prefer to use the new remotes over the traditional controller: this comment applies to how smart devices like the Philips Hue lights are controlled, the light bulbs can be toggled on and off with a conventional light switch, but for their additional functionalities an user has app or other specialized external device.

Outcome

For the Netherlands, the main reason of interest into smart home technology is towards the appliance of saving energy. Making their house more secure is the second most popular reason. The cause of the difference, in consumer priorities between markets, is due to the needs that different markets have. This doesn't mean they are completely different, but the focus of interest is slightly different for the respective markets. The exact user-motivation causing this change was not identified decisively within this analysis.

Another lesson, that can be drawn from this research, is that the level of autonomy a product should have is an important factor to keep in mind. In the market research, it was found that users would be interested in smart home technology if it adds comfort to their lives or saves time. However, this is not necessarily achieved by completely automating the chores of users. Not all consumers are seeking for a ‘The Jetsons’ lifestyle as was found in this research. They don't want to become too dependent on the technology, they much rather keep control and preferably are still the ‘actuators’ themselves. But by all means, this doesn't imply that users are hostile towards smart home technology. Especially when it comes to the more sophisticated lifestyle of families, a keen interest is expressed in making life more comfortable and easy. Rather than having tasks automated, customers rather seem to show interest in assistance with carrying out their daily tasks.

It should be kept in mind that within this part of the research a general user research was conducted, mainly based on what was found in research papers on smart homes. To get a more detailed user research, the users of Toon themselves were studied specifically. More on this topic will be discussed in a later chapter.

Chapter 2.3

What is a Toon?

Before the report starts to cover research on Toon and its users specifically, this section aims to explain what Toon is as a product and the functionalities that it offers. Later in the analysis phase, the technical details of Toon will be discussed.
Toon combines many functionalities into one product, they can be summarized into 3 categories: smart thermostat, home energy management and smart home functionalities.

Illustration 7: The homescreen of Toon. (Image by Eneco)

Illustration 8: Toon consumption graph. (Image by Eneco)

Smart thermostat

Toon is a smart thermostat: it improves the efficiency of the heating program depending on the housing situation. It learns how long it takes to warm up the room to the desired temperature, and further optimizes its functioning based on this. At the right side of the display, the user has acces to the temperature settings (illustration 7). The user is able to save 4 programs with pre-set temperatures based on their activity: home, comfort, night and away (translated: thuis, comfort, nacht en weg). These programs can be activated at any time by tapping on the display. The temperature can also be further adjusted manually based on the situational preference of the user. The Toon apps, for smartphone and tablet, also allow the user to change the temperature over distance. A subscription is required for these features, more on can be found further in this chapter. Toon is currently sold for €275 which includes installation.

Home Energy management

Toon also functions as a home energy management system, allowing users to gain insight into their energy consumption. The users are presented information about both gas and electricity usage. Subscribers have access to historical data on their energy consumption (illustration 8).
Information about the energy usage is presented to the users through the applet-tiles on the left side of the home-screen. Users are able to customize this side of the display on which applets should be displayed, and in which order they should be navigated through.

Not all Toon's applets focus on energy consumption. There are also applet-tiles to get information on the weather and traffic situations.

Illustration 9: Smart home products for Toon by Fibaro and Philips Hue.

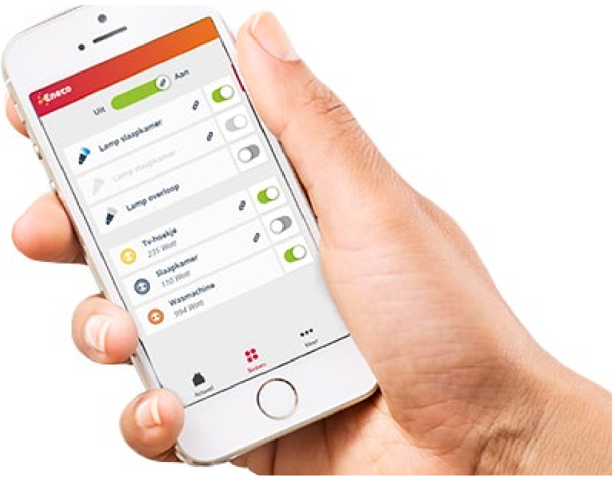


Illustration 10: The smartphone app for Toon. (image by Eneco)

Smart home on Toon

More recently Eneco proceeded with releasing smart home functionalities for Toon through software updates. With these updates, Toon is also becoming a smart home hub. Products that are currenclty integrated include the Philips Hue lights and the Fibaro smart plugs and smoke sensor. The Fibaro products are rebranded as ‘slimme stekkers’ and ‘slimme rookmelder’. The smart home products for Toon are displayed in illustration 9.

Additional services for Toon

Toon subscription

For most of Toon’s functionalities, the user needs to become a subscriber and pay a monthly fee. Subscribers have access to the Toon apps, giving them remote access to their Toon and the ability to see historical data. The costs of the subscription is €3,50 per month.

Zon op Toon

This is an expansion pack for Toon called ‘Zon op Toon’ (price: €99,-). It allows the user to connect Toon with their solar panels. Toon is then able to present data on the solar panels productivity on its display and in the apps. The ‘energy-harvest’ can be displayed in euro’s and kWh's. When a customer gets ‘Zon op Toon’ a special kWh-sensor is placed and their Toon gets a software upgrade to access these functions.

Toon App - Smartphone

The functionalities that Toon offers can also be accessed from the Toon app for smartphones. The user has the ability to adjust the temperature settings and view historical data. From the app the smart home functionalities can be accessed as well. The user can control the products that are connected with their Toon, such as Philips Hue lights and smart plugs. The Toon app can be seen in illustration 10.

Toon App - Tablet

The tablet app has more functionalities than the smartphone app. On top of the regular functions, the tablet app also has Toon coach, which is basically an interactive quiz about energy saving. The design of the app is optimized for the larger screen of a tablet, allowing a better presentation of the energy consumption charts.

Chapter 2.4

The users of Toon

Introduction

In order to gain a better overview of the current customers of Toon, the user base of Toon was analysed. The users were analysed based on their charesteristics and how they currently use and experience their Toon. The information about the user characteristics was obtained from a research conducted by Eneco [29]. This research took place when the first 50,000 Toon's were sold, therefore it contains information that might be slightly inaccurate as it is a bit outdated. To verify and re-update the obtained information an interview was held with a market analyst from Eneco [28]. Information on the current user experience was obtained through user experience researches, which are conducted every 2 months.
Some of the questions that were aimed to be answered with this research were:

- Who are the current customers and users of Toon?
- How do the users currently interact with the system?
- Are the users satisfied with the current product?

The customers of Toon typically...

have a ...

- household with children
- own house
- higher social class
- 1,5 - 2x modal income
- high energy consumption

don't have a..

- households without children
- rental-house
- apartment
- lower social class
- below modal income

Illustration 11: An infographic on the users of Toon

Contents

The further contents of this chapter is not included in the public version of this bachelor report due as it is to remain confidential. The original content, gave further details about how the customers of Toon currently interact with the product, and what product-features they like the most. The customer profile was also analyzed in this stage of the project.
Instead, an edited conclusion is presented to summarize the findings that can be included within the public version of the report.

Conclusion - Public version

Although the customers of Toon generally have a higher income, the relatively high product price for smart home products seems to be a barrier for purchasing additional products. This is something that should be kept in mind when it comes to generating the ideas and concepts: customers are not standing in line for just another expensive product. Just like the rest of the Dutch market, the users of Toon are interested in saving energy, and the biggest motivator is saving money. The functionalities that focus on energy saving are very popular, likely for this reason. Although Toon is initially a smart thermostat, perhaps it distinguishes itself with the energy management features for its users.

Chapter 2.5

Data and Hardware

Introduction

As a final chapter of the analysis phase, this chapter looks into certain technical aspects of Toon. The hardware inside the Toon and what kind of data Toon collects, were further researched. Based on findings mentioned in previous chapters, these were two aspects that had to be analyzed further before the ideation of the extension could start. The Hardware of Toon, specifically how products (and with that extensions) can be connected is essential to keep in consideration as it will put fixtures on what will be possible. Toon also collects a lot of data, this data could also provide interesting services to base new extensions on. Previously, this aspect was not given much attention in the report yet; this chapter will also include that information.

Sensors and data Toon

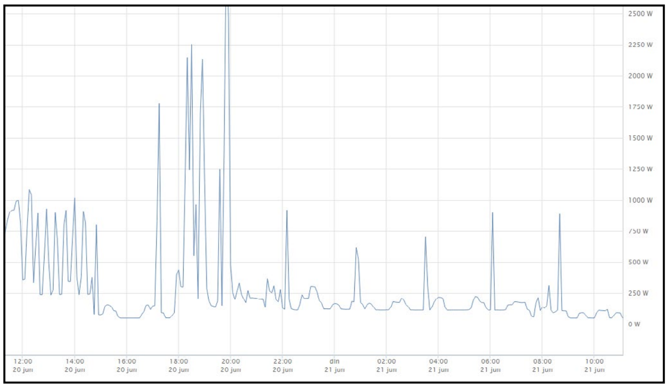
With all the sensors that are equipped into a Toon, it can gather a lot of data about its users, the energy consumption, and the house in general. During the project, a meeting was held with the testing manager for Toon at Eneco [33] to learn more about these topics. During this meeting information was obtained on what data Toon can register, at which frequency samples are taken and with what accuracy these data samples are recorded. And with that, how further down the road, this data is processed.

Toon has internal and external sensors. The internal sensors are located in the Toon itself; these sensors focus on measuring the temperature of the surrounding environment. Based on this information, the boiler gets adjusted. The external sensors are able to measure the electricity and gas consumption; these are placed in the electricity cupboard. Depending on the power meter present, the customer is given a suitable sensor. The data that these sensors gather is directly displayed on the display of Toon. Additionally to that, Toon is also compatible with the OpenTherm protocol [34]. If a boiler is equipped with this protocol, Toon can retrieve detailed information from the boiler on many fronts. Such as when the boiler is heating water, what the temperature of the water is, how much gas it uses, when the boiler is experiencing an error (and what kind of error) and so on. Every 5 minutes Toon sends the obtained data to a cloud where it is stored. When Toon needs to display historical data, this data is retrieved from the same cloud again. User settings and thermostat programs are also saved in this cloud but saved locally on the device itself as well.

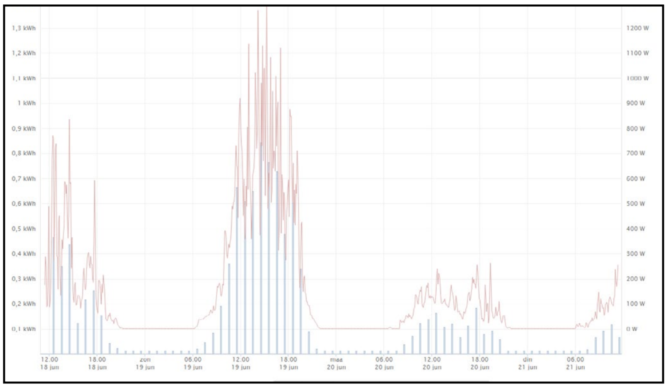
Cloud

The data that Toon gathers is saved in a cloud located at Quby, most of it is not stored locally on the Toon. The custom settings of the user regarding heating programs, are saved locally but are also shared with the cloud to connect them with the apps. When a Toon needs to display historical data, or needs to do more complex computational tasks, then the cloud takes care of that as well. This allows the Toon to complete these tasks much faster and overcome the hardware limitations. It also lets users control their thermostat over distance. Users are currently in control what of happens to their data: they can decide if Eneco has the

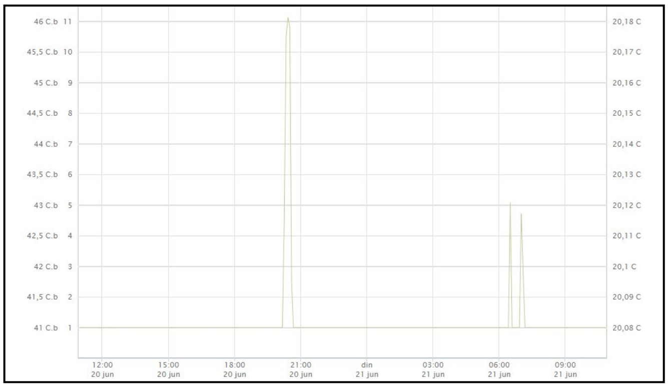
Electricity usage



Solar electricity flow



Gas usage



Room temperature

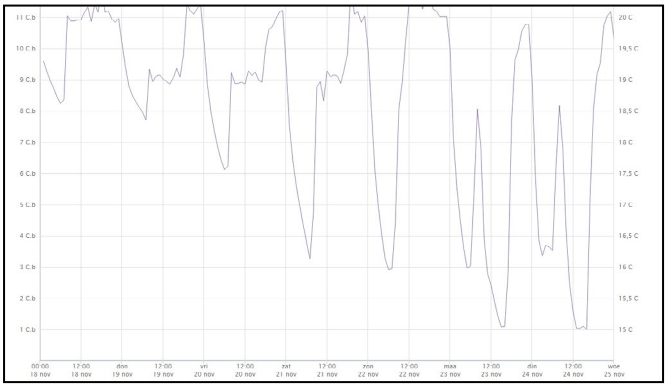


Illustration 12: An overview of various graphed datasets. The graphs that are displayed here contain information that is also displayed on the Toon in a different format.

right to analyze their data. If they agree with sharing their data, their data is not being sold to other parties; it is kept private. For Eneco, it is useful to have the data of their customers available for analysis. Based on customer data, new products and functions for Toon can be developed, and marketing campaigns can also be adjusted based on insights from customer data (to give a few possible applications).

However, many customers are currently not that keen on sharing their data with Eneco. For many users, their data is considered too private or valuable to share without gaining a benefit. Research has shown, that users have no objection on sharing data as long as they acquire a benefit from it [35]. Currently, they do not experience such benefit, which may explain why they prefer not to share data. This assumption was later on confirmed in an interview with a marketing expert at Eneco [36].

Hardware Toon

Should the extension become a physical product and reliant on being able to communicate with a Toon, the communication hardware is an important aspect to keep in mind. The distinction can be made between hardware-related extensions that are not physically connected to Toon (wirelessly connected) and extensions that are physically connected to Toon (connection by wire). Another meeting was held with a domain architect at Eneco [37], to verify certain assumptions on the hardware and learn more about this topic in general.

For wireless Toon expansions, it is important that the extension can communicate with its Toon. Therefore it is limited to the use of either Z-wave or Wi-Fi for local usage, as these are the types of communication hardware that Toon supports. The only exception applies when another piece of hardware could act as a translator, say a smartphone. In this case, BlueTooth could be used making extension mobile. As long as it is in the range of the smartphone, it can communicate with the Toon (given that the smartphone receives internet).
Underneath the Toon, there is a USB-port and an ethernet port that could be used to connect a product to Toon. In theory, the USB-port can be utilized as a power supply but also as a serial port for data exchange. The main advantage for designing an extension that is directly connected with the Toon, is that it could save a lot of hardware. Hardware components such as communication modules (Wi-Fi and Z-wave), the power supply and display are some of these examples. The drawback is that the system becomes also more limited, as building further upon the hardware comes with certain payloads. The dominant payloads would be the power supply (as the Toon doesn't receive a lot of current) and processing power within the Toon (mainly graphical-limitations: processing can be done in the cloud).

Conclusion

When comparing what Toon can register with all of its sensors, compared to products of the competitors, it appears that Toon can obtain more data: most smart thermostats only limit themselves to temperature and gas consumption, for example. This advantage can be used with the data-driven extensions: competitors can't copy them easily. With the data that Toon can collect, a lot of interesting features and services could be ideated in the next phase of the project.
For Eneco, it is important to have customers willing to share their data. However customers are currently not keen on this in general, as there is currently no actual benefit in sharing data. Research has shown however, that when users have a benefit in sharing data, they are way more willing to do so. This particularly, is an interesting insight to include in the design of the extension.
Besides having identified how Toon manages and process data, it was found how an extension could be connected to Toon. This is also valuable information for the next stage of the project, as technological constraints on 'what will be possible', and how the current system can be used, is essential. But it also identified the possibility to share hardware: this could lower the cost-price of the extension should it require hardware.

Part 2 - Analysis phase

Conclusion

During this stage of the project, research with a broad scope was conducted to learn as much as possible about Toon as a product, its users and smart home products in general. The research-papers and other sources of information that Eneco was able to provide, significantly accelerated this stage and provided information that is very useful for the rest of the project. By no means is this analysis, but given the time that was planned for it, a lot of interesting findings have been found.The current customers of Toon are happy with their Toon and they rate it with positive scores. However, they are dissatisfied with the subscription service due to the lack of bonus-features it offers.

A lot of interest is being expressed in the development of new features for Toon by its customers. For many of its users, Toon was not necessarily a decisive step towards a smart home. As Toon was initially distributed as a thermostat with energy managing capabilities, offered to customers combined with a utility-contract. Later on, the step towards a smart home platform was made with an update. Perhaps this is also the reason they might prefer to see cheaper smart home products to be released for Toon: they were given access to it but are hindered by the high price of smart home products. What can also be partly concluded from this, is that it is interesting to identify how smart home products could be made cheaper by connecting it with a Toon directly. This way, hardware can be saved and the product can be offered for a lower price. This is an interesting input for the next stage of the project.
As these are not typically the kind of consumers that stand in line for gadgets, it is important to offer an extension that adds unique value to them, as they are not likely to replace a product by default, besides that, it should also have an attractive price.

Based on the information on the current user base, it was possible to create detailed persona's, and with that, simplify how they use and interact with their Toon, and what kind of smart home products they would be interested in. These are not included in the public version of the report.
As has been identified, for most of the Dutch consumers (and the customers of Toon as well) saving energy is the main-motivator for being interested in smart home products. Besides energy saving features, smart home products that add comfort, safety or monitor health are also capturing a lot of interest from consumers.

When comparing Toon with its competitors, it is the complete package that makes Toon stand out. Due to all the sensors that are equipped with the system of Toon, a lot of valuable data is being gathered. Many customers are currently not that willing to share this data with Eneco by default, as there is no real benefit for them. This data might be a very interesting basis for new extensions, and will be further explored during the ideation phase amongst others: both Eneco and the customer could both benefit from a data based extension. If the data of customers could be used to help them save energy or any of the other functions they would like smart home products to have, it could become a very interesting combination for both parties.
On the whole, a lot of interesting perspectives have been identified that could be used as input for the ideation phase.

Part 3

Ideation phase

In this part of the report, the process behind the generation of ideas that would later be used in the concepts, will be presented. After having completed the analysis phase, various idea generation methods were applied to generate new ideas. The findings from the analysis phase were used as input for these methods. Some ideas already came into existence during the previous stage of the project. But in an attempt to keep the report easier and more pleasant to read, they were not brought into the picture yet.
To bring extra structure in the idea generation process itself, methods and tools such as TRIZ and disruptive images were used additionally. For both of these methods, the used techniques and outcomes are given.

The ideas presented will focus on the aspects of saving energy, adding safety and comfort, and the monitoring of health as product features. These features were found to be the most appealing to consumers during the analysis phase.
In this phase, a clear distinction was made between ideas that required new hardware to be realized, and ideas that did not. For many consumers, the smart home products are currently too expensive. For this reason, a focus was put on trying to generate ideas that can already be realized with the current Toon-hardware, so no new physical product has to be purchased. Though, the ideas were not limited to non-hardware ideas: if they required hardware to be realized, they were still considered valuable as long as they fit the requirements. In order to keep the hardware- and non-hardware requiring ideas separate they will be discussed in different parts.

During this stage of the project, new ideas were often discussed with various employees of Eneco. This was mainly done to find out more information on how realistic or interesting an idea might be for Toon. This offered the opportunity to gain already valuable feedback on the ideas in an early stage.

Since not every idea made it further than the sketchbook, and in order to keep this stage of the project related to the content further on in the report, not every idea will be discussed in detail: only the ideas that were relevant in the long run are presented. All the ideas that were excluded in this part can be found in appendix 3. The selection criteria used to select the ideas are given in appendix 4.

Chapter 3.1

Extensions that don't need hardware

This segment of the ideation phase focusses on ideas that don't require additional hardware to be realized. Comparatively, all the ideas focus on adding functionalities to Toon making use of (big-)data. The problem-solving methodology TRIZ was applied to come up with new ideas and will be discussed in this segment. Not all the ideas shown came into existence with the aid of TRIZ, however, some originated while using TRIZ simultaneously.

Using TRIZ

In this chapter, several TRIZ tools will be used for idea generation. TRIZ is a Russian acronym for 'teoriya resheniya izobretatelskikh zadach' which can be translated to 'theory of inventive problem solving'. The content of this chapter contains TRIZ-jargon and concepts. To make it more readable for those that are not familiar with the method, short explanations were added where possible. However, sometimes theory is presented as it is, and will not be explained further (this was done to downscale the size of this chapter).
(More information on TRIZ can be found in [38])

How TRIZ will be used

When using TRIZ, the system and its problems (contradictions) are being abstracted. For the abstracted system an abstract-solution is found which is then objectified into a 'real-world'-solution. This process is illustrated in illustration 13. Approaching a problem like this, aims to combats mental inertia and stimulates a systematic ideation process.

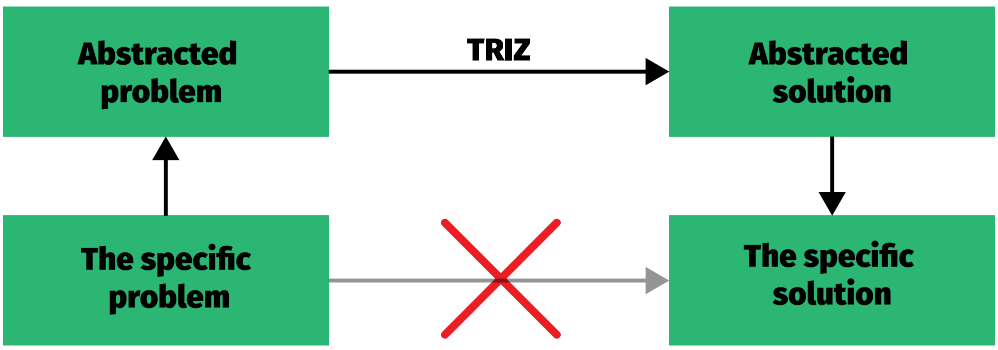


Illustration 13: How TRIZ is different compared to normal problem solving. Instead of jumping to a solution straight away through trial and error, the problem is solved using TRIZ's methods.

Following the TRIZ-mindset and its trends of technology evolution, the trend of system convolution can be applied to Toon. These trends predict how a product or technology can be optimized further by giving guidelines. The trend of system convolution was used in this approach. This trend describes how a system reduces the total amount of components, but will maintain its functionality regardless. To gain more ideas out of this process, it was decided to fictively 'add' sensor-modules from brands like SmartThings and Fibaro (see market research), as if they were connected to Toon. By increasing the amount of function in the system, more options for reducing the amount of components would arise.

Functional analysis

Before TRIZ can be applied, the system has to be modeled into an overview of the complete system. This is done in a so-called FA-model (functional analysis - model), it maps how functions are distributed within a product, its users, and its surrounding. Based on the FA-model, relations between system parts will be identified. Within this model, Toon and all the added modules, including their surrounding and users, were taken into account. Simplifications were made by combining small components of the system into a 'batch'-category. By these simplifications, the model remains comprehensive and useful for further analysis. The FA-model is displayed in illustration 14. Based on this FA-model, a TRIZ-tool called trimming will be applied.

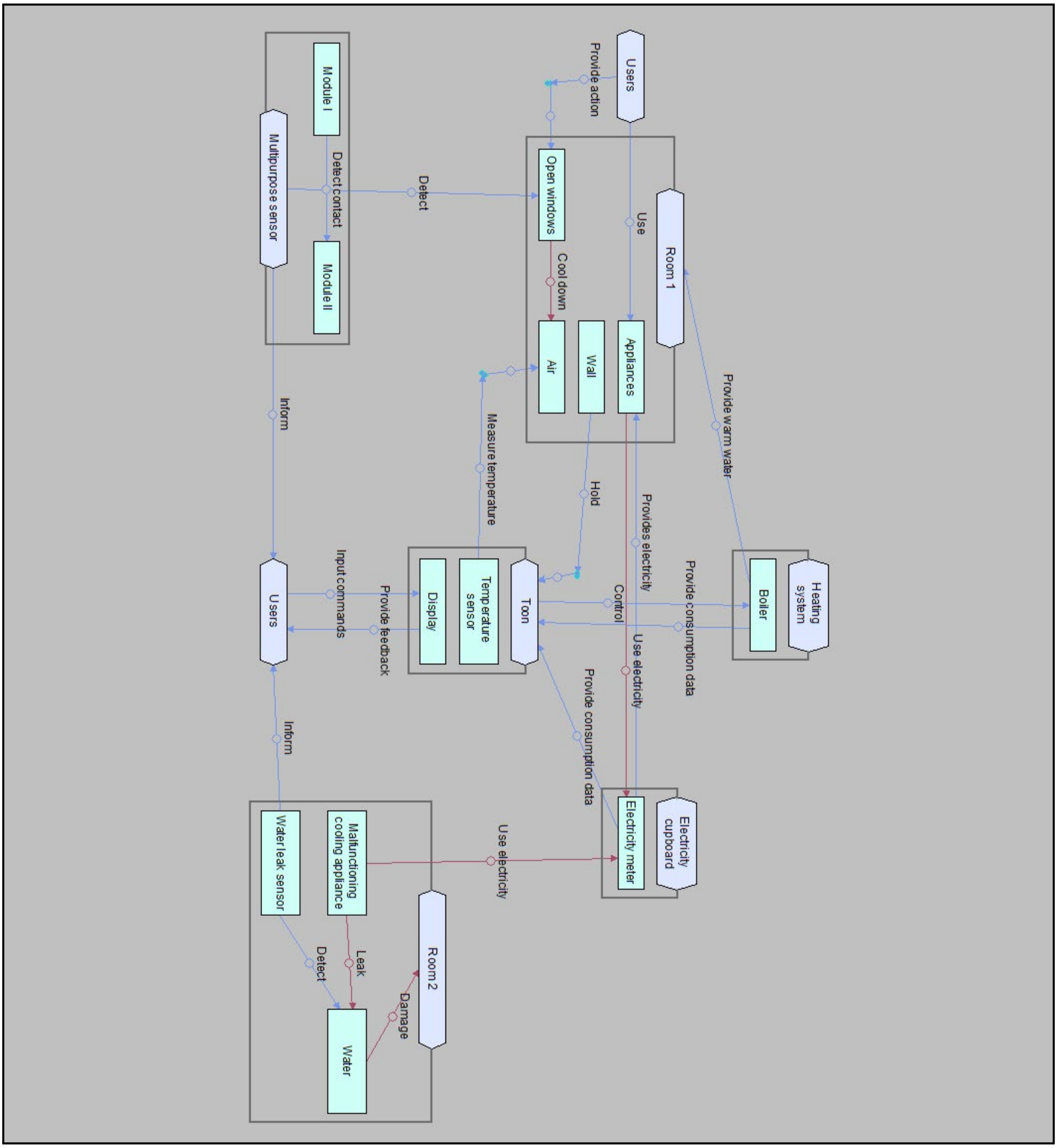


Illustration 14: The FA-model, including Toon and the added sensor modules

What is trimming?

The goal of the trimming tool is optimizing a system's degree of ideality by identifying and removing 'excess' objects within a system. However, the purpose of this plan is not to eliminate the functionalities themselves. Instead, it aims to add new useful features to the system through trimming. This process is in line with the trend of system convolution.
The underlying thought process behind this approach is that the sensors equipped within the 'Toon-system' can be used to trim away the 'excess' hardware, without a loss of functionality. The functions Toon will adopt will result in ideas that can be utilized for new Toon extensions. This trimming strategy is based on the following scenario: an object can be trimmed if its function can be delivered by an object which inherits a function. In this scenario, Toon (as a system) is the object that receives a new function, making the original function carrier (the fictively added sensor-module) obsolete.

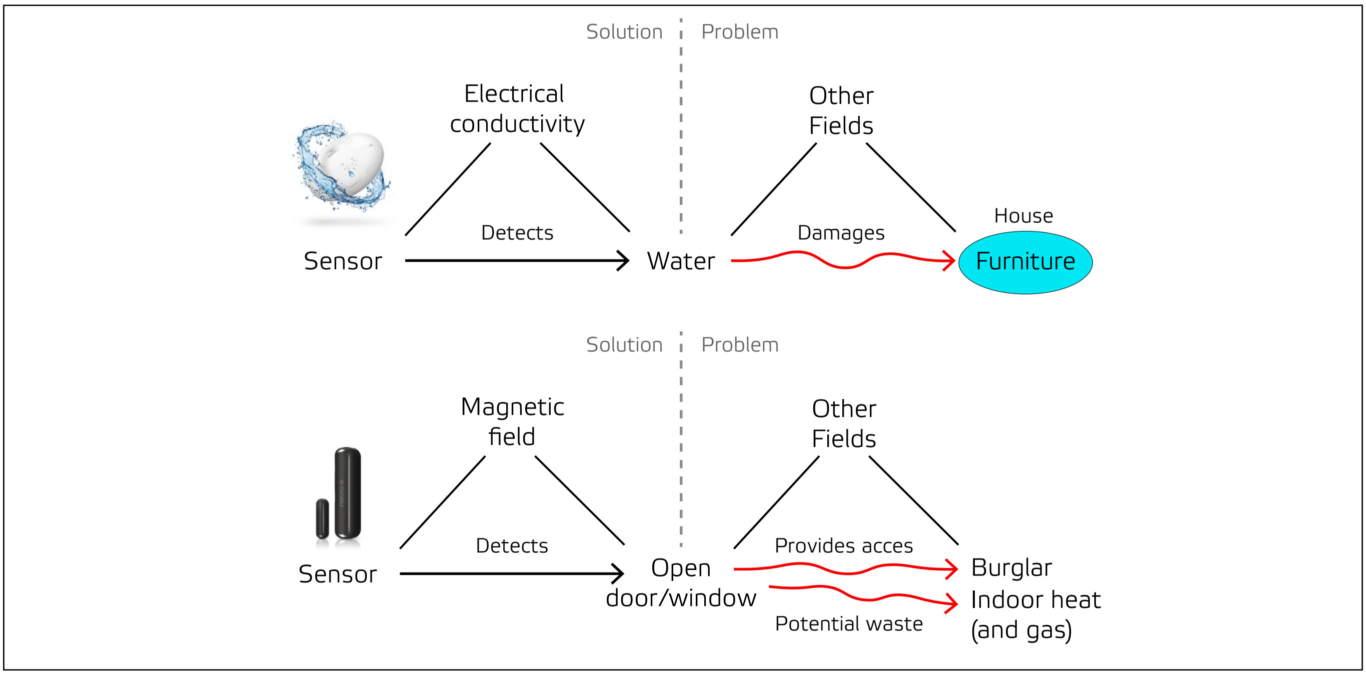


Illustration 15: SU-fields based on the FA-model. The SU-fields model a function in the physical domain, displaying what physical field is being controlled or measured.

Using the inventive standards

To aid the ideation process, TRIZ provides shortcuts to achieve goals such as trimming, these shortcuts are called inventive standards. Since the goal is to trim away the excess hardware subsystems, the inventive standards are prescribed by TRIZ. As this condition doesn't allow for new components to be introduced to the system, the inventive standards from class 2 (evolution of systems) can be used.
These inventive standards, the shortcuts, prescribes the following: From a su-field (substance-field - which is a model of a system in the domain of physics.) perspective, this can be achieved through either inventive standard 2-1-1; the introduction of a new component (also called a subsystem in TRIZ), or as inventive standard 2-1-2 prescribes; the introduction of a new physical property (known as a field in TRIZ). These standards state that the efficiency of a SU-field system can be improved by transforming one of the parts of a SU-field into an independently controllable SU-field, thus forming a chain SU-field. What this means, is that by physical properties, that can be controlled or measured, an action can be fulfilled in such way, that a component can be removed from the system (without the loss of functionality)

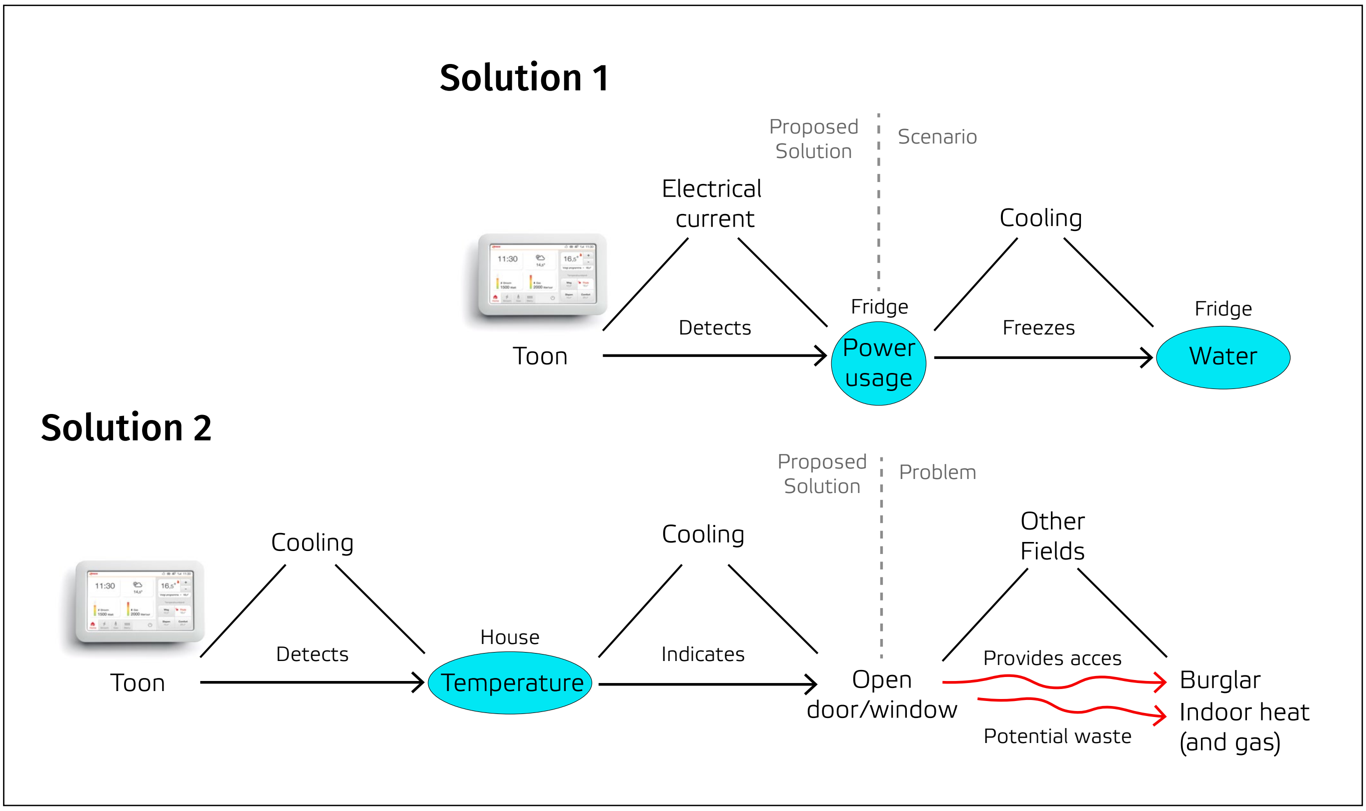


Illustration 16: SU-fields showing the proposed solutions. The fields are based on the shortcut presented in the given inventive standard

Found solution

Through Su-Field modeling, new possible solutions were identified for preventing water damage from a broken fridge or freezer, and it was identified how Toon could detect an open window or door. For both solutions, the subsystem (the components) and field (physical property) were changed. In both cases, logically, Toon became the newly introduced subsystem; the component that fulfills the action (inventive standard 2-1-1). The new physical property that is measured is different for both solutions, the fridge-solution uses electrical current (previously: conductivity), and the open window/door uses temperature (previously: magnetic field). The new SU-fields can be seen in illustration 16.

By translating the abstract solution back to an objectified solution (illustration 13), it was found that the sensors equipped in the Toon could be able to adopt some of the functionalities of the overcomplete system. For the door and window sensors, the equipped temperature sensor and information received through OpenTherm (a communication protocol used by Toon and the heating system) could indicate if a window or door is left open. And the functionalities of the water leak sensors can be copied through analyzing the power consumption behavior of the cooling devices.
This function adoption comes with its limitations: the big advantage, that the sensors modules from competitors have, is that they are mobile and not limited to a particular usage scenario. However, they are too expensive for most consumers, as was discussed in the analysis phase. Both of the solutions would solve that problem, as no new hardware is needed to realize these solutions.

Other ideas for using data

As was shown in the TRIZ analysis, data collected by the Toon can be used for new extensions. Two possible appliances were identified based on the functionalities of other smart home products. The same data that is used there can also be used for other functionalities. These ideas were not necessarily relevant to the TRIZ process.

Standby usage

One of the things that came forth from the analysis phase, is that people struggle with keeping track of their standby electricity consumption. They express that they are not aware how much electricity they use and forget to turn their appliances off. Children also have an impact on this. They are not paying for the electricity bills and therefore often have no real motivation (except when being disciplined) to turn the lights and appliances they were using off when they leave the home. This adds even more up to the electricity bill. For parents, it is hard to keep track of this.
A possible solution to help users to gain insight into this would be through an extension that gives insight into energy consumption when they are not at home or asleep. By analyzing the energy consumption data, the user could be notified that they consume a lot of electricity while sleeping or being away from home. Another solution would be to help the user reduce their standby electricity usage through an app that motivates them to reduce the amount of kWh consumed. The possibility to save energy would be the motivator, as this is the most used argument for buying smart home products. Saving money is appeared to be the main reason for this motivation. Toon currently has a similar function on the tablet app, but like the Toon coach functionality, its not very popular. Users have to track their progress for themselves, and due to its limited availability to the tablet app, it is not available to every customer.

Energy efficiency of cooling appliances

Previously, it was found that the energy consumption behavior of a cooling appliance could predict if it has stopped functioning. However, more information can be collected on the status of the product based on the power consumption behavior. Ice formation within a cooling appliance is something that regularly occurs in regular freezers (the exception is freezers with an anti-frost function). This negatively impacts the energy efficiency of a fridge, which in turn can be measured. The typical peaks, these appliances produce, on the kWh-chart will occur more frequently or will last longer (combination of both would also be possible). Depending on the severity of the ice formation, it can double the energy consumption of a cooling appliance [39]. As cooling appliances are using the most electricity within a household per year [40], it is valuable for the user to keep them efficient. By presenting how the energy efficiency of a cooling appliance drops over time (due to icing), the user can be nudged towards unfreezing it. The result can then be displayed concerning how much money is being saved, giving the user a feeling of accomplishment.

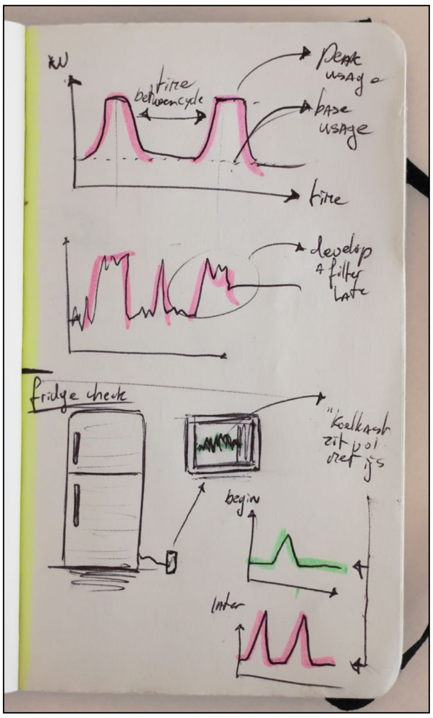


Illustration 17: A photo of a page in a sketchbook showing an ideation-sketch what data could be used.

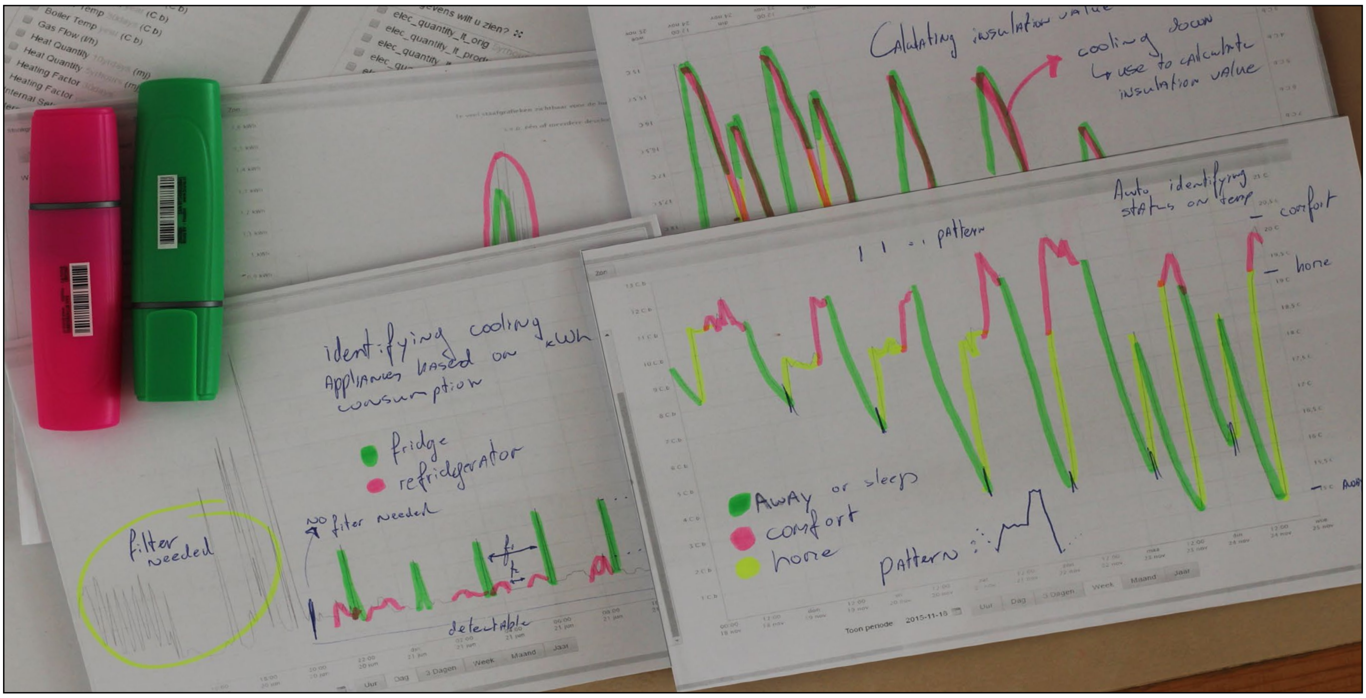


Illustration 18: Various printed graphs of data collected by a Toon, these graphs were used during the ideation process. To identify patterns in user-data, these patterns have been marked.

Insulation values of a house

In a previous example, the idea of analyzing temperature drops, within the house, to predict if a window was left open, was demonstrated. This feature is interesting from a home-safety perspective. But with some adjustments, the idea can also be used for energy efficiency.
The same principle can be used to determine the insulating value of a house. By analyzing how a house cools down and heats up, information about the insulating capabilities can be obtained from the data. This can be used to give insight into the efficiency of their house, and adjust the thermostat program to a more energy saving program. Additionally, it can also be used to predict how improving the isolation values, like through adding cavity wall insulation, can reduce the costs of gas made each year. This could show the user the value of making their home more isolated, but also could help them to predict the return of investment. In the current situation, people have to consult tables with generalized examples to predict how much they will save: this idea aims to offer a way more detailed and accurate advice.

Further usage

As the previously presented ideas are data-driven, they don't require new hardware.
All the necessary data can be measured with the sensors that are already onboard on the current system. This makes the idea suitable for a software extension that could be released as a software update. Making them basically a free functionality, if not to be exclusive for subscribers, to the users of Toon.
The usage of data in benefit of the Toon-user is also attractive for Eneco. Users have their doubts about sharing their data with Eneco, as currently, it is not beneficial for them. This is something that Eneco would like to improve; realizing functions that demonstrate the user value in sharing their data could help to increase the willingness to share data, and make both parties benefit from this trade.

Chapter 3.2

Expanding on Toon's hardware

In the previous part, the focus was put on ideas that could be realized without the need for additional hardware. However, it is still relevant to ideate what would be possible without this constraint: this part contains the ideas that do require new hardware to fulfill its function. In the analysis phase, it was identified how Toons's hardware can be used to reduce the amount of required hardware, and how an extension can communicate and connect with Toon. These findings will be applied to the ideas presented in this part.

Disruptive images

Another method to generate new ideas, as was done previously with TRIZ, is through disruptive imaging [41]. At the core of the approach, it aims to stimulate the generation of creative design ideas. Disruptive images in itself is an informal technique for developing and presenting ideas in the early stage of the design process. The technique is based on design visions that are envisioned in the form of images. The use of images makes cross-discipline communication easier. Especially due to the higher level of abstraction, in which verbal descriptions of ideas could cause confusion or misunderstanding. Therefore the method can be used to communicate and discuss ideas.

Before starting to use this method, the design brief should be expressed in such a way that it allows for a creative interpretation: "Design a new extension for Toon" is not a very useful briefing for this method, since it already creates certain constraints. Instead its restated in such way that it allows for a more imaginative approach that could lead to more creative solutions. So for this method, The briefing was changed to "Design a new way for controlling a house to..." in which the final part would be completed with one of the key functionalities from the analysis: saving energy, adding comfort or safety and monitoring health. Which makes it for example; "Design a new way to control the house to add comfort".

Findings

One of the designs that came forth from this method, is a product that turns off all the appliances within a household with the press of a button. Smart plugs can do the same, but only for one device instead. The optimal place (from a system perspective) for this product would be in the electricity cupboard. As this is the place in a house where all power cables come together, it is an ideal location to turn of larger quantities of appliances at the same time. The product would be very useful to reduce the standby energy consumption by small and major appliances within a household: with the press of a button, all electricity towards these devices would be cut off. The shortcoming of this system was that it can only control the entire electricity-group within the cupboard, making unsuitable for individual control of appliances (like smart plugs do). By using Wi-Fi, it could be connected to Toon. Since it will be installed inside the electricity cupboard, Wi-Fi will give a better connection than Z-wave does. When the user leaves the house or goes to sleep, the product will prevent the flow of electricity towards the appliances. This will allow the user to save money: even when the devices are turned off, most of them will still consume power.

Illustration 19: Some of the disruptive images that were created. These images focus on how energy can be saved by controlling the house with an on/off button which will turn all of the appliances off

Besides saving money, it also adds comfort: it would no longer be required to do a 'checking round' through the house before leaving or going to sleep to check if all appliances are turned off.

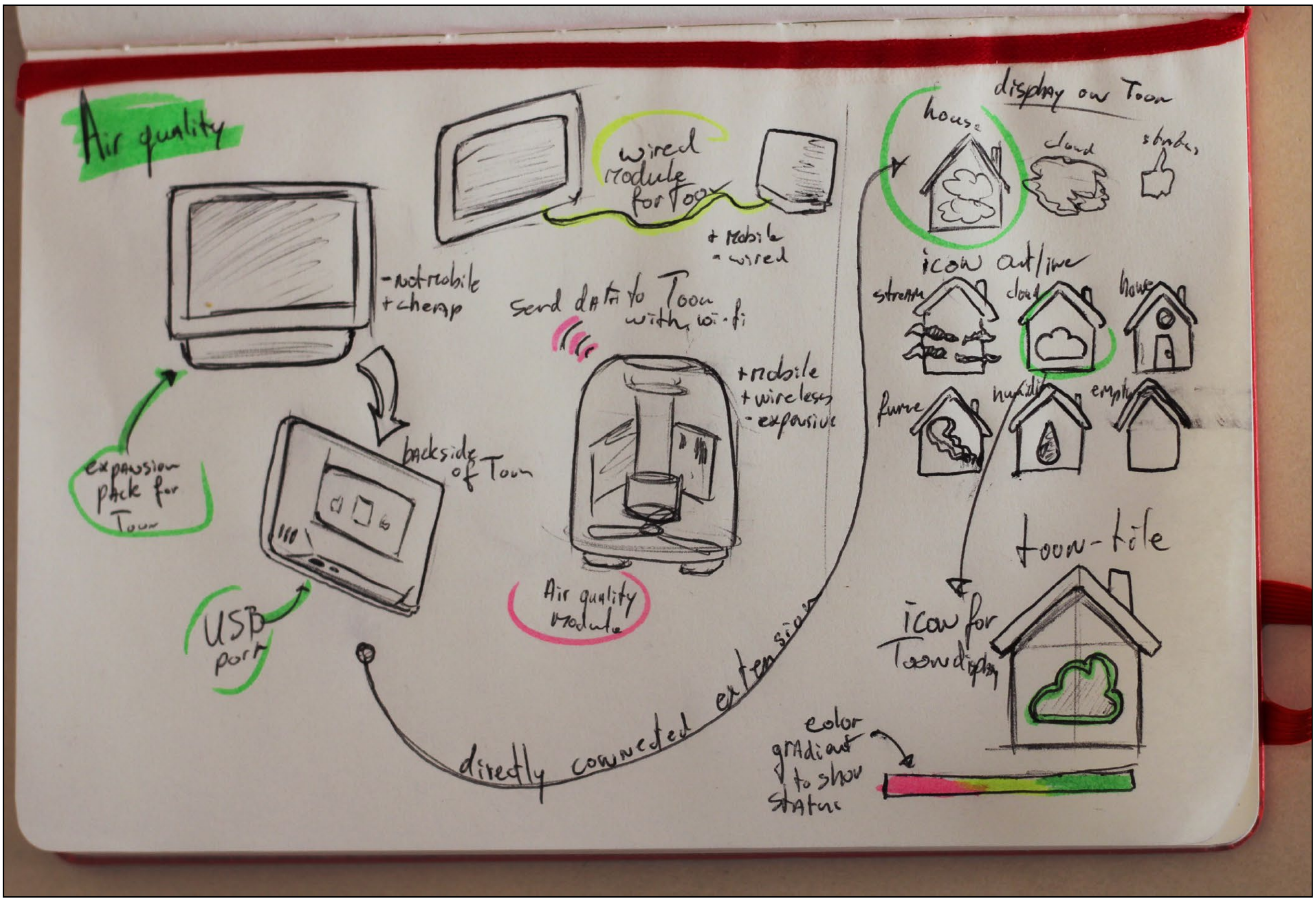


Illustration 20: Various sketches on how Toon could be used as an air quality monitor by expanding upon the original hardware, or by pairing it with a wireless sensor module.

Toon as an air quality monitor

An idea that came to be during the analysis phase, was to expand the Toon with the capabilities to become an air quality monitor. As was found, during the same phase, people are very interested in an air quality monitor for their home, yet they experience that the current products on the market are too expensive. By adding air quality sensors to Toon, a relatively cheap air quality monitor could be realized. Only a few sensors have to be included in the product for it to work as an air quality monitor. Most of the required hardware to make use of these sensors is already present in the Toon. By connecting these sensors to Toon, a cheaper air quality monitor could be realized than what is currently on the market. Some applications of the sensors would be to identify when the air becomes too dusty, has high CO2 level, becomes too humid or dry and contains other organic pollutions. Once identified, Toon could tell the user what to do to bring these levels back to a healthy level, and give insight in how the users' lifestyle impacts the air quality in their home. In illustration 20 one of the sketches focussing on this idea is displayed.

The data, from the air quality monitoring, could also be used to save money: it can aid in making the heating program within the house more efficient. By keeping factors such as air humidity in mind, the heating program can be adjusted by the Toon. The humidity is one of the factors that has a lot of influence on temperature perception in a room, but also the rooms capabilities to increase in temperature [42]. It could also warn users when their house is too humid and warm, and should be vented. Bad ventilation can lead to the generation of mold inside the house. As homes become better isolated, they ventilate air less well, and this has increased the development of mold in houses [43].

Part 4

Conceptualisation phase

After the ideation phase, the ideas that were most promising, were selected to be developed into concepts. As was stated in the introduction of the ideation phase, the ideas that were chosen were the ones that have been displayed in the ideation phase. Some of these ideas were combined into one concept. However, this was mainly done with the ideas that are based on using data.

These ideas were selected based on the findings from the analysis phase, and their current relevance for Eneco, this was determined by discussing the ideas with employees of Eneco. Another criterium was that an idea should not already be in development by Eneco.
A lot of Eneco's employees are involved in creating new functionalities for Toon, typically spread amongst various departments. Because of this and the 'closed culture' of many of the ongoing developments due to confidentiality, it was hard to gain an oversight of what Eneco was already developing early on in the project. For this reason, it happened various times that an idea formulated in the analysis, or ideation, phase was already under construction. To keep this project more relevant and compelling: ideas that were already being developed, or were no longer considered relevant /useful due to upcoming developments, were not considered to be taken to the next step as well. A list of the requirements can be found in appendix 4.

The goal of the conceptualization phase was to create concepts that could be presented to Eneco. The concepts were presented during an oral presentation making use of lean-canvasses: so besides a 'visual' concept, a possible business model was also imagined. The lean categories on the canvas were used as a framework for concept development. The goal of this presentation was to gain feedback on the concepts and support in making a choice on which concept to develop further in the upcoming phase of the project.

Smart energy saving

In many households, a lot of energy is being wasted simply because people are not aware of their behavior, or because they don't realize its being wasted in the first place. The data that Toon collects could not only help to inform users about this, but also with its prevention. This concept consists of some ideas that could help the users of Toon, based on their data. Functionalities that have been released in the past tried to do something similar, but were not successful. These tools were generalized tips for users to apply, but were often of low relevance towards most users. However, by using the data of the user, these functionalities can be way more personal and helpful for the user. The concept aims to fulfill the wish of current Toon consumers: more functionalities on Toon that don't require, often expensive, hardware.

When a Toon registers an unexpected faster decline in temperature, it can be used to determine if a room or window has been left open. This functionality can be used from two different perspectives: saving energy and home security. When people forget to close a window when leaving the house, it becomes an easy target for burglars. At the same time, heat is also being wasted: the heating system has to use more energy to keep the room at the configured setpoint. The user could be warned and prompted to take action.
It can also be used to determine how efficient the house is with regards to its isolation: this functionality is used in another concept later in the chapter.

By analyzing the repetitive peeks in the electricity consumption, cooling appliances can be identified. Due to its frequency, strange 'behavior' can be detected. When a cooling appliance stops functioning properly, and wont cool anymore, the ice inside will start to melt. The owner can be warned before the ice starts to melt and possible water damage occurs.
The formation of ice inside a fridge can also be tracked over time: cooling appliances can use up to two times more power due to the ice inside them. This way the user can keep track of this, and get more motivation to defrost the fridge. The improvement that this action brings can also be logged.

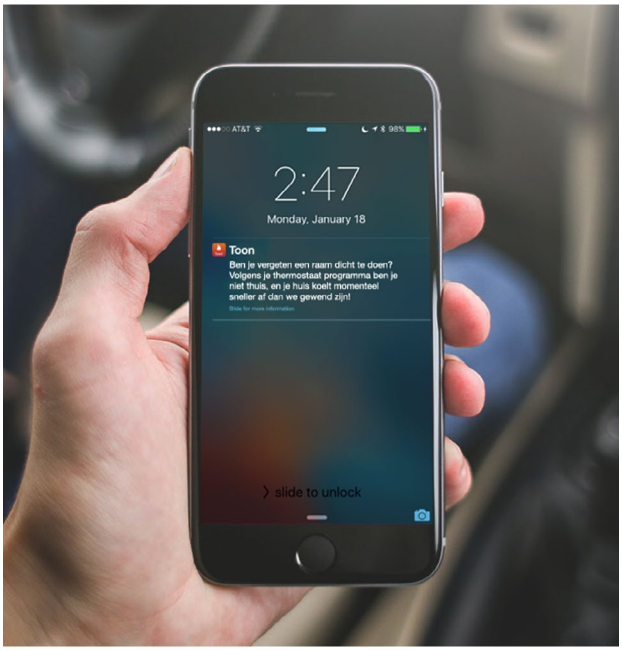


Illustration 21: images that were used to visualise the concept during the pitches at Eneco

Air quality monitor

The curiosity towards the air quality in our homes and the products that give customers insight into this, are quite a trending topic for a while already. Right now, many consumers express interest in purchasing an air quality monitoring device. The price tag, is keeping them back: as was shown earlier, many air quality monitors on the market are too expensive to be adopted on a big scale.
This concept aims to create an affordable air quality monitor. Most of the currently available air quality monitors are too expensive, or when affordable, do not live up to the customer wishes due to a more limited amount of functions. To realize this goal the concept will expand upon the hardware already equipped in the Toon. By doing so, a lot of hardware components can be saved compared to a 'stand alone' product, which can lead to a lower shelf price. The concept can be illustrated as an expansion pack that can be mounted underneath the Toon. It will receive its electrical power from the Toon and send its data directly to the Toon using the USB-port.

Like Toon gave its users insight into their energy consumption, this extension aims to give insight on the air quality in their home. It will show the user how well quality of their air is, and warn them if they need to take action. Also, the effect of air polluting activities can be monitored and acted upon. By using various sensors, the concept will be able to distinct different types of pollution, and in turn tell the user what to do in order to reduce the pollutants concentration within the air. This information will be displayed on the Toon and in the Toon-apps. A tile on the home-screen will picture the general status of the air, by opening the applet a more detailed overview will be shown.
Other than being beneficial to the health of the user, monitoring the air will also be useful for the indoor heating system and its efficiency. Factors such as the air humidity affect how we perceive temperature and how much heat capacity the air itself has. By taking these variables into consideration, Toon will be able to manage the heating system better, from both a comfort and efficiency perspective.

Illustration 22: Illustrations used to present how the concept is connected and how information is displayed on Toon.

Energy consulting

Typically energy is spent due to 2 main factors: the efficiency of the house itself, and the behavior and needs of its users towards energy consumption. Toon can show its users how their energy use affects their utility bill. For many of its users, Toon helped enabled them with saving up to 10% on their annual utility bill. But these savings were achieved by giving people insight into their energy consumption behavior. But what if we could show them how their house is affecting their energy bill? And with that, identify if home insulation would be a sound investment for an user to make.

Generally speaking, investing in a better-insulated home is a sustainable investment that gives a higher interest than most banks and funds do. However, this process comes with uncertainty as the return of investment is being generalized: there is no definite answer available on how much will be saved through such measures exactly. And besides that, there are other barriers hindering people in the decision to insulate their home further: the topic of ‘saving energy’ is not exciting for the majority of individuals. After a long day of work (or when taking rest during the weekend), they don’t want to devote time to a topic such as this.

This concept aims to aid users in showing with what measures they will save the most energy and money. When the data, that Toon can gather, would be combined with data from other data sources, a detailed advice can be given on what could be the best strategy to reduce energy consumption. This advice contains information about the house itself, but also how the consumption behavior impacts the utility bill.

The advice on how to save energy most effectively can be tailored towards the user. People with an energy saving habits gain more from investing in better isolation measures than users who do not: If you don't live with an energy saving mindset — having the windows open while heating — would cavity wall insulation really be that effective for the house?

Illustration 22: images that were used to visualise the concept during the pitches at Eneco.

Standby usage

Even when turned off, many devices keep using electrical power in their standby mode. This so-called standby energy consumption is a waste of energy in most of the cases, but still, makes up a significant part of the total electricity consumption of an average household.
On top of the standby power consumption, some people also tend to forget to turn off their appliances from time to time: this is more often experienced in families with younger children, as their children forget, or don't care, to turn off devices.
This concept aims to reduce the money spent on standby power consumption by locally managing the electrical output of the fuse box, which enables to turn off the electricity, when possible, completely. Either when there is no one awake, or no one at home, energy can be saved with this product. The product can be connected to Toon is such a way, that when the users change the heating settings to ‘away' or ‘sleep', it will be activated (or after a few minutes of delay), and deactivated when the users set Toon to ‘home' or ‘comfort' modes.

As every fuse box has a different layout and composition, the concept is designed with modularity in mind: it can be adjusted to the specific situation of the user. And besides that, some power groups should not be ‘turned off' at all, and therefore will not need to be managed by this product. Cooling appliances and alarm systems should still get electricity even when the user is asleep or away.
The product consists of two different units, a master and a slave unit. The master unit controls the slave unit and contains the communication hardware to connect with Toon. When triggered by the master unit, the slave unit is able to block the electricity flow like a relais. Only one master unit will be needed per fusebox, the amount of slave units will depend on the number of fuses that need to be controlled.

Besides saving electricity, the product will also add comfort and safety. No longer will the user have to check if all the lights are turned off before leaving the house or going to sleep. And when the user is away for a longer period, the product could also be used to fake their presence, by switching lights on and off during a holiday, to fend off burglars.

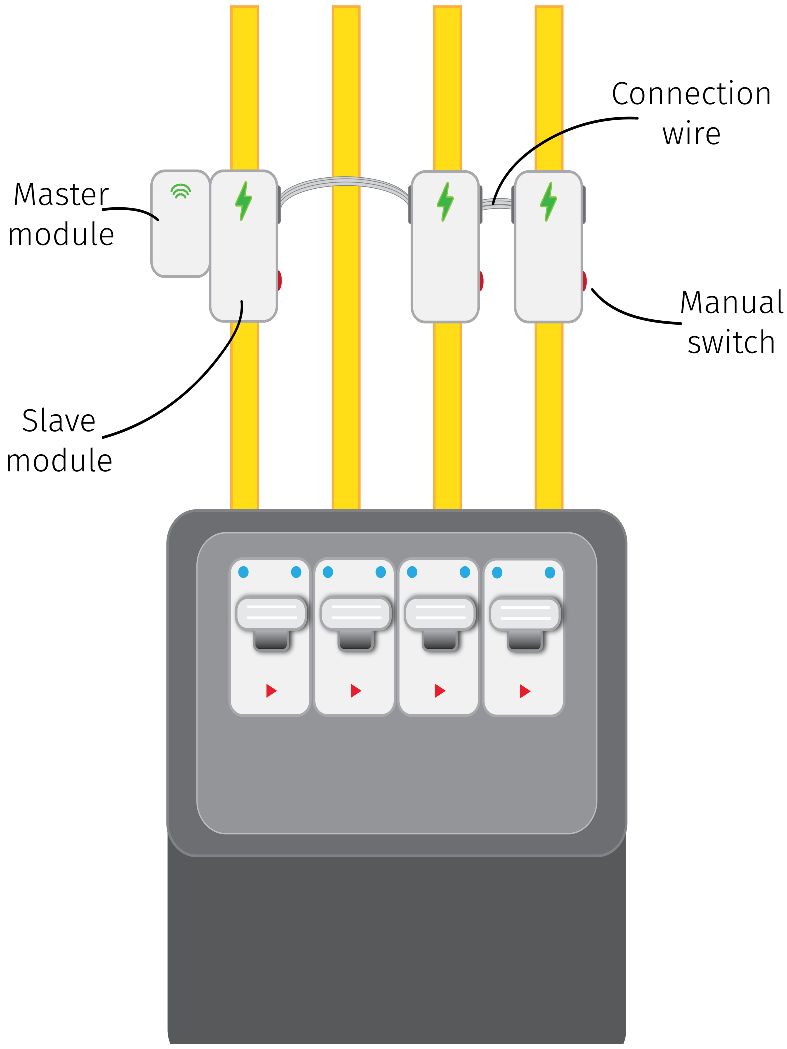


Illustration 23: how the master and slave units would be placed on the power groups.

Part 4

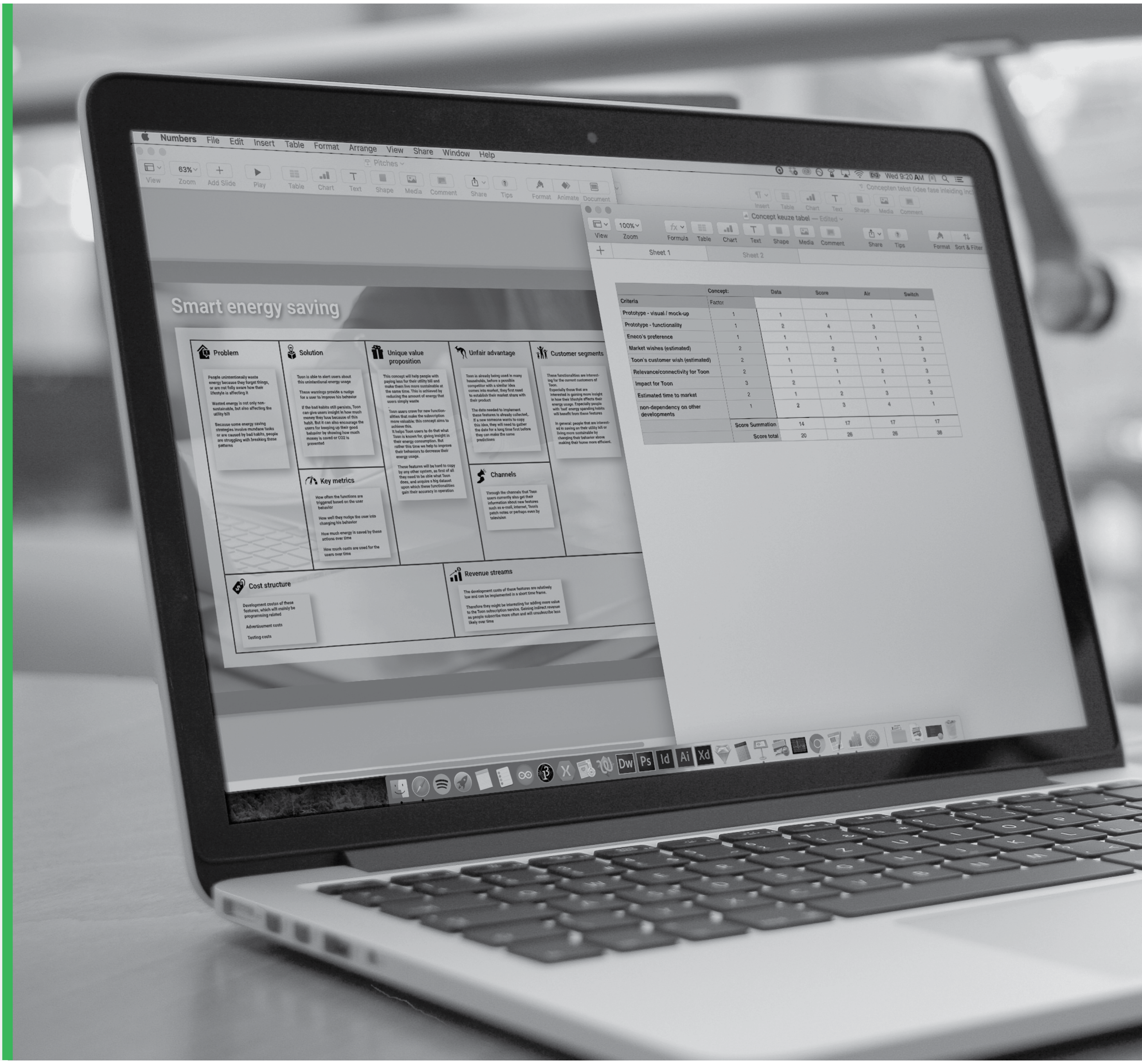
Selecting the concept

Presenting the concepts

Once the concepts were formed, they were presented to both Eneco and Quby. This was done in separate sessions: multiple presentation sessions took place at Eneco, and one presentation was held at Quby (appendix 8 contains some of the used presentation sheets). The concepts were received with enthusiasms: both the data-driven concepts and the air quality monitor were best received. As was already discussed in the analysis: the ideas that make use of the data can be very beneficial for both Eneco and their customers. Though, the air quality monitor would be a positive boost for Toon as well, as it offers a new perspective on what the product could be used for.
Initially, the presentation was supposed to be the milestone in the project where a concept would get selected for further development. However, Eneco and Quby were not decisive on which one should be developed: all four of them had potential according to them, and preferably should be taken onwards to the next stage. As much as this was a compliment, it was not possible due to the scope of the project. For this reason, the concept that would be developed further would be selected through a more rational approach.

Selecting the concept

As the four concepts are inherently different, it was not useful to make a direct score-ranking based on a comparison. The concepts were initially ranked on more global criteria, to give a few examples: what concept would have the shortest time to market? Which concept would have the biggest impact for Toon? Which concept would require the least amount of resources to be developed into a product?
For each criterion a score was given between 1 and 4, to make some criteria more important than others weighing factors for each criterion were taken into account as well. In the end, the scores were not decisively enough to make the selection based on this method: The difference in scores was too low between 3 remaining concepts. At this point, a lot of time was spent into selecting a concept without a result.
Therefore a more drastic approach was taken: the concept that could have the most impact for Toon, as soon as possible, would be selected. Based on this criterion, the energy saving and data-driven concept I was chosen for further development.


Smart energy saving
Problem
Solution
Unique value proposition
Unfair advantage
Customer segments
Key metrics
Channels
Cost structure
Revenue streams

Part 5

Prototyping

In accordance with the goals set at the start of the project, the selected concept would be developed towards the level of a Minimal Viable Product (MVP). On the other hand, the time required to fully advance this particular concept towards this level, would go out of scope for this project. Accordingly, the desired level of development was adjusted

The MVP — which would be a complete application — was split up into a ‘front end’ and ‘back end’ part. Both of these parts would be aimed to be completed.
The front end and back end were developed in unison. In short, both the user interface, the front end, and some of the code, the back end, would be worked on for the rest of the project. The user interface for each feature would be matured to a high level of fidelity. The overview of how it would be included in the current product would also be taken into consideration. The back end would be realized in the form of a console application, it would demonstrate the validity of the concept on a functional level. For both parts, it would be done is such a way, that the outcome would be directly useful for the actual MVP, should it be completed afterwards.

This part of the report documents how the concept, which was chosen in the previous part, would be further developed.

Changes that were made to the concept
Before the building towards an MVP started, a slight pivot was made to the concept to be developed. The emphasis of the functionality of each feature would be put on the theme of saving energy. Within the presented concepts regarding data, some were leaning towards functionalities to improve home security as well. The reason for this pivot, is that based on the findings within the analysis phase and interviews with marketeers at Eneco [44], functionalities regarding this theme were more likely to be of interest to the user. Because of this, it was decided to focus on these product-functions instead within the MVP. In short, the MVP would focus on saving energy, and with that money, instead of adding safety related features to Toon.

The minimal viable product and its goal

Since there are various definitions of MVP’s being maintained, within this project, the definition is as such:
An ideal MVP is the smallest solution that can be build, but also captures customer value. Once created, it can be tested with real customers to validate customer interest into a product. Based on the feedback, the solution can be iterated further upon. The main difference with a MVP and a regular prototype is that a prototype only focusses on one aspect such as functionality, while an MVP aims to deliver an early stage product. That being said, they are also used by Eneco to build and test new features. In the end, the goal of the MVP will be to add value to Toon for its customers, and also test if it increases the customers' acceptance to sharing data with Eneco.

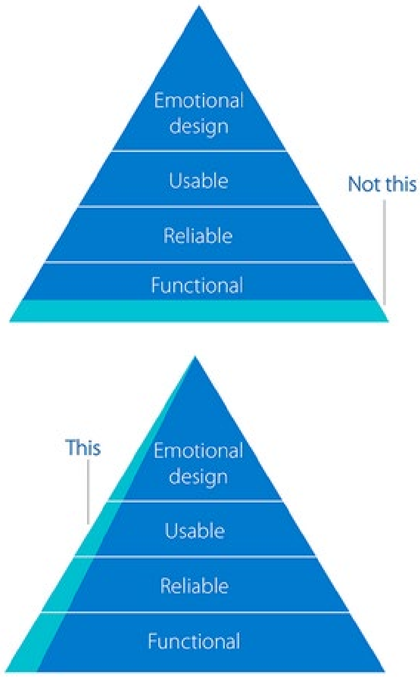


Illustration 24: the difference between a prototype and a MVP [45]

For whom will the MVP be developed?

For testing MVP’s, Eneco makes use of a group of product testers. Depending on the feature and state of release, it's tested by employees first and later by a group of selected field-testers (“vrienden van Toon”). Although they are more interested in technology and Toon than the average consumer, they are still considered representable for the actual Toon user-base. They are interested in new technology and generally accept the shortcomings that come with technology that is still being developed, making them ideal candidates for testing a new feature [46].

Development platform: smartphones

Toon is a multi-platform product, developing the concept for all platforms straight away would not be very efficient. When a problem is found or a new feature is added, it has to be updated for every platform. Therefore, it was decided to develop the MVP for smartphones initially. Developing the MVP for smartphones offers certain advantages over developing it for the physical-Toon directly.
The advantage of using the smartphone, or tablet, as a platform for prototype development is that it is generally easier to develop compared to physical-Toon. Smartphones and tablets come with less hardware related restrictions than the Toon itself. As it takes less time and resources to develop new features for smartphone applications than it does for the Toon, and updates can be distributed more quickly, it was chosen to be the MVP release platform.
The main reason to develop the MVP for smartphones instead of tablets is that the smartphone is more commonly found in households than tablets [47]. Another advantage is that if the feature would also be released for the tablet app in a future stage, it is easier to make the conversion this way than the other way around; it is simpler to scale up an interface than to scale it down.

Chapter 5.1

Technical validation

Introduction

This chapter focusses on the development of the back end part of the MVP. Given the time that was available for this part, a complete application with all functions implemented, could not be realized. Therefore, the focus was put on validating the retrieval of data from the cloud, as this would be the foundation of the features functionality.
To retrieve the data from the cloud, the Toon API was used [7]. A description of what an API is and how it work is also included in this chapter. As this is part is fundamental for the MVP, a focus was put on the development and understanding of this concept.
During the development, two different test setups were used: the first setup was in a virtual environment, the second was done with an actual Toon in a real setting. How the API was used within these two different test setups will also be described.
At the end of the chapter a flow diagram is presented which will outline how the prototype functions. Besides the work that still needs to be done before the feature is ready to be released, the improvements that can be made to the code will be included in the recommendations.

Using the Toon API

This section contains the technical explanation of how the code retrieves its data from the cloud and is used within the project. If you are thoroughly familiar with API's and OAuth this section can be skipped.
In this stage of the project, the information, on how to use API's and such, was obtained through multiple meetings with employees at Quby, who developed the API themselves [48]. The technicalities of the whole API process will be described on the next page. By no means is this chapter meant to completely illustrate and explain everything in a high level of technical detail. Instead, it is a summarization of how an API works, and roughly what processes are involved. The aim is to quickly illustrate what goes into getting data from the cloud, and how this data will be used later on.

A short recap on data exchange

In order for the code to work, it needs data about the users' electricity consumption, room temperature, and thermostat settings. The sensors that Toon uses register this data, also report this data to the cloud.
This cloud is maintained by Quby and contains all the data of the users. This data is only accessible when the user gives permission of access to the data. This is done by checking this option on their Toon. When authorized, the data can be requested from the cloud. Subsequently, this data can be used in the code as input variables. The code can request this data from the Quby cloud using an API.

How an API works

An API (Application Programming Interface), can be explained as a contract provided by one piece of computer software to another that allows communication between the two. Another way to illustrate it would be to imagine it as an “user interface” that software uses to interact with other software.

The program will make requests to the Quby data cloud. These requests are send through a cURL-command (not to be confused with Curl, a programming language). The cURL-command is basically a message that can be interpreted and understood by the server (in this case the Quby data cloud). These messages are called ‘calls’. The type of calls a client can make, and thus will receive a response, are predefined by the API itself. They are typically labeled as GET, POST, PUT or DELETE calls [49].The types of calls and their core functions are pretty self explanatory:

- GET call: requests a data package (JSON-object) which obtains data
- POST call: sends a data package (JSON-object) to the server
- PUT call: updates or changes certain data currently saved in the server (cloud)
- DELETE call: deletes specified data from the server

The server will reply with a HTTP (HyperText Transfer Protocol) status code. A familiar HTTP status code is the well known ‘HTTP 404 page not found’ used when your internet browser cannot open a webpage. The codes provided by the API are pretty similar. A code value of 200 indicates the call was successful, 400 indicates a client error and 500 indicates an internal server error. [50]

Based on the contents of the call (typically with a GET call) the server will also send a JSON-object with its reply. A JSON-object is basically a data container. This container includes data stored in the forms used by programming languages, such as basic types (such as char, int, long etc.), booleans but also larger objects like arrays or strings [51]. This type of API call and response styled architecture is called a REST-API (Which stands for: representational state transfer - application programming interface).

The Quby cloud contains personal data of Toon customers, therefore it may not be accessed by just anyone. To prevent unauthorized access, the data that is retrieved through the API commands is protected by OAuth. What OAuth is will be explained below.

OAuth

OAuth is a simple way to publish and interact with protected data. It is an authorization framework that enables a third-party application to obtain access to a HTTP service for a limited time [52]. In turn, this allows the request-response protocol between client and server. In this case, the application is the client and the server is the Quby data cloud.

When the authorization process is completed, the client is given an access-token. This token can be used by the client to make API calls. Without this token, no access will be granted to the data. The access-token is included in every API call with the exception of the first step of the authentication process (as this process obtains the token).

JSON-objects

JSON (JavaScript Object Notation) is a data-interchange format commonly used with API's. The benefit of using JSON-objects is that it's easy to read and write for humans, and easy for machines to parse and generate. Another advantage of using JSON is that it is an ideal data-interchange-language. It's a text format that is completely language independent but uses conventions that are familiar to programmers of the C-family language (C, C++, C#, Java, JavaScript, Python to name a few examples). [53]

Summary

The Toon API is a REST-API using OAuth for authentication and authorization. It can be accessed through any programming language or tool. In order to communicate with the cloud, the code sends a message defined as a call. The Quby cloud gives a response on the calls using HTTP codes indicating if they were successfully received, and depending on the type call a JSON-package. These packages contain the data that the code needs for its analysis.

Testing environment

Virtual Toon

Quby hosts a virtual-Toon which works like a sandbox environment, it is available for testing purposes. The virtual-Toon simulates everything a regular Toon does; it has its datasets on energy consumption and even a preprogrammed thermostat program for every day of the week. The simulated data from the virtual Toon is also stored in the same cloud as the data from the regular Toon's.

Using the virtual Toon has its benefits, but also knows its limits. Data that is obtained through these API calls is somewhat predictable and even seems to follow certain patterns. This is useful when doing the initial API-calls during the testing, as you are roughly able to predict the result. However, the simulation's dataset does not simulate an average household realistically. Therefore, the switch was made to a real Toon for further testing.

JSON-objects

As it would be cumbersome to set up the code from scratch that can set up cURL commands to communicate with the API from the start. Therefore the Google Chrome extension Postman was used [54]. With the Postman extension cURL commands can be created in just a few minutes. It also takes care of sending the API call and printing the response. Examples of this process can be found in appendix 10. The obtained responses were used for comparison with the results from the programmed code for verification.

Using a real Toon

Once the API calls were successfully able to retrieve data from the virtual environment, the development continued using a real Toon. The Toon was placed in a house to create a testing environment. Currently, data can only be obtained from the Toon's that are flagged for testing purposes, when using the API. The used Toon was set up accordingly with the help of Eneco and Quby before the trial began. Additionally, a smart plug was also connected to read out specific consumption data from a fridge.

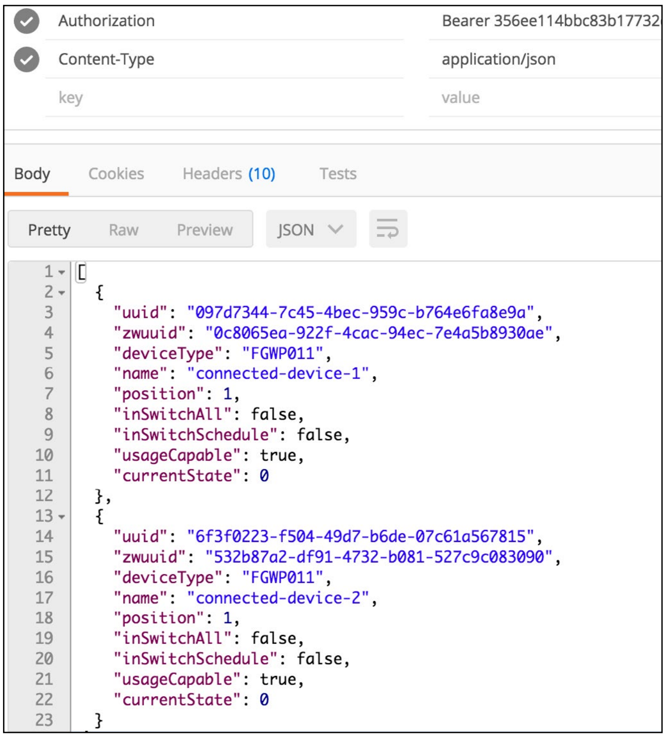


Illustration 25: A JSON-object received in Postman during the testing with the virtual Toon.

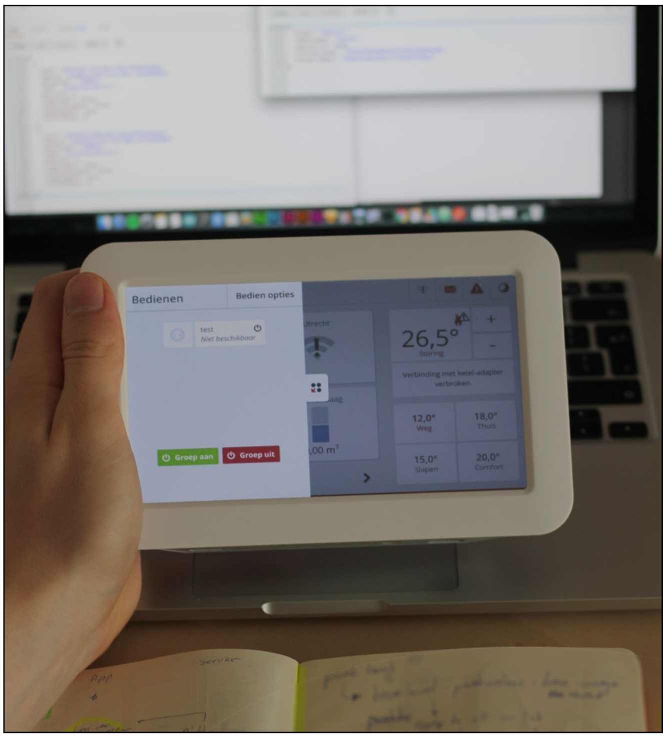


Illustration 26: Testing the API-calls with a real Toon using Postman.

By making slight changes to the API-calls used previously, data was retrieved from the Toon (and the smartplug) successfully. From this point on, a program was coded that can make the API-calls automatically and use the obtained data to test functions further.

Developing the code

During the development, the upcoming development steps (integrating the code in a mobile app) were kept in mind. Therefore the code was programmed in such way that it could be used on mobile devices running Android and iOS operating systems. To prevent that the code had to be developed in both Java and Swift, the code was developed in the C# programming language using Xamarin Studio [55].
Using the real Toon setup, the test API-calls that were used during testing with the virtual Toon, were translated into a coded program. To give an overview of the methods and classes in this program, a flow diagram is presented on the next pages. Some parts of the actual code can be found in appendix 11.

Why the use of C# and Xamarin Studio

C# is an adaptable programming language that seemed to have proper API integrations with libraries. This makes it more convenient to develop code for this purpose.
Due to how C#, just like most C-family languages, can handle API calls and responses, more time is being saved. Some languages require you to set up a callback-URL, which acts as a database on which the cloud can post its data. The C# language has built-in functions that handle the API response both for the HTTP-code and JSON-package without having to set up such a callback-URL.
Xamarin Studio was used because this program can retranslate code in particular languages in such way that both mobile devices using the Android and iOS operating systems can use it.

Code flowchart

The code flowchart is not included in the public version of the report. Initially, the chart explained how the prototype worked and gave an overview of the methods involved in it. The prototype that was programmed during the assignment is able to retrieve all the data it needed to fulfill the functions for the designed features. Besides that it is
A small part of the code can be seen in appendix 11 to give an impression.

Chapter 5.2

User Interface Design

Introduction

This chapter will focus on the development of the User Interface (UI), it will be the front end of the MVP. As the MVP will be an expansion upon the already existing app, which already has a large and established user base, it is important to maintain UI-continuity between the new features and the current app.
As these users are already common with the existing app, they're going to expect similar experiences (not only the menu flow but also how particular interaction with the interface will function). This is based on an user experience heuristic; recognition rather than recall. Besides maintaining a good user experience, it also maintains the brand identity that the user is familiar with For this reason, the current app was analyzed before the design of the new features began.

To further improve the user interface, two UI-design guidelines were used: the Shneiderman's heuristics for interface design [56] and the Nielsen and Molich's UI design guidelines [57]. These guidelines were chosen because they go further than just usability; they also aim to make the UI frustration-free and more desirable. Usability is the bare minimum requirement of delivering a decent user experience. Desirability is what separates a good user experience from an average one [58].

UI-fidelity level

Due to reasons that will not be addressed further in the public version of the report, it was decided that the UI had to be developed on a high level of fidelity.

Screensize

Generally, a phone application is designed in such a way that it adapts to various phone screen resolutions, either achieved through responsive or adaptive design. Within the scope of this project, the design of alternative screen sizes and resolutions for different smartphones was not taken into account. Instead, the mock-ups are designed based on a 1080 x 1920 pixels (Full HD) screen. This screen resolution is found amongst the smartphones that are currently used the most [60] and will be equipped with smartphones that will be released soon [61].

Illustration 27: Screenshots from the Toon smartphone app, more can be seen in appendix 14.

The visual style

As integration, into the current Toon app, would be the end-goal, the functional principles of the UI were done in the same manner as found in the Toon apps. On the visual style of the UI, slight updates will be made compared to the current UI. Since the visual identity of Eneco, and with that, the Toon apps, will be updated in the near future, the mock-ups will be presented in accordance with the new visual identity.
Both the visual style and the way the text in the app addresses the user are made in accordance with the style guide [62], and the UI mock-ups were also reviewed with a communication expert within Eneco [63].

Illustration 28: UI development from low- to high-fidelity. More can be seen in appendix 20.

Developing and testing the UI

For each of the features, the UI was first designed at a low level of fidelity, this was done through sketched prototypes. At that point it would be shown to users and non-users of Toon for their feedback on the usability. These participants were typically people within the Eneco World building: the open office on the first floor made an ideal location to get quick feedback on the designs.
Once an UI on low fidelity level was established, it was further refined up to a high level of high fidelity. This was done in small steps, and a lot of UI-components were tested independently. A summary of this complete development cycle can be seen in appendix 17. Besides user feedback, the UI guidelines presented earlier were also consulted. The implications of this are also included with the appendices. In appendix 23 a summary is found on the application of each of the used UI-guidelines. Finally, in appendix 19 some additional suggestions for the implementation of the features within the current Toon-app can be found.

Insulation and efficiency check

To give users information on the isolation efficiency of their house, a check-up on their heating system, and the ability to see if their thermostat program is efficient, this feature measures the temperature inside their house for seven days. When the measurement is completed, the feature gives the user an update for each category. This update aims to induce a change when something is wrong: when the thermostat settings are not optimal, it should make it easy enough for the user to do something about it.

The general user-flow within this UI is based on the behavior model of BJ Fogg (FBM) [64]. According to the FBM, three elements converge at the same time when a behavior occurs: motivation, ability, and a trigger. To give a few examples about the appliance: What triggers the user to use the feature in the first place, is a notification about the availability. This information will be sent in the form of a push notification. To motivate the user to start the measurement, anticipation is created by indicating that money can be saved through the use of this feature. The ability is given through the functions in the feature, giving the user more information about what to do, or by doing it automatically with the push of a button. Furthermore, the UI was designed with the Nielsen and Molich's, and the Shneiderman's user interface design guidelines in mind to develop a better user experience. A mock-up of the UI can be seen in illustration 29 and 30, and a more detailed overview is found in appendix 21.

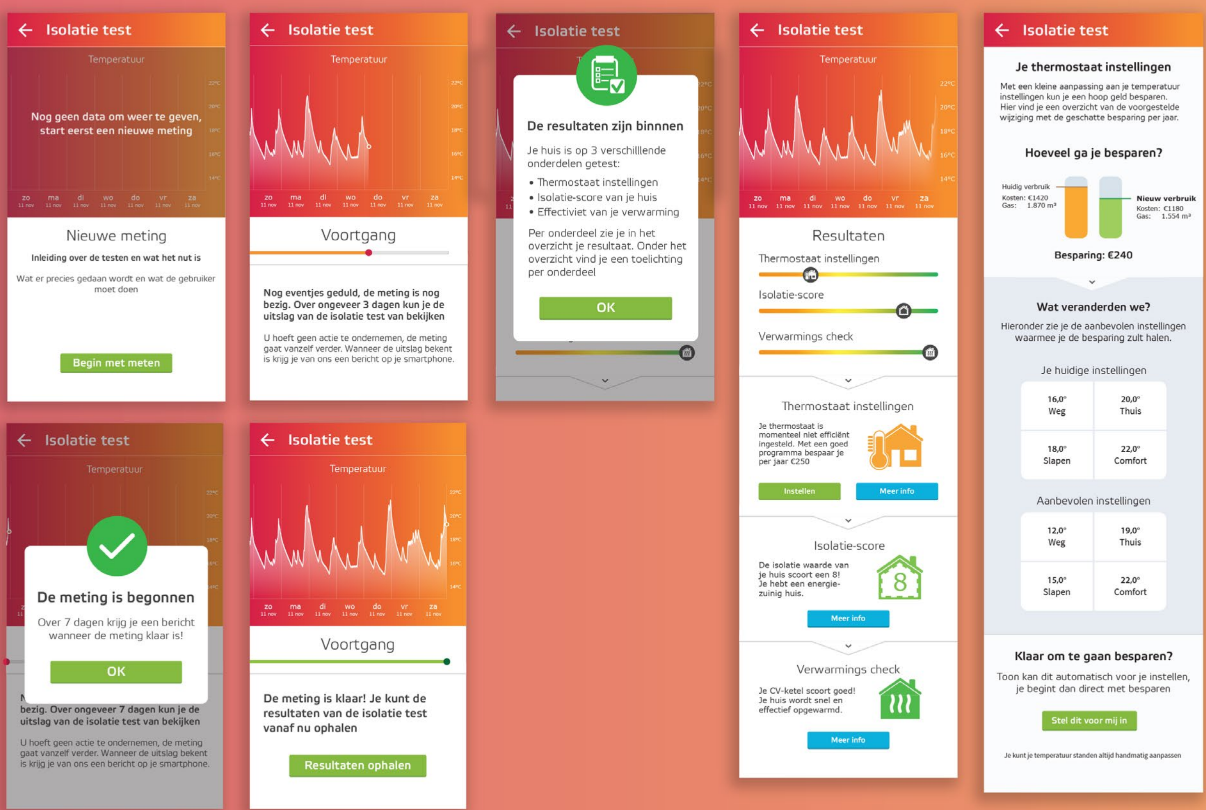
The UI keeps the user informed on its status and what's going on through different kinds of feedback. Before the user starts the measurement, the UI tells that the procedure can be started, what the outcome will consist of and how long it will take. Once started, it shows the progress of the measurement up until it is completed. After the seven days of measuring, the user receives a notification, if allowed, that the results can be obtained.
At this point, three different kinds of scores are presented for the following categories: the thermostat settings, the house insulation value, and the efficiency of theheating system. Directly underneath the graph, there is a summary, followed by more a more detailed overview of each category.
To keep the levels of navigation minimized, the user reads through the report by scrolling vertically. The categories are presented in chronological order, in agreement with the order in the score summary. The temperature graph can be scrolled through horizontally, which is the same for other charts found in the app, to maintain consistency.

One of the findings, from the usability testing, was that the categories needed more distinction. Participants were troubled to identify the link between the score summary and the detailed report for each label below. To prevent this confusion from happening, icons were designed for each label: the use of icons makes the labeling of each category more clear and concise. The buttons are made visually distinctive. Their color is also in accordance with the style of Eneco: green for action buttons and blue for information buttons. The green buttons change when they are pressed to indicate that the operation is completed, and can be pressed again to reverse it.

To reduce the amount of inputs required from the user, shortcuts have been added to the UI. When updating the temperature settings to the recommended settings, pressing a button will do it automatically. This way the user does not have to do this manually.To create a match between the UI and the real world, the temperature tiles are designed similar to how they are graphically represented on the Toon display.

Illustration 29: A mockup of the UI for the 'insulation and efficiency check' feature.

Illustration 30: In horizontal direction, the UI-flow is displayed from starting the test until receiving the results. In vertical direction different states of each step are displayed. This can be seen in more detail in appendix 22.



Standby energy usage

For this feature, the UI consists of two segments. When opening the feature, the first part functions as the landing page. It gives a dashboard-styled summary about the standby power consumption of the past day and general improvements. Its counterpart provides a more detailed overview of the standby power consumption.

As it aims to encourage its user to lower the standby power consumption, some gamification elements were applied. First, the power socket found on the first segment changes depending on the recent performance of the user: appearing happy when performing well, and becoming sadder as the performance drops (illustration 31). On the second screen, the user gets a report on how much improvement is made over time, and an illustration of how much money and energy are being saved. The user can also compare his consumption to others (this feature was also present in the tablet application). A mock-up of the feature can be seen in illustration 32.
These gamification features make use of two types of motivation: intrinsic motivation, and extrinsic motivation [65]. The intrinsic motivation stems from internal emotions such as curiosity and satisfaction from learning and improving. Extrinsic motivation comes from emotions such as fear (bad performance related) and desires such as saving money.
The motivations comply with two types of fun: so-called hard fun, and serious fun [66]. The hard fun comes from elements such as challenge and sense of accomplishment. The serious fun enters into play when confronted with the impact of positive behavior, how their effort is making the difference. Both types of fun are similar to the psychological- and ideological-pleasures as described within the four pleasures model of Jordan [67].

Another important aspect, of the UI, is feedback and the way it is presented. Software and applications that do not give feedback when an action is performed (or when the user improves on something) are less enjoyable for the user than one that does [68]. Within the current design of the UI, feedback is given trough the gamification elements (the power socket, overview of recent progress, review of achievement over time and comparing with others) and the chart in which users can look into their progress-history.

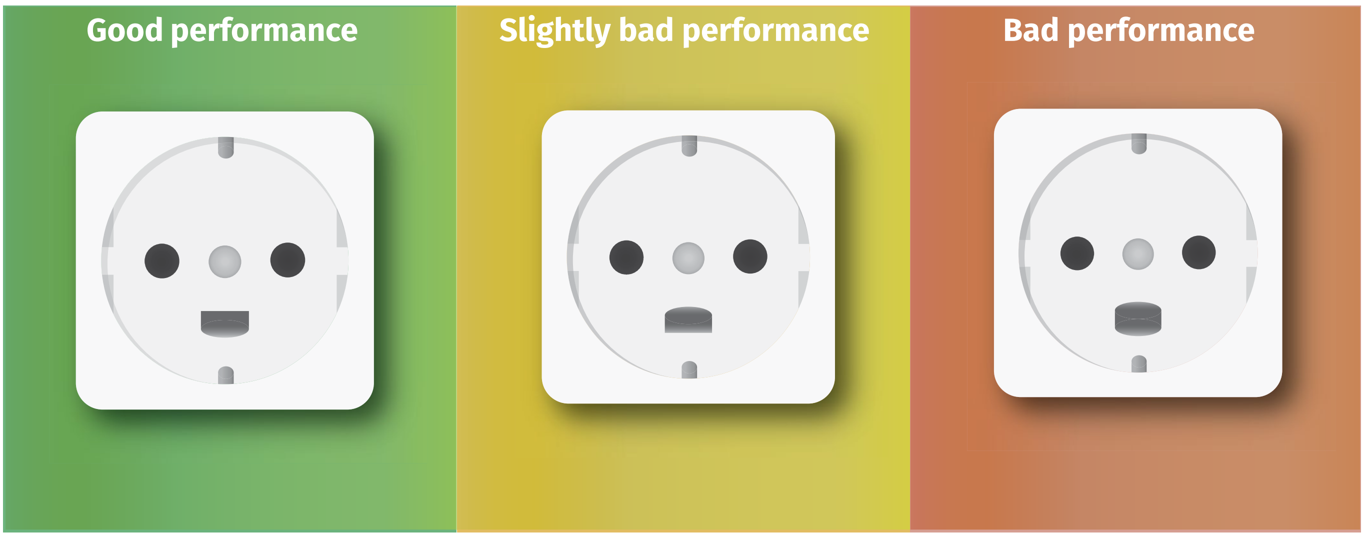


Illustration 31: The powerplug for various performance related states giving feedback to the user on the standby energy consumption.

Illustration 32: A mock-up of the 'standby energy usage' feature. Both the dashboard- and overview screen are presented for various states.

Cooling appliance check

This feature gives users accurate insight into the status, energy consumption and performance of their cooling appliances. The UI of this feature consists of a single screen. The user can access it through the sidebar in the Toon app. As this feature is not likely to be used on a frequent basis, it is not necessary to place it on the home screen of the Toon app. The feature's UI is displayed in a mock-up in figure 33.

Before the feature can be utilized, the user first has to connect a cooling appliance with the feature. To guarantee that this process will go effortless, the UI guides the user through this process step by step. This process commences with selecting which smart plug will be used to monitor the appliance. When a user chooses a smart plug, the LED-ring on the actual smart plug will blink, this allows the user to distinguish between smart plugs without having to remember their original names. Once selected, the user can continue to the next step. In the second step, which is the final step, the user needs to choose what kind of appliance they are connecting: a freezer, refrigerator or a combined fridge-freezer. This last action is done to ensure that the algorithm can give an accurate advice on how energy efficient the appliance is. When the user wants to add another cooling appliance, they can connect another smart plug at any time using the same through the same procedure.

Once a cooling appliance is connected, its power consumption will be presented in the chart. Directly underneath the chart, a banner shows the current status of the appliance(s). The background color and icon will indicate the status, backed by the text that is being displayed to give more detail. If there is something wrong, the banner will unfold and display extra information for further troubleshooting.
If the cooling appliance shows strange behavior such as no longer drawing power, or increasing electric consumption significantly within a short time frame, the user will also be given a warning through a push notification. As this can indicate that the fridge is broken, disconnected, or the appliances door is left open, it is imperative to warn the user in time. Below the banner, information regarding how efficient the cooling appliance is combined with its annual electricity costs, are displayed.

Appendix 20 shows the UI in more detail.

Illustration 33 A mockup of the UI for the 'cooling appliance check' feature.

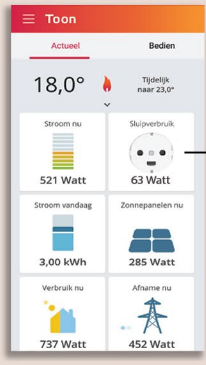
Feature implementation

This page aims to present how the features would be implemented within the current smartphone app. More can be seen in appendix 19

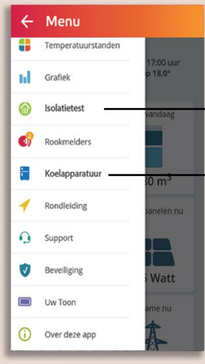
App introduction and main menu's

Guide

Push Notification



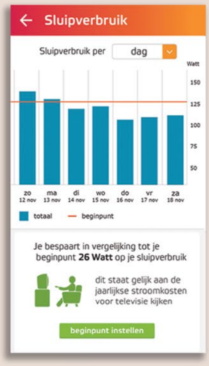
Menu



Sidebar

Standby energy usage

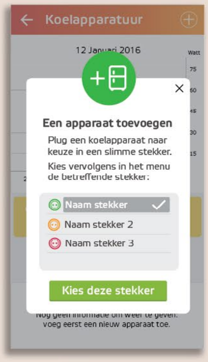
Dashboard



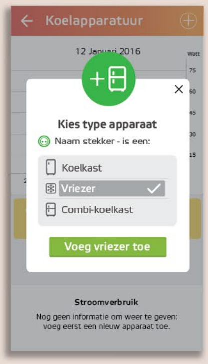
Overview

Cooling appliance check

Start



Select plug



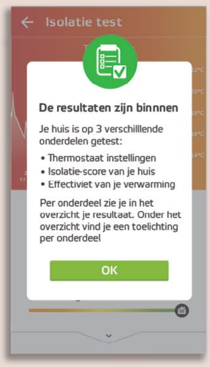
Select device

Overview

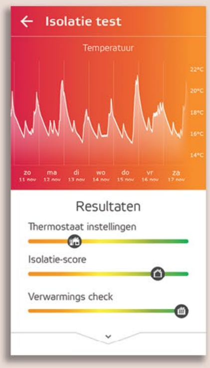
Home isolation and efficiency check

Start

In progress



Measuring done



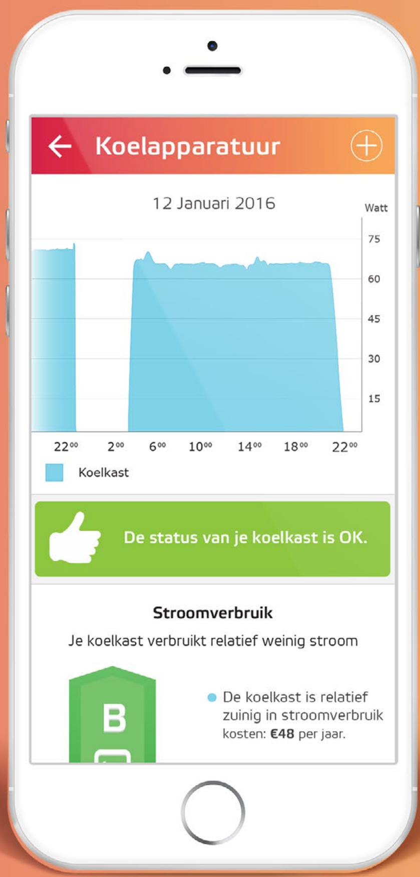
Results

Adjusting program

Feature overview

Standby energy usage

Insulation and efficiency check



Cooling appliance check

Part 2 - Analysis phase

Conclusion

In this stage of the project, steps were made towards building a MVP of the chosen concept. Slight changes were made to the concept, making them focus more on energy saving features. In total, the MVP consists of three different features:

- A home insulation and efficiency check. This feature gives user insight in how well their home is insulated and if their heating system is optimally functioning and set up. This is done by measuring the temperature for seven days.
- A cooling appliance check. It keeps track of how well the cooling appliances in houses are performing over time and how energy efficient they are. It will also give a warning if a cooling appliance is not working properly.
- A feature that helps to reduce the standby energy usage. By using some gamification elements, this feature seeks to make its users more successful in reducing their standby energy usage. This is done by presenting the user their daily personal performance, showing them how much money and energy they are saving compared to others.

The development of the features was split up into two parts: a front end and a back end. The goal of the front end was to show what the features would look like and how users would use them, while the purpose of the back end would be to validate the design from a technical perspective.
An UI was designed on a high level of fidelity for the front end part of the MVP. For each of the three features, a separate interface was designed. Before the design process started, it was analyzed how it would best integrate within the current Toon app. User experience and interaction design related factors were also taken into account.
Like the back end part, the UI was designed to be integrated within the Toon app. To evaluate and aid the design process, two different UI-design guidelines were used (Nielsen and Molich's & Shneiderman's guidelines). Additionally, a suggestion has been made on how to implement them into the current app.

For the back end, a prototype was programmed that can retrieve the data from the cloud needed to build each of the features. The functional prototype was build upon testing with an actual Toon that gathered real data, which it would save to the cloud. By using the Toon API, it was possible to retrieve this data from the cloud. This prototype both verified the validity of the features and formed the foundation for further development: as it is programmed in such way that it can be continued further upon and will be suitable for mobile devices as well. Based on this prototype some recommendations for further development can be made. These will be addressed in the next section. Besides that, an approach for further development will also be discussed.

Further development

As was concluded at the start of the previous phase of the project, the remaining time left would not allow for the MVP to be completely realized. However, within the remaining time for each of the three features that were developed, the feasibility of the MVP was confirmed and an UI was designed on high fidelity level. Both the front and back end part will have to be developed further before they can be merged into an MVP.

Based on the outcome of this phase, some recommendations can already be given for further development. Unmistakably, the prototype needs to be developed further on a functional level. Aforementioned, this will not be discussed in a high degree of detail here. Instead, it will focus on more fundamental recommendations.

Back end

In the current back end prototype, significant improvements can be obtained when it comes to lessening the amount of data traffic, and with that the stability and functionality of the features. These improvements came to light after the coded prototype was created and evaluated.
Currently, most data is obtained through the use of GET-calls. This will be no problem for small scale testing, but should the concept be tested outside of Eneco in a Beta test (or perhaps even in Alpha), it would be advisable to implement a Push-event preferably. Instead of always requesting the server to send all types of data, the server will only send the data values that are modified since the last post. This will substantially reduce the load that the features will put on the server from which it receives data, as the data traffic gets reduced a lot.
Besides that, the code was produced in such way that it can be executed entirely on mobile phones. In hindsight, this is not advisable: should the user not have continued access to the internet then some features will not function correctly. Therefore it's advised to make a server request and analyze the data for the user instead, and make the smartphone app only request the outcomes. Besides securing that the features will function properly, it will also significantly reduce the amount of data traffic for the user: since most mobile phones are bound to limited data plans it is in great favor of the user to lessen the volume of data traffic, the app will need.
As these suggested improvements will have an influence on how the back end will work, it is advised to effectuate these improvements before the further development of the back end.

Front end

For the front-end, the designed UI, a functional prototype should be created that can be used to verify the design with real users. Although the UI was tested on a lower level fidelity with employees of Eneco for early feedback and to verify smaller details, it remains essential to repeat this with actual users in a proper usability test. Based on the outcome of these tests, new insights will be brought to the surface that can be used to optimize the UI further.
But perhaps most importantly, a functional UI demo could also be used to check if the current customers of Toon would be interested in the features. And with that, verify if customers would be willing to share their data with Eneco, to obtain these features in their favor in turn. Should this be the case then the MVP has a compelling business case for Eneco.


Isolatie test
Temperatuur
22°C
20°C
18°C
16°C
14°C
zo 11 nov
ma 12 nov
di 13 nov
wo 14 nov
do 15 nov
vr 16 nov
za 17 nov
Resultaten
Thermostaat instellingen
Isolatie-score
Verwarmings check
htc

Conclusion

The goal of this bachelor assignment was to design a new extension for Toon. This extension would focus on expanding the functionalities Toon has to offer within the smart home domain. The design process was based upon main the steps in the Design Thinking process, but also incorporate principles based on the lean startup methodology. The outcome of this bachelor assignment was the design of an extension that uses the users' data to help them with saving energy.

Analysis phase

As was identified during the analysis phase of the project, the current market demands for smart home products, are products that can save energy, add comfort and safety and monitor air quality. This trend was identified for both current customers of Toon, and non-customers of Toon. The technical details of Toon, such as its hardware and how it measures and stores data were also analyzed. During this analysis, it was found that Eneco would benefit if their customers would have a more positive mindset towards sharing data with them. As currently, this is not the case, an extension that would be able to change this mindset would be interesting for Eneco. In turn, such an extension could also be in great benefit to the user.

Ideation phase

Based on the findings of the analysis phase, ideas were generated in the ideation phase. In the end, four idea-directions were selected for further development into concepts. Based on criteria set up based on the outcomes of the analysis phase, and how relevant the idea would be when taking upcoming developments by Eneco in mind.

concept phase

The diversity in ideas led to four different concepts, two of these focussed on extending Toons functionalities with the use of big data, while the others were physical products that could be connected to Toon. For each of the concepts, a business case was developed based on the lean business canvas. The concepts were pitched at Eneco and were received with great enthusiasm, resulting that Eneco was not able to make a decision on which concept should be chosen. In the end, the concept that would have the most estimated impact and the least amount of development time was selected: this was a combination of the concepts that focussed upon using data.

Prototyping phase

In the final phase of the project, the selected concept was further developed. This concept consisted of three individual features, each of them aims the user to save energy in a different way. A programmed prototype was created to demonstrate the validity of each of the features, by retrieving the required data from the cloud and using it for basic functions. To visualize the features and show how they would work in context, a high fidelity user interface was designed as well.

Should the project be continued after this bachelor assignment, then the MVP will need to be finished so it can be presented to the testing panel of Toon. This will indicate if the users of Toon are interested in the new features and would be more open to sharing their data with Eneco as a side effect. Should this be the case, then the designed extension will benefit both Eneco and the customers of Toon. From that point on, the MVP can be developed further into a real extension for Toon.

Personal reflection

What was challenging

The primary challenge within this bachelor assignment was the amount of freedom that it allowed. At the same time, however, this is also what made the assignment truly exciting for me, as it offered a lot of opportunities to take initiative and challenge myself. Besides that, working by yourself on a project like this that requires many different skills, while learning new skills very quickly on the go.

What could have been done better

One of the things that could have been done better is decision making in general and especially for the milestones within the project. At the end of the concept phase for example, too much time was spent on selecting a concept to be further developed. But also on deciding when it is time to continue with the next stage of the project: the transition between the analysis and ideation phase was rather vague during the project. Although research questions were defined and answers were found, new questions kept arising. The result was that the analysis phase lasted longer than it was initially planned, while the ideation phase started earlier and both phases were happing at the same time during an unplanned transition period.
Working individually on this project also taught me that I need to learn how to manage my time better. From time to time, I caught myself spending too much time on the unimportant of details and losing sight on the big picture instead.

What was learned

Before I started this bachelor assignment, I had not designed new features or products which are data-driven. Learning how to use data, both to the advantage of the company or the user, in a new design, or in this case extension, is something I found interesting. On top of that, I also acquired more technical knowledge that comes with this, such as how API's work and can be used. As many of today's smart products and even social media such as Facebook are making their API's available for open innovation purposes, plus the impact big data will have that is estimated for the near future, this is a skill set that is likely to come to use again later on. Besides that, I also learned to approach my ideas more entrepreneurial, learning how ideas and services can create revenue for a company, be it an existing or a new one.

Other than that, I also got to experience how it is to work in a bigger company. Learning both about the benefits, and how to use them in your favor, and disadvantages and how to deal with them.

What was experienced

For me, it was interesting to see how the knowledge gained during my bachelor studies could be applied within a project such as this one, and within the setting of a big company. I have been able to experience how a wide array of skills can be utilized and if needed enriched. Besides that, the ability to communicate as an industrial designer with experts from various disciplines has also proven to be very helpful.

Looking back

In total, I've worked a little longer than three months on this assignment at Eneco. Besides having learned a lot during my time there, I'm also able to look back on three months of working on a fascinating project in a very friendly and inspiring environment. For me, it was a great final chapter in my bachelor studies of Industrial Design.

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Appendices

Some appendices are not included in the public version of the report. To give an impression of the actual contents, they are included in the list below. If an appendix is not included, it is noted after the title.

Appendix 1 - Market research - product analysis

Brand & product	Dimensions	Communication hardware	Range	Detection / sensing	Status interfacing	Connection interfacing	Alarm interfacing	Shelf price
Eneco								
Toon	190 x 120 x 30 mm	Wi-Fi, Z-wave and ZigBee	-	Electricity consumption, gas consumption, opentherm	Display and smartphone apps	Display and smartphone apps	Display and push notifications	€275,-
Rookmelder (Fibaro)	65 x 28 mm	Z-Wave	up to 30 meters	Smoke and temperature	Battery status check by Toon and sms	Connecting test through Toon	Alarm by LED and sound (85 dB)	€64,99
Slimme stekkers (Fibaro System)	43 x 65mm	Z-Wave	up to 30 meters	kWh-consumption	kWH-usage shown by RGB color values	Wireless connecting test	Blinking LED and RGB LED ring	€64,99
Philips Hue	Depend on bulb	Wi-Fi & bridge (hub)	-	n/a	On/off	n/a	n/a	€34,99
Nest								
Thermostaat	3.3 x 3.3 x 1.21 inch	Wi-Fi	-	Temperature, presence, ambient light, humidity	Display and smartphone	Display	Notification on smartphone	$249.00
Rookmelder	5.3 x 5.3 x 1.5 inch	Wi-Fi	-	Smoke, CO, temperature	Light, sound and smartphone alert	Light and sound feedback	Smartphone messaging and LED light	$99.00
Camera	4.5 x 2.8 x 2x8 inch	Wi-Fi, Bluetooth	-	Sound and movement	LED on the device	Notification on smartphone	Notification on smartphone	$199,-
Fibaro								
Home Center 2	-	Z-Wave, LAN connection	up to 30 meters	-	SMS/ push notifications	Through App	-	€549,-
Flood Sensor	72 x 28 mm	Z-Wave	up to 30 meters	acceleration, temperature and conductivity	-	Through App	SMS / Push notifications	€59,95
Motion Sensor	44mm (radius)	Z-Wave	up to 30 meters	Temperature, ambience light, sound and acceleration	LED	Through App	SMS / Push notifications	€57,95
Smoke Sensor	65 x 28 mm	Z-Wave	up to 30 meters	Smoke and temperature	Battery status check by Toon and sms	Through App	Alarm by LED and sound (85 dB)	€64,99
Wall plug		Z-Wave	up to 30 meters	kWh-consumption	kWH-usage shown by RGB color values	Through App	Blinking LED and RGB LED ring	€64,99
Door/window sensor	76 x 17 x 19 mm	Z- Wave	up to 30 meters	Temperature, Reed-sensor	Through App	Through App	SMS / Push notifications	€48,45
Smart things (Samsung)								
Hub	4.2 x 4.9 x 1.3 inches	Zigbee, Z-wave, IP	50-130 feet	n/a	Through App	Through App	Through App	$99.00
Motion Sensor	2 x 2 x 0.8 inches	Zigbee	50-130 feet	Motion/ infrared	Through App	Through App	Through App / Push notification	$39.00
Multipurpose Sensor	1.9 x 1.35 x 0.57 inches	Zigbee	50-130 feet	Reed-Sensor, temperature, acceleration (vibration)	Through App	Through App	Through App / Push notification	$39.99
Outlet	2.4 x 2.6 x 2.4 inches	Zigbee	50-130 feet	kWh-usage	Through App	Through App	Through App	$54.99
Arrival Sensor	0.98 x 1.9 x 0.46 inches	Zigbee	50-130 feet	Proximity through GPS	Through App	Through App	Through App / Push notification	$29.99
Water Leak Sensor	2.34 x 1.49 x 0.85 inches	Zigbee	50-130 feet	Humidity and temperature	Through App	Through App	Through App / Push notification	$39.99
Elgato								
Eve room (indoor)	79 x 79 x 32 mm	Bluetooth 4.0	up to 30 meters	'Air quality', temperature, humidity	App	App + homekit	-	$79,95
Eve weather (outdoor)	79 x 79 x 32 mm	Bluetooth 4.0	up to 30 meters	'Air quality', temperature, humidity	App	App + homekit	-	$49,95
Eve door & window	54 x 24 x 23 mm & 18 x 18 x 8 mm	Bluetooth 4.0	up to 30 meters	Electromagnetism	App	App + homekit	-	$39,95
Eve energy	49 x 49 x 73 mm (europe)	Bluetooth 4.0	up to 30 meters	kWh-consumption	App	App + homekit	-	$49,95
Avea-Bulb		Bluetooth 4.0	up to 30 meters	-	-	App	-	$39,95
Avea-Flare	22cm (hoogte)	Bluetooth 4.0	up to 30 meters	-	-	App	-	$95,95
Avea-Sphere	25cm diameter	Bluetooth 4.0	up to 30 meters	-	-	App	-	$99,95
Philips								
Philips bridge	88 x 88 x 26 mm	ZigBee (certified) LightLink-protocol 1.0	15-20 meter	n/a	App	App	n/a	€59,-
KPN Smartlife								
Slimme stekkers	87 x 52 mm	ZigBee	15-20 meter	-	-	-	-	€51,50
Afstandsbediening	68 x 38 x 15 mm	ZigBee	15-20 meter	-	-	-	-	€33,50
Rookmelder	105 (dia) x 42 mm	ZigBee	15-20 meter	-	-	-	-	-
Deur/Raamsensor	85 x 24,6 x 19,5 mm	ZigBee	15-20 meter	-	-	-	-	€36,50
Bewegingssensor	94 x 64 x 42	ZigBee	15-20 meter	-	-	-	-	€57,50

Appendix 4 - Idea selection criteria

Based on the analysis phase and the project briefing, some criteria were created which were used to select the ideas from the ideation phase. As no design-direction was defined more specifically than “design a new extension for Toon’, the requirements were defined on a general level so it could be used to evaluate all of the ideas.

Demands:
The extension should be relevant for Toon (as a smart home platform). Therefore it should be technically feasible to realize the extension and connect it with Toon.

The extension should be attractive to the users of Toon. As the analysis phase has shown, consumers (both Toon and non-Toon owners) are currently interested in products that enable them to save energy, add comfort and safety to their home or give them insight into health-related conditions such as air quality. For this reason, it was decided that the extension should include one of these functionalities.

The extension should remain affordable for the customers of Toon (exact price varies per type of extension). As the high purchase price of smart home products is keeping consumers from buying them, the price should not be too high. Even better; the extension should earn itself back over time (see preferences).

Finally, the extension itself, or a closely related concept, should not already be developed by Eneco. To ensure that the project and its outcome remain relevant this criterion was taken into account.

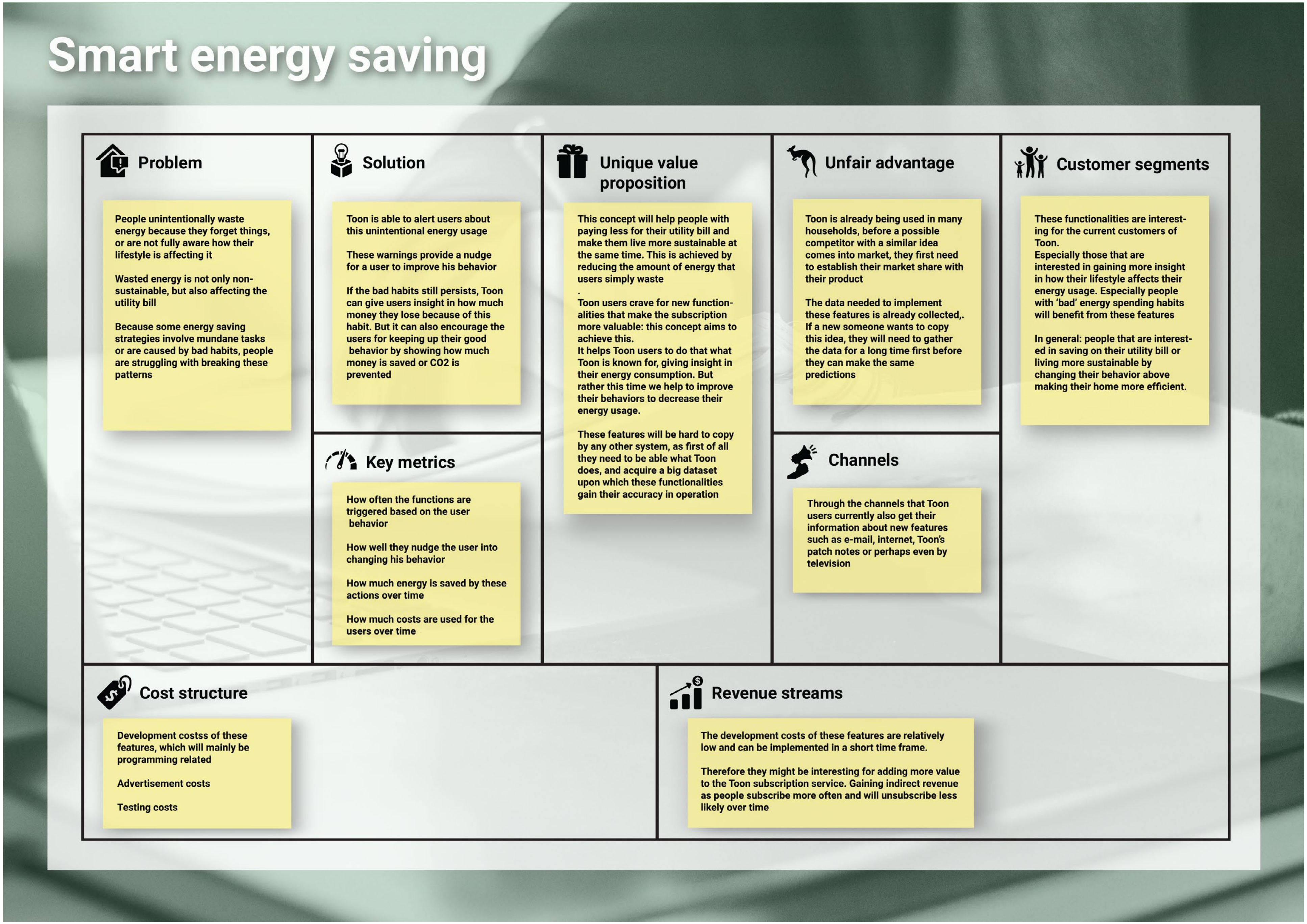
Preferences:
As smart home technology is seen as an investment, the product should preferably help to earn its purchasing price back over time.

The extenstion should be interesting for as many Toon-customers as possible.

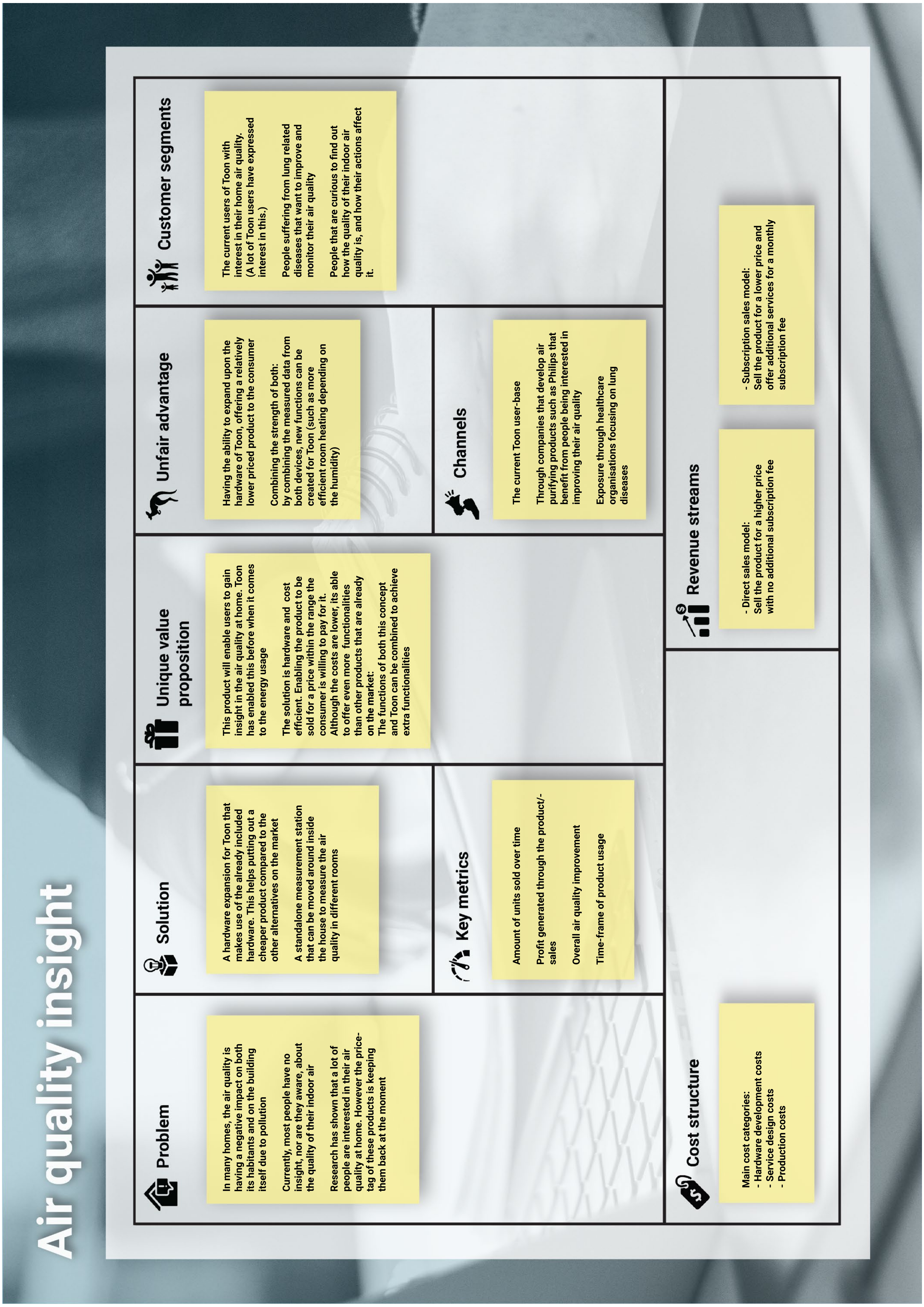
If the extension provides a function that an already existing product also delivers, it should preferably be cheaper than the competitor.

As Eneco focusses on supplying its customer with green energy, therefore, the extension should preferably also have a sustainable mindset.

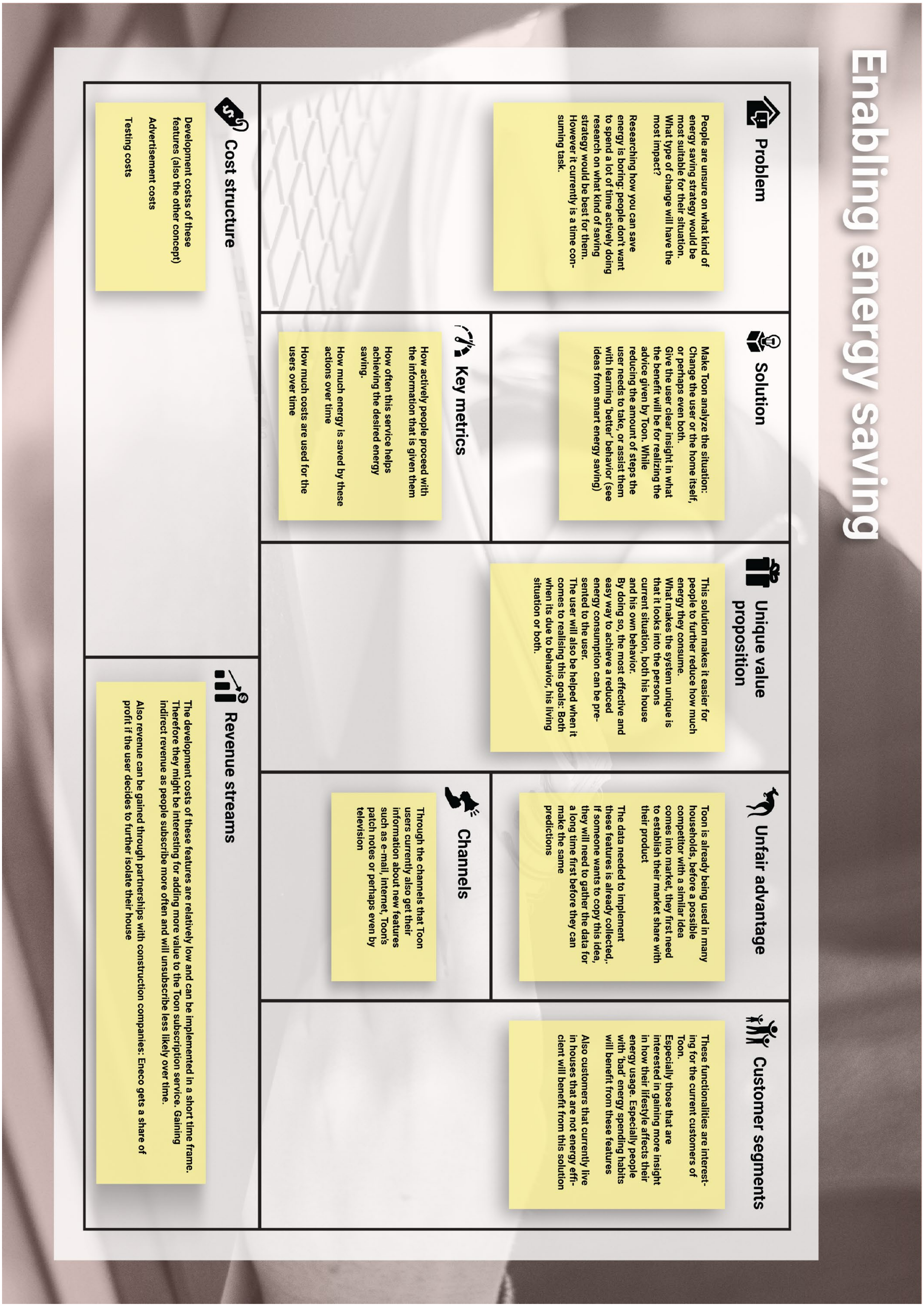
Appendix 5 - Lean canvas, Concept 1



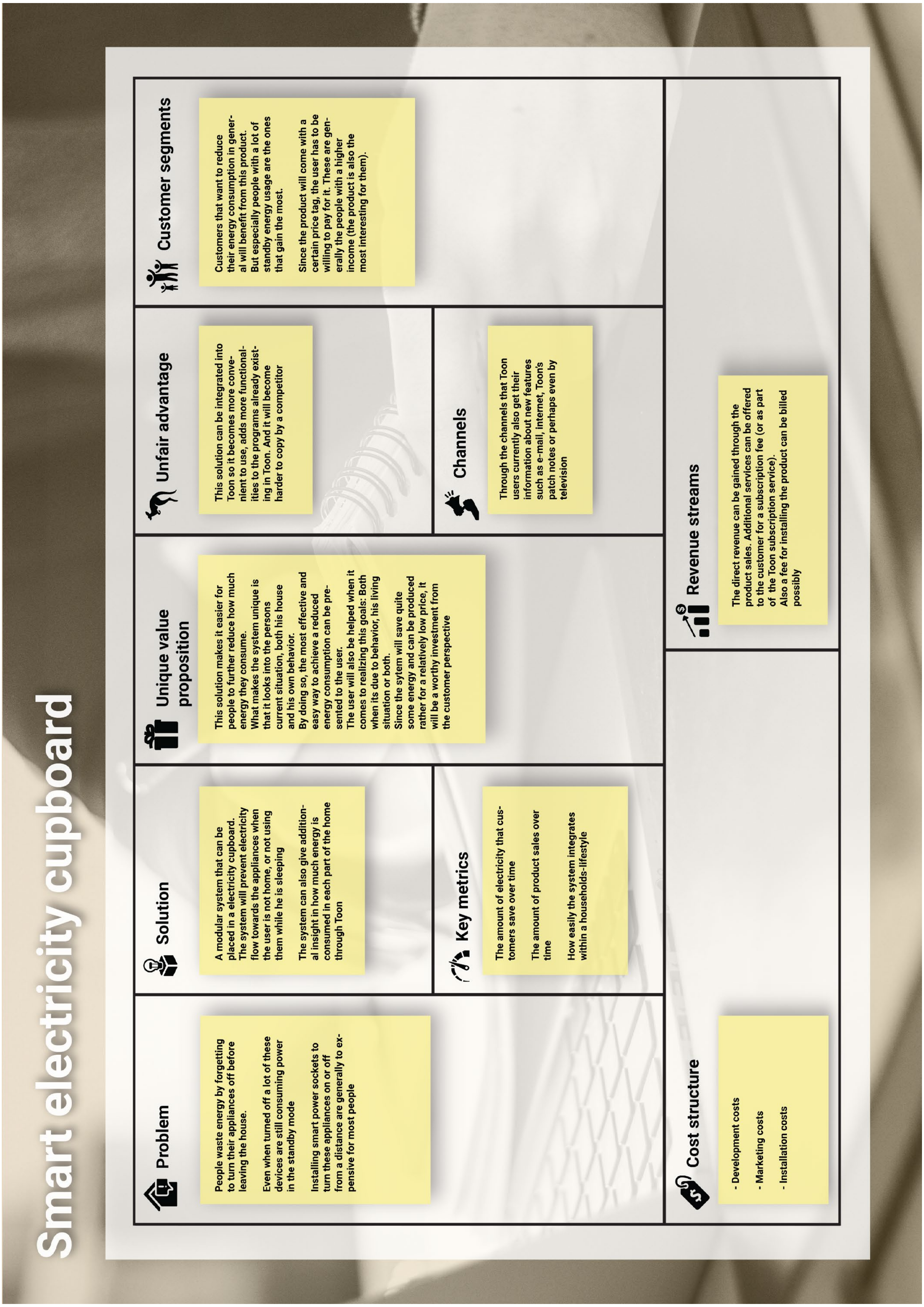
Appendix 6 - Lean canvas, Concept II



Appendix 7 - Lean canvas, Concept III

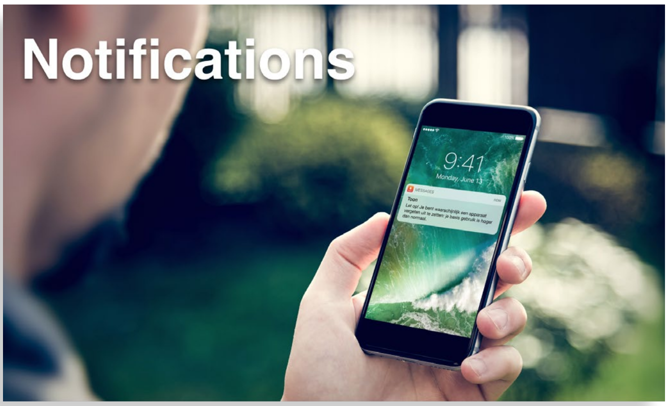


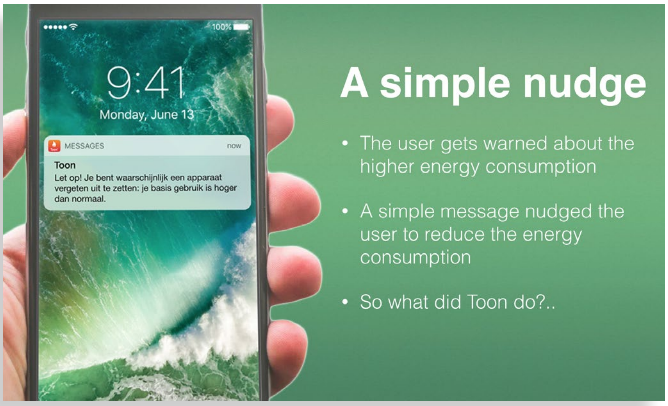
Appendix 8 - Lean canvas, Concept IV

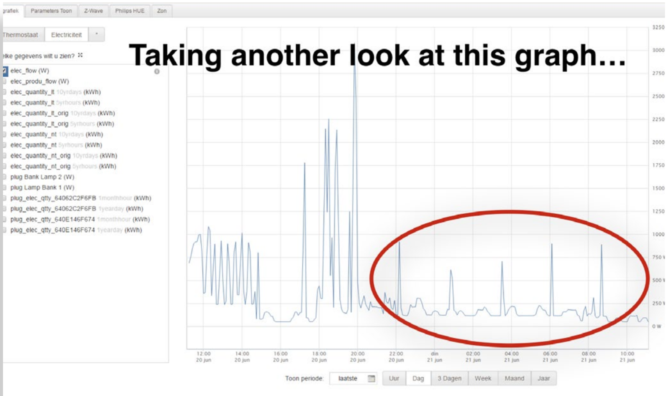


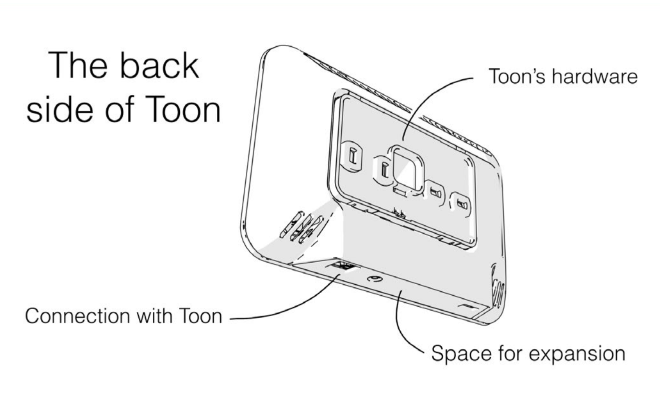
Appendix 8 - Concept pitching sheets

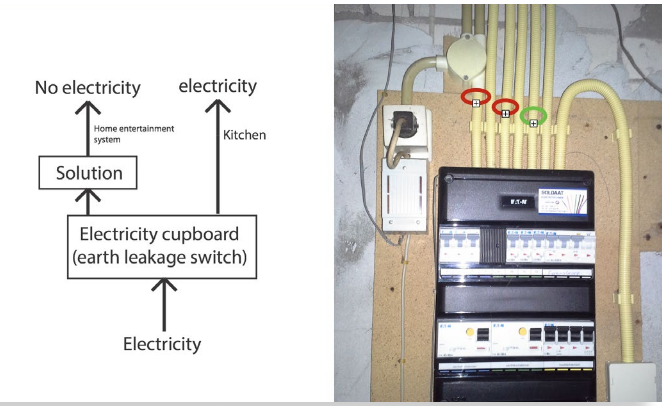
This appendix contains several sheets from the presentation that was used during the pitching of the concepts at Eneco and Quby. For each of the concepts, 2 slides are displayed.

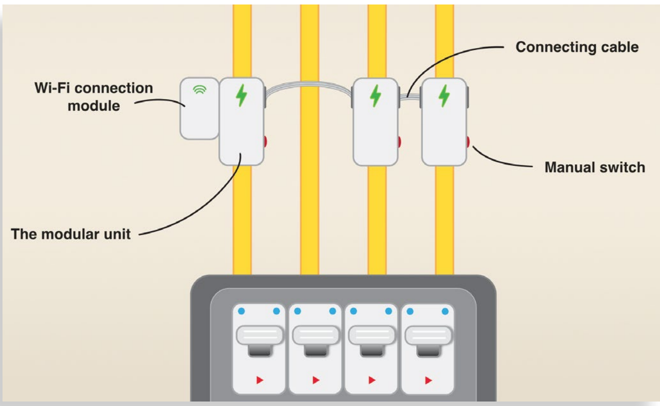






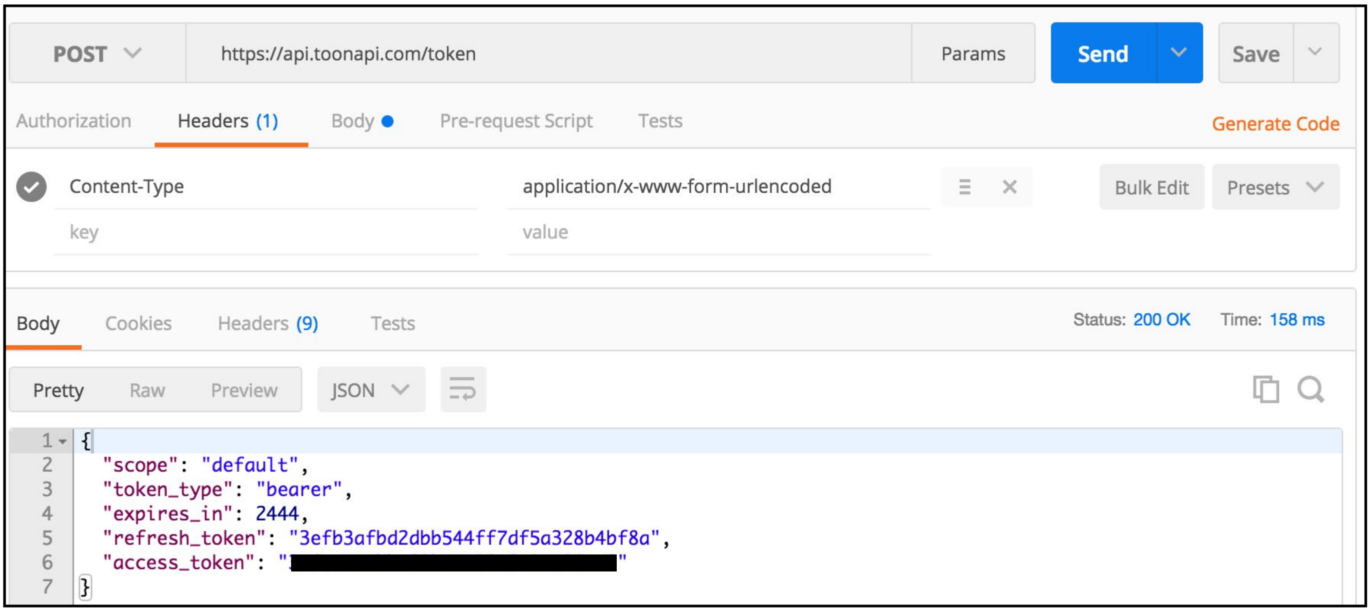




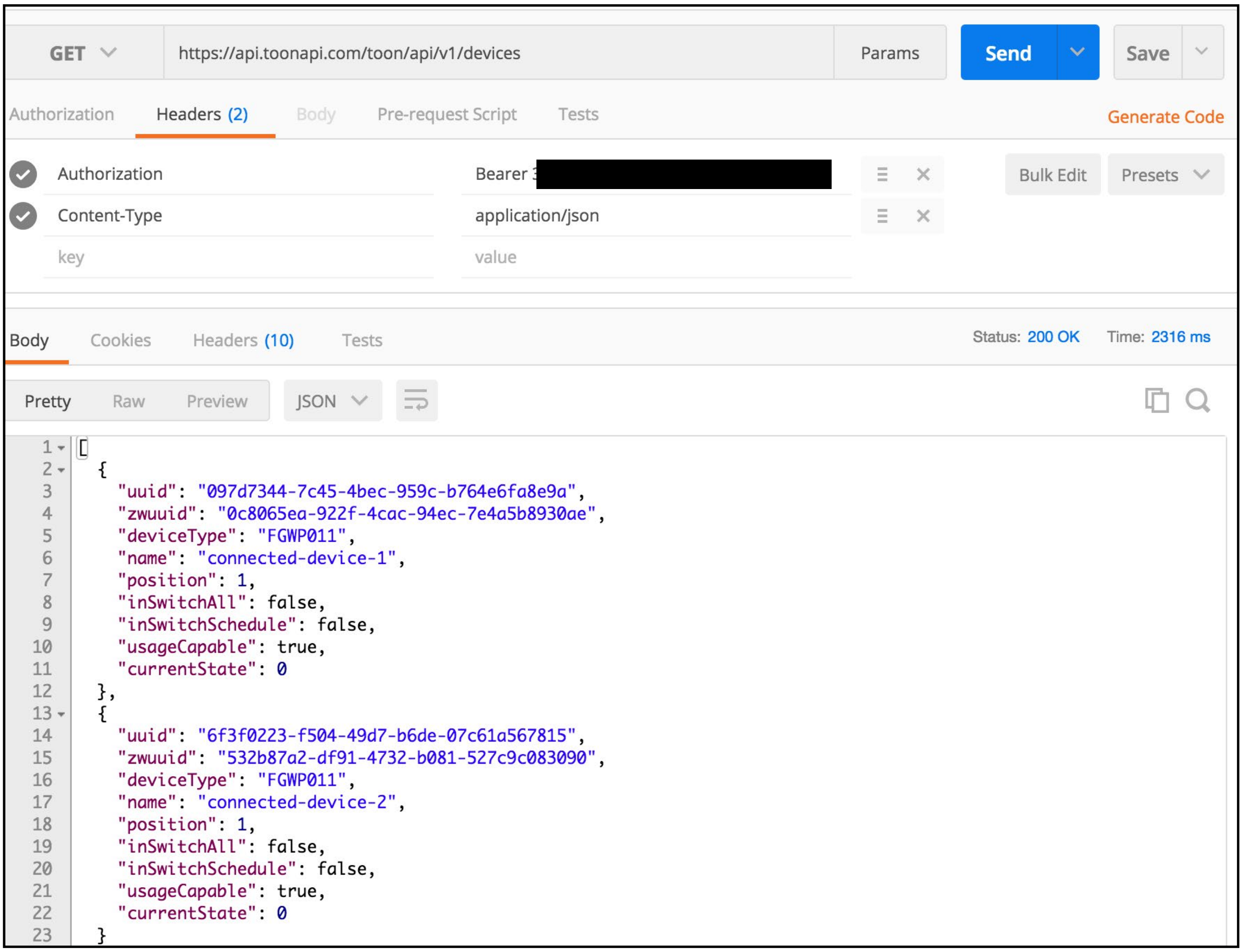


Appendix 10 - API calls using Postman

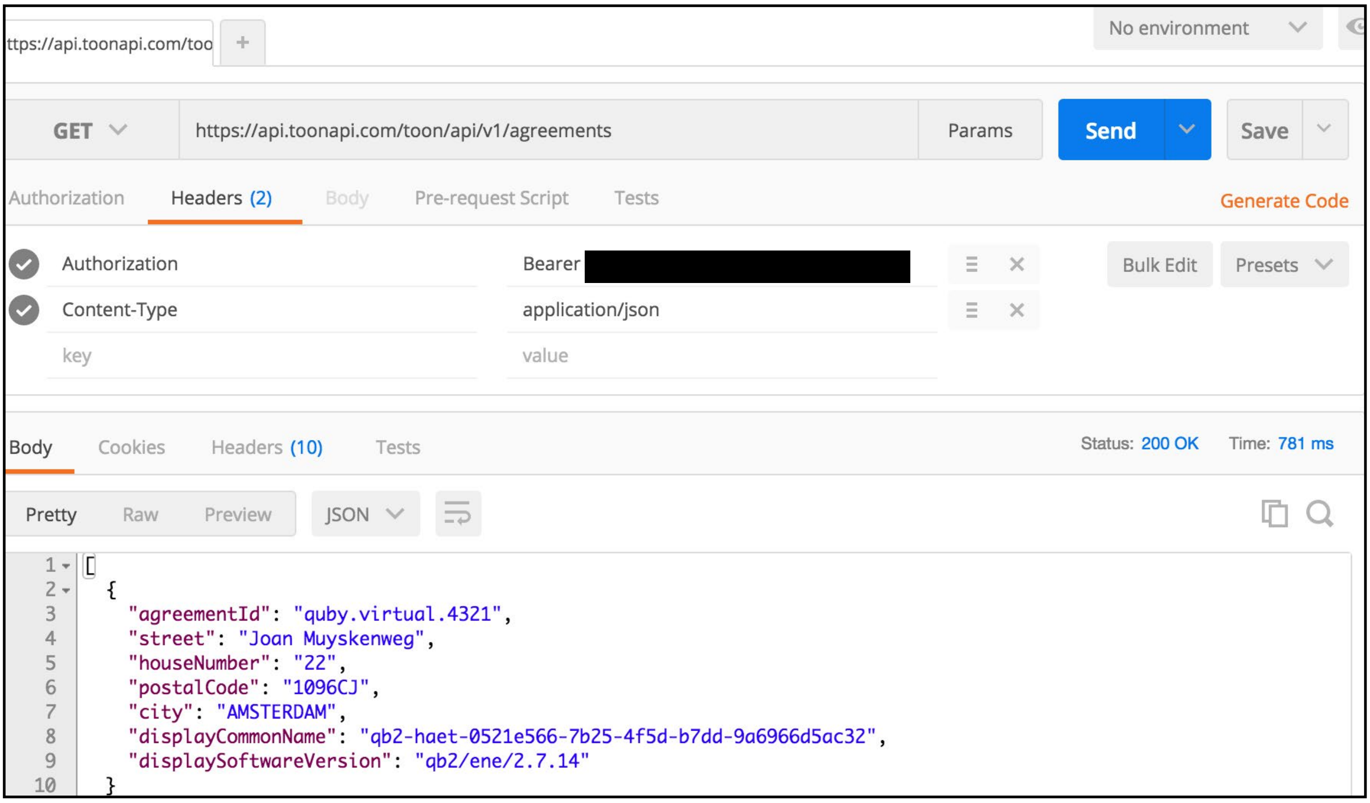
Obtaining an access token (POSt call)



Obtaining the data-sharing agreement information (GET call)

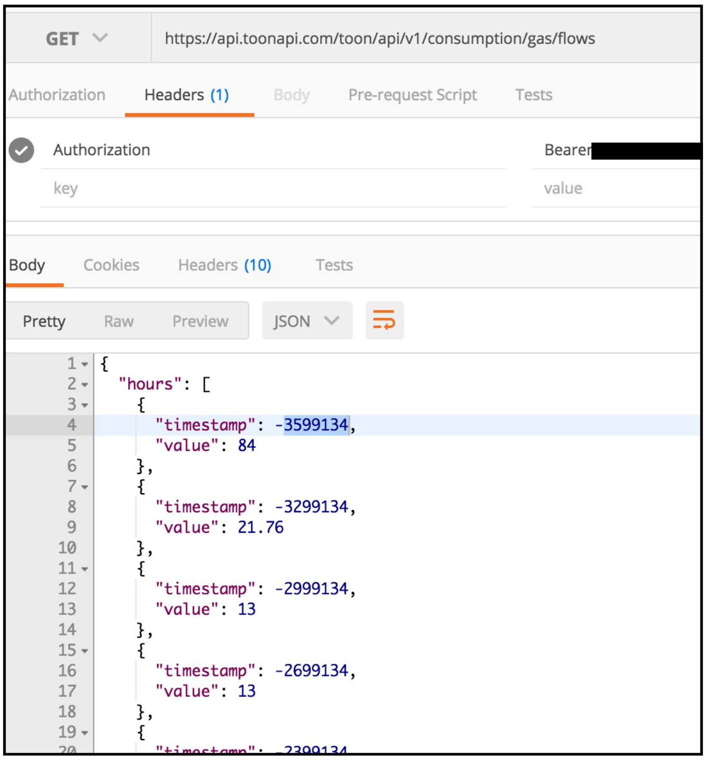


Requesting data agreement - confirmed (GET call)



JSON-object examples

kWH consumption JSON-object



Display info JSON-object


```
{
  "success": true,
  "thermostatInfo": {
    "currentTemp": 2000,
    "currentSetpoint": 2250,
    "currentDisplayTemp": 2250,
    "programState": 0,
    "activeState": -1,
    "nextProgram": -1,
    "nextState": -1,
    "nextTime": 0,
    "nextSetpoint": 0,
    "randomConfigId": 1804289383,
    "errorFound": 255,
    "boilerModuleConnected": 1,
    "realSetpoint": 2250,
    "burnerInfo": "1",
    "otCommError": "0",
    "currentModulationLevel": 100,
    "haveOTBoiler": 0
  }
}
```

Appendix 11 - API calls in C# code

This appendix contains 3 methods used in the coded prototype. At which point they are used in prototype, can be seen in the code flowchart in the report. As not every method will be displayed, 3 functional, but essential, parts of the code are displayed. They focus on illustrating how the GET- and POST-calls are constructed.

- The first example shows a POST-call used for obtaining an access token. This call can also be found in the previous appendix when it was used using Postman
- The second example shows a GET-call for obtaining the selected temperature program. This variable is used in the 'standby energy usage' and the 'insulation and efficiency check' features.
- The third example also shows a GET-call. However, this one also verifies if the data obtained is actually new data by comparing the timestamps. This is used to indicate when the data was uploaded to the cloud.

Comments have been added to the code to further explain of emphasize certain details.

Example 1: Obtaining an access token (POSt call)

```
// This method is used to request an access Token using a POST-command
public string PostToken()
{
    using (HttpClient client = new HttpClient())
    {
        //This part constructs the cURL-command
        var APIkeyANDsecret = string.Format("{0}:{1}", APIKey, APISecret);
        var authorizationHeader = Base64Encode(APIkeyANDsecret);
        client.DefaultRequestHeaders.Authorization =
        new AuthenticationHeaderValue("Basic", authorizationHeader);
        var content = new FormUrlEncodedContent(new[]
        {
            new KeyValuePair<string, string>("grant_type", "password"),
            new KeyValuePair<string, string>("username", Username),
            new KeyValuePair<string, string>("password", Password),
        }
        );
        //This part sends the cURL-command to request an access token
        client.BaseAddress = APIManagerBaseAddress;
        var result = client.PostAsync("token", content).Result; //defines the POST-call
        string stringResult = result.Content.ReadAsStringAsync().Result;
        var jsonResult = JsonConvert.DeserializeObject<JObject>(stringResult);
        var Token = jsonResult.GetValue("access_token").ToString();
        return Token;
    }
}
```

Requesting the display data (GET call)

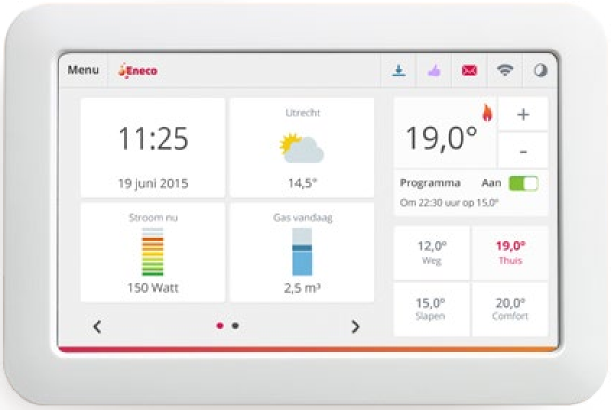
```
// This method obtains the current temperature-program using a GET-command.
// Notice how this method is similar to the bottom part of the PostToken method
public double GetTemperatureProgram (var Token)
{
    using (HttpClient client = new HttpClient())
    {
        client.BaseAddress = APIBaseAddress;
        client.DefaultRequestHeaders.Authorization =
        new AuthenticationHeaderValue("Bearer", Token);
        var result = client.GetAsync("status").Result; //defines the GET-call
        string stringResult = result.Content.ReadAsStringAsync().Result;
        var jsonResult = JsonConvert.DeserializeObject<JObject>(stringResult);
        var jsonObj = jsonResult.GetValue("activeState");
        var temperatureProgram = jsonObj.ToObject<JObject>().GetValue("activeState").ToString();
        return temperatureProgram;
    }
}
```

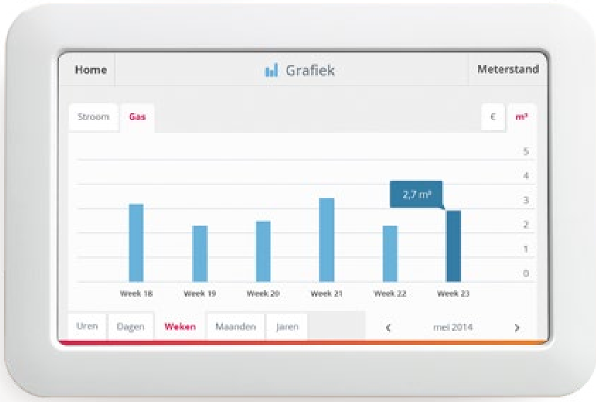
Requesting the electricity consumption data (GET call)

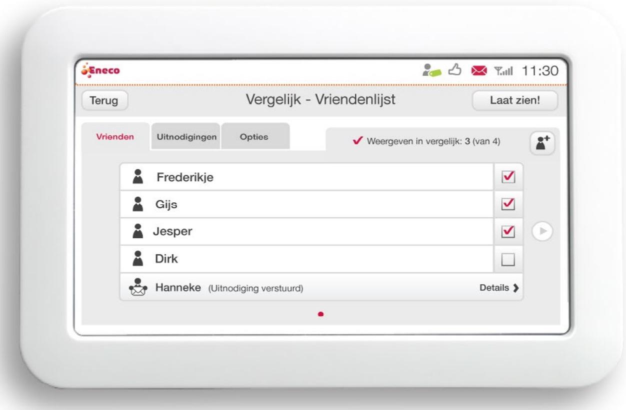
```
public double GetElectricityConsumption (var Token)
{
    using (HttpClient client = new HttpClient())
    {
        client.BaseAddress = APIBaseAddress;
        client.DefaultRequestHeaders.Authorization =
        new AuthenticationHeaderValue("Bearer", Token);
        var result = client.GetAsync("consumption/electricity/flows").Result;
        string stringResult = result.Content.ReadAsStringAsync().Result;
        var jsonResult = JsonConvert.DeserializeObject<JObject>(stringResult);
        var jsonObj = jsonResult.GetValue("timestamp");
        var timeStampUnformatted = jsonObj.ToObject<JObject>().GetValue("timestamp").ToString();
        long timeStamp = long.Parse(timeStampUnformatted);
        // This if-statement varifies if the obtained data is new or old data
        // if the data is new, it will be submitted. Old data will be flagged as -1
        if (timeStamp != timeStampSAVED)
        {
          var jsonObj = jsonResult.GetValue("value");
          var kWhConsumption = jsonObj.ToObject<JObject>().GetValue("value").ToString();
          int formattedkWhConsumption = Int32.Parse(kWhConsumption);
          timeStampSAVED = timeStamp;
          return formattedkWhConsumption;
        }
        else
        {
          formattedkWhConsumption = -1;
          return formattedkWhConsumption;
        }
    }
}
```

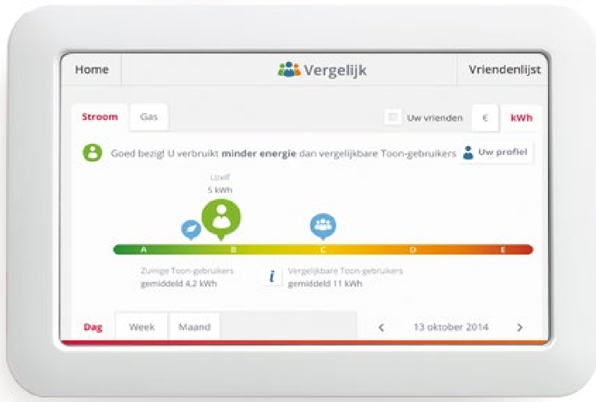
Appendix 12 - The interface of Toon

This appendix contains pictures of a Toon displaying various parts of the interface (images by Eneco.).







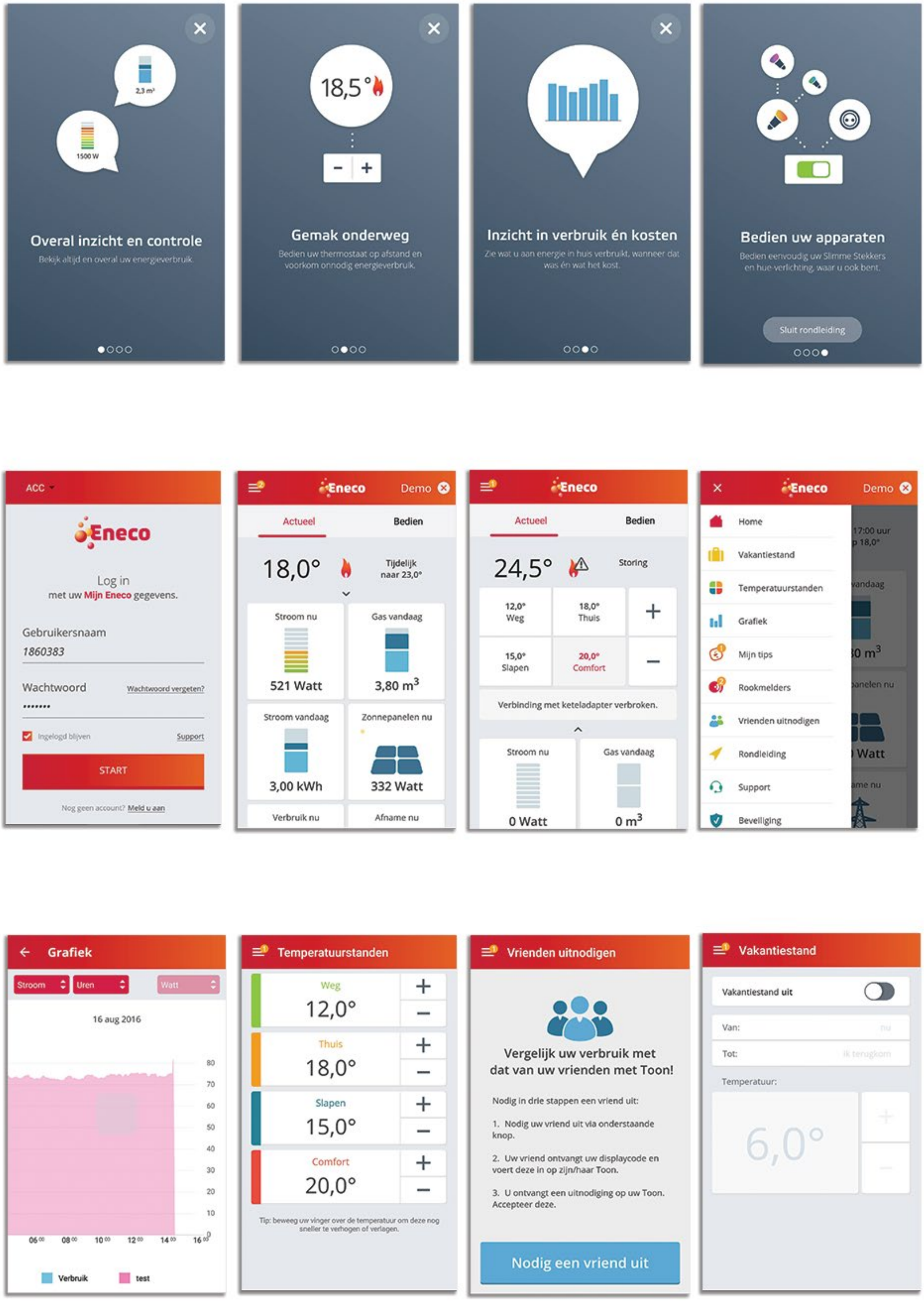


Appendix 13 - Style elements of Eneco

This appendix contains various style elements that were obtained from the Eneco style guide [62].

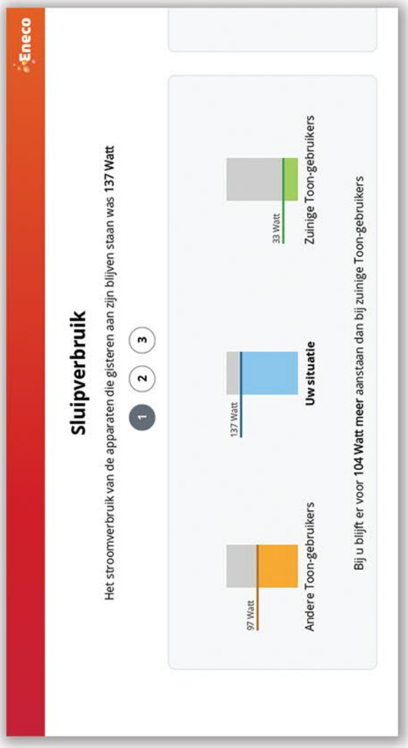
Appendix 14 - Toon's smartphone App UI

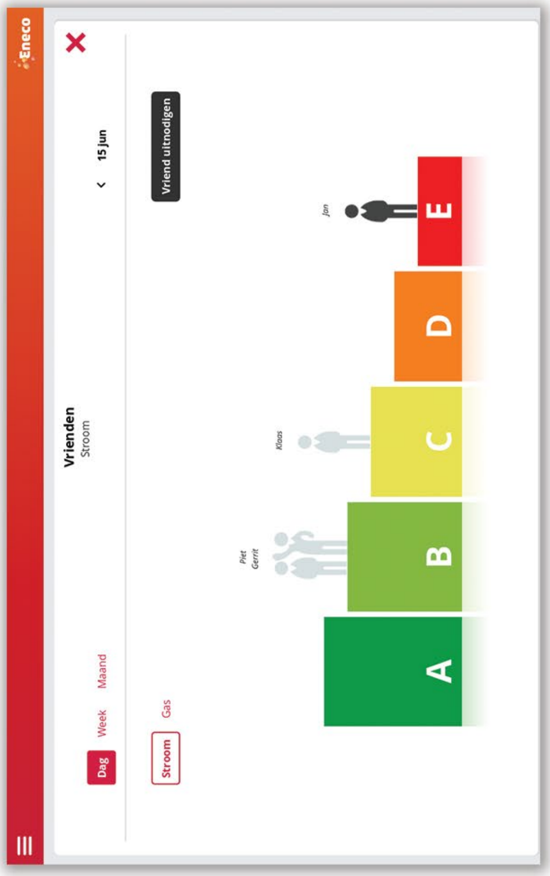
Various screenshots that were made of the current Toon smartphone application (version 2.4).

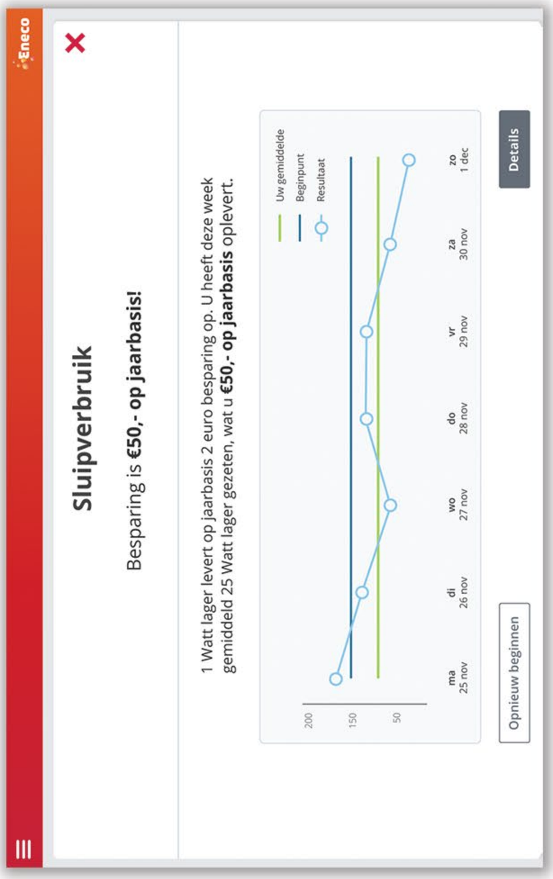


Appendix 15 - Toon's tablet App UI

Various screenshots of the Toon tablet application. Some of the features from the 'standby energy' feature found in the tablet app, were also used in the design of the 'standby energy usage' feature as these were not yet included into the smartphone application.

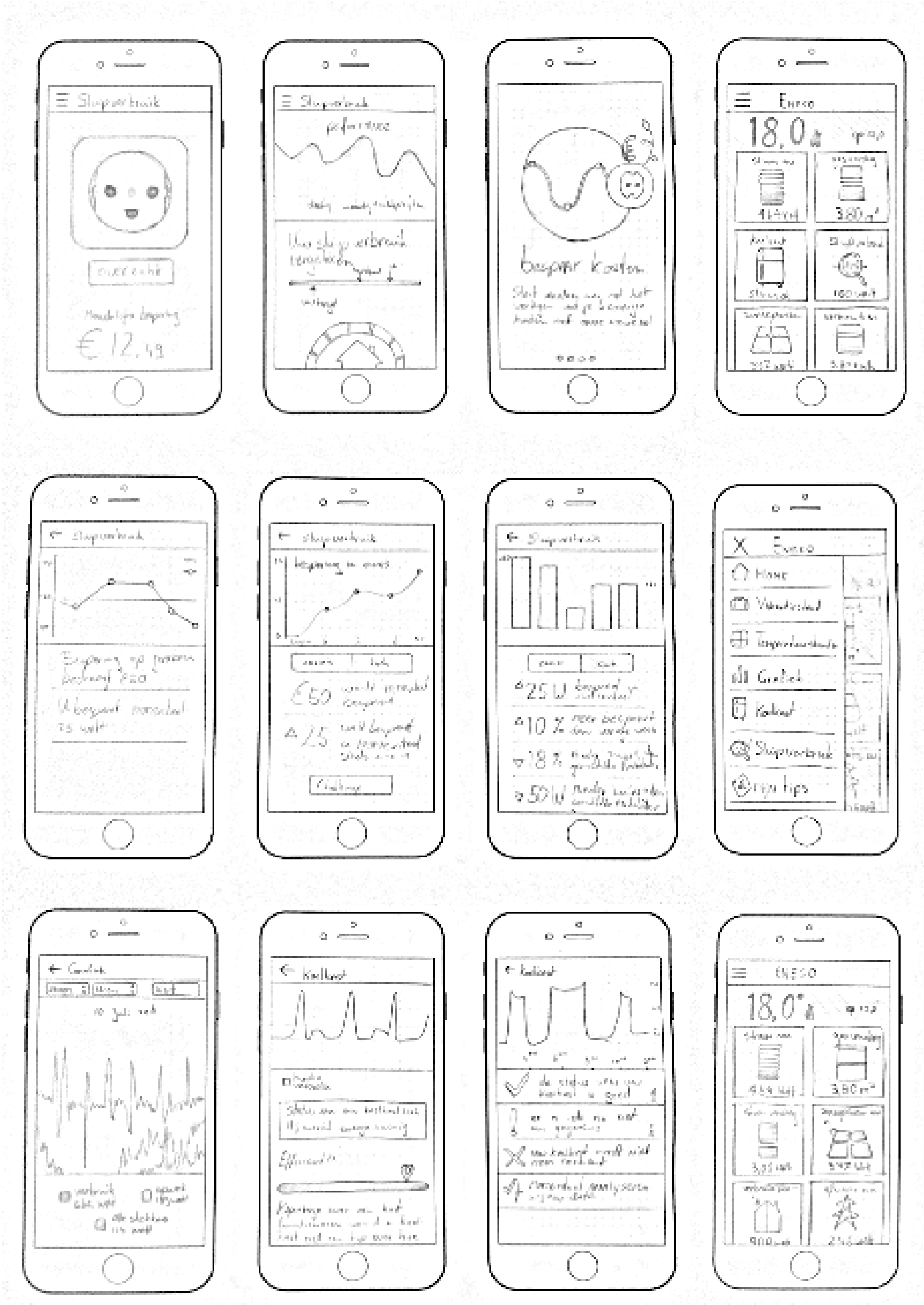




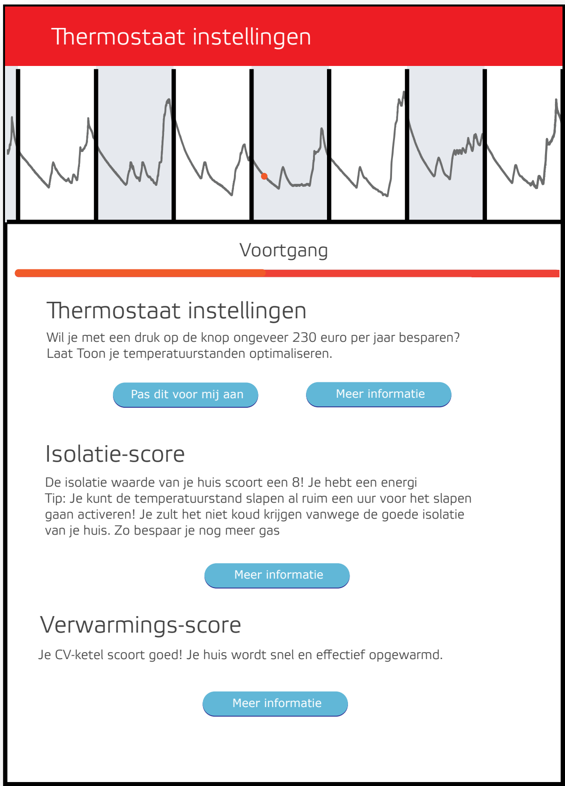


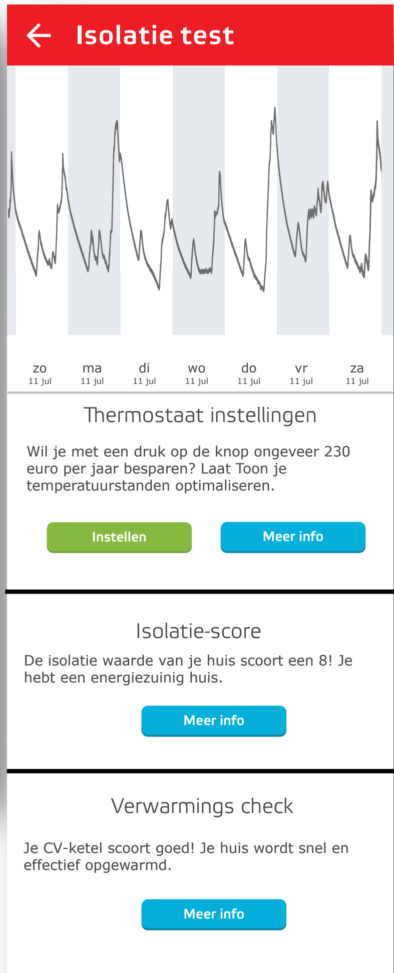
Appendix 16 - Low-fidelity interface sketches

Some of the low-fidelity sketches that were made during the design of the UI.

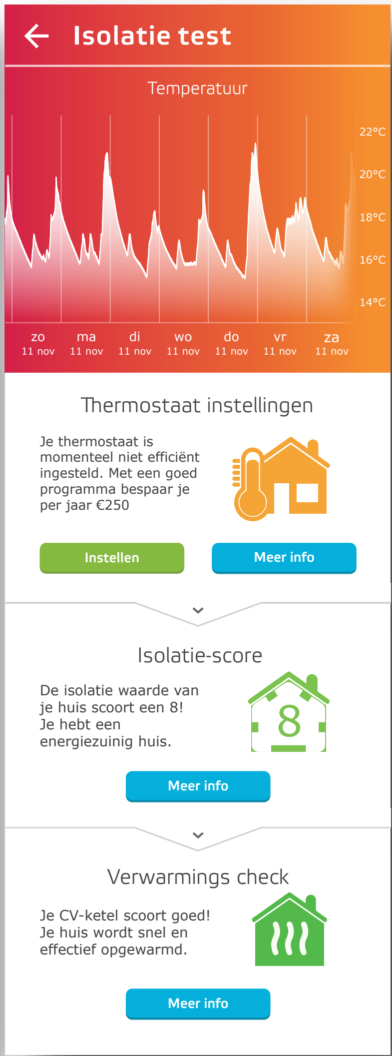


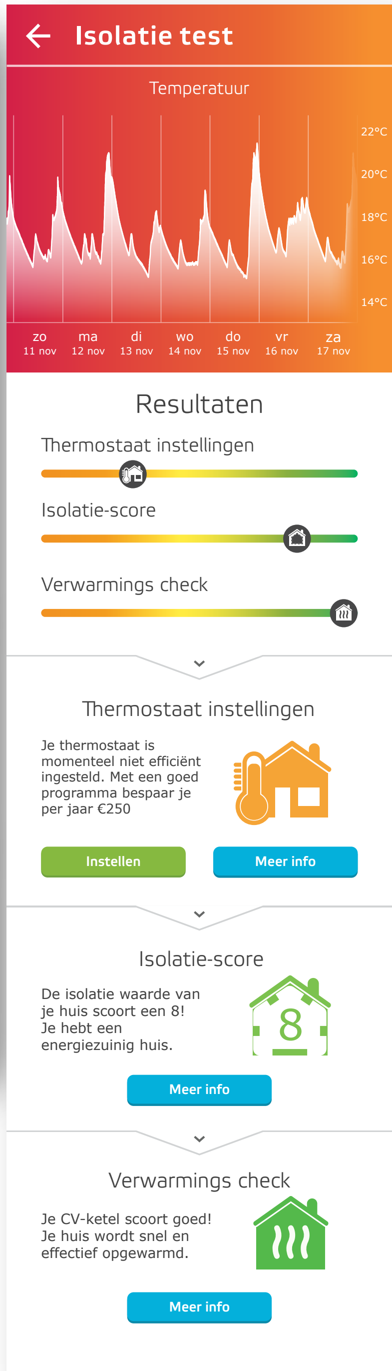
Appendix 17 - UI development process






Isolatie test
zo ma di wo do vr za
11 jul
Thermostaat instellingen
Wil je met een druk op de knop ongeveer 230 euro per jaar besparen? Laat Toon je temperatuurstanden optimaliseren.
Instellen
Meer info
Isolatie-score
De isolatie waarde van je huis scoort een 8! Je hebt een energiezuinig huis.
8
Meer info
Verwarmings check
Je CV-ketel scoort goed! Je huis wordt snel en effectief opgewarmd.
Meer info

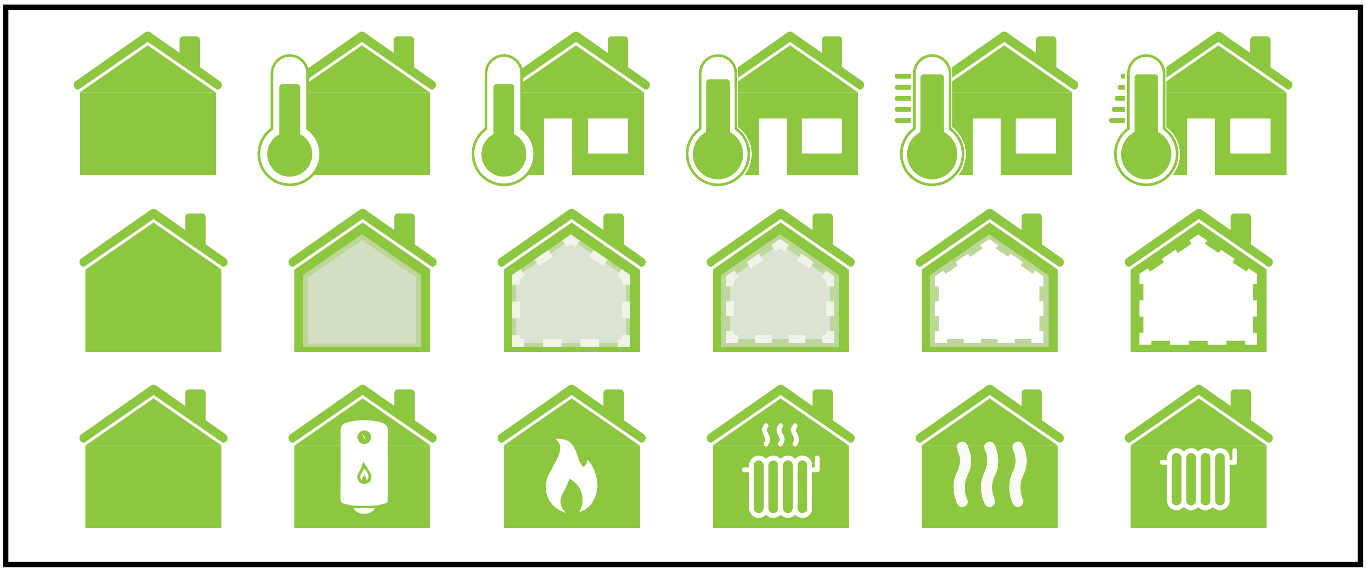

Isolatie test
Temperatuur
22°C
20°C
18°C
16°C
14°C
zo ma di wo do vr za
11 nov
Thermostaat instellingen
Je thermostaat is momenteel niet efficiënt ingesteld. Met een goed programma bespaar je per jaar €250
Instellen
Meer info
Isolatie-score
De isolatie waarde van je huis scoort een 8! Je hebt een energiezuinig huis.
8
Meer info
Verwarmings check
Je CV-ketel scoort goed! Je huis wordt snel en effectief opgewarmd.
Meer info


Isolatie test
Temperatuur
22°C
20°C
18°C
16°C
14°C
zo 11 nov
ma 12 nov
di 13 nov
wo 14 nov
do 15 nov
vr 16 nov
za 17 nov
Resultaten
Thermostaat instellingen
Isolatie-score
Verwarmings check
Thermostaat instellingen
Je thermostaat is momenteel niet efficiënt ingesteld. Met een goed programma bespaar je per jaar €250
Instellen
Meer info
Isolatie-score
De isolatie waarde van je huis scoort een 8! Je hebt een energiezuinig huis.
8
Meer info
Verwarmings check
Je CV-ketel scoort goed! Je huis wordt snel en effectief opgewarmd.
Meer info

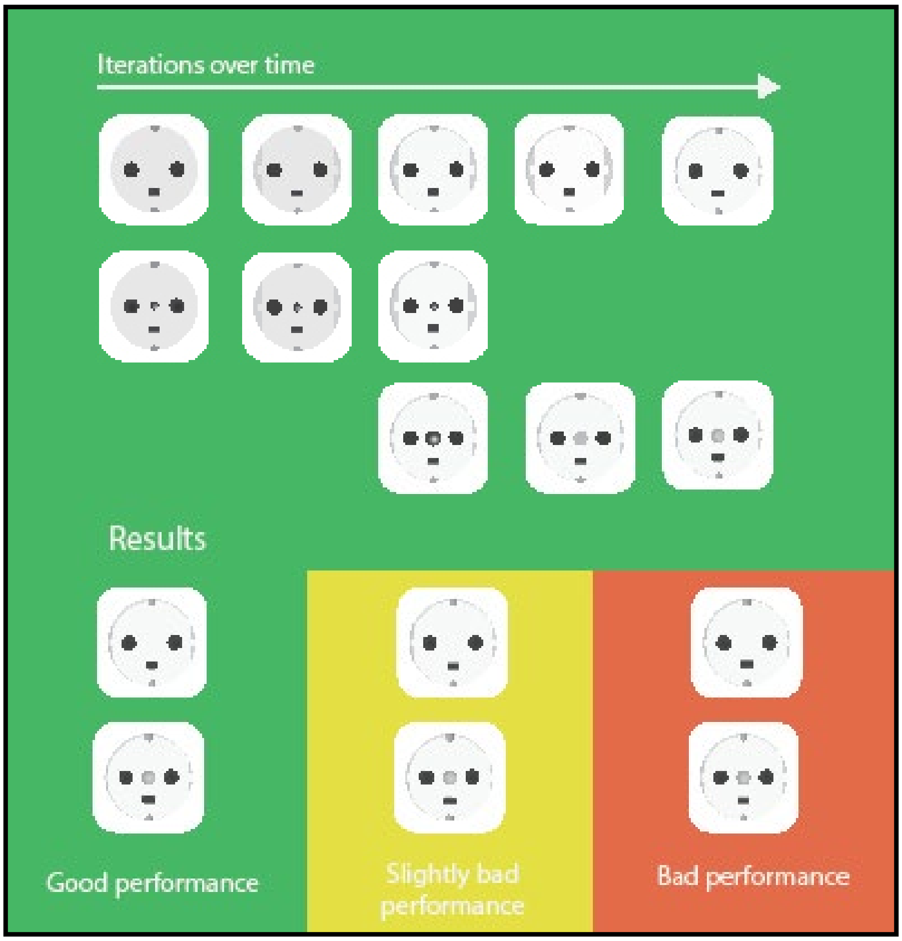
Appendix 18 - UI high-fidelity development

This appendix shows the design process of some visual elements for the high fidelity UI's.

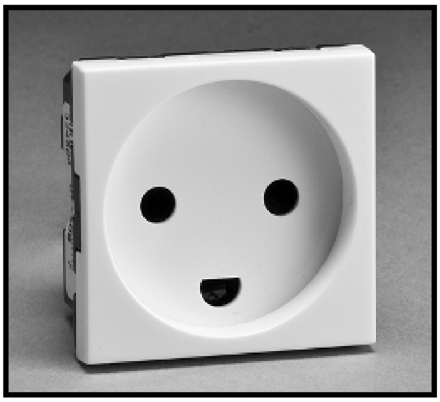
Insulation and efficiency check - icon design process



The design process of the smiling power socket

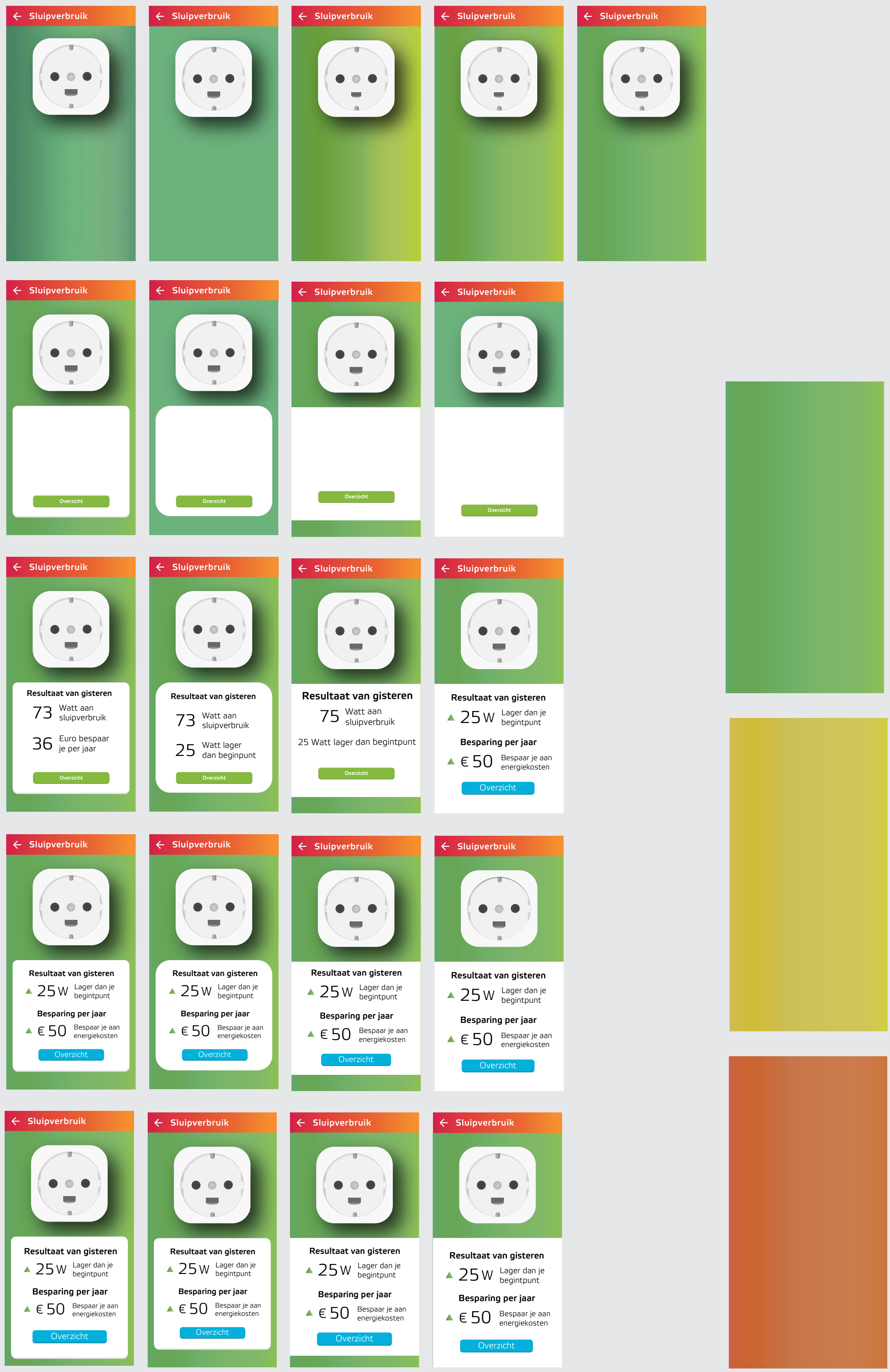


Inspiration:
Danish power socket



Dutch power socket

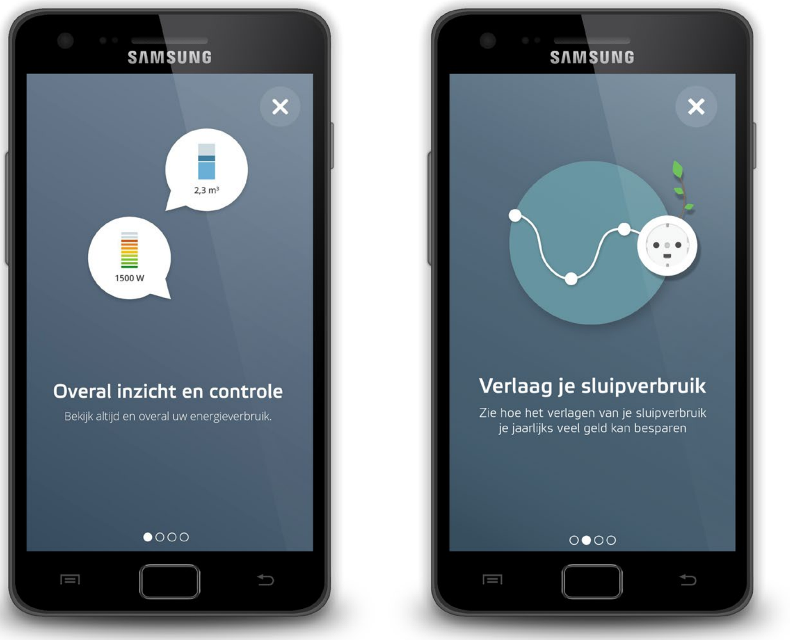
Step by step creation of the high-fidelity UI in Adobe Illustrator



Appendix 19 - App implementation

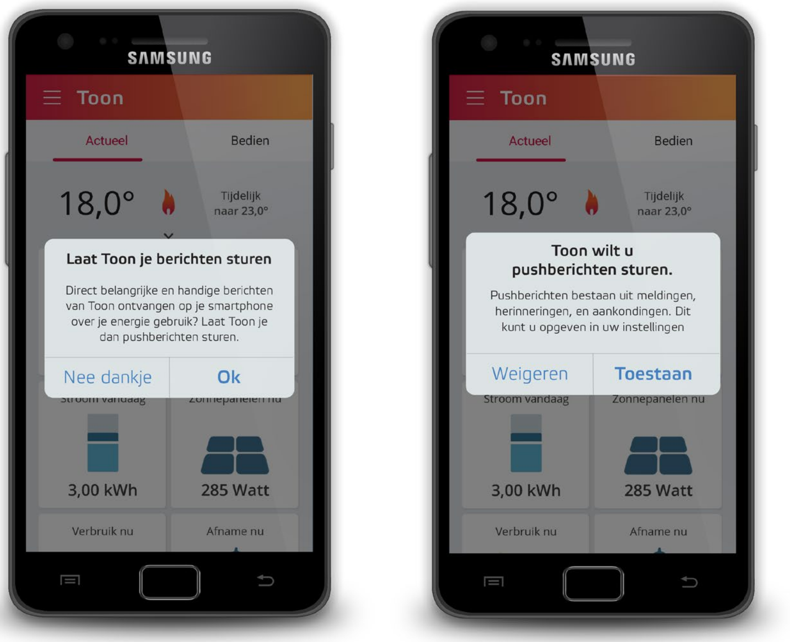
This appendix highlights some of the interface elements that do not necessarily belong to one of the features, but rather on the existing Toon app.

Showcasing the new feature (right)



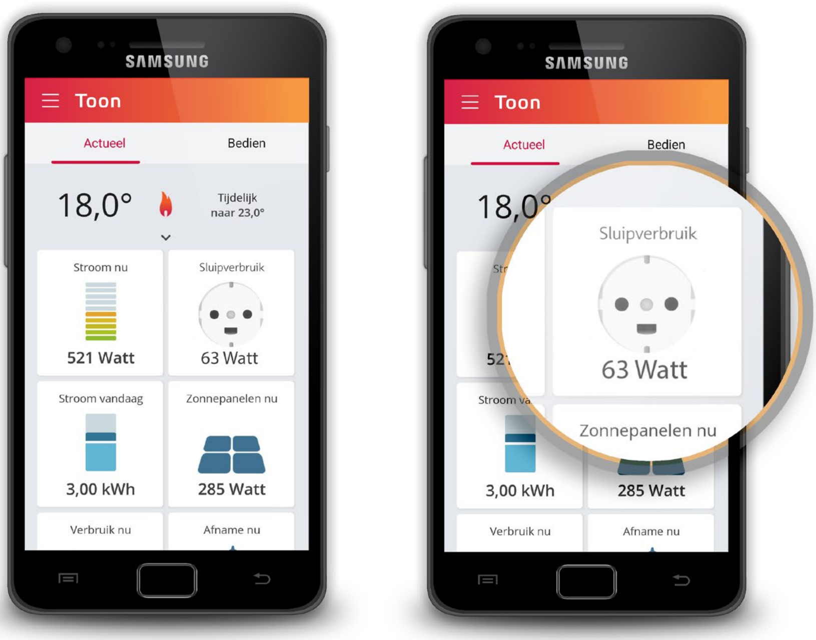
Left: a Guide-page from the existing app which explains a feature.
Right: a design for a new Guide-page explaining the new ‘standby energy usage’ feature.

New proposal for push notifications



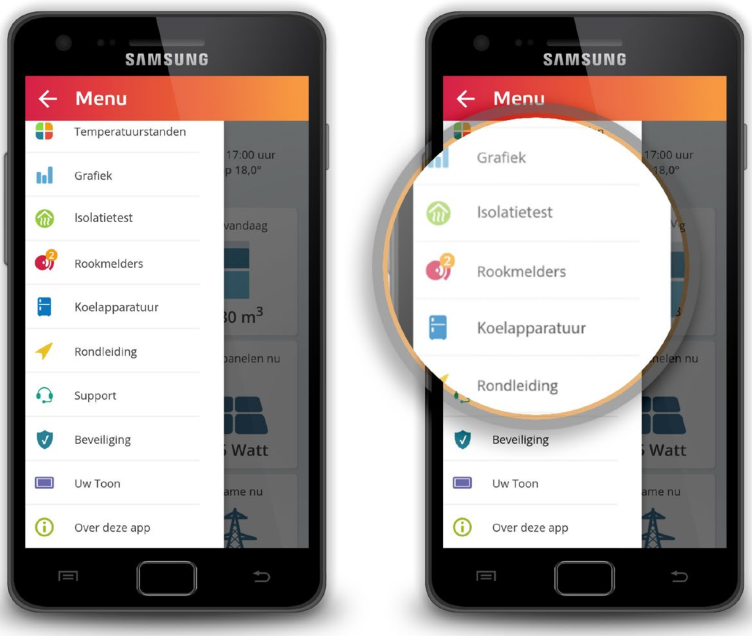
A proposal of how the user can be asked for permission to send push-notifications in the new version of the app. Prior to asking permission, the user is given an explanation of the benefits of allowing these notifications to be send.

Menu locations I



An UI-mockup of how the ‘standby energy usage’ feature can be integrated within the main menu. The power socket icon was used for the tile as well.

Menu locations II

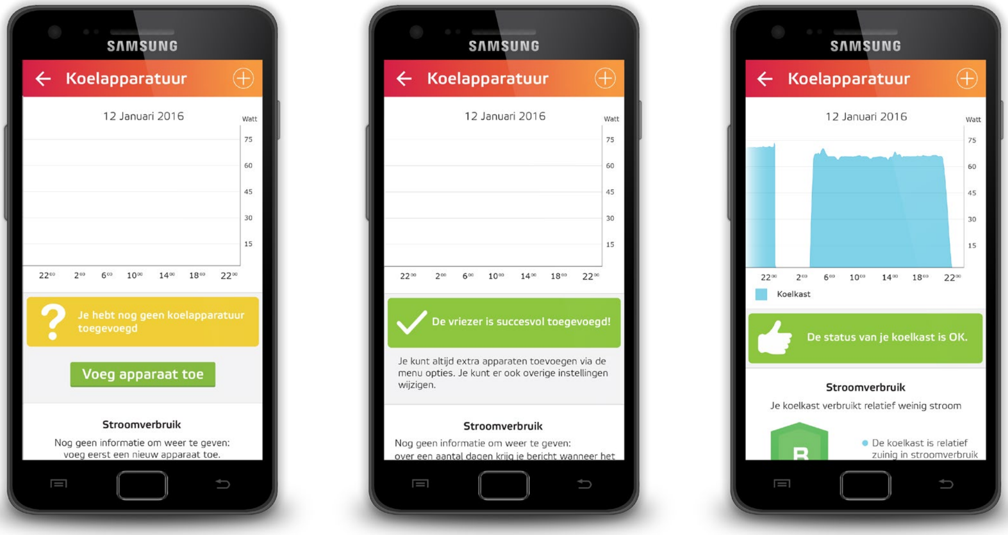


An UI-mockup of how the ‘cooling appliance check’ and ‘insulation and efficiency check’ features can be integrated within the side-menu of the existing app.

Appendix 20 - Cooling appliance check UI

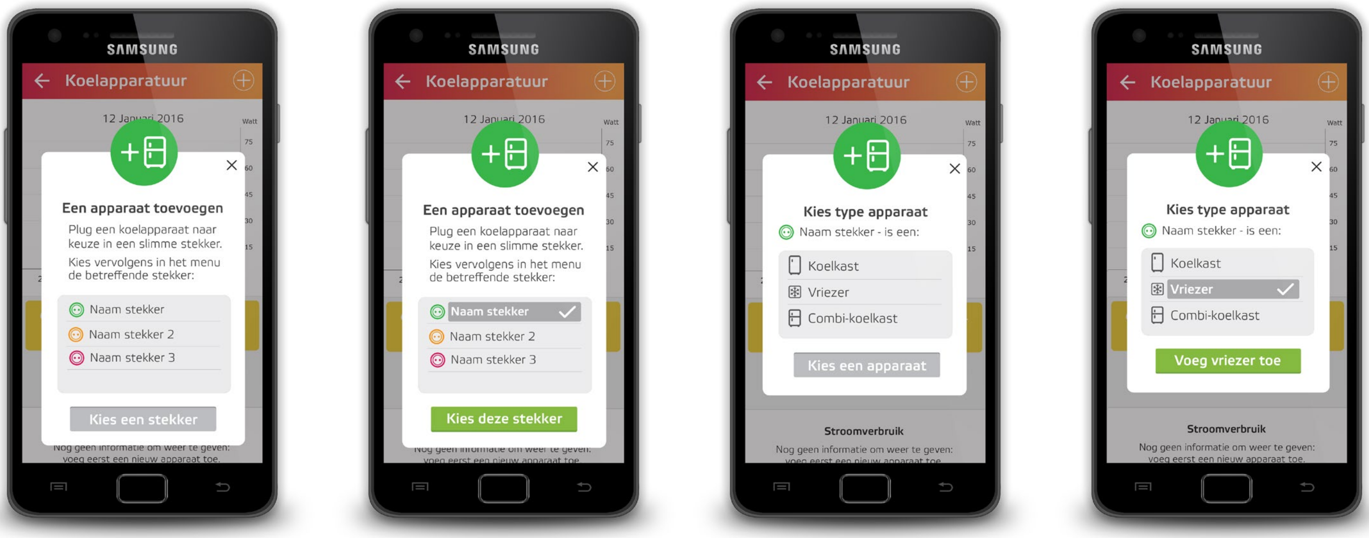
A more detailed overview of the cooling appliance check feature.

No device | **Device added** | **Data displayed**



From left to right are the three different phases of the UI-displayed:
No device added, device added (no data yet), device added (data displayed)

Select plug | **Confirm plug** | **Select device** | **Confirm device**



The 2 step process of adding a new device. To prevent confusion, users can only continue to the next part of the UI, once a selection has been made.

Information displayed - good results

In the plot, the consumption data of the cooling appliances is shown. Below, more information can be found on the status of the appliances and how energy efficient they are.

Information displayed - bad results

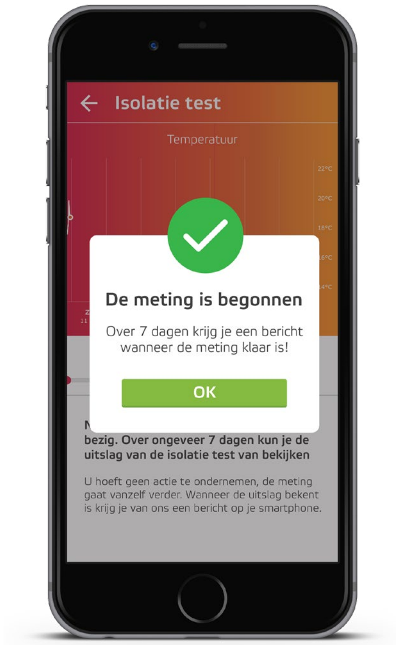
For the bad result; the user is also given troubleshooting information to improve the energy consumption of the cooling device.

Appendix 21 - insulation and efficiency check UI

A more detailed overview of the insulation and efficiency check UI. Both the start of the test, the measurement phase and the displaying of results is presented in more detail.

1. Starting the test

test not started



test started

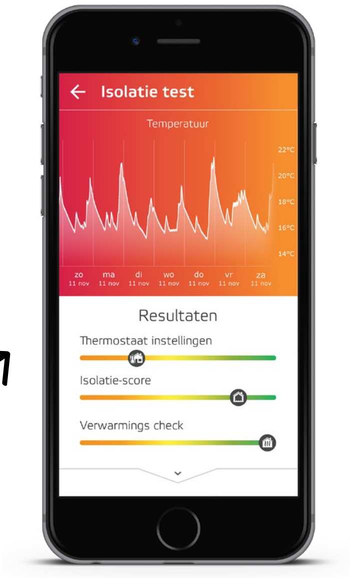
2. Waiting for results

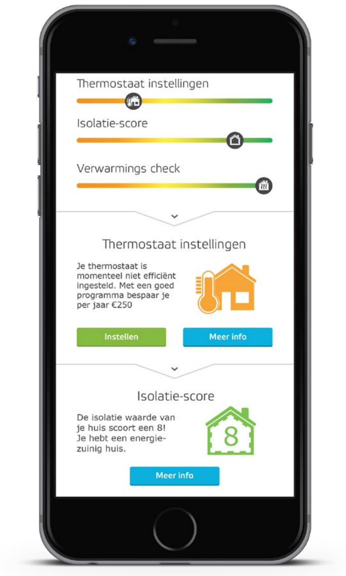
test in progress

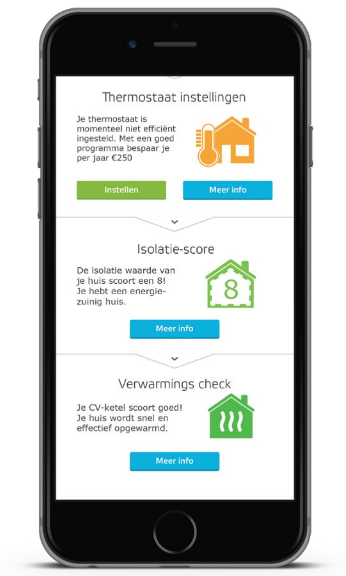
test complete

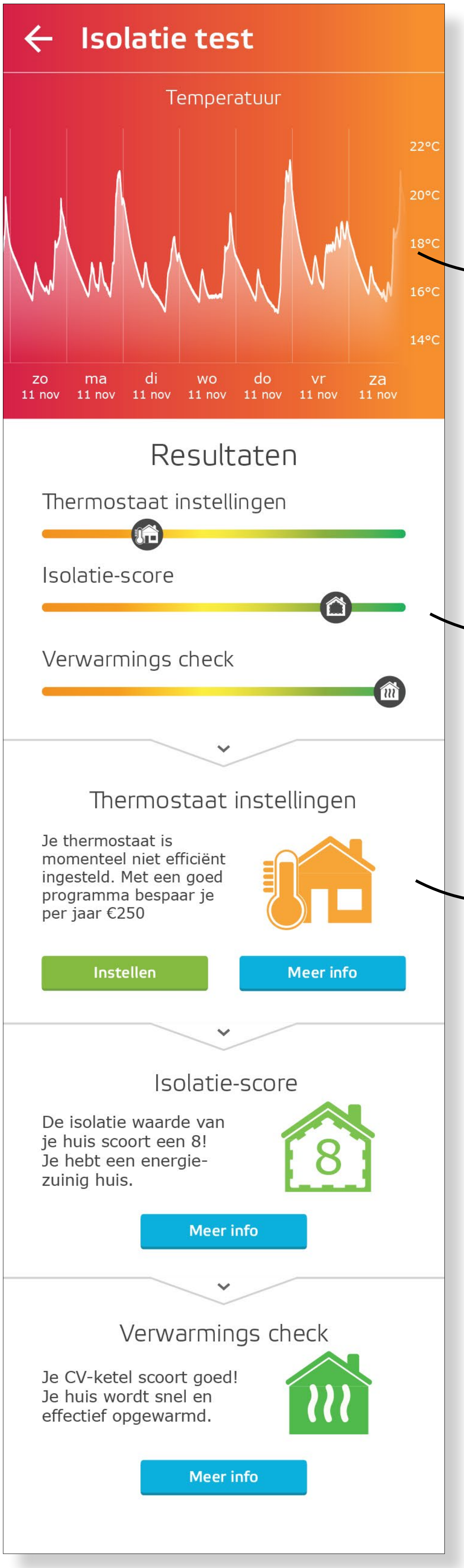
results obtained

3. Viewing the result







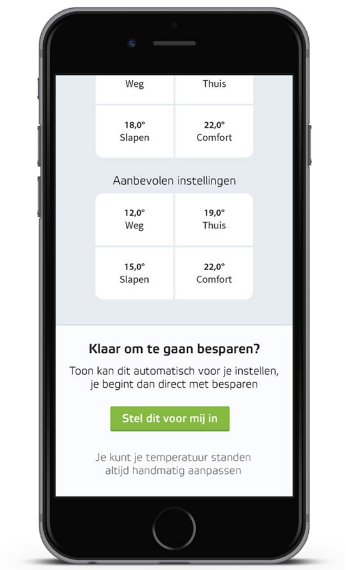


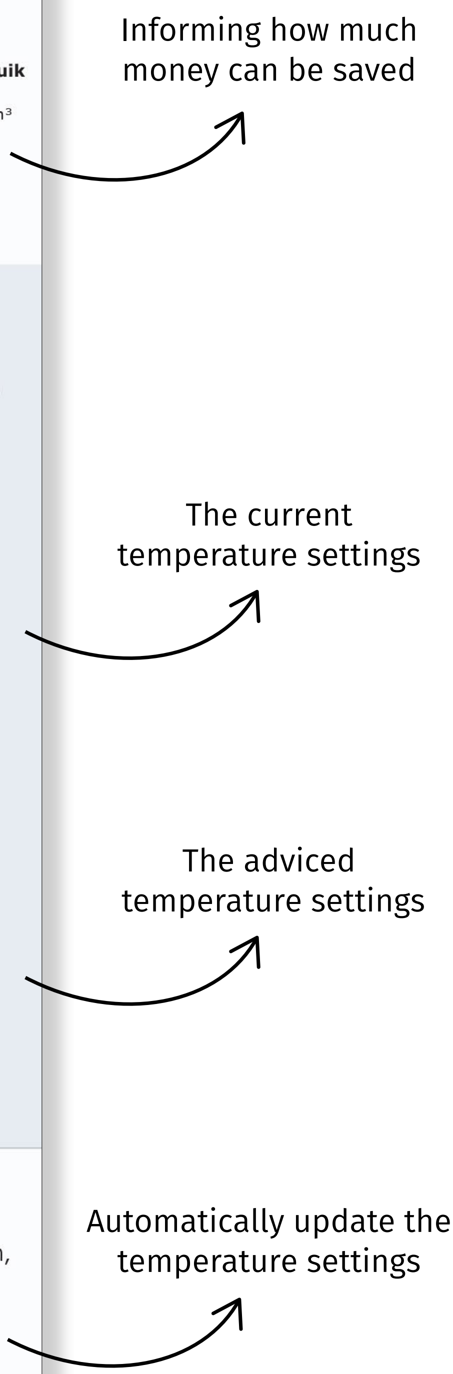
A plot of the data

Summary of results

Result in more detail

4. Consulting the advice





Appendix 23 - UI review

This appendix contains a summary of how the principles from the used UI guidelines were applied within the design of the UI. For both of the guidelines, a separate guideline was made. Although the UI has yet to be tested with users, some recommendations can already be made using these guidelines. Were applicable, they were included.

Nielsen and Molich's UI design guidelines [57].

Rule of thumb	How is this rule applied	Is this rule currently violated?	How can this rule further improve usability, utility and desirability
1. visibility of system status	In the 'home insulation and efficiency check', users can keep track the status of their measurement through the status bar. In the 'Cooling appliance check' users can see in the overview if their appliance is added. After it is added, they can see the status of their cooling appliance in the banner.		Currently there is no summarizing overview of what the current features and Toon in general is going. This might a suggestion for a next development step.
2. Match between system and the real world	In the 'Home insulation and efficiency check', A bond between the real and system world is created with the temperature tiles. These tiles are similar to the ones found on their actual Toon.		
3. User control and freedom	Users are always able to move back through the different menu's	Users are not able to stop certain features in the current UI	Allowing users to stop certain features when they wish. this is currently not the case for the 'Home insulation and efficiency check' and the 'standby usage check' would be an improvement
4. Consistency and standards	The UI was designed in such way that it resembles the design of the already existing app-UI		
5. Error prevention	The UI flow is done in such way that users are not likely to make an error. Should they make an error, then the actions are reversible with the press of a button: at the temperature change settings in the 'Home insulation and efficiency check' for example.	Errors that are not prevented can be identified with usability testing.	
6. Recognition rather than recall	The UI was designed in such way that it resembles the design of the already existing app-UI. And the users own temperature tiles are also visible when comparing them to the advised temperature settings in the UI of the 'Home insulation and efficiency check'		
7. Flexibility and efficiency of use	Flexibility: this was done similar to how the current App when it comes to the structure of the navigation. Efficiency: shortcuts are added where possible. Either to reduce the amount of manual input required, or to reduce the amount of actions required to fullfil a task.		
8. Aesthetic and minimalistic design	The design of the app was done similar to how the existing app is designed. Graphic features within the app surve a specific purpose.		
9. Help users recognize and recover from errors	When an user makes a decision they are able to revert it: either the buttons becomes and 'undo-button', or there is a back button present in the top left corner.		
10. Help and documentation	Help: some help is included in the description of actions. Other than that, this was not yet included in the UI. Documentation: this was not included so far in the design of the UI	Due to incompleteness, documentation or troubleshooting is not yet added to the UI	Once flaws are detected in the usability testing, or during functional tests in the beta, help and documentation can be added (tooltips were mistakes are made often for example).

Shneidermann's "Eight rules of interface design" [56].

Principle	How it is applied
Strive for consistency	To maintain consistency within the design of the UI, the UI of the existing app was studied. Based on how the current interface handles action and presents information, the new features were designed as well.
Enable shortcuts for frequent users	It was estimated that the 'standby energy usage' feature would be used more often than the other two features. Therefore it was placed in the main menu of the application so it can be accessed faster. Other than that, most of the features and functionalities will not be used frequently.
Offer informative feedback	All the text and visual elements in the UI serves an informative purpose. Explanations and informative feedback are offered through text. Visual elements are used to enhance the feedback.
Design dialogue to yield closure	The dialogue with the user is held in such way that it is to the point and the choices/actions the users has to take are discussed.
offer simple error handling	Error handling is not yet included within the design of the UI, with 1 exception; The cooling appliance check gives troubleshooting information should the data indicate that something is not right.
Permit easy reversal of actions	Users are able to go one step back in the interface by using the X or the arrow mark in the top left corner. If the action implies a new configuration, they are able to reverse them with a 'reverse' button; Should users configure new temperature settings by accident, or want to change it due to a change of mind, they can always reverse them with the same button. The button changes itself to a reversal button once it is pressed.
Support internal locus of control	Users remain in control as they are always able to navigate freely through the application. Before the application will update specific settings or needs extra permissions, the user will be an acceptance dialog first.
Reduce short-term memory load	When setting the system up, the user only has to perform one small step at a time. Each step gives feedback on what should be done at the time that the user needs it.