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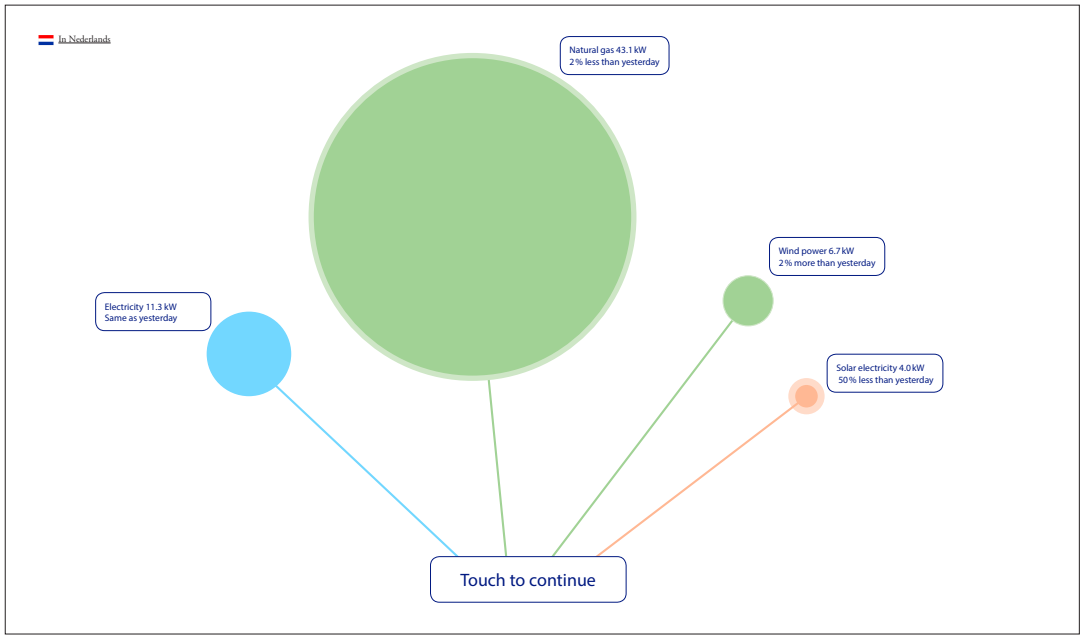

Development of an energy visualisation tool for commercial buildings

Master of Science Thesis in Industrial Design Engineering

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Cover:
The visualisation shows the front screen of the software meant for
a public energy display in commercial buildings, see pages 43–50.

Chalmers Reproservice
Gothenburg, Sweden 2012

Abstract.

The EnergyMirror from Priva is a product for visualisation of energy flows in commercial buildings, such as electricity and gas consumption, as well as wind and solar power production. The product is in need for revision and the goal of the project is to create a realisable product concept for the new version, which can support organisations to reach their environmental goals and help them express their environmental work and ambitions.

The target group and needs of the customer have been redefined by conducting interviews with important stakeholders: in-house market managers, a partner, a branch office and a customer. The analysis from the interviews concludes that organisations want to show the impact of an investment for increased energy efficiency and create awareness about energy among their occupants. Furthermore, ways to make energy data more interesting and graspable have been explored.

The result is a hardware independent software solution made for touch screens. The concept has a modular base, possible to tailor for each organisation. It contains elements for quick visual comparison of energy, and an interactive interface so the users can discover more information according to their own interests.

Preface.

This report presents a master's thesis project of 30 ECTS, comparable to 20 weeks of work. It was carried out during the spring 2012 in cooperation with Priva BV, located in De Lier, the Netherlands. The thesis is the final part of the studies at the Masters of Science programme in Industrial Design Engineering at Chalmers University of Technology, Gothenburg, Sweden.

I would like to thank my examiner Dr. Pontus Engelbrektsson, and academic supervisor Ph.D. student Anneli Selvefors—both at the Department of Product and Production Development, Division of Design and Human Factors—for their flexibility and great support during the project.

Thanks also to Karin Ljungberg and Josefin Sohl, who served as opponents to my work.

Last but not least I would like to thank Judith van Zanten, design manager, and Christian Klep, product manager, at Priva, who have supported and helped me during the project.

Throughout the project I have talked to many people, read a lot, and reflected over and about energy and the environment. One quote that I discovered during my endeavours stayed in my mind, I would like to share with you. If it is the only thing that stays with you after reading this report, is it at least something:

> *"If all the insects were to disappear from the Earth, within fifty years all life on Earth would end. If all human beings disappeared from the Earth, within fifty years all forms of life would flourish."*
>
> *—Jonas Salk*

Henrik Enkel Larsson
Amsterdam, June 2012.

Table of Content.

1 Introduction.

1.1 Background.

Organisations are more and more concerned about the environment, and want to act in a sustainable way and be perceived as working for a sustainable future. One step in the right direction is to have an energy efficient climate solution for the office buildings, and combine it with renewable energy sources as sun and wind power.

Energy flows
is defined in this report as flows of water, natural gas, heat, and electricity, and can be both produced as consumed energy.

This project has been carried out in collaboration with Priva, which is a Dutch privately owned company that develops and supplies sustainable solutions for automated climate control within built environment and horticulture.

A sustainable climate solution for commercial real estate is nothing that is visual for the occupants or visitors of the building,as it is hidden in the construction. This can be seen as a disadvantage both for Priva, as for the organisation where it is installed. For this reason Priva developed a so-called EnergyMirror, a public energy monitor, which is a tool to show visitors and occupants the impact of the climate installation in an organisation's building. This monitor shows the energy flows in the building, and translates it to tangible measures for comparison. It is supposed to create awareness about energy.

Figure 1. The Priva campus in De Lier, the Netherlands.

1.2 Purpose.

The competition in the market concerning energy monitoring is increasing rapidly; to stay ahead and attract new customers Priva needs to improve its existing EnergyMirror.

The purpose with the project is to define the direction of development of the next version of the EnergyMirror, which aims for organisations that have a clear sustainability policy.

For Priva the purpose with the product is also to increase their position in the use-phase of climate solutions, partly to increase the strength of their brand.

1.3 Goal.

The goal is to create a realisable product concept of a new version of the EnergyMirror, which should be attractive and express high quality. The project should define how the product could engage the occupants to reduce their organisation's energy and water consumption. As important is to find how the product can support an organisation in reaching their environmental goals and how to express their environmental work and ambitions. The product should also make use of Priva's automation installation and make it—and Priva—a visual part of the building. With further development by Priva, the new EnergyMirror should be released on the market 2014.

Summarised, the goal is to develop a product concept that should:

» be ready for the market in 2014

» express organisations' environmental ambitions

» help organisations to reach their environmental goals

» make Priva a visual part of the building.

1.4 Delimitations.

Due to the limited time and focus on the exploration phase no detailed construction drawings, calculations or detailed interface design will be made, nor any detailed investigations of the product's manufacturability.

2 Method.

In the first section of this chapter the project process will be described. The theory behind the methods is explained in the second section.

2.1 Project process.

Planning.

In the initial phase of the project, the scope and deliverables of the project was discussed with the supervisors at Priva. Which parts that should be focused on and which resources available were also discussed. With this information in mind, the project was planned and structured using a Gantt-chart. The chart was detailed on day-level. This to easier estimate the time required for the different phases, and balance them against the goal of the project.

During the project the initial planning was continually revised with help of linked Gantt-chart. This to keep track of which parts could be adjusted so the project would comply with the time frame.

Data collection.

Except continual discussions with the product manager at Priva, to further understand the project and the product, unstructured interviews with other internal stakeholders were carried out. In total, four half an hour interviews with the Segment Manager, the Manager Marketing, the Chief Operating Officer and a Business Developer were conducted. Notes were taken during the interviews.

With the internal interviews as a foundation, the the data collection was done through literature research and unstructured group interviews with one of the existing customers, a Priva partner and a branch office in Germany. The interviews were carried out to map the customer needs and wishes, and to create an understanding of the role of the existing EnergyMirror. The literature studied was both internal documents about the product market as well as state of the art within energy monitoring and energy conservation in commercial buildings. The interviews were voice recorded and the relevant statements or questions were transcribed. Furthermore, I visited the exhibition known as VSK, held every second year in Utrecht, to find inspiration as well as collecting information for benchmarking, which was further done by visiting companies websites and contact them via email for more detailed information and pricing.

The existing EnergyMirror was studied both by observing a handful first time users when they were spontaneously introduced to the product, as well as doing empirical studies of the interface myself. Moreover, internal documents describing the product, as well as a data log of the product use, were examined.

VSK

is a fair for heating, sanitatry, air conditioning and cooling technology (Verwarming, Sanitair, Klimaatbeheersing en Koudetechniek). Many of the large competitors to Priva are present at the fair and presents their latest technology.

Besides that, I visited twelve larger organisations in Amsterdam, to create a picture of their lobbies and public area, among them were Philips, Akzo Nobel and Hotel Amstel. Photos were made when it was possible, and used as inspiration for the idea generation.

Many ideas came up during the data collection, both from external as well as internal sources. All ideas were written down and collected, and used as inspiration for the concept generation.

Figure 2. Observations at organisations. Here, a presentation wall at Philips, how can a public energy monitor suit this entrance hall?

Data analysis.

The interviews with the internal stakeholders were summarised into a product strategy document.

The information from the competing products was formed into a summarising benchmarking table and conclusions were drawn.

The interviews with the external stakeholders were analysed using the KJ-method, where each relevant statement or question were printed on a separate piece of paper. Problem areas were possible to identify and summarise.

The internal documents describing the original target group together with the analysis from the interviews made it possible to redefine the target group for this project. Basically the original target group description was extensive and formed a base, where needs could be added and removed based on the new input.

Two scenarios were created after the analysis phase. The scenarios were developed to represent two future customers, hence, elements used when creating a persona were brought in.

Figure 3. Wall of ideas collected during the project.

Idea generation.

As an experiment, social media was used to create input to the project. More than three hundred people were invited to an event called *The amazing creativity challenge* using Facebook. There was a short description of the idea with the event and a link to a more detailed description of the creativity challenge:

What would make you interact and get inspired by a public energy monitor on a regular basis? And in that way create awareness about energy.

The invitees where asked to send their ideas and thoughts via any means, as email, Facebook, phone and others. See appendix 1 for the complete description. Twelve people accepted the invite to the event and three actually responded, of which two actually did not officially accept the invite.

I facilitated two workshops of one hour each. For the first workshop twelve Priva employees from different fields—somehow involved in the product—were invited, and all came. After a short introduction, the brainstorming started and continued around the topic:

What would make you interact and get inspired by a public energy monitor on a regular basis?

The focus was on the occupants of the building. All ideas were written down so everyone could see them.

For the second workshop six Industrial design engineering students participated. The purpose of the workshop was introduced including a short description of the project and what types of energy flows can be measured. The brainstorming started around the theme: *how to visualise energy.* All ideas were written down so the participants had an overview. In the second half brainwriting with the three plus method was used to sketch ideas on the same theme. After the session the participants were asked to present the most interesting ideas. The sketches were collected and used for inspiration in the concept development phase. Focus for this second workshop was only the visitors of a building.

Figure 4. Reversed morphological matrix work in progress.

The ideas from the workshops were categorised using the KJ-method, and the result was used both to generate concepts as well as defining needs for the two user-groups: occupants and visitors.

Concept generation phase 1.

In the first phase, ideas of how the product can look and where it can be placed were generated and sketched. The brief concepts were evaluated with a traffic-light matrix. This resulted in four basic concepts to proceed with, describing the shape and context of the product.

Concept generation phase 2.

The four concepts were further developed and defined using a modified, or reversed, version of the morphological matrix method: Instead of writing the features—or partial functions—in a matrix, the features were written on post-it notes, and attached to the best-suited basic concept. In this way the concepts were possible to distinguish from each other, and many different features were possible to integrate and present. During this process it was also necessary to split one concept that was merged in the first concept generation phase, which resulted in a total of five concepts.

Midterm presentation and concept selection at Priva.

The concepts were presented for Priva. In total eleven representatives from different departments at Priva were present during the presentation, discussion and voting. The presentation contained important findings from the research and of course the presentation of the five concepts. After the presentation the concepts were discussed, and later a voting took place. The eleven participants could give two votes, but where not allowed to put more than one vote per concept.

The goal with the breadth of the concept range in the concept generation phase was to be able to discuss many possible ideas at the presentation, which later could be integrated into one final concept. In this way it was also possible to steer the group to discuss the basic idea with the concepts, and not new possible and different solutions.

For a just evaluation, the concepts were presented in the same way, and it was important that the concepts would appear as equally developed.

After the session a meeting with the product manager and the design manager was held to discuss the result from the voting and decide which concept to proceed with.

Further development and design.

After the concept was chosen, it was further defined with possible features to implement, derived from the previous idea generation. Each feature suitable for the selected concept was considered and judged if it should be implemented; based on the needs, requirements and definition of the concept. The two scenarios were also used as support for the decision-making and the design process.

Moreover, the software architecture, the hardware and the possibilities were discussed with the Chief Architect and the Hardware Innovator at Priva.

The ideas of how each function and feature should be represented were first separately designed by simple sketches on paper. When all functions were clear, they were merged into a possible layout and processed into a final graphical layout made in Adobe InDesign. Some icons were taken from the existing EnergyMirror, and a few new were developed as well.

User tests.

To assess the result of the final concept user tests were carried out. The eight participants were Priva employees invited to evaluate the design of the new version of the EnergyMirror, and the test was said to take 15 minutes. All of them knew what the existing EnergyMirror is about, but the level of experience of the product varied from none to the actual product manager. The majority of the participants were engineers, and since they are working with products that have to do with climate and energy, they can be seen as having domain knowledge higher than the average user. It was six men and two women.

Before the test, the participant was given a short introduction to the test and what they could expect. If there were no questions, the scenario was introduced and the test procedure could start. For the full description of the procedure, see appendix 2.

For the test, eight slides with the suggested layout of the user-interface were presented on a normal 23-inch computer screen. The presentation was made clickable, but only in such way that a click on the correct button or icon leads to the next slide.

The user were asked to explore in the two first steps and were given oral instructions of what to do in the following steps, since there were only one correct way to go. The interaction was done via a regular computer mouse. The tests were voice recorded and the participants were asked to think out loud.

The test was followed by a questionnaire about emotions and regarding the product semantics. The scale about emotions evoked was in six steps and based on Plutchik's (2001) eight basic emotions. The semantic scale was in five steps and the expressions are based on the questionnaire used in Karlsson (2007b), with some minor adjustments. See appendix 2 for the complete questionnaire. During the second test, *inviting* was added to scale.

The participants were asked to explain their answers in the questionnaire, to assess the reason behind and which parts added to their rating. Furthermore were two interview questions asked: if they reflected over the colours, and if the product was easy to understand. The latter to stimulate a discussion about the participants' thoughts about the product and its interface. Moreover, notes were taken to register where the participants clicked if it was not according to the plan, and the voice recording was used as confirmation.

2.2 Methods.

In this section the theory behind the specific methods used in the project will be briefly explained. The methods are presented in alphabetic order.

Benchmarking.

Benchmarking is a according to Ulrich & Eppinger (2011) a method to find, visualise and become familiar with competing products in order to find weaknesses and strengths, know how to position the new product and also to evaluate a new product concept. The benchmarking is done by collecting and structuring information about products with similar functions. Moreover, the research can give inspiration to new ideas.

Brainstorming.

The basic idea with brainstorming according to Michalko (2006) is to facilitate idea generation and take advantage of a group's collective competence by not allowing judgment of ideas and in that way create a large amount of ideas, which in turn stimulates more ideas. Normally a group of 6–12 people brainstorm around one topic, and one person records the ideas so everyone can see them.

Brainwriting, the three plus method.

The basic idea is to sketch the ideas instead of saying them out loud, this ensures that the loudest voice do not prevail and prevent social loafing and production blocking. For the three plus method, in Michalko (2006), each participant writes down three ideas separated on a piece of paper. After approximately five minutes the ideas are passed to the neighbour, who continues to develop the ideas or sketch new ideas for another five minutes. The session continues until the participants get their first sheets back.

Gantt chart.

A Gantt chart is according to Johannesson *et al.* (2004) a simple method to visualise time requirement, and start and end of main tasks. A more developed version of the method is the linked Gantt chart, often used in computer software where follow-up, adjustments and control of the project is possible.

For this project a computer software was used. It is called Merlin 2 and developed by ProjectWizards, found at www.projectwizards.net.

Interviews and group interviews.

Interview is the most basic method to collect information about customers and users, about their needs, visions, opinions, et cetera. Interviews can be structured, semi-structured or unstructured. With structured interviews the interviewer has predefined questions, which gives little flexibility to follow-up questions and hence find user needs. A semi-structured interview is carried out with an interview guide, which is a help for the interviewer with some prepared and often open questions. The questions should be designed as a funnel, with easy questions at first and increased difficulty and depth in the end. (Karlsson, 2007a)

KJ-analysis.

A KJ-analysis is a method to structure, categorise and visualise large amounts of verbal data, according to Karlsson (2007a). The method is based on a bottom-up technic, where each statement or idea is written on a separate piece of paper and then placed on a wall or a big piece of paper. If a statement is related to the one of the previous statements they are grouped, otherwise a new category is created. In the end the different stacks are grouped into themes and then named.

Morphological matrix.

A morphological matrix is a method to generate concepts of a number of partial solutions, and described by Johannesson *et al.* (2004). Each partial function needed to comply with the requirements is listed in a table together with the corresponding partial solutions. By selecting one of each partial solution a concept or total-solution is generated.

Persona.

A persona is a made up user character and intended user of the product, or the future product. Often are several personas developed with differentiated and exaggerated characteristics, and not the typical average user. The short description of the persona contains information as name and age, but also hobbies and their relation to the product or other relevant information. (Karlsson, 2007a)

Scenario.

A scenario is a made up future use situation. If the scenario is based on the data that has been collected and analysed it can be used to describe and communicate the goal with a product development and how the product can be seen in use in the future. (Karlsson, 2007a)

Traffic-light matrix.

The traffic-light matrix is a procedure to quickly evaluate and sift out 3–5 concepts out of approximately 10–20 concepts in the first stage of a concept generation process. A selection of important criteria for a successful product is listed on one axis in a table, on the other axis the concepts are listed. Each concept is given green, yellow or red light for each criterion, corresponding to if it will fulfil the criterion without major problems, with much more work, or not at all, respectively. An overview of feasible concepts is created. Red light means that the concept is eliminated, and the amount of green respectively yellow lights creates a base for discussion. Furthermore, it gives an indication of what should be prioritised in the next stage of development. An example of the use of the procedure can be seen in Enkel Larsson *et al.* (2009).

User tests.

A user test is a method to evaluate the usability of a product or a product concept together with the intended users, in other words to collect information about how the users interact and understand the product. The test is carried out by giving the test-user a number of predefined tasks to perform on a prototype or a model of the product. Karlsson (2007a) distinguishes concept test and prototype test, where the first is carried out in an earlier stage in the process to verify if it is the right direction to go. A prototype test is a user test when the product in principle is finished.

When performing the user tests a think out load technic can be used to be able to understand what the users base their decisions on. To measure the usability a number of methods can be used, for instance count number of errors, or using a questionnaire to assess the perceived usability. (Jordan, 1998)

3 Theoretical framework.

This chapter provides information about Priva, the product and systems behind it, as well as the theory needed to create a new product concept that complies with the goals of the project.

3.1 About Priva.

Priva's business.

Priva started with climate control in greenhouses in the late fifties, and started within the building management sector in 1983. In their own words they describe themselves as following (Priva, 2012a):

Priva partners and branch offices.

Priva is a business to business company that sells through partner organisations. Outside the Netherlands Priva has branch offices to support the partners as well as market Priva in that region.

Our take on the world:

Priva provides sustainable solutions for the more efficient control of energy and water within indoor environments, as a means to conserve scarce resources and reduce our impact on the planet.

The reason we exist:

Priva is a world leader in developing and supplying sustainable technologies for the control of indoor environments within horticulture and the built environment.

Our solutions:

Together with local partner organisations, we offer our customers across the world access to high-quality hardware, software and services.

Priva's core values

Sustainability

Priva market themselves as a company who act for sustainability in all their operations. Priva help business and horticulture to reduce their energy consumption by providing horticulture process management and building control solutions.

Innovation

Priva believes in innovation stimulated by shared knowledge and therefore collaborate with universities, research institutes and business partners. A global and multi-disciplinary approach is needed to stimulate new ideas.

Everything revolves around people:

Priva believe that trusting in talent and allowing room for development brings out the best in people.

Think global, act local:

Priva think strategically about global opportunities and have branch offices in seven countries, and can hence offer local and tailored service to their customers.

3.2 Building energy management system and the EnergyMirror.

Building energy management system (BEMS).

One step towards achieving a high energy efficiency in a building is to have a so-called Building energy management system (BEMS). It is defined as the software, hardware, and services associated with the intelligent monitoring, management, and control of energy, specifically for reducing overall energy consumption and lowering energy costs, according to Pike Research (2012). However, these tools for monitoring and analysing the energy consumption are not designed to be used by the occupants and visitors of the building, and in many cases actually eliminate the users-control of for instance lights and temperature. According to Priva's segment manager (Kerdel, 2012), installation cost is increasing with increasing user-control in automated climate control systems. Hence, important to know is that these systems vary in level of automation and functionality.

BEMS, EMS and BMS.

In priniciple does the three terms refer to the same thing. Building energy management system, Energy management system and Building management system, respectively.

Priva TC Energy and the relation to the EnergyMirror.

The data from building energy management systems can be complicated to understand. TC Energy is a software tool from Priva that uses the data from the BEMS to support facility managers to optimize the energy usages in their building in a user-friendly way. TC Energy is a prerequisite to have an EnergyMirror. Therefore, the EnergyMirror does not need to provide any energy analyses, and should only focus on the occupants and visitors, and what they can do.

Simplified, data about the energy flows—necessary for a public energy monitor—comes from the BEMS via TC Energy, and the number and types of meters can be customized for the particular requirements for a specific building, see figure 5.

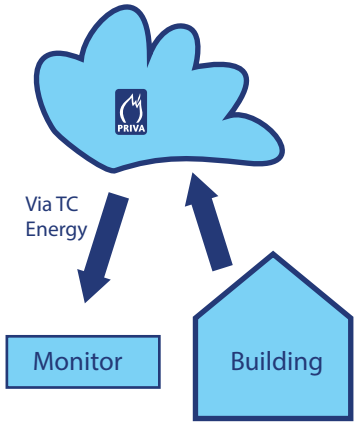

Figure 5. Energy flows from the building to the Priva server, and via TC Energy to the monitor.

The data visualised on the EnergyMirror is updated every 15 minutes, and the time interval is at the moment not possible to reduce, according to the product manager (Klep, 2012).

EnergyMirrors in use today.

There are six EnergyMirrors in use today, all of them in the Netherlands, where three are test or demo products at Priva's campuses. Two are installed at corporate organisations, Avantes and Pon, and one at Hogeschool Zuyd, which is a college in the south of the Netherlands.

Figure 6. The EnergyMirror at Hogeschool Zuyd.

The EnergyMirror and its user interface.

The glass front of the product measures 200×65 cm and behind is three different screens, run by one computer each. See figure 7. The interaction is done via the grey touch slider underneath the screens.

It is normally connected to Priva's server via a mobile 3G connection, since WLAN is not supported, and Ethernet not always possible.

The product has a standby-mode with reduced information and text, and larger animations. It is activated by proximity of people, detected by the built-in camera.

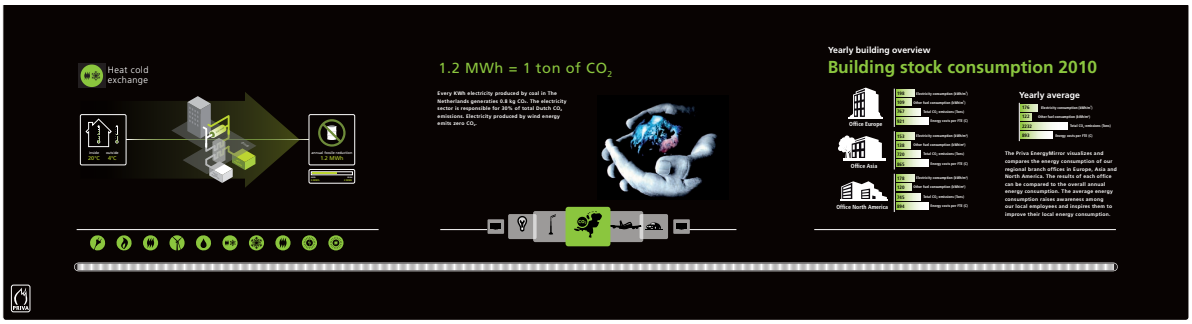

Figure 7. The EnergyMirror with its three screens. The one to the left shows the energy flows, the one in the middel the energy translated to different measures, and the one on the right shows some general information as time and weather.

Energy visualisations on the EnergyMirror:

- Electricity
- Gas
- Heat
- Wind
- Solar electricity (PV)
- Solar heat
- Thermal storage
- Water
- Combined heat and power (CHP)
- Eco water

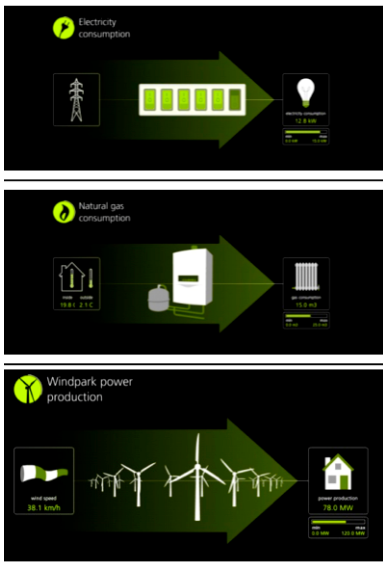

Figure 8. Example of graphics on the existing EnergyMirror, to illustrate energy flows. Top: Electricity. Middle: Natural gas. Below: Wind power.

The left screen shows a visualisation and actual consumption of one of the installed energy flows at the time, and is automatically rotating, but also possible to change by touching the slider underneath the icons shown on the display. It is also possible to access historical data.

The middle screen shows the value from the energy flow selected on the left screen, and compares it with the energy consumption of cars, EnergyMirrors, incandescent light bulbs, et cetera. The comparisons are shown in a carousel—and as for the left screen—the one that is shown is changing automatically, but it is possible to manually select by swiping your finger along the touch slider.

The right screen shows the time and weather forecast, and some information about the organisation where it is installed. No interaction is possible at the moment.

3.3 Energy conservation in commercial buildings.

The need for energy conservation.

Researchers agree on that energy conservation through behaviour change is both possible and needed at the office as well as in domestic homes (Lockton *et al.*, 2011; Lehrer, 2009). As an example are the EU goals to increase the amount of energy produced from renewable resources to 20 percent, and at the same time reduce the energy consumption with 20 percent untill 2020 (European commission, 2011). Moreover, new and more aggressive policies are coming and will require continues measuring and performance verification (Lehrer, 2009).

Tools for behaviour change.

A vast number of studies have been conducted to evaluate different means to influence households' energy consumption. Direct feedback of the energy consumption is one of the most effective means to change behaviour and conserve energy, according to the review of 38 studies made by Darby (2001). Direct feedback is in most cases provided by the means of a digital display, and facilitates energy savings of approximately 10 percent (Darby, 2001). The amount of consumer products for energy feedback and energy conservation—often in form of a meter, software and a display— is increasing rapidly. This could be explained with evident energy savings and cheaper technology.

Moreover, both historical and normative data is valuable as feedback (Lehrer, 2009). Office buildings can be difficult to compare and the data can be misleading for non-expert users if the data it is not normalised (Lehrer & Vasudrev, 2010).

However, according to McCalley & Midden (2002) energy feedback should be combined with goal setting. Feedback without goals was not useful at all, but with self-set goals or induced goals energy savings up to 20 percent were achieved, according to their study.

For an organisation, where big part of the energy-use is automated and where there are many actors involved (see figure 9), is it difficult to say that the behaviour would have such an impact. Moreover, very little research can be found in this field and Lehrer (2009) is one of the first studies on this topic. To target the issue—what the occupants actually can do—he proposes that even if it is not clear how much the occupants in fact can affect the energy consumption, they should be engaged in the operation of the building and given means so they can contribute in a positive way. Moreover, Lehrer & Vasudrev (2011) state " … for energy feedback to be effective, it needs to be immediate, easy to act on and interactive".

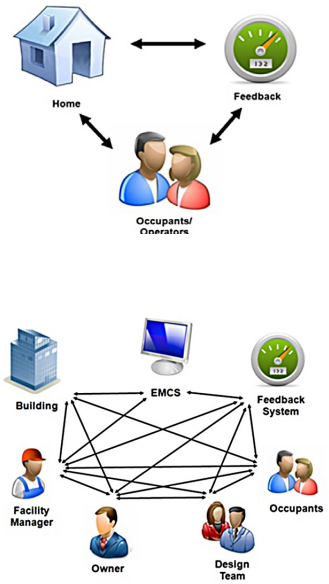

Figure 9. Lehrer (2009): Relative complexity: Household (upper) and commercial building (below). Reused with permission.

Operation and user control.

Regarding the operation of a building, Lehrer & Vasudrev (2010) found that there is a need for a communication tool between facility mangers and building occupants. Today this is often a one-way communication via normal means as discussions, phone, email, and sometimes logged in a building management system. Feedback about if and when the complaint was resolved is lacking.

Thermal comfort and energy savings.

For Priva indoor climate control, air quality and thermal comfort are important, and climate automation installations are most of the time adjusted to keep the temperature on a constant level all year around, at least during office hours. However, if the indoor temperature range can be extended with maintained perceived comfort—energy can be saved by reducing the difference in temperature between indoor and outdoor. Lockton *et al.* (2011) describes that investigations to find factors, which influence perceived thermal comfort, are on-going, but are also giving examples of possible concepts to affect the perceived thermal comfort. Some of their suggestions are:

» Allow occupants to affect the temperature

» Inform about the temperature

» Have different temperature in different parts of the building

» Heating and cooling the immediate workspace.

Low cost software.

Even though Google and Microsoft ended their projects for energy tracking (Google, 2011; Microsoft, 2011), there are indications that energy advises and software to support behaviour change for energy efficiency will increase and become cheaper in the future. (Lockton et al., 2011)

Energy efficiency
is in this report defined as ways to save energy, both through more effecient technology as through behaviour change.

Social green networks.

At the time of writing there is research going on to investigate the benefits of using a social green network at the office to increase energy awareness and energy efficiency. The first part of the research is published (Lehrer & Vasudrev, 2011), which presents the basic idea: A social green network, where every occupant has an account, can serve as a forum to view and share information about energy in the building, this to increase both awareness about energy, as well as engage the occupants to support energy efficient operation of the building. The energy information is individualised, so each and every occupant can track their own energy consumption, set goals for themselves and join groups and competitions. Via personal correspondence, since the report is not finalised yet, Lehrer (2012) explains that the response of the testing phase with about 130 subjects is positive and that a social green network indeed might be a useful way to engage and create awareness among people.

Drivers for energy efficiency.

The most important driver for energy efficiency actions for companies is cost reduction, but other not so obvious reasons to mention are that people—especially talented and environmentally conscious people—can be easier to attract and employ. Furthermore is it not unusual that energy efficiency interventions increase productivity. Moreover, stakeholders put pressure on companies to increase energy efficiency, so there is a risk with not taking action. (Economist intelligence unit, 2011)

For households the cost reduction is an important driver for energy conservation, as well as for companies. The difference is that the occupants in company buildings are not affected by the energy cost at all, while the occupants of households often are.

3.4 Exhibition design.

As a public energy monitor can be seen as a small exhibition—with the goal to communicate a message, with the intention to create awareness and change behaviour amongst occupants and visitors—the findings of Karlsson & Polson (2011) will be elaborated on below.

In their study they divided the communication strategy into three parts: information content, didactical approach and media technology. For this project the information content is yet to be determined.

Media technology.

A toolbox for the media technology was developed by Karlsson & Polsson (2011) and is basically a map over interaction technologies. This tool can be used for inspiration when designing the interaction for the public energy monitor. Interactivity is seen as important for this project, which is aligned with findings of Karlsson & Polsson (2011). Interesting technologies to support this, partly derived from the tool mentioned above, is listed in table 1.

Didactical approach.

The didactical approach developed by Karlsson & Polson (2011) is designed to inspire to action among the visitors to an exhibition, and can be suitable for a public energy monitor as well. Their approach is based on five steps and the first step is to create an interest among the visitors—to catch the visitors' attention. This should be followed by engagement and an experience, which also should maintain the visitors' attention. The experience is supposed to elicit emotions, and these emotions will lead into action. Desirable emotions in this project would be a feeling of importance, trust in the system and excitement to take action.

Technology.	
Multi touch tables.	A large touch screen oriented as a table that users can gather around and interact with. It is a suitable tool for mediating discussion whereas all the users are equal in the sense that they can all participate in the interaction.
Object recognition.	The multi touch tables described above can be used together with physical objects that are placed on it. The table can recognize predefined objects, identify where the object is placed, in what direction it is oriented, and interact with it.
Motion control system.	This type of technology can e.g. be found in different gaming consoles and uses cameras, accelerometers and sensors to detect motion. The user's movements are continuously registered which enables touch free interaction.
3D video.	By using 3D video spectators can get a thorough understanding of the spatial aspects of a concept and complex problems can be better communicated and discussed. A 3D movie also effectively catches the attention of the viewer.
Projection mapping.	This technology utilizes projection of images or movies onto irregular surfaces to create optical illusions. This can e.g.be used to add effects and atmosphere to the environment of the exhibition.
Near field communication (NFC).	NFC is a set of standards for smartphones and similar devices to establish radio communication between the devices, by having them in close proximity. It includes data transaction and setup of more complex communication. It is also possible to use a so-called tag, an unpowered NFC chip, for different purposes. (NFC Forum, 2012)

Table 1. Interesting technology for using in an exhibition, or for a public energy monitor, derived from the research of Karlsson & Polson (2011).

4 Analysis.

4.1 EnergyMirror analysis.

Usability issues.

From the use perspective there are some issues that should be considered while developing the next version of the product. However, an extensive use-analysis has not been carried out, and is not within the scope of this project. The issues are extracted from observations and internal documentation.

- It is difficult to select the desired function due to slow response and lack of feedback;
- It is difficult to select the end objects of the carrousel due to software issues;
- The interface is not always intuitive, for instance is it difficult to understand how to reach the historical view;
- The language is not consistent;
- There is an inconsistency regarding the use of kWh and kW
- It is difficult to understand the connection between the left and the middle screen. A rounding of the figures makes the connection even weaker;
- The layout is designed to be viewed from a greater distance than what is comfortable to interact with the touch strip.

For the last issue, empirically defined, a good reading distance to the EnergyMirror is approximately 130 cm, and a comfortable interaction distance is 45–60 cm. Guidelines for good readability says that a proper text height is the reading distance divided by 200. See figure 10 for an example of the issue.

Figure 10. The product manager, to the rigth in the picture, presents the EnergyMirror to a group of people. Notice how far they are from being able to interact with the product.

Use frequency.

From the data log—where every request of more detailed information is logged—was it unfortunately not possible to extract any reliable use-frequency figures. From a manual examination of the data it can be seen that the EnergyMirror is not used more than a few times a week, and not on a regular basis.

From the interviews with Hogeschool Zuyd this is confirmed. The students hardly ever interact with the EnergyMirror. More about the result from the interviews in section 4.3.

4.2 Benchmarking and product stategy.

Energy monitors for commercial buildings.

Many companies who deliver building energy management systems also have an energy monitor to offer as well. These energy monitors are all software solution presented on a third party display—some with interaction and others without. Some focus on learning or tips for energy saving behaviour while others only presents figures and relations. The price ranges from 5 000–15 000 euro. See table 2.

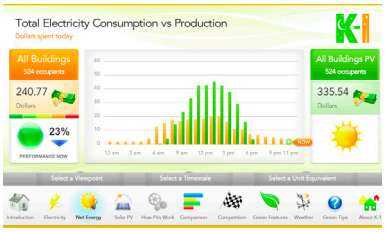

Figure 11. Lucid, Building Dashboard.

Figure 12. Trend, EnergyEye.

Real-time data.

Most of the companies promote their system as showing real-time data, but update interval varies from a few seconds to an hour among the systems. According to personal contact with Priva's facility manger (Voogt, 2012), is there no need to have shorter interval than 15 minutes for visualising of the total consumption. In a larger office building, the total consumption is relatively stable, because of the large number of energy consuming devices. However, if the measuring is done on a detailed level, the update frequency should be higher than what is acceptable for the total consumption. For instance, if the consumption for a computer is measured, it is valuable to see if it was turned off for short moments, instead of just see an average consumption per hour. As stated in the section 3.3 Energy conservation in commercial buildings: energy feedback needs to be immediate to be effective.

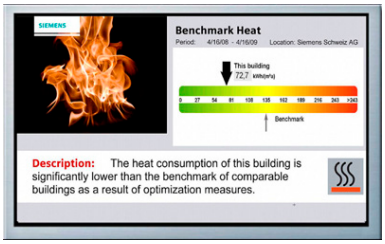

Figure 13. Siemens, Green building monitor.

Table 2 contains a selection of the most interesting competitors. A few other systems worth to mention, but not possible to extract so much information from, are: Ecoreflect from van Dam Groep, Energy dashboard from Alerton and Carbon Footprint Monitor from Noveda Technologies. See appendix 3 for links to all companies.

Noveda technologies with MakeMeSustainable (2012) and Lucid (2012) with their Building Dashboard Network have started to lever on the benefits of social media to address the occupants of a building. The occupants have their own account and can track their own energy consumption and compare it with others, as well as share knowledge.

In the cradle of development are also apps for tablets and computer-like phones that use the energy data from the BEMS. There is, however, a risk that the apps are not containing information useful and interesting for the user more than just once. Considerations should also be taken as not everyone has access to such a handheld product, and those who are frequent users are recommended to be more careful with downloading apps, especially in corporate context, since the apps can contain harmful code (Smitt, 2012). To be able to see the energy monitor via a web interface is seen among a majority of the competitors. This makes it universal accessible from any computer and many devices, and different from the apps as no downloading is required.

Table 2. A selection of the most appealing and competitive systems. Information comes from company websites and email correspondence with the companies. Some data is missing and some data have been contradictory especially regarding the price and where the server is located. Hence, the table is more to be considered as an overview.

Benchmarking—energy monitors for commercial buildings.

Company	Priva	Lucid	Trend	Siemens	Enigin	QA Graphics	Delta Controls	Neo Technologies
Product	**Energy-Mirror**	**Building Dashboard**	**Energy-EYE**	**Green building monitor**	**Eniscope**	**Energy Efficiency Education Dashboard**	**Earthright Energy Dashboard**	**Green E-value**
Price approximately [€]	30 000	From 7 000	6 000 + monitor		From 5 000	Affordable		
Market entry	Mid 2010		Mid 2009	Late 2009	Mid 2008	Mid 2008	2010	Late 2010
Size and proportions of display	Custom, 2×0.7 m	Standard	Standard 32"	Standard			Standard, not included	
Interaction	touch strip	touch	no	no	no	touch	touch	
Historical data	x	x	x	x	x	x	x	x
Real-time data, or update frequency	15 min	1 min	x	1 hour	15 min	x	1 hour	1 hour
Energy translation	x	x	-		x	x	-	
Company info.	-	x	x	x	-	x	limited	
Weather	x	x	x	x		x	x	x
Quick status check	-	-	x				-	x
Target value and comparison	-	x	x	x	x		x	x
Benchmark	-	x	-	x		x	x	x
Server	External	External	Local		local	local	External	
Internet access	-	x	x		x	x	x	x
Mobile platforms	x	-			x	x	x	x
Water	x	x		x	-	x	x	x
Electricity	x	x	x	x	x	x	x	x
Gas	x	x	x	x	x	x	x	x
Heat storage	x	x			-	x	x	-
Renewables	x	x		x	x	x	x	-
Compatibility with other system	x	x	x		-			-
Multiple sites	-	x	x		x	x	x	-
Target visitors	x	x	x		-	-	x	-
Target occupants	x	x	x		x	x	x	x
Claimed savings	x			10 %	up to 40 %	x	-	
Learning/tips	-	x			-	x	x	
Prediction	-	-	x		x			

Consumer products.

There is a vast number of consumer products focusing on visualising energy flows, especially household electricity. So far, most of them are limited to specific appliances or the total consumption. More detailed information require more meters, comparable to building management system, which is much more expensive. The consumer products also have a clear focus on energy conservation. An extensive list of consumer products in this field can be found in Berglund & Hartelius (2010).

EnergyMirror advantages .

After the benchmarking it is possible to define the unique properties of the EnergyMirror:

» Unique proportions and size

» Nice graphics and energy visualisations

» Comprehensive energy flows and visualisations, from water to combined heat and power.

EnergyMirror strategy.

"The EnergyMirror belongs to the Energy & Performance range of products, which contributes to Priva's mission to provide optimal conditions for comfort and productivity against lowest possible use of energy resources and lowest possible impact on the environment." (Priva, 2012b)

The EnergyMirror 2 should, hence, contribute to the overall energy efficiency and comfort. It is also important to just have the product in the product range, and in that way be a more attractive supplier, according to personal communication with Klep (2012).

4.3 Analysis of the interviews.

Interviews with a customer, a branch office in Germany, a partner and people internal at Priva have been conducted. The KJ-analysis resulted in a few categories, which are described and analysed below.

Why having an EnergyMirror?

Many reasons to why organisations would like to have and use an EnergyMirror came up during the interviews. It can be summarized in two main reasons, or functions:

» Show the impact of an investment for increased energy efficiency

» Create awareness about energy among occupants and visitors.

Moreover, the customers seem to be partly looking for an energy monitor; the desire to buy is not created by the product itself. Since they knew what they were looking for a market driven product development process should be considered, where the customers should have a saying in the development of the product.

An investment for increased energy efficiency

can be anything from better insulation to investments in sustainable energy production.

Usability issues.

The findings about usability issues in 4.1 EnergyMirror Analysis are confirmed by the interviews. Mainly it is lack of feedback due to slow response and only visual feedback. It is also difficulties to understand how the EnergyMirror should be used due to lack of compatibility with other touch devices as computer-like phones and tablets. People tend to push the icons, as if it was a touch screen, instead of using the touch slider.

Not used.

In internal promotion material the EnergyMirror is described as a piece of art. It seems to be a correct but an undesired feature—the interviews confirm that the EnergyMirror is hardly ever used, and if the occupants interact with it, it is only once. From one interview it is described as something you look at once, but then tend to be blind to:

"… just like a painting on the wall."

Another interviewee explained it as:

"it is too nice, I do not dare to touch it."

This can be seen as one of the most important findings and design challenges for the EnergyMirror 2:

How can the EnergyMirror be designed so it is used on a regular basis, so it actually can be used as a means to communicate?

The EnergyMirror has more potential.

In general people see the potential to use the EnergyMirror as a mean to inform and communicate, but it seems like they do not take advantage of it:

"There is a lot of possibilities with the EnergyMirror we do not use today."

A reason to this could be that there is distrust if the information will reach the target, as people tend to ignore the product. Again, more integration of the product, so it is used on a regular basis, will lever more of this potential.

Many customers also ask for the possibility to show a homepage on the EnergyMirror. This is not possible today. The needs behind are simply to be able to update the content, and show organisation specific information.

The EnergyMirror and the individual.

For some customers an important reason to have an energy mirror is to create awareness and behaviour change among the occupants of the building. The role of the individual in a building is non-existing in the current product, which makes it difficult for people to relate to the figures displayed, and why and how to act. For instance is one example given:

"If we could see on the EnergyMirror the meaning of turning thousands lamps of … how much electricity we save."

Many questions in this area where asked, and also the complexity of a commercial building described in the theory chapter:

"Who is earning the money, if one employee changes something to save so much, who is getting the money?"

This pinpoints the issue with feedback as an incentive to conserve energy in a commercial building.

Cost & markets.

The EnergyMirror is confirmed to be a product in the highest price range, and for the large projects and companies the price starting at 25 000 euro is not a problem, but the market is very limited. From the interviews it is clear that it is a need for a product in the mid-segment of the market. A product that is more affordable. The interviewees are aligned and means that a price at 5 000 euro is a reasonable compromise. However, it can be seen that some organisations find a simple product up to 5 000 euro appealing, especially if they want to have it in several buildings. Other organisations would probably find a product of a higher price and higher quality more appealing, even up to a cost of 10 000 euro.

The market outside the Netherlands is also much more competitive, where Priva also has a very low market share compared to in the Netherlands. As the product is meant to increase international sales, this should be considered in the product development process and the decision-making.

CSR and CSR.

There are two terms: Corporate Sustainability Reporting and Corporate Social Responsibility. They should not be mixed up, since only half of the of the companies include energy efficiency in their Corporate Social Responsibility policy according to the Economist intelligence unit (2011).

4.4 Target group identification.

The EnergyMirror is today directed at the very high segment of the market: companies with a clear corporate social responsibility-profile, and a price starting at 25 000 euro. This makes the market very limited.

From the interviews it is clear that there is a wish from many organisations—not only corporate—to have a more affordable public energy monitor. For this project, the target group have, hence, been redefined based on the interviews and internal Priva documents, which in turn are based on interviews with customers, but sometimes also market estimations and educated guesses, according to personal correspondence with the previous product manager (Fluks, 2012).

Three different types of organisations have been identified: businesses, government institutions and higher educational institutions. The target group is wide enough to cover future potential users as hospitals, gyms or secondary education institutes. Below, characteristics of the three organisations are described.

Business.

"Look at us, we are helping to save the world!"

Reason why a profit-organisation wants a public energy monitor:

- Demonstrating commitment to reducing energy usage.
- Show performance of energy efficiency investments
- Creating energy awareness among occupants and visitors
- Reducing the organisations energy consumption
- Reporting to stakeholders.

Special wishes to show on the monitor:

- Multi location performance
- Environmental policies
- Planned or current internal programs (competitions)
- CSR activities.

Government institutions.

"Together can we save the world!"

Reason why a government institution wants a public energy monitor:

- Taking the lead in energy and CO_2 control and reduction
- Promoting renewable energy and energy efficiency activities
- Informing about energy use and CO_2
- Reducing the community's energy consumption
- Reporting to national government.

Special wishes:

- Show figures from other governmental buildings
- Show targets and activities
- Show segment figures (Industry, household, transportation)
- Help other organisations increase their energy efficiency.

Higher educational institution.

"Our students are going to save the world!"

Reason why a higher education institution wants a public energy monitor:

- Supporting existing school programs run to reduce energy use and CO_2 emissions
- Creating awareness among the students
- Inspire students to contribute to reducing the carbon footprint
- Showing the public that the school is taking this topic seriously.

Special wishes to show on the monitor:

- Information, target and status on current projects and initiatives
- Student energy projects (PV-panels, wind turbines)
- Performance of other schools.

4.5 Users, visitors and occupants.

So far, only the customers have been discussed. The customers are the most important source to understand why the product should exist and which impact it should have. The users of the products are, however, not irrelevant. They are different depending on organisation. Assumed for this project is that they are adults and have—or are busy with—a higher education, even though it is unlikely to be valid for all users, especially among visitors to governmental institutions.

Moreover, there are different needs and interests between visitors and occupants. Visitors are more likely to be interested of an overall view of the performance, and changes over time, while occupants are more likely to be interested in tools to individually measure their energy use and savings over a day, week or longer period of time (Marini, 2011).

4.6 Needs and requirements.

From the analysis two fundamental things need to be implemented in the EnergyMirror 2. First, increased interaction and engagement. The product is not used today, and can hence not be used as a communication tool. Second, it needs to be tailored for the organisations it is supposed to be in use at. There are different needs among different organisations, the level of automation and energy flows vary, as well as number of buildings and occupants. Also energy efficiency installations can be a range of different things. A more extensive list of needs and requirements can be seen in table 3.

Table 3. An overview of needs & requriements. This is an early stage of the needs & requirements list, why it is on a high level. Details and measures are difficult to give. Measures important for the outcome of this project are, however, given. Type: Binary = requirement, possible to measure. Prio= needs, might be difficult to measure objectvely. Prio1, high priority; Prio 2, important but not extremely important. SH: Stakeholder that the need or requirement comes from: G=Goal of the project; P=Priva, C= Customer and user.v

Needs & requirements.				
No.	**Description**	**Type**	**SH**	**Explanation**
1	Ready for the market in two years.	Binary	G	The current EnergyMirror is soon outdated, a new product needs to be ready within a reasonable time.
2	Suit the layout of, and flow of people in, a corporate building.	Binary	P	The most important target group for Priva is business.
3	Suit the layout of, and flow of people in, a university building.	Prio 1	P, G	The target group is extended for this project.
4	Suit the layout of, and flow of people in, a governmental building.	Prio 2	P, G	The target group is extended in for this project, due to the lack of research of governmental buildings this has lower priority.
5	Create first time interest for interaction.	Prio 1	C	The first time people see the product they should notice the product and it should create a desire to want to know more.
6	Create regular basis interest for interaction and use of the product.	Prio 1	C	If the product is only seen or used once, it cannot serve as a tool to reach environmental goals for the organisation.
7	The product should have a positive impact on the net energy consumption.	Prio 1	G	A product that is supposed to increase energy efficiency, losses its value if it consumes more energy than it contributes to conserve.
8	The partners should be able to set it up.	Binary	P	Priva sells all its products through partners.
9	The product should create awareness about energy among occupants.	Prio 1	G	To create awareness about energy is central with the product, but also difficult to measure. For occupants this can lead to energy saving actions within the organisation.
10	The product should create awareness about energy among visitors.	Prio 1	G	To create awareness about energy is central, but also difficult to measure. For visitors this will give a sustainable image of the organisation, and might also lead to action at the visitors organisation.
11	The product should help organisations to reach their environmental goals.	Prio 1	G	As stated in the goal description.
12	The content that is shown on the product needs to be flexible.	Prio 1	C	Different customers have different needs, and the needs changes over time, it needs to be flexible and updatable.
13	The customer should be able to add and change organisational and time specific information.	Binary	C	The customer might run energy saving campaigns, or update their environmental policies and should be given tools to change the content shown on the product without asking Priva or the partner.
14	The product concept should be scalable to suit different segments of the market.	Prio 1	P, C	The current EnergyMirror is for the high segment of the market, both internal and external stakeholders wish to see it in other segments as well.
15	The price should be less than 15 000 euro.	Prio 1	C	Many organisations can not afford the current EnergyMirror and are looking for other solutions. However, it is outside the scope of this project to decide the final retail price. See also need 14
16	The product should distinguish itself on the market.	Binary	P	Priva strives to be product leader.
17	The product should express high quality.	Binary	P	Priva strives to be product leader.
18	The product should use units that are correct and understandable.	Binary	G	There is an inconsistency in the units that are shown on the existing EnergyMirror.
19	The product should be aligned with Priva's core values.	Binary	P, G	Sustainability, Innovation, Everything revolves around people, and Think global, act local. For more details see section 3.1.
20	The product should show and compare several buildings within the organisation.	Binary	C	Some companies have more than one building, to be able to compare and improve it is important to see the different buildings.
21	The product should show and compare buildings outside the organisation.	Prio 1	C, G	Comparison is important to create interest and understanding.
22	The product should have good usability.	Binary	C, G	The existing EnergyMirror has usability issues, as poor feedback, which is one factor to why it is not used.
23	The product should invite for interaction.	Binary	C	The customers want people to use the product, to interact with it. In that way it is possible to use it as a means to communication.
24	The product should be able to show all energy flows the existing product can.	Binary	G, P	From the benchmarking it can be seen that the EnergyMirror is unique by showing many different kinds of energy flows.

4.7 Scenarios.

Two scenarios were created based on key elements from the research and analysis, and formulated in a more vivid way. The scenarios will be used as support in the design process.

Fastsat.

Fastsat is a company who develops and sells customer tailored adhesive technology and products. It is a family owned company with approximately two thousand employees, most of them based at the campus in the UK, which is composed of three buildings: marketing and sales, the research and development lab, and the factory. Mr Klister, the CEO, has a clear vision for the company: be market leader in sustainable adhesive technology. This does not only count for the products and production, it should permeate the whole organisation. For this reason they recently invested in new windows and a new heating and climate control system, to make their office buildings more energy efficient. They are also looking into the possibilities to invest in sustainable energy production. Of course many of their products are already market leading when it comes to sustainability.

The employees feel proud of working for a company that actually cares about the environment. But to be honest they have not yet completely embraced Mr Klister's ambition about being sustainable throughout the whole organisation. Often they feel lack of influence and importance on the topic: Does it really matter what they do? And can they do anything? Often they take for granted that the board will make sure the company makes the necessary steps towards being a sustainable company …

Mistral College.

At the Mistral College there are approximately three thousand students in different fields, amongst other: architecture, arts and business. The facility manager Mrs Wind is constantly striving to reduce the campus buildings' energy consumption. She is also very interested in the latest research in the field, and often lectures about energy to create awareness and has conversations with students to get to know them and their standpoint. The college has a goal to reduce their CO_2 emissions with 20 percent until year 2020. Mrs Wind is planning for interventions as changing lighting and computers, but she knows that the students need to take action as well, sooner than later, and wants to provide them with basic knowledge to do so. Important is also to stimulate the students to be creative and come with their own suggestions of how the school can reach their goal. One way could be to compete with other schools.

However, the students seem to be ignorant about the issue. They often leave the lights on during daytime and overnight as well. The school is also open for the students until late in the evening, and heating with natural gas is the main contributing factor to CO_2 emissions.

5 Concept development.

5.1 Concepts: basic shape and context.

In total were twelve concepts developed, which describe the shape and context of the product. See figure 14–25 for a short description.

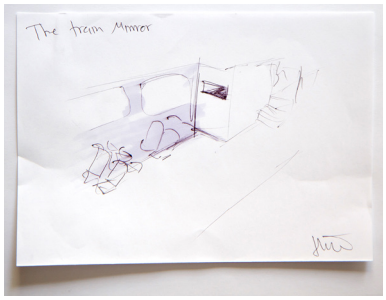

Figure 14. Train Mirror. In the train people have time to look.

Figure 15. The Mirro, combined with narrowcasting and a quick status.

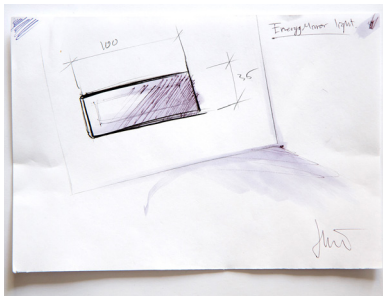

Figure 16. Energy Mirror light. Touch and smaller than existing product.

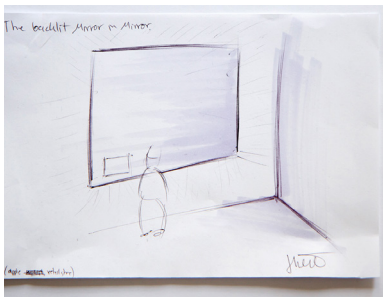

Figure 17. Mirror in Mirrror. A large static advertising screen with a small screen built-in with more info.

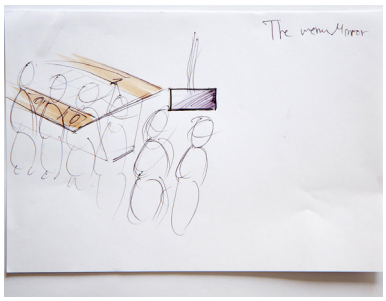

Figure 18. Menu Mirror. A location people walk by every day.

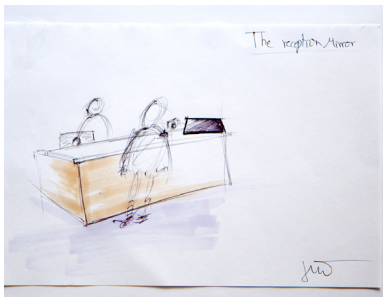

Figure 19. Reception Mirror. A small display on the reception desk.

Figure 20. Meeting Mirror. Placed in the meetingrooms.

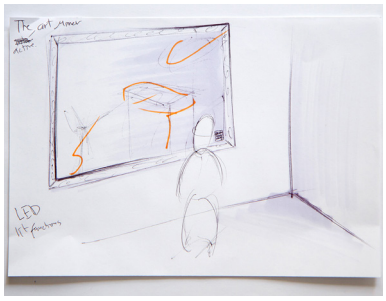

Figure 21. Art Mirror. Visual energy art that creates attraction.

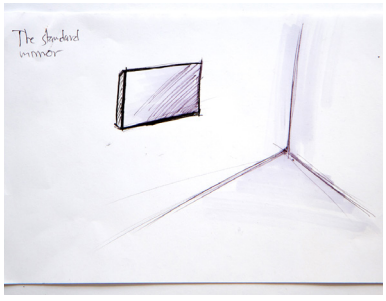

Figure 22. Standard Mirror. Normal screen with focus on software.

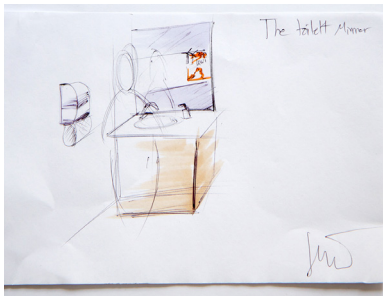

Figure 23. Toilet Mirror. It is possible to intigrate a display in a mirror.

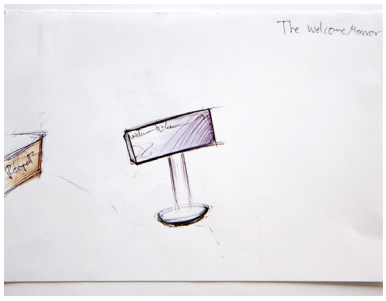

Figure 24. Welcome Mirror. Apparent and welcoming.

Figure 25. Coffee Mirror. Small display in the coffee room.

5.2 Concept selection and further development.

The traffic light matrix generated an overview of the concepts, and it was possible to merge different concepts into one direction, see table 4. For instance was the Coffee Mirror, extended to include some ideas from the Toilette Mirror and the Reception Mirror. Finally, four concepts could be sifted out:

» The Coffee Mirror

» The Mirror in Mirror

» The Art Mirror

» The EnergyMirror light.

The four concept was refined and attached features, and the interaction was defined. In the process it was necessary to ungroup the merged concepts *The Standard Mirror* and *The EnergyMirror light* to be able to give the concepts clear features and a clear direction. Hence, it is five concepts presented in the next section 5.3.

Table 4. Traffic light matrix. On overview of the concepts and important criteria. Green, yellow and red mean: Fulfils, needs more work and cannot fulfil the criterion, respectively.

Traffic light evaluation table.

Need no.	Short description	Train Mirror	Art Mirror	Meeting room Mirror	Double Mirror	Standard Mirror	Mirror in mirror	Toilette Mirror	Welcome Mirror	Menu Mirror	Mirror light	Coffee Mirror	Reception Mirror	Original EnergyMirror
1	Market in two years	🟢	🟡	🟢	🟢	🟢	🟢	🟡	🟢	🟢	🟢	🟢	🟢	🟢
2	Corporate building	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🟢	🟢	🟢	🟢
3	University building	🔴	🟢	🟡	🟢	🟢	🟢	🟢	🟢	🟡	🟢	🟢	🟡	🟢
4	Governmental building	🔴	🟡	🔴	🟢	🟢	🟢	🟢	🟢	🟡	🟢	🟡	🟢	🟢
5	First time interaction	🟢	🟢	🟡	🟡	🟡	🟢	🟢	🟢	🟡	🟡	🟢	🟡	🟡
6	Regular basis interaction	🟢	🟢	🟡	🟢	🟡	🟡	🟢	🟢	🟡	🟡	🟢	🔴	🟡
7	Energy efficiency	🟢	🟢	🟡	🟡	🟡	🟢	🟢	🟡	🟡	🟢	🟢	🟢	🟡
9	Awareness occupants	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🟢
10	Awareness visitors	🟢	🟢	🟡	🟢	🟢	🟢	🟡	🟢	🟡	🟢	🟡	🟢	🟢
11	Help reach goals	🔴	🟡	🟡	🟢	🟡	🟡	🟢	🟢	🟡	🟡	🟢	🟡	🟢
12	Flexible content	🟢	🟡	🟢	🟢	🟢	🟡	🟡	🟢	🟢	🟢	🟢	🟢	🔴
14	Scalable concept	🟡	🟢	🟢	🟢	🟢	🟢	🟡	🟢	🟢	🟡	🟡	🟡	🟡
16	Distinguish on market	🟡	🟢	🟢	🟢	🟡	🟢	🟢	🟡	🟡	🟢	🟡	🟢	🟢
	Conclusion/combination	🔴	🟢	🔴	🟢	light	Art	Coffee	Stand.	🔴	🟢	🟢	Coffee	🔴

5.3 Concept presentation.

The Coffee Mirror.

The Coffee Mirror is a table top, or wall mounted small interactive display that can be placed at social meeting points in different departments of the organisation, or for instance at the reception desk. With several devices in the same building it can show the local air quality, with temperature and CO_2 levels, and also the local energy consumption. With a device easy accessible for the occupants it is a powerful tool to run energy saving programs or competitions between departments. It brings the energy mirror closer to the individual.

The Coffee Mirror in a list:

- Focus on the occupants and behaviour change
- Local energy and climate zones
- Communication tool
- Energy saving tips.

The application-based software makes it easy to extend and update the product. New applications can be developed over time. Valuable such would be a tool to communicate with the facility manager, rating of the inside climate and for instance room control. The ratings can be used to both adjust and suggest improvements for the climate automation. The possibilities are endless.

New information about organisation sustainability policies can be presented, as well as energy saving tips. The idea is that the concept should initiate discussions around energy and energy conservation. Discussions would lead to awareness and deeper understanding about energy, as well as the local and global climate.

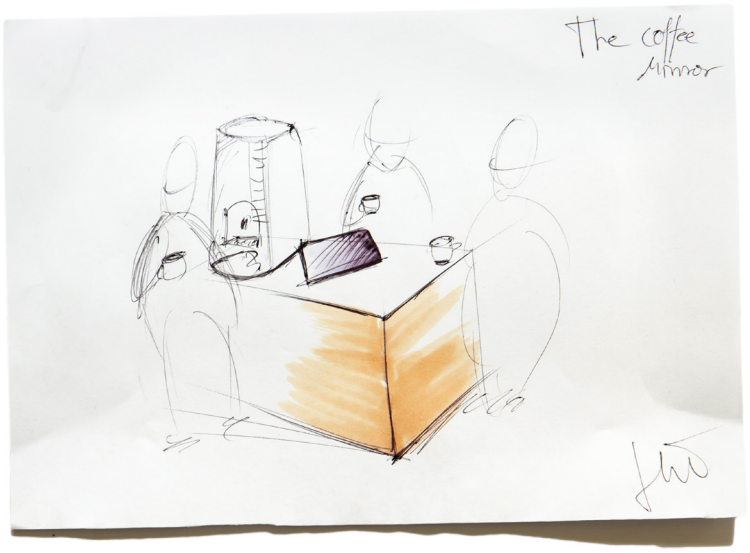

Figure 26. The Coffee Mirror. A small display, to be placed in social meeting areas, that can serve as a tool for communication with the facility manager.

Pros. It is a flexible solution and easy to add new features. It can help to provide an optimal climate.

Cons. It is not a pure energy mirror, it is a new type of product, and it might not suit the whole target group.

The Standard Mirror.

With the Standard Mirror there is a focus on the software, which is built for standard proportions screens. The software fit different screen sizes, and is modular so the different organisations can set up what they need together with the Priva partner. The hardware comes from third party. Apps for tablets and computer-like phones should also be developed to extend the use, especially for the occupants.

To make the energy-use clearer for people, it should be measured or estimates how much of the energy that goes to lighting, computers or coffee machines etc. Heating is—in northern Europe and Canada—one of the largest parts of the energy consumption. But where does the heat go? The Standard Mirror will provide information where the losses are. Is it mostly in the roof, walls, doors or windows?

However, this type of information can be a little bit complicated, and to make this easier and make it a unique product it should be more personalized. The first thing you do when you interact with the product is that you define your personality: you pull the sliders to tell your awareness about energy, and if you are a more technical or emotional person. The user interface and the information that is presented will then reflect those characteristics.

Pros. It is flexible and fairly easy to update. It is also technology independent.

Cons. It is difficult to be unique; this is what all the competitors are doing. The competition is tough, so a lot of effort needs to be put into the software development, also over time.

The Standard Mirror in a list:

- Scalable and modular software
- Standard hardware from third party
- For tablets and computer-like phones
- Shows energy consuming devices
- Personality question and adoption.

Figure 27. The Standard Mirror. Third party hardware with focus on software, possible for tablets as well.

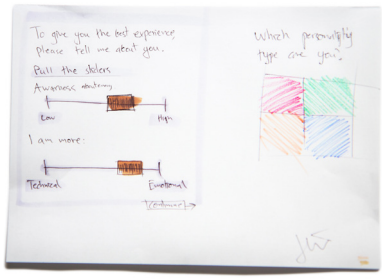

Figure 28. Ideas of how the user's personality should be entered. Sliders or by selecting the colour of your personality.

The Combination Mirror.

Everywhere when you step into an organisation you see some kind of display with narrowcasting, information about the company.

This concept combines the energy monitor with the narrowcasting. When we combine it we can add features in the casing of the product, as for instance lights to quickly see the status of energy saving projects. This also makes it possible to integrate different technology, as motion detection, to have standby, and changes when people walk by.

The big difference with this concept from the other is that there is no interaction; instead this concept should be combined with a social green network to address the occupants of the building.

The information is easy to grasp, you can just walk by and still get it. People in general do not stop for very long in the lobby area. It will however, remind of the energy usages in the building and create an interest for the social green network, as energy saving targets and results discussed there and shown on the display.

The Combination Mirror in a list:

- Frequent new information
- Quick status check
- Only visual
- Social green network.

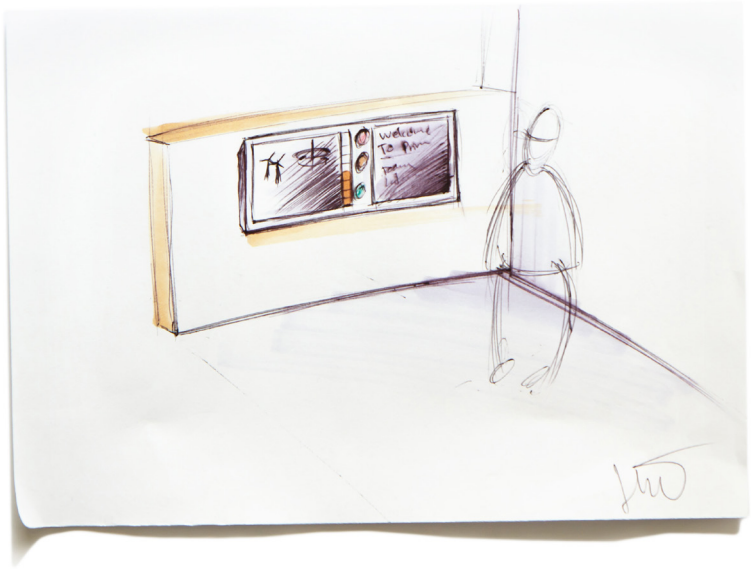

Figure 29. The Combination Mirror. Two displays, one for energy and one for narrowcasting. Quick status and combined with a social green network for the occupants.

Pros. It is a unique integrated solution, which would distinguish itself on the market. The development will be fairly easy, even though it is a new casing; everything is based on existing reliable technology.

Cons. The fact that it is dependent on the social green network to have an impact is a disadvantage, because this type of social media is still in its cradle. Moreover, it can be a problem that one size does *not* fit all. Different organisations have different needs and wishes when it comes to their narrowcasting.

The Art Mirror.

The Art Mirror is based on two things: information is beautiful and effortless interaction. The information is projected on a big painting. The energy is displayed in relativity with circles, instead of with numbers. The difference between renewable energy sources, grey electricity and natural gas can be understood by just throwing a glance at the product. To create a large impact, the information is simplified and sometimes exaggerated.

The interactivity—to change what you see—is done by walking. Walk to and stand on the figures on the ground to change the content of what is presented. This will create a desire in people to explore more. What I call effortless interaction.

The elephant is one example of simplifying and making the information more vivid and graspable. It is an attempt to make energy and carbon dioxide emissions tangible. Instead of saying that an organisation emits two hundred tonnes of carbon every year, which for most of the people does not say anything, the Art Mirror represents carbon dioxide emissions with elephants. Two hundred tonnes of carbon over a year would be equal in weight to sending up one elephant every week in the atmosphere. And it is not only this organisation; it is the organisation next to yours, and in the rest of the country, in fact the rest of the world. All sending up elephants! And they are all flying around up there. If people see the picture in their heads, hundreds of elephants sailing around in the atmosphere, they might think:

Oh my God, we have to stop this!

The Art Mirror in a list:

- Energy circles
- Vivid and exaggerated
- Visual awareness
- Effortless interaction
- Carbon elephants.

Figure 30. The Art Mirror. Vidid and easy to compare energy information. Effortless interaction by walking.

Pros. The Art Mirror is absolutely unique, a product that creates attention, and a desire for interaction. All important attributes according to the evaluation criteria.

Cons. The design and features are experimental, it will be a challenging development, which is a risk in this project, with such short time to the market.

The Energy Mirror light.

The Energy Mirror light is basically the same idea as behind the existing EnergyMirror; to make a unique product that create awareness about energy. It is a little bit smaller, to make it a little bit more inviting and interactive.

The Energy Mirror light in a list:

- Distinguish from other energy monitors
- Comprehensive information and comparison
- Usability, ease of use
- Near-field technology
- Personality.

The focus is on ease of use, with access to comprehensive information about energy, as energy history, comparisons, and building efficiency, also cost and extensive CO_2 comparison. There should be possibilities to make your own graph, by selecting different elements to compare. Basically a lot of information about energy in an easy to use package.

The concept is about to create a new version of the EnergyMirror and make more interactive, attractive and usable based on the input from the users.

Moreover should Near-field technology be integrated so you—as an occupant—can use your entrance-card or your phone to login and in that way quickly access what you would like to see when you just walk by, for instance personal savings or traffic information.

Last but not least should the product change colour and intensity depending on the weather, to make it more alive and with personality. In that way it creates an interest to look at more than just once.

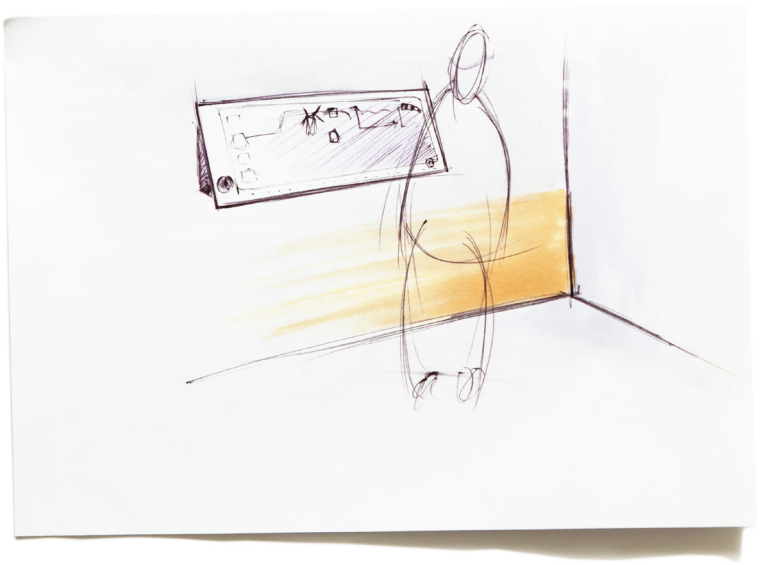

Figure 31. The EnergyMirror light. Unique proportions and comprehensive information. Ease of use and near-field technology for login and access personal settings.

Pros. The advantage is to have a unique energy monitor, and also keep it aligned with the expression and the market recognition of the predecessor.

Cons. It is only an energy monitor, without added value other than better usability. There is a risk that it will be just another parenthesis. It is also challenge to develop hardware in the proportions of the existing EnergyMirror.

5.4 Concept evaluation.

When the concepts were presented for Priva, the Art Mirror created interest in general, and in particular its interaction. However, most people preferred the flexibility and straightforward development with the Standard Mirror. See figure 32 for the result of the voting. The combination mirror fell on its interfering with non-Priva technology in a building, moreover can the social green network not be a prerequisite for having an EnergyMirror.

After the evaluation it was decided to continue with the Standard Mirror and bring in inspiration from the Art Mirror. The Standard Mirror also fulfils wishes from Priva to make the product easy adaptable for the Canadian market, since it is a software solution.

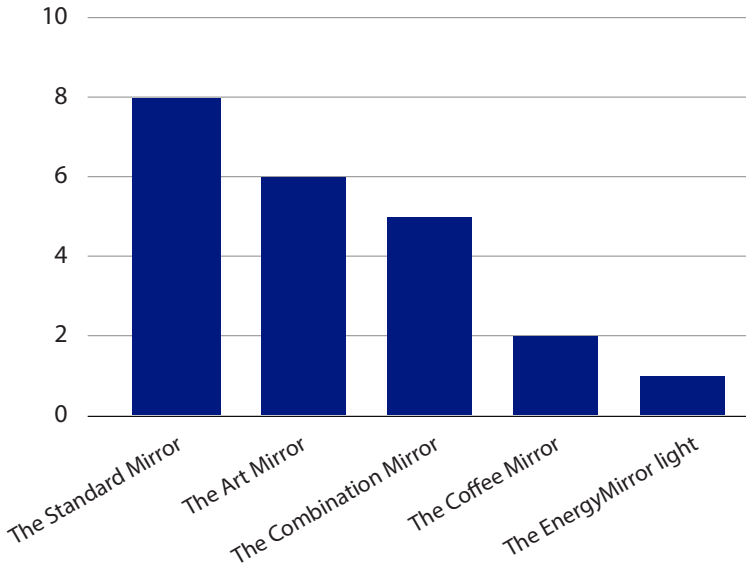

Figure 32. Voting after the concept presentation. Eleven participants and two votes each.

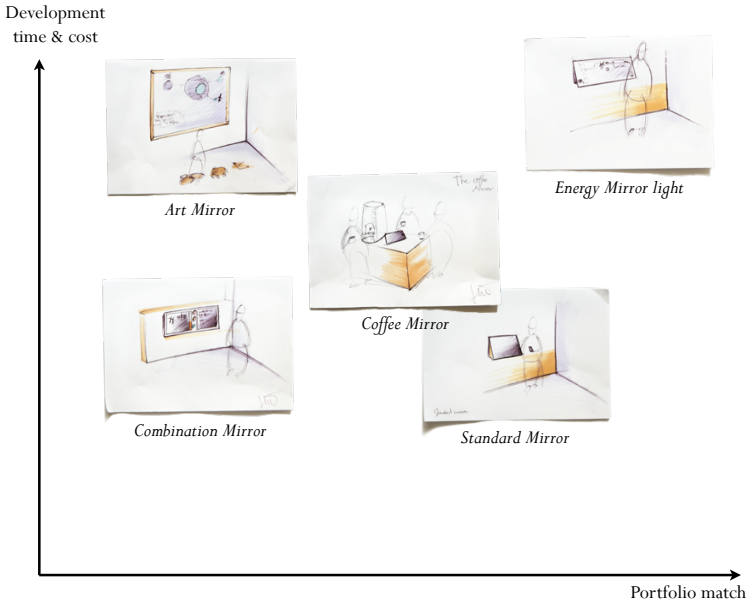

Figure 33. Mapping of the concepts over development time & cost and match with the Priva product portfolio, shown during the presentation. The mapping is made with broad and general assumptions and should only be seen as an estimation.

6 Further development.

In this chapter the theoretical development of the final concept will be explained, including the evaluation of possible features and ideas to bring in, since the concepts in the previous phase mainly determined the hardware configuration.

6.1 Concept conditions.

Functionality from the existing EnergyMirror.

Based on the research there is no reason to not keep the existing EnergyMirror's basic functionality as a foundation: visualise an extensive range of energy flows—from Eco water to combined heat and power—and do it real-time as well as provide historical data.

The Standard Mirror with inspiration from The Art mirror.

The Standard Mirror is supposed to work with any touch-screen device, hence, no additional technologies other than a touchscreen with a computer can be used, such as cameras or motion detection technologies. Based on this, the features that can be included when combining the Art Mirror with the Standard Mirror are:

- Measured or estimated energy for different consuming sources, for instance computers, lighting or printers
- Energy circles—a way to easy compare energy quantity
- Adaptable user interface depending on answer of introduction question about interest or personality
- Video—promotional or explanation videos can be shown
- Smartphones and tablets—the application can be developed for handheld devices as well.

What would people have time for?

People—at least the workshop participants—are unwilling to give up there valuable time to look and interact with an energy monitor, especially if they do not believe there is something in there for them. The key question during the project has been:

How do we make it interesting?

Two ways to address this problem are discovered in this project. First, find and present information that is relevant and interesting for people. Relevant information is elaborated on in next section, 6.2 Design features. Second, have a quick and effortless interaction. Effortless interaction is what the Art Mirror is based on. It is a way of—with minimum input or effort from the user—provide feedback or create an interest large enough to inspire the user to take another step. It is a mind-set to help create and evaluate the design.

Occupants and visitors.

With a standard hardware it is difficult to create a desire to interact with the public display among the occupants. To do that, a personalised interface and individualised energy data is needed. For the public display it is not feasible to have a login to access a personal profile. These kinds of ideas are more suitable for a personal computer or an app for tablets and similar devices.

Hence, the interaction with the public display should be designed for visitors. However, the standby state should bring relevant information to the occupants by providing a quick status check. And of course the occupants can interact with the public display as much as they feel like, and it should be kept in mind, but it cannot be assumed that they will.

Delimitations.

Included in the concept is that the software can be developed for computer-like phones and tablets, and as mentioned that would be the way to address the occupants. Another way to address the occupants is to create a web interface suitable for a normal PC, including customisable and personalised information about energy. This would be the main way for occupants to acquire knowledge and feedback to stimulate energy conservation behaviour. Within the timeframe of this project it is, however, not possible to develop such a concept. Furthermore, Priva still needs to develop this type of technology and architecture to support individualised energy measures. Hence, it will not be part of the final concept, instead recommendations for further development in section 9.3.

It has not been investigated how to measure the heat energy lost in walls, roof, windows and doors separately. It would probably be possible to estimate it for each building, but would also most probable be a time consuming endeavour, and questionable if it would be worthwhile. Hence, this feature has not been further developed.

6.2 Design features.

During the project a vast number of ideas or features have been collected, from interviews, exhibitions as well as from the workshops. All features have not been feasible for all concepts, and have also been too specific for the first and second phase of the concept development. Now, when a software-solution and a standard hardware have been chosen, the possible features to implement have been collected and evaluated in three steps: Yes, implement; Preferably implement (might not be possible or feasible, but maybe in future development); and No, do not implement. A short description of the underlying reason is given for each decision. The result is shown in the table 5, and will be used as a base for the design process, but can also be used for the future development.

The selection is based on the idea that the energy monitor should

show nothing else than information about energy and climate in a building, which is part of Priva's domain. For instance could it be interesting for people to see traffic information, but if one mix in such other interesting information together with the energy information, there is a risk that the focus on energy is lost. Then one also loses the purpose of the product.

Table 5. Features that might be interesting for the Standard Mirror, now and in the further development. Yes, Pref and No mean Yes, implement in this concept; in further development; and No, do not implement, respectively. A short explanation of why is also given.

General information.				
No.	**Feature.**	**Category.**	**Go?**	**Why?**
1	CO_2 level inside and outside the building.	Climate	Yes	Carbon dioxide is a measure for inside-air quality. A new feature for Priva, important to introduce the climate in the product. Outside level should be measured for comparison.
2	Inside climate prediction.	Climate	Yes	If people know the inside temperature tomorrow, compared to today. They can select suitable clothes and the comfort level will be higher. This could also be used to save energy, by adjusting the temperature depending on weather and let people know in advance.
3	Calculate total savings per policy.	Energy target	Yes	Very important feature to create awareness and promote an energy saving behaviour. Also brought up in the interviews.
4	Traffic light concept, quick status check.	Energy target	Yes	Feedback is the most effective mean to conserve energy, to give easy interpreted feedback on status of target savings or consumption is important.
5	Comprehensive comparison.	Understanding	Yes	Energy is difficult to understand, and different ways to explain it suits different people. With and extensive comparison all users can hopefully find something they understand.
6	Weather and energy consumption dependence with colours and movement?	Climate	Pref	To make the product more alive, and interesting it is good if it can react on energy-related data, and have it visible from a distance.
8	Questions. Then compare to what other people said, today, trend over years, and at other companies.	Energy and target	Pref	If people are asked questions, and then can see what others answered depending on different things, as country and gender, it will create more interest. For instance, it might be possible to see sustainable campaign results in peoples perception.
9	Special target or energy saving goal (computers or lights for instance, production company?)	Energy target	Pref	For organisations it is important to be able to conserve energy, and the product is a means to do so. It would be nice if possible to combine measuring of for instance computers, and related it to a target.
10	Weather forecast.	Other energy	Pref	Weather and energy are related, and would create an interest on general basis. Hence, it feasible, but not a prerequisite.
11	Energy weather forecast (wind, sun radiation, temperature difference prediction).	Other energy	Pref	Predict energy production is done by energy production companies today. If the organisation has invested in power production it would be an excellent feature to bring in to differentiate on the market.
12	Building Energy label.	Other energy	Pref	Government policies are getting tougher and are more and more important for organisations. It is on the wish-list from partners.
13	Organisation-info.	Other info	Pref	The organisation should be able to inform about themselves.
14	Energy cost.	Understanding	Pref	For many people energy equals cost, and it is easier to understand and relate to the unit. However, who is saving the money?
15	CO_2 elephants, derived from the Art Mirror.	Understanding	Pref	The carbon elephants concern energy at a different level. It is a way to bring in humour and create a greater understanding and positive view on the topic, important for branding reasons.
16	Everything in percent or in relation to something.	Understanding	Pref	The idea was to never present only a figure by itself, it should always be in relation to something. This is an interesting idea, and should be used as much as possible, but might not always be feasible.
17	Tip of the day.	Energy saving	No	It is not Priva's core business to provide energy saving tips, it would not be feasible for Priva to create such a list. A connection to another source, for instance energy companies or other pro-environmental organisations could, however, be feasible.
18	Movement detection (Art mirror).	Other	No	A standard touch screen will not provide such features. It is preferable feature, so it might be possible at a later stage.

General information.				
No.	**Feature.**	**Category.**	**Go?**	**Why?**
19	Campus tour-guide.	Other	No	If combined with augmented reality, it would be an interesting feature. However, it is too early to say that this is "standard" in two year time.
20	Near-Field communication.	Other	No	It is a technology to set up simple communication, between devices. For instance it could be used for setting up a wireless network and download an application for your computer-like phone or tablet, by just holding the device next to the product.
21	Twitterbox.	Other	No	Twitter is a social media people and organisations use computers and handheld device to communicate with their followers and the world with. Twitter is one means to communicate, an EnergyMirror another. However, a dedicated newsfeed for organisations to show on the product would be feasible of the same reason.
22	Sound to create attraction.	Other	No	Sound is the only human sense we cannot turn off, it is therefore excellent for warnings and important announcements. It would probably create more irritation than value to the product. However, sound for feedback or short video clips could still be feasible.
23	Involve transportation.	Other energy	No	The EnergyMirror should focus on the energy flows Priva is involved in, of brand reasons.
24	Food energy.	Other energy	No	The EnergyMirror should focus on the energy flows Priva is involved in, of brand reasons.
25	500 people walked by today.	Under-standing	No	To show how many people interacted with the product can have a negative effect, if not so many actually used it during that period of time.
26	**Individualised information.**			
27	How, and what can people do?		Pref	This is not a real feature, more a way of thinking that should be implemented to create awareness and interest.
28	Was this interesting? Rate. Other people looked at this as well.		Pref	This is a feature often seen on sites on the Internet, to suggest information that is relevant.
29	See personal savings.		Pref	Difficult to implement with the current solution.
30	Recognise actions people take.		Pref	If achievements could be measured on an individual level it would give valuable feedback and appreciation.
31	Personal energy guesstimator.		Pref	For this feature we need to involve everything that has not to do with the measured building. However, a generic estimated value, possible to compare to your own energy share of the building is an interesting feature.
32	Food energy.		No	The EnergyMirror should focus on the energy flows Priva is involved in, of brand reasons.
33	Involve transportation.		No	The EnergyMirror should focus on the energy flows Priva is involved in, of brand reasons.
34	Make your own graph.		No	To inspire creativity and increase interactivity.
35	CSR-statement made individualised.		No	A CSR-statement is nothing that is general for all organisations. Instead organisations should have energy saving targets, or similar, that should be formulated also on an individual level.
36	**Social add-ons**			
37	Competition, different departments. (Or within the EnergyMirror network).		Pref	The product should support incentives as competition between departments and organisations to create more awareness and energy savings.
38	Support socialising, to talk about energy temperature and comfort.		Pref	Not a feature, more a mindset. If people will talk about the product and what is on there, it will create an interest among people and possible to use as a means for communication.
39	Dedicate the energy saving money to something particular (investment in sustainable energy for example.)		Pref	If people see that the cost-savings go to something good, and not only profit the owners of the company, it might be a good incentive for people to take action. But this is not something the product should decide.
40	Tragedy of the commons, the energy game.		Pref	A nice feature to create more interest, engagement and awareness.

6.3 Conceptual ideas.

In this section, the more conceptual ideas from the idea generation—suitable for the Standard Mirror concept—will be elaborated on, as well as explanations of why and how they should be implemented.

Create attraction.

To create attraction there needs to be an element that catches the eye. From biology we know that the human vision is created to be an excellent motion detector. This explains why the workshop participants gave examples that often involved movement: motion, rotation, spinning, fluctuation, changing and alternating. Naturally, to create attention and attract people, motion and alternating should be implemented in the product visuals.

Sound can create attention; both are not always associated to the attractiveness of a product, why sound only should be added for feedback reasons.

How can energy be visible?

The participants in the workshops discovered that motion and light are two elements that both create attraction and represents energy. With other words two important elements to bring in to the product.

Compare data.

A conclusion from the workshops is that comparison is important. Numbers are abstract and difficult to compare and put into relation.

Information is beautiful.

In his book Information is Beautiful McCandless (2009) makes an attempt to presents information in a format that is more visual, easier to grasp and puts it into perspective. Examples are everything from most popular US names to the carbon dioxide cycle. He shows that it is possible to present information in an attractive package, and has been a source for inspiration.

6.4 Hardware.

The public display for the Standard Mirror concept requires third party hardware. There are different solutions for that, but this project will not cover a deeper analysis of what would be the best option. A touch screen connected to a PC is a well-tested solution, and would allow Priva to migrate to other hardware if needed at a later stage, according to Priva's Hardware Innovator. There are solutions on the market where the PC and touch screen is integrated to one unit, for instance from Polytouch, see figure 34 [www.polytouch.de], and Friendlyway [www.friendlyway.com].

The size of the screen should not be dependent on the software, it should be possible to present on a range of screen sizes. As a start, 32-inch is assumed to be a preferred size, and the interface has been developed with that in mind.

The experience of the interaction and the product is dependent on the hardware, since fast response is important for perceived high quality.

Figure 34. All-in-one touch screens from Polytouch made for public presentations. Comes in 22- and 32-inch size. (Press picture from Polytouch).

6.5 Concept development.

Front screen.

The standby screen, the screen that is shown for both occupants and visitors needs to be both attractive, inspire for interaction and at the same time be of use for the occupants. The occupants quickly walk by, and do not interact, hence, it should provide information in just a second or two.

Interaction for different personalities.

The idea that the interface should have different faces—depending on the answer on the personality question when starting to interact with the product—was considered to be more of a hinder than help for the interaction. First, it should be effortless interaction; it should not give a feeling of investment of time or energy in the product. Second, both difficulties to find how to design different interfaces that still would provide in principle the same information, as well as what type of questions that would give the desired outcome. Because of that, the risk that the product should create an undesired experience was considered more important to minimise.

Levels in the interface.

Instead of personality dependence, the interface should be designed with different levels, so the users can explore more if they are interested. In that way the user are in control of the interaction, which hopefully leads to a better experience.

Energy visualisations from the existing EnergyMirror.

The animation of for instance wind power on the existing EnergyMirror is nice. On the other hand, many organisations do not have anything other than electricity and gas or other means of heating, and these energy flows visualised on the current product are not so attractive. A more adaptable and neutral way of presenting the data is chosen in form of energy circles. The data is relative to the diameter of the circles instead of the area. The main reason is that smaller changes are easier to compare, hence, visually stronger.

Introduction and home screen.

Visitors that have never seen an EnergyMirror before needs to get an introduction to it, otherwise it can be difficult to interpret the information, and put it in perspective, or understand why it actually exists. Hence, it was decided to give the opportunity for the organisation to express why they actually have it, and what they intend with it. It should be done on the home screen—the first screen the user sees when interacting with the product.

Sustainable projects.

As the research in this project pinpoints, it is very important for organisations to express what they are doing or have implemented to reduce energy or to be more sustainable.

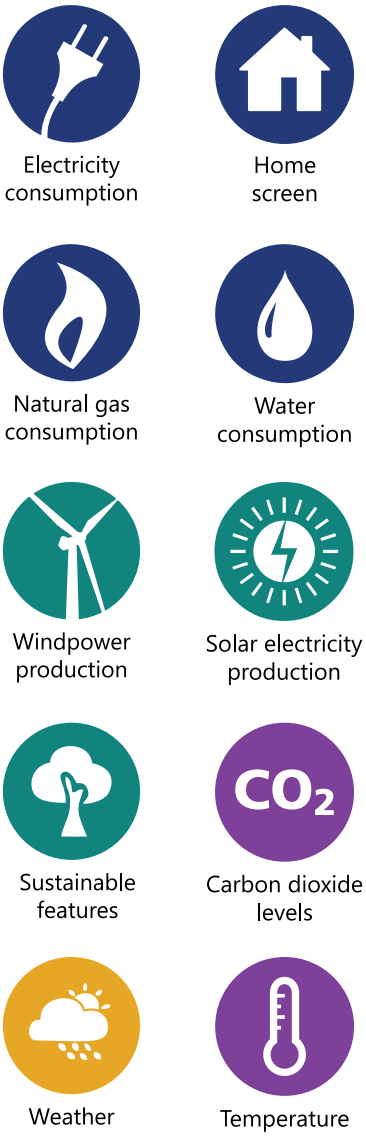

Figure 35. Development of icons. Home screen and the four lower are new, and the other five come from the existing EnergyMirror. The icons use Priva's house colours: Priva dark blue, Priva petrol, Priva ochre and Priva purple.

Figure 36. Energy balance icon, a function to compare energy.

The basic idea of how to present the information is clear: the organisations should be able to present the projects themselves, in words and pictures. More thoughts were instead put into how it should be accessible. It should be one of the most important things, but on the other hand it cannot be too obtrusive and take light from—or be more important than—the energy data. It was decided to have it on the same level, and accessible in the same way as the energy data.

During the design process it was discover that it was possible to have the sustainable projects in the same format as the introduction on the home screen, and also made accessible from there as well. In that way the desired accessibility was achieved.

The name of the function was after some considerations decided to be called sustainable features.

Weather.

Weather is very much related to energy consumption and indoor climate and was in the process found to be easy to implement as a separate function.

Icons.

Most of the icons are borrowed from the existing EnergyMirror, and a few are newly developed. The icons use Priva's house colours: Priva dark blue, Priva petrol, Priva ochre and Priva purple. The idea with the colour setting is to distinguish the different categories of functions: energy consumption; energy production or savings; climate data; and weather. See figure 35.

Energy and comparison.

The basic idea is to provide energy data that always should be compared to something. It is difficult to compare with something that is universal, and the simple answer is just a benchmark. Other comparisons can be added when possible, for instance a target value.

Different energy flows compared.

One important function is to compare different types of energy flows. For instance how much gas versus electricity is used. One idea was that the user should add energy flows by drag new energy flows into the picture when another was shown. The idea was considered to be too non-intuitive. Instead a separate energy comparison function was developed, selectable via its own icon, see figure 36.

Carbon dioxide levels and temperature prediction.

Both the carbon dioxide levels and temperature prediction can be considered as features for the occupants of the building. On the other hand, the two functions will give a message to the visitors: the indoor climate is nice and they are using new interesting ways to save energy. This is why they are implemented in the final concept.

Energy consuming devices.

The different electricity consuming sources for instance computers, lighting or printers should be presented as a more detailed level of electricity consumption. Exactly how it should look and function has not been developed, and will not be part if the final concept, instead given as recommendations for further development, in section 9.3.

Calculate total savings per policy.

If a company introduce a policy or request that—for example— the occupants should turn off the lights when they are leaving a room, a highly desired feature would be if the saving of that particular incentive could be measured. How this should be visualised or calculated has not been completely developed. The basic idea is that a date can be presented in the historical overview, linked to the date a description of the policy should be given. If it is possible to calculate the savings from that point is not clear, or if the user needs to do their own estimation. Hence, the function will not be part of the final concept, instead given as recommendations for future development.

7 Final concept.

An example of the user interface has been developed. The representation of the concept is made on a descriptive level with static graphics, the interaction and animated objects will be described in writing.

7.1 Introduction to the user interface.

The interface is designed to provide an easy and quick overview with possibilities to read and explore more, since that is dependent on personal interest and time available. It is a balance between good guessability, inviting looks and relevant information

Guessability

refers to how easy it is for a first-time user of a product to understand it (Jordan, 1998).

Stand-by

is used to describe when the product is showing the front screen and waiting for someone to interact with it—it is in stand-by.

Basic functionality in levels.

The interface is created with four levels. An overview is presented below and with figures 37–40:

- The front screen, which is the standby mode of the product, see figure 37;
- The home screen, which is the first the user sees when interacting with the product by pressing touch to continue, see figure 38;
- From the home screen all basic energy and climate visualisations, as well as sustainable projects are accessible, se figure 39;
- From the energy visualisations historical data or more info is accessible, see figure 40.

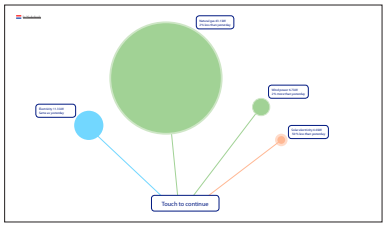

Figure 37. Front screen.

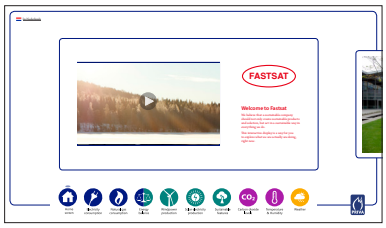

Figure 38. Home screen.

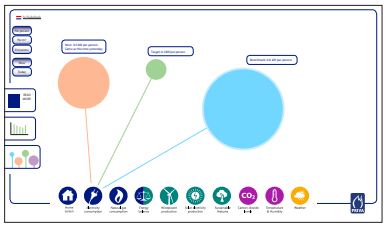

Figure 39. Energy visualisation.

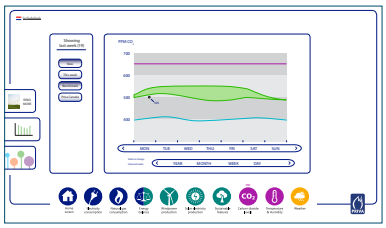

Figure 40. Historical view.

7.2 Front screen.

Design.

The front screen—the interface the occupants and visitors first meet—is designed to create attraction, from a distance, amongst visitors and give a glimpse of the current status to the occupants, as well as be inviting to explore and interact with when studied closer. The clear circles together with a lot of empty space creates contrast, which both create attraction and is apparent from a distance. See figure 41, front screen.

Which and how many circles that are shown on the front screen can be tailored for each customer. In the example in figure 41 four circles are shown, which represents the four energy flows: total electricity consumption, natural gas consumption, wind power production and solar electricity production.

The size refers to the quantity of energy and the colours: green, blue and red represents good, neutral and poor respectively. In the example in figure 41 the colours are determined by comparing with the data from yesterday: better, same or worse than yesterday, where less consumption as well as more production is better and are given a green

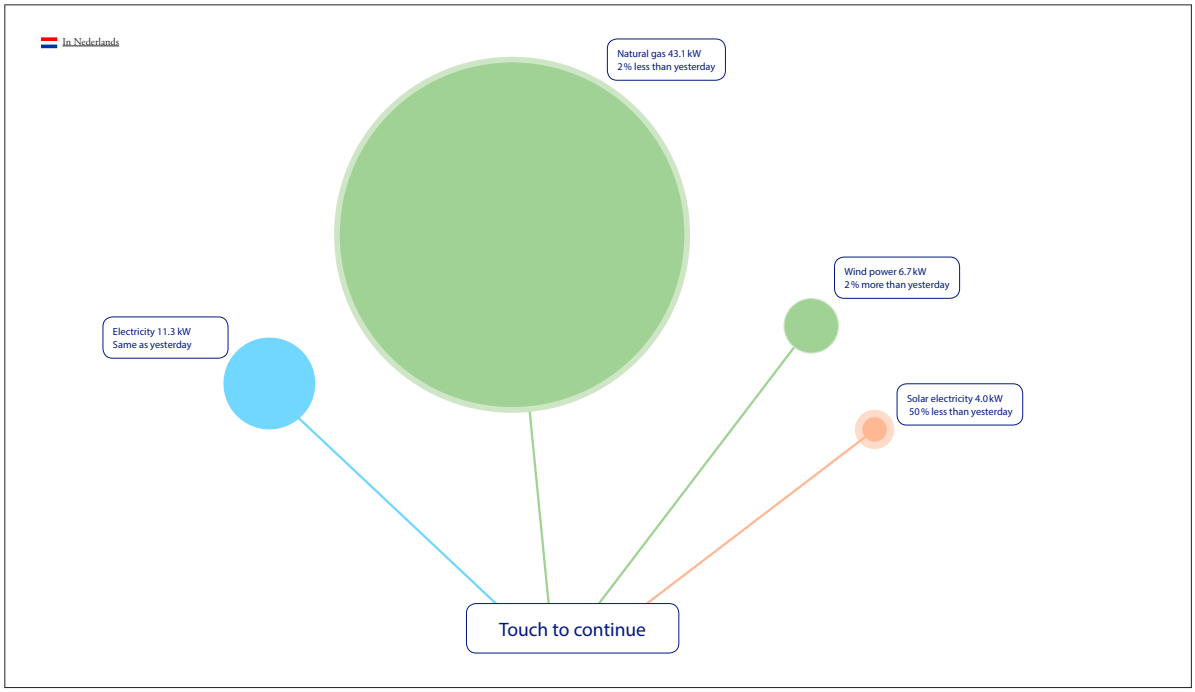

Figure 41. Front screen. Designed to create attraction from a distance amongst visitors and give a glimpse of the current status to the occupants, as well as be inviting to explore and interact with when studied closer.

colour, and vice versa. The faded outer circle represents the difference. Other comparisons can be set, for instance compared to target, or compared to another time-span.

The occupants can use the front screen as a quick status check, without interacting. They can quickly walk by—without interacting—and get an idea of the current status and be reminded of that energy is being measured, and then create a feeling of that energy is important.

Animation.

Since the fluctuation of the data—and, hence, the circle diameter changes—are minor over an hour or even a day, the circles are given other attributes to make them more alive. They pulsate both with colour intensity and size, as well as floating and bouncing around in a gentle way.

Swiping left or right?

If one swipes left, it means that the content on the screen will move to the left, hence, new things from the right will show up.

7.3 Home screen.

Design.

First, the user is given an introduction to the product and the organisation; in form of text, and picture or video, see figure 42. To start to explore, the user can either swipe to the left and will then be introduced to sustainable projects—see section 7.5 sustainable projects—or the user can press one of the circular icons to view energy or climate details.

The number of icons—within a reasonable amount—does not affect the layout of the interface, and is, hence, possible to tailor for the customer. A small indicator shows which feature is selected. In figure 42 representing the home screen, naturally, the home screen is indicated.

Overall is the interface minimalistic and non-cluttered to not distract, scare or confuse the first-time user.

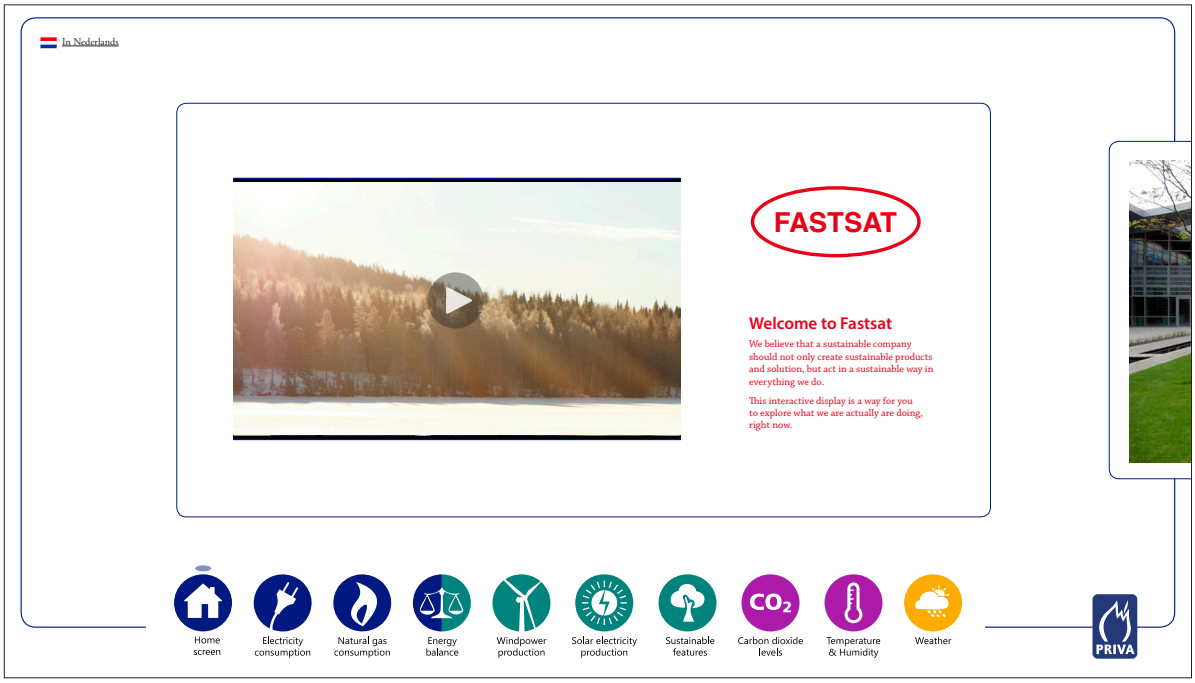

Figure 42. Home Screen. Uncluttered interface and easy to start to explore.

7.4 Energy visualisation.

Energy flows.

When the user pushes one of the energy flow-buttons, for instance electricity consumption or wind power production, a circle comparison will be presented together with the values they represent. The data is relative to the diameter of the circles. In this way the user gets a quick overview of the current status. In the example in figure 43, both the target for the organisation and a benchmark are compared with the real-time data.

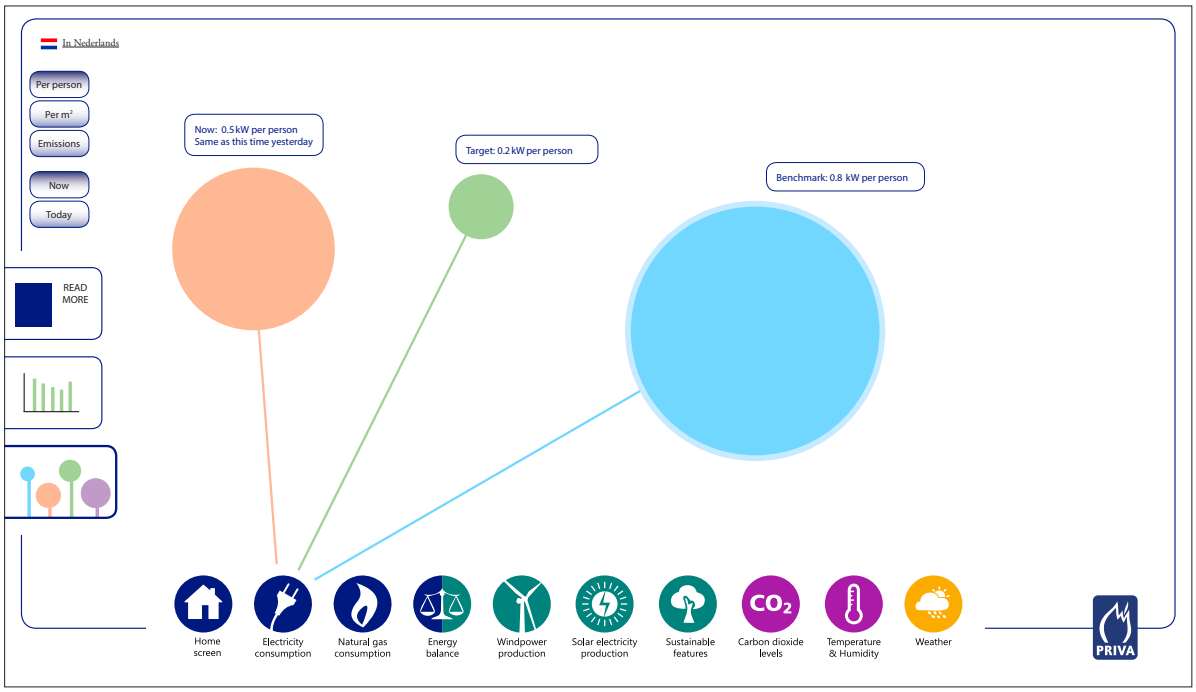

Figure 43. Energy flow visualisation. In this example electricity consumption is shown and compared to target (small) and benchmark (large).

Additional buttons is shown in the upper left corner to give the user the opportunity to explore and compare more within the selected energy flow. For instance *per square meter* instead of *per person*. Moreover, there is a possibility to integrate different buildings or departments in the same manor, but is not shown in the example.

The idea is that the number of occupants should be measured in real-time, in that way it is possible to visualise how the energy is related to the number of occupants, which could be especially interesting out-side office hours. If not real-time data of the number of occupants in the building can be provided, a statistical estimation should be developed for the organisation.

Energy balance.

The energy balance is the same as used for the front screen in figure 41. The difference is that the lines connect to the icons of the different energy flows, and the user can with the buttons in the upper left corner set how the energy flows should be compared, see figure 44.

Statistics.

When an energy or climate function is selected, the users can access a more detailed overview and historical data by tapping on the column chart icon on the side, see figure 45. The user can select time, and time granulation, as well as select different benchmarks or add other internal measures.

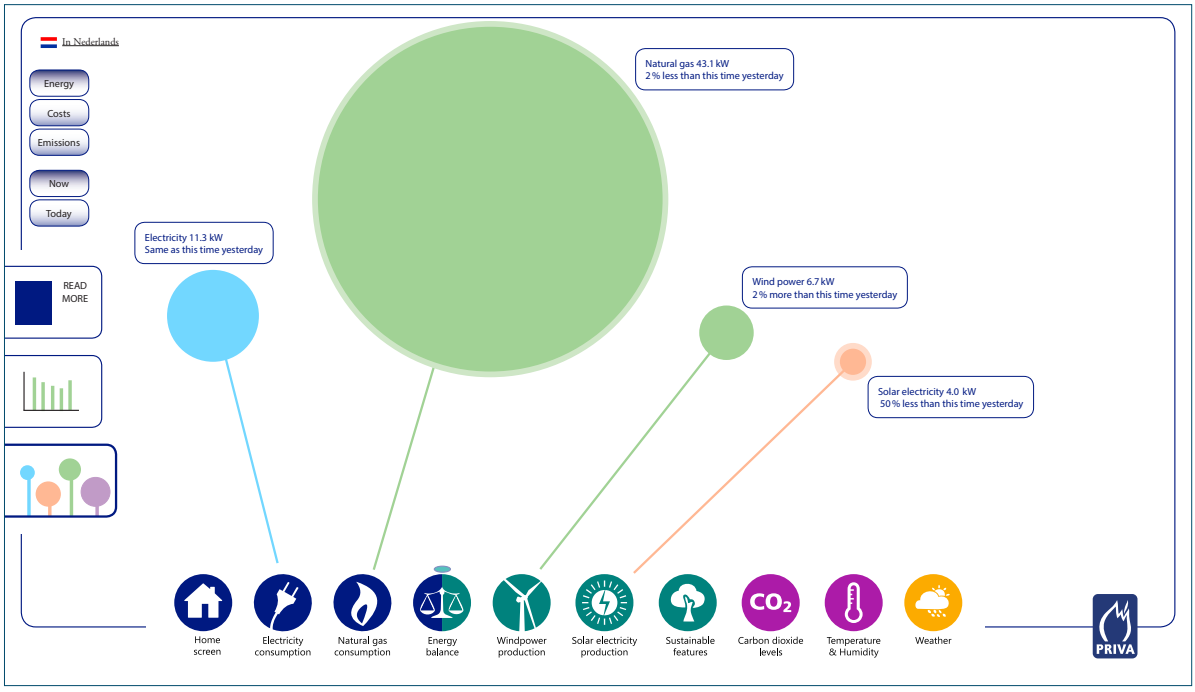

Figure 44. Energy balance visualisation. In this example energy consumption and production is shown.

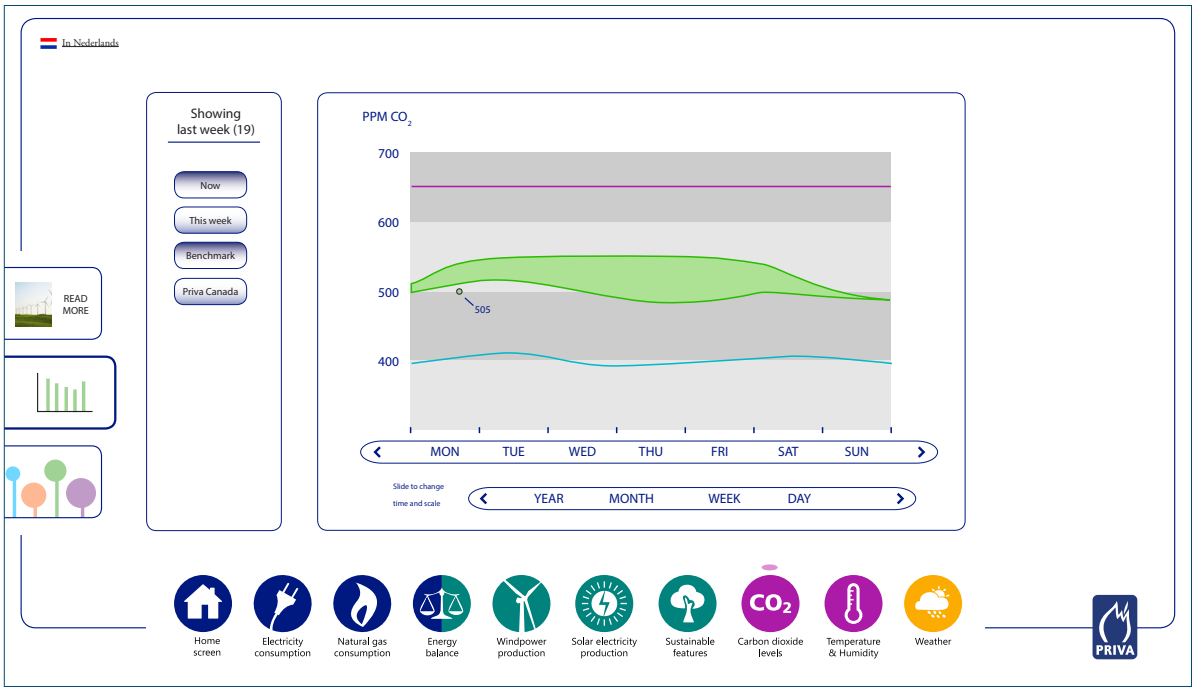

Figure 45. Historical overview. In the figure is the carbon dioxide levels shown. See section 7.6 for more info.

7.5 Sustainable projects.

Since a project for increased energy efficiency can be anything from recycling paper to an investment in wind power production the product has a flexible format where the organisations themselves can describe their endeavours. A format similar to the home screen is used, where the organisation with their own words, pictures and video describe their projects. The function is called sustainable features, figure 46.

The user can also access the sustainable features instantly by swiping left on the home screen; vice versa can the user also go back to the home screen from sustainable features.

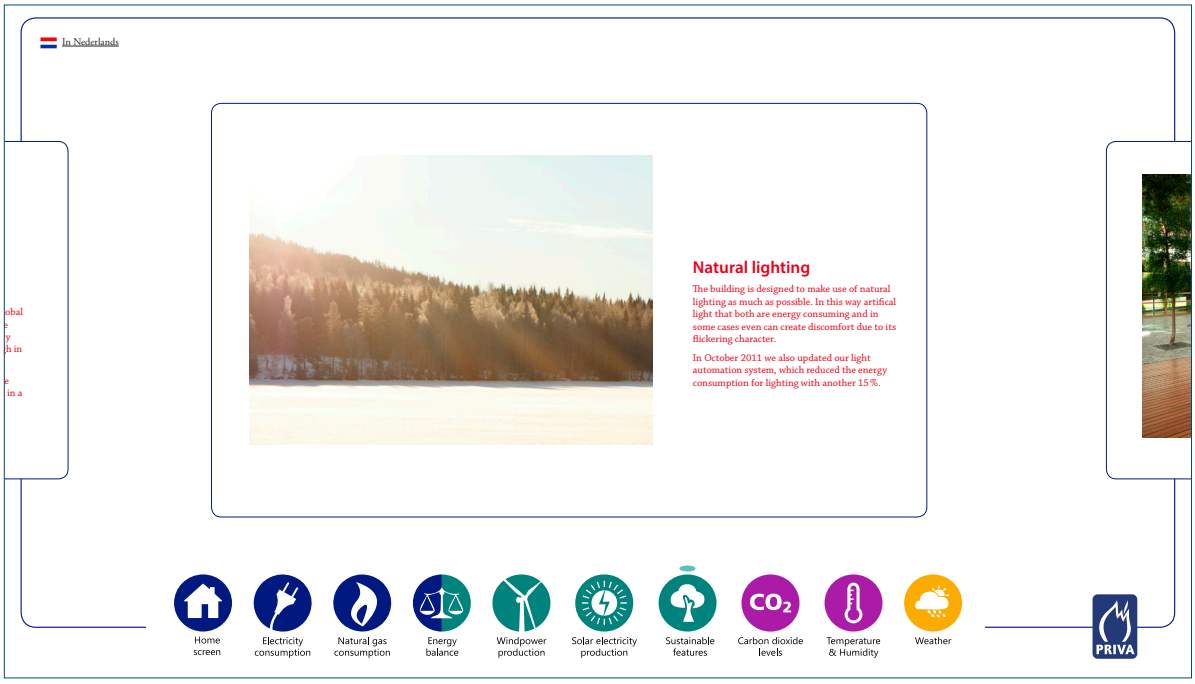

Figure 46. Sustainable features. The organisation can present there projects for increased energy efficiency. The user swipes left to see more.

7.6 Indoor climate and energy.

Energy and climate belongs together, globally as locally. People in general most probably think of the global warming when they hear carbon dioxide, but in fact it is also a measure for indoor air quality. People together with poor ventilation leads to increased levels of carbon dioxide; ventilation and adjusting for the difference in temperature between outside and inside consume energy.

Two new features have been designed for this purpose: indoor carbon dioxide levels and indoor temperature prediction. The first to express what Priva is good at—deliver technologies for control of indoor environment. And at the same lever on the media focus on carbon dioxide and put it into a new perspective, see figure 47. The latter is a way for organisations to save energy: By keeping people informed about the actual temperature, as well as the prediction for the next day, the temperature can be adjusted depending on the outside climate to save energy, and give the occupants a fair chance to adjust their clothing to maintain a high comfort level, see figure 48.

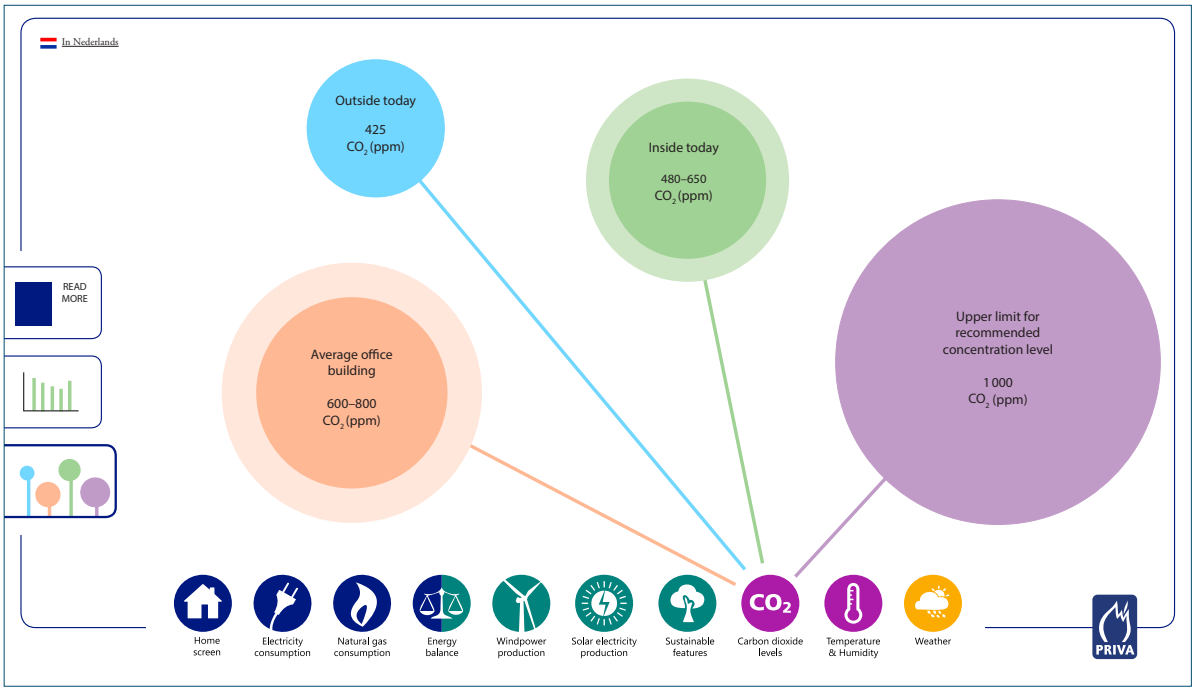

Figure 47. Carbon dioxide levels. An upper limit, average office building and outside is used as reference.

7.7 Setup of the user interface.

Partner setup.

The interface is built up in such a way that it is possible to create a tool for Priva's partners to setup the features when installing the EnergyMirror at the customer. This can be done in a similar way as done for Priva's TC energy. There can the partner via a web interface select which energy flows are installed in the building, and connect them to the right meter, so TC energy will work accordingly to the building setup.

Organisation setup.

In the same way should the organisation be given tools for easy editing of the information that is not dependent on the energy flows. Such as special targets, the home screen with text, pictures and video, as well as Sustainable features. However, the partner should make the connection to energy data if it is needed.

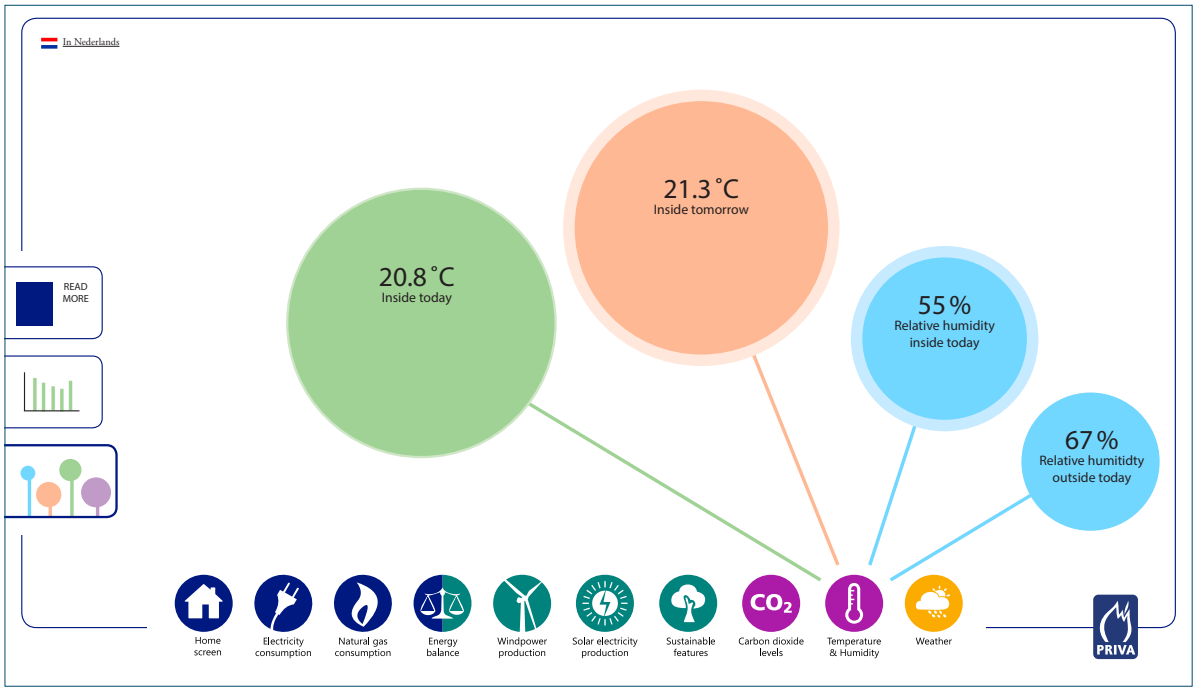

Figure 48. Temperature and prediction, as well as humidity is shown.

7.8 Target group.

The target group: business, higher educational institutes and governmental institutions can all make use of the product. It is hardware independent, so the organisations can choose which size and in how many buildings they would like to have it, and also easily compare the energy use in different buildings, internal as external. The organisations can show their policies and projects for increased sustainability, and as they are given the possibility to change the information on the home screen, they can also inform about current campaigns. It is, however, not clear if governmental institutions can use it as a tool to promote energy efficiency actions.

Figure 49. Photomontage of the graphics presented on a screen from Polytouch.

8 Evaluation.

The evaluation with users resulted in input both in form of usability issues, and possible improvements. The result will be presented in the same order as the test was carried out. The general feedback from the evaluation was positive, but there are room for improvements, which will be presented in the conclusions last in this chapter.

Figure 50. Display ready for test.

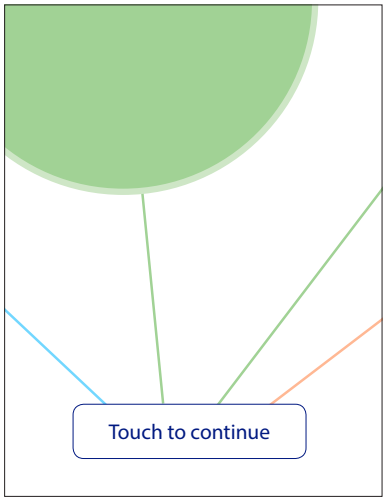

Figure 51. Touch to continue on the front screen.

8.1 Result from the empirical user test.

Front screen.

All except one participant pressed *touch to continue* as their first choice. However, one tried to change language (even though she mentioned it would probably not work), but said her second choice would be touch to continue as well. Since all eight participants were native Dutch speakers, it is unsure if the reason was that they did not notice it, or if they believed it was not developed. Anyhow, it is a minor issue, and the language can be changed at any time during the interaction process.

Home screen.

Five out of eight participants chose to play the video, one said he would do it later and another said:

"I am afraid the film is too long [edit: so I would not have time before my appointment]".

As a second choice, since the video was not possible to play, one person pressed electricity consumption, one solar electricity production and one sustainable features, which the latter explained as curiosity to see what other organisations are doing to be more sustainable. The other participants waited for instructions.

A majority read the text next to the video, but in a real situation it would probably be fewer. The participants seemed to be inpatient when reading it.

Electricity consumption.

All participants clicked the electricity consumption as their first choice when they were asked to, even though a few hesitated, or search with their eyes on the screen for a moment.

The information was presented as kWh per person; some participants did not completely understand that. Moreover, there were some difficulties to understand what the benchmark circle actually represented. One comment was:

"What do I see now, I really have to think."

Two participants explored the buttons on the side to change to per m^2 for instance, and the other did not seem to notice it or mention it, even though a few more took their time and explained what they saw.

Two participants commented on that now and today was the same thing for them. While the idea is that now is the real-time and today is the average of the day.

Compare energy production with consumption.

All participants hesitated when the following task was presented:

You see that they have wind and solar power, so you would like to see how much they produce compare to what they use.

Only three participants clicked the intended energy balance as their first choice, the task was repeated for four participants and out of them two asked for help to find it. One of the participants who asked for help said that he would like to see "renewable energy versus energy out of oil".

This could actually be seen as a more relevant comparison in many cases, since electricity from the grid can come from both sources. However, for a so-called net-zero energy building it is still relevant to see produced versus consumed energy.

Net-zero energy building
is a term to describe buildings that produce as much energy as it consumes.

A majority of the participants pressed wind power production or solar electricity production as their first choice. And two participants thought that to drag and drop or select several energy flows was the correct way.

And it should be made clear what type flow it is, as one participant made an incorrect conclusion:

"I do not see negative, so I assume they have a positive net production."

Positive response was given for the lines that connect the circles with the energy flow icons.

Sustainable features.

All except one participant clicked sustainable features when they were asked to:

"Have a look at other sustainable efforts they have implemented!"

A problem was that the text was a bit small, because the mock-up unfortunately only could be presented on a 23-inch screen, instead of the 32-inch it was initially designed for. This is, however, important facts since the software should be scalable.

Most of participants understood that by swiping left or right more projects could be seen. One participant wished an overview of the projects.

Moreover, big differences in interest among the participants were apparent: Many were neutral to the information about sustainable features, one found it very interesting and one said it was not interesting at all and questioned the credibility:

"This is for me bullshit, this is not real data, this is just a story".

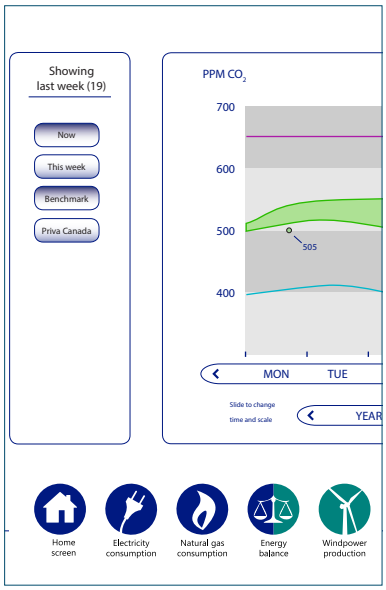

Figure 53. Historical data and the confusing surface.

Carbon dioxide levels.

As intended many participants were positively surprised of the information behind the icon of $C0_2$. The faded circles spread however confusion. It was meant to represent the interval, but it did not work since it was used as a difference earlier. One participant tried to measure and compare the size of different circles, to see if that could bring any new conclusions.

Suggestions were given to merge upper limit with average office, as well as make it more clear what an average office represents. Moreover were there comments on the values: the upper limit for recommended should be 800 ppmCO_2 for Priva standard and that it is 1200 ppmCO_2 according to the law.

Historical data.

Somewhat surprisingly—since many commented that they were not sure—all participants clicked the bar chart icon when they were asked to look at the historical data, which was the intended action.

However, issues regarding the actual interface of the function were detected: The surface was not clear what it meant, which week it actually represented and how to distinguish the different days.

Temperature.

In general the response on the temperature prediction was positive and aroused curiosity and interest. Some comments and questions were:

"That would be cool."

"How do you know? And why is it higher?"

"Nice to predict temperature, but you cannot predict the humidity?"

Other comments were how relevant it actually is to present the temperature with circles, since the changes will be minor.

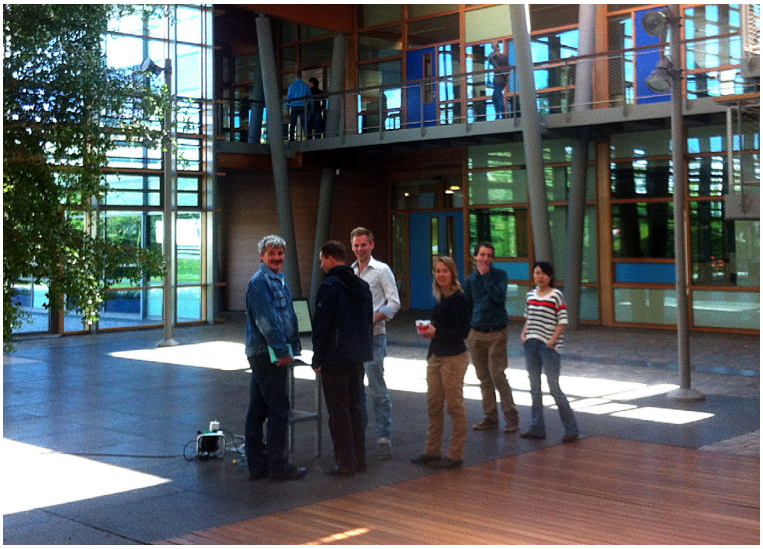

Figure 52. During lunch break at the test day the display showed the front screen. Some people stopped and also tryed to interact with it. But as it was not a touch screen, nothing happened. How big parts of the attention that came from "something new in the environment" and the actual graphics is hard to tell.

8.2 Comments from the interviews.

Faded part of the circles.

The faded part of the circles was confusing for people. Two persons thought it meant less than yesterday, which is in principle correct, but were then confused when it meant an interval for the functions temperature and carbon dioxide levels. A contradictory statement that might summarise the issue was:

"It is quite intuitive, when you know it."

Colours of the circles.

It was only one participant who interpreted the colours in the way it was intended. However, half of the participants did not reflect of the colours at all. The idea is that the colours should give an indication of the status, but it was difficult for the participants to interpret the colours, also since it was a problem with inconsistency. When the participants were asked if—and then how—they interpreted the colours some comments were:

"Green was gas, I think."

"I asked first if it was green energy …now I do not know what it means."

"No, not really."

One participant was colour blind, but did not have any noticeable problems with the interface. However, the quick overview to see and compare red and green might be difficult.

Further comments and possible improvements.

It might not be clear for the visitor that the organisation actually have wind or solar power production, it could also come from an energy production company.

The marker that shows what is selected is not clear to people, both the energy flow icons below and the buttons on the side.

One participant asked for a button to change the interface back into the front screen, so it would be possible to leave it in the same way as it was from the start.

8.3 Result from the questionnaire.

Semantics.

In figure 54 the mean of the participants' ratings is shown. The result shows that the concept is not boring, childish or disgusting. And even though some consistency issues appeared during the test, the rating of consistency is rather high. Moreover, it seems like that the concept is considered to be interactive and inviting. The in between rating—even though it is on the higher side of the scale—of professional and youthful is evident, and one participant explained it as a good balance between professional and attractive. He pointed out the difficulties of making it very trustful and approachable at the same time.

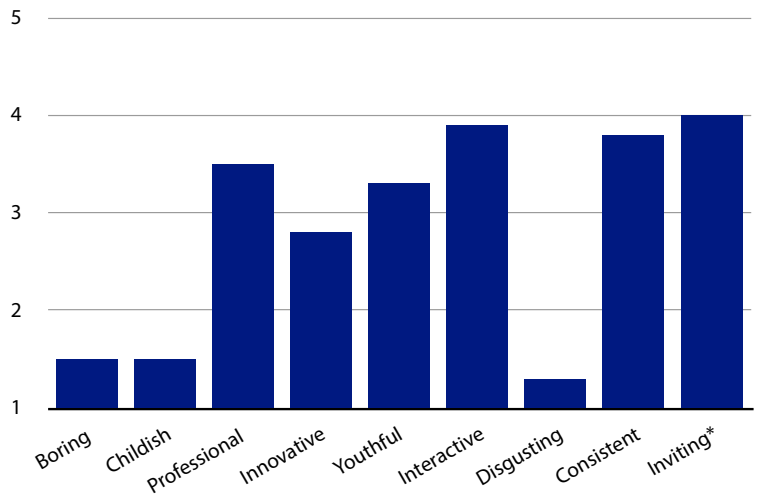

*Figure 54. Semantics. The mean result from the questionnaire. Scale from 1 = do not agree, to 5 = completely agree. Eight respondents but *seven for inviting.*

Emotions.

In figure 55 the mean and the standard deviation of the result from emotional questionnaire is presented. The ratings differ among the participants, but some tendencies can still be seen. Fear, anger and disgust are very low, which is a positive thing, and one participant commented it with:

"It felt safe to explore."

Sadness is relatively high and a clear explanation to why the participants felt a little bit sad was not given. Many participants felt a little bit surprised, and it was explained as a positive feeling and a reaction to how the information was presented, and also what type of information especially, considering the temperature prediction function and carbon dioxide levels.

Feelings of anticipation, joy and trust varied a lot between the participants and can also be considered as fairly low. Anticipation was something the participants had difficulties to interpret, and the result should, hence, also be interpreted with caution. One comment on joy—where the participant refers to the situation given in the scenario for the test—was:

"I was happy that I had something to do, while I was waiting."

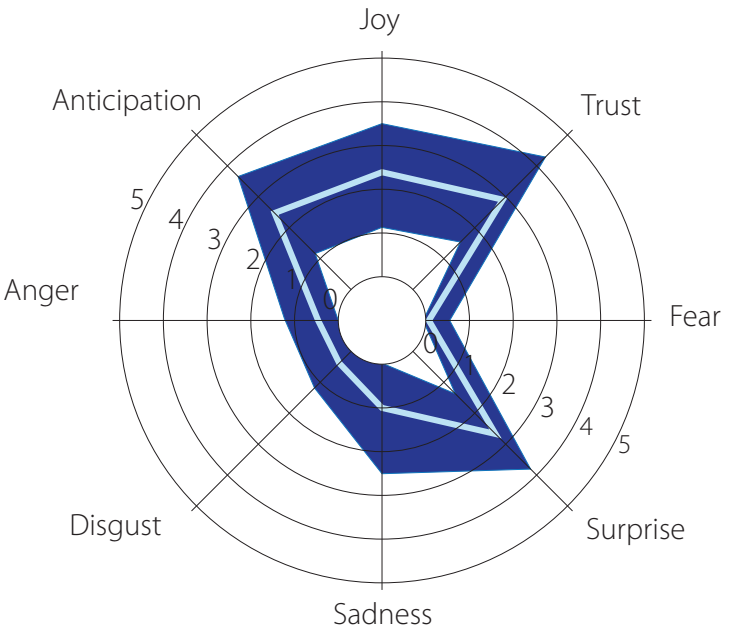

Figure 55. Emotions. Spider-net chart with mean and standard deviation graphically represented. Scale: Evoked a feeling of … 0 = not at all, and 5 = very strong.

8.4 Conclusions.

Users and interest.

It is evident that different users are interested in different things about the product; it is also difficult to predict who is interested in what. The users should have the freedom to explore the product themselves.

Time.

The visitors' limited time should also be considered in the design, and an improvement would be to present the length of the film clips, so the user can judge if they will have time with it. And naturally, the film clips should be very short, probably all less than a minute, and the introduction video preferably as short as 15 seconds.

Circles.

The colours are not so clear to people, and are also noticed to be inconsistent in the design. The colours: green; blue; red; and purple, should represent: good; neutral; bad; and non-real-time measurements, respectively. Non-real-time measurements would be a benchmark, comparison, target, a recommendation or similar.

The faded part of the circles was confusing for people, mainly because of inconsistency in its use. The part should only be used to represent a difference for energy flows. Further investigations needs to be made to see if it is useful at all.

Carbon dioxide.

The two comparisons spread confusion. The benchmark and average office should be merged, and given a purple colour. See figure 47.

Temperature prediction.

The overall verdict of the temperature prediction was positive. Despite their reaction it cannot be said anything about the usefulness of it, even though it is an interesting function. Moreover, to represent the temperature with circles, when the changes are minor, should also be changed to distinguish from the energy flows.

Text and graphics.

Several commented that it was a lot of text. It is probably the combination with explaining texts on the circles together with text on the home screen and sustainable features. It takes too much time to try to interpret what the circles means. Graphics suitable to describe what the circles represent is difficult to create, but desirable. Another way to reduce the perceived amount of text is to hide it and create popup info-boxes that are shown when tapping the circles.

Energy comparison.

Obviously energy balance is not an understandable term and net energy could be more appropriate. Since it is an important feature from many different perspectives, the interface and interaction should better be redesigned. A new name on the icon could help, but a more desirable solution would be if the user could—in an intuitive way—select and compare different energy flows and in that way be active in comparing different types of energy: renewable, fossil, production and consumption.

Area, instead of diameter.

As mentioned, one participant tried to measure the size of the different circles to compare them. The users should be given opportunity to pull the circles over each other for easier comparison; it then also makes more sense to represent the amount of energy with the area of the circle, instead of the diameter.

Historical view.

The historical view is not so developed and needs more work. A bar chart with lines representing the benchmarking and comparisons is better to use. Moreover, which day and how to change time and time granulation needs to be further developed, since it was not clear for the test users.

Buttons to change settings.

Many of the participants did not notice or comment on the buttons on the side when the energy flows is shown, see figure 43. This is not considered to be a problem, since it is one of the ideas with the user interface: if you are not interested in more information, you should not be bothered by it.

Sustainable features.

To make the sustainable interventions more credible they should be connected to the actual data. For instance if new and more energy efficient lights have been installed at one point in time, instead of just writing "reduced energy consumption with 15 percent", the savings should be extracted from the real data and visualised in attractive way. It could for instance be a continuously updated saving of total electricity consumption, in percent, or comparison between energy consumption of the new lighting one week and the old light at the same week of the previous year.

One participant wished an overview of the sustainable features. If this actually is feasible needs to be further investigated. One advantage would be that the users are more in control and the interface more interactive and relevant for the specific user. They do not have to swipe through—for them irrelevant—features and projects. On the other hand the user might discover unexpected features that they would not have selected in the overview.

General interface improvements.

Which function is selected needs to be made more emphasised. The indications for the energy flow icons below, as the buttons on the side are not clear enough.

Last but not least a button to put the display back in standby-mode, which means back to the front screen, should be implemented, so the user can leave it in the same way it was when he or she came to the product.

9 Discussion.

9.1 Process and methods.

Data collection.

The external input to the project, which can be seen as highly relevant and has a big impact on the result, only comes from one direct source—one customer. This because it was not possible to get in contact with the other two customers, even though several attempts with different strategies were done. Efforts to get in contact with potential customers was also done, but without result. The other input has already been processed and can be seen as second-hand information. Furthermore, the interviewed customer is a college and not a business organisation, which is seen as the most important target for the product. The development of the target group and scenarios are, hence, based on many assumptions. Later in the design process it was discovered that the actual needs from the different end-customers were vague, since it was not sure if the results from the analysis were valid. Furthermore, no research including the actual user of the products has been carried out. This since it was considered not so important in the beginning of the project. The input of what the occupants and visitors would like to see is the result from the idea generating workshops. These two shortcomings made the decisions making and the design process more difficult, which in turn mean that the relevance of the final concept can be questioned.

The literature research was mainly focused on energy conservation, as this was considered to be the most important factor to justify the product. It was also a challenge how to interpret the research regarding household energy conservation, when the difference to a commercial building is big. In the end, the most of it was considered to be invalid for this project.

Idea generation and workshops.

The creative challenge using social media was an attempt to get inspiration from a broader audience, the outcome with only three respondents out of three hundred, was approximately what I expected, and the result actually brought in valuable inspiration, both for the concept generation and the planning of the workshops. The description of the task was made in writing, and probably difficult to interpret, see appendix 1. A video explanation was considered to be presented instead, but was never created. This could have generated a much higher engagement and then a higher response rate.

Concept generation.

The reversed morphological matrix was a great way to work since it did not require that all concepts should have all types of partial functions, or only one of each kind. This was possible since the partial functions were not determining the systems basic functionality, only the added value. The process was, however, challenging since it was iterative, but the iteration also generated the final concept.

Concept selection.

The selection of the Standard Mirror concept was mainly based on opinions, many of the participants at the midterm presentation had previous knowledge and preconceived ideas, since they are been involved in the existing product. The needs or requirements of the users, organisations or Priva were not discussed very deeply.

The Standard Mirror also limits the occupants' use of the public display, since no persona login can be used. There was no discussion around if an app alone would be able to address the occupants.

Visitors, occupants and energy savings.

In the beginning the visitors and occupants were not studied separately. It was actually not until late in the design process it was discovered that it was difficult to fulfil the both user groups needs with one product. If the two groups had been separated earlier, and then also the different needs had been studied, a decision could have been made earlier, and together with Priva, of what the main focus should be.

Another reason to why it has been difficult to separate the two is that some voices within Priva focus only on the visitors, while some both, in combination with the fact that the purpose of the product is lost if it consumes more energy than it actually can help to conserve.

Goal constraints.

During the spring it has of different circumstance been increasingly important for Priva to have a new concept on the market in 2014. This has changed my mind-set, and sometimes limited the vividness of my ideas and what is possible. Hence, also affected the innovativeness of the final concept.

Evaluation.

The evaluation was carried out with Priva employees and they can be considered to have higher domain knowledge than the average intended user. More critical users—with less knowledge about energy—would have been preferable, but the time constraint did not allow a more selective selection of participants. However, considering the outcome of the user test, the result is highly relevant and most probable valid at this conceptual stage.

Another factor that might have affected the result was that there was only one correct way to go, the participants could not freely explore the interface, instead they were told which function the looked for. There were no possibility that the test user could get lost, and not know how to go back. However, the interface is designed so the function buttons in the bottom always are apparent and the risk of getting lost is minimal. So, even if it affected the result it is not seen as critical for the evaluation.

Hindsight, also a measure of the interpretation of the energy data presented in the test would have added value. For example could the participants have been asked to rate the performance of the building.

9.2 Result.

Awareness.

The product is based on effortless interaction, that it with minimal effort from the users should give feedback that inspires to more interaction. The interface makes it possible to reach all functions in a very easy way. The circles also provide an instant comparison. However, as seen in the evaluation, it is considered to be a lot of text and difficult to interpret what the circles actually represents. Moreover, if the interaction is truly effortless, it might be too superficial and easy to ignore. It is with other words unsure if it will create awareness as intended.

Appability

is a term used in this report to describe the capability and knowledge of how to handle apps for computer-like phones and tablets. High appability in a group means high rates of hand held device, as well as knowledge how to download and use them.

A google search shows that the term has been used to describe usability of apps in a few cases. Which, I think is less appropriate.

The interface is designed to be interacted with, but also to create attraction and provide a quick status check from a distance. The compromise is difficult, and the main focus has been interaction in the development process. The idea is that the big circles should attract and stimulate a first-time user to walk closer to discover what it is. For the occupants the circles are given colours and they can learn what the colours and circles represents, and can then see it from a distance. However, since the colours do not represent the energy flows, instead the status, it can be difficult to distinguish the circles, since there is nothing else than the location that indicates what they represent. On the other hand, as the circles change in size it is difficult to have a symbol or animation of what they represent.

Temperature prediction.

The temperature prediction did receive positive comments. However, if the function at all should be useful, the occupants needs to have it accessible in other ways than just via the public display, especially outside the office, since the purpose is that they should be given a chance to select clothes depending on the indoor climate in the building. On the other hand it is a unique feature that also stands for sustainability.

Sustainability.

The concept in it is current configuration cannot be said to help conserve more energy than it consumes. From this sustainability perspective the design needs to be improved. The first step is to introduce a web interface, so it is universally accessible for the occupants, and not just via the public display. Tablets and computer-like phones could also be a feasible platform to support, especially considering the target group consisting of higher educational institutes, where young people with high appability are the occupants. This improvement would not to any appreciable extent increase the total energy consumption for the product, but would hopefully increase the use.

Energy saving tips was rejected in the development process, the two main reasons were that it is not aligned with Priva's business to provide such kind of tips, and that it is difficult to find tips that are valid for a generic commercial building. Some tips seen during the benchmarking were completely irrelevant, for instance concerning washing machines and dryers. However, if the tips are provided by the organisation itself, and especially in combination with the web interface, it can be feasible to support it.

To make the product further interesting for the occupants, more detailed measures or estimations needs to be developed. The total energy consumption only gives limited feedback to the occupants. As a start, measures per room and separated into energy categories as lights and computers is interesting.

By introducing a web application, the opportunity to create a social green network rises. A social green network at the office, where the occupants can share tips and see detailed energy data might be a very good way to promote sustainable behaviour.

9.3 Recommendations for further development.

Usability issues.

With the current concept there are some usability issues. One more serious issue is that the circles takes time to interpret. Focus for the coming development should be to increase the graphical representations, so it is directly clear what the circles represent. The other issues and suggested improvements are found in section 8.4.

Web and app.

My recommendation is to develop the concept so it is accessible via a web page, and in that way make it more accessible for the occupants.

Before developing and app, my recommendation is to seriously consider the value for the users of having the app on their tablet or computer-like phone. It is fairly easy to develop an app, but why would the user want to have it?

Energy details, more data is better!

The detailed level of the electricity consumption needs to be developed. This includes the measuring or estimation of different electricity consuming sources, for instance computers, lighting or printers. It also includes how the interface should function and look. The fundamental idea is to tap the circle with electricity to reach more details.

Moreover, policy energy calculations should be created and visualised. This is an important function to visualise the sustainability incentives. The idea for the interface is to include it in the historical view, with a marker for the point in time combined with an explanation of the policy. From this point it might be possible to see a decline, or it should somehow be calculated. This view should also be made accessible from the sustainable features, if the policy is presented there.

Branding.

To distinguish on the market both details regarding the product looks can be further developed as considering branding possibilities with the hardware. The Priva logo very evident in the layout, it might be too much for the customer. It should be investigated if Priva can use a standard hardware from a third party, but still have a Priva unique housing. I that way the interface can be stripped on the Priva-logo, since it might be too apparent in the actual interface.

10 Conclusion.

The purpose of the product is to create awareness about energy among occupants and visitors to organisations that have a clear sustainability policy, as well as engage the same group to help the organisations to reach their environmental goals. Furthermore, the purpose of the product is to increase Priva's position and brand reputation in the so-called use-phase for climate solutions.

The investigations within this project show that there is a need from organisations to express their actions for increased energy efficiency as well as create awareness among occupants and visitors. The existing EnergyMirror lacks means to do so.

The new concept sets the direction for the new product development and is a hardware independent software solution made for touch screens. The concept has a modular base, possible to tailor for each organisation and allow the organisations to express their work and ambitions for environmental actions.

The concept has an expression that invites for interaction and contains elements for quick visual comparison of energy, and the users can discover more information according to their own interests. The evaluation shows that the users understand how to interact with the concept. However, the usability issues described in section 8.4 need to be corrected for to fulfil good user interaction.

With the new concept Priva provides the tool and the energy data and it is up to the organisations to provide the more descriptive material in form of text, pictures and video, and finally up to the users to decide what they take out of it. Hence, the product concept cannot by itself change people's attitudes or behaviour, but it is a means to communicate about energy. The concept serves the purpose by providing a tool to help create awareness and to help engage the occupants and visitors to reduce the organisation's energy consumption. However, the products usefulness —if it will be used and increase awareness among occupants and visitors—has not been determined in the project. To find that out will be possible through pilot testing.

The foundation for the software development is made, and with the current configuration there are no obvious hinders to have a product ready for the market in 2014.

There are clear indications from the market that this type of tool is desired, and it is developed to be aligned with Priva's product strategy. From a market point of view are there no doubts, but from a sustainable point of view the public display needs to be combined with an app and a web interface that addresses the occupants—or at least the latter—to be truly worthwhile. But first of all, Priva needs to decide if it wants to promote sustainable behaviour.

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Lehrer2009-IR-Visualizing.pdf> [Accessed 3 June 2012]

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Appendix 1, the amazing creativity challenge.

Hi all friends,

Hereby I invite you to a social media creativity experiment. Simply, your creativity will be challenged, your ideas will be collected, and you will contribute to both research in the field of creativity and to the particular project.

The creative challenge:

A public energy monitor is a display (in any size) that can show real-time energy data, for instance electricity and water use in a public building or an office. Anything that can be measured can be shown.

What would make you interact and get inspired by a public energy monitor on a regular basis? And in that way create awareness about energy.

Important is that to be open-minded and NOT critical at all: All ideas are good, welcome and important. There is no right or wrong, everything is possible!

What is in there for me?

All your ideas will be collected, organized and send as feedback to you. Maybe you find this very interesting! More, you will be part of a new field of research and if this experiment turns out well you can use the method if you one day need creative input to a project!

But I would like to win a price, like a car or a weekend in Amsterdam.

I am sorry, no prices. I hope you will see something else in this. And you never know: if you participate it might lead you to unexpected opportunities!

Inspiration:

Take some time and look around you, what do you know about the energy?

What would you like to know? And the important question: when you know that, what would you like to know next week, and the week after that?

Is there something else you would like to see on a display in your building, today, tomorrow, and next week?

What do you do every day? Watching the news? Brushing your teeth? Switching on the light? How can this inspire you?

How can you improve your ideas, can you add something, or combine something?

Where is it located? How big is it? How do you interact?

How do I tell you my idea?

Make a drawing, video, write something or send an internet link with explanation, and just send it to me in any way: email, sms, whatsapp, skype, facebook, mail, call, grab me on the street, tell my family. If I reach the message, then it is okay! Be creative!

erased@student.chalmers.com

Skype: Erased

+31 619-ER AS ED

+46 702-ER AS ED

Is this all?

Yes! However, a team at the company will do the same thing. Will you be able to come up with more ideas than them?

I do not understand what I should do, but I really want to do it!

Please tell me, maybe the explanation needs to be changed.

More information about the project:

I am doing my master thesis, or graduation project, for a company that knows everything about building automation. In other words: heating, cooling, ventilation and lighting of a building. For the occupants of the building this is often invisible, especially the energy consumption.

This is the reason they developed a public energy monitor, where energy consumption as gas, electricity and water is shown to the occupants of the building. Also produced energy from solar panels and wind turbines can be shown. This to create awareness about energy.

My task is to improve this existing product. One of the issues I found is that people only look and interact with it once, and then it is not interesting any more.

Appendix 2, user test scenario and questionnaire.

Evaluation

Introduction.

Welcome to this short evaluation of the new version of the EnergyMirror. I am very glad you took your time for this.

The EnergyMirror is redesigned based on an analysis of the customer needs. For the new product Priva only develops the software. The hardware comes from a third party, and is basically touchscreen with a built in computer.

Today we are not going to test the actual software, since the product development is in a very early stage. I am going to show you a draft of the graphical layout.

Since it is not fully developed, it is for the moment only one correct way to go. I will let you guess sometimes, but also lead you the right way. Please take it easy and explain how you are thinking.

The example of graphics is made for a company scenario, and the company is called Fastsat. I am going to show you the graphics and explain a few things around them for a few minutes, and then I am going to ask you to fill in a form afterwards, and also explain your answers.

The screen we see is not a touchscreen, we are going to use a normal mouse to navigate.

To be able to go back and maybe quote something, I would like to record. Are you okay with that? Any questions so far?

So, you are coming in to entrance of this company, you know a little bit about the company, but never been at their head office before. You have some time before your meeting, so you take it easy and look around a little bit. And you see this display. So, please, have a look at the product.

The first to step you are going to do yourself, it is a test to see what you find interesting.

1. Frontscreen, let them explore
2. Introduction, let them explore
3. Find out about the electricity consumption
4. You see they have wind and solar power, so you would like to see how much they produce compare to what they use.
5. Have a look at other sustainable efforts they have implemented
6. You are curious about the carbon dioxide levels
7. You decide to explore some historical data, some statistics
8. Finally you have a look at the temperature

Emotions.
The product and graphics evoked a feeling of:

	Not at all					Very strong
Joy	☐	☐	☐	☐	☐	☐
Trust	☐	☐	☐	☐	☐	☐
Fear	☐	☐	☐	☐	☐	☐
Surprise	☐	☐	☐	☐	☐	☐
Sadness	☐	☐	☐	☐	☐	☐
Disgust	☐	☐	☐	☐	☐	☐
Anger	☐	☐	☐	☐	☐	☐
Anticipation	☐	☐	☐	☐	☐	☐

Semantic , what the product expresses.
The design is:

	1 = do not agree				5 = Completely agree
Inspiring	☐	☐	☐	☐	☐
Boring	☐	☐	☐	☐	☐
Childish	☐	☐	☐	☐	☐
Professional	☐	☐	☐	☐	☐
Innovative	☐	☐	☐	☐	☐
Youthful	☐	☐	☐	☐	☐
Interactive	☐	☐	☐	☐	☐
Disgusting	☐	☐	☐	☐	☐
Consistent	☐	☐	☐	☐	☐

Questions

Did you reflect over the colours of the circles? If, what did you think they meant?

Do you think the product was easy to understand?

Appendix 3, web addresses to energy displays.

Benchmarking

Displays (display not always included)

www.trendenergyeye.com

http://www.noveda.com/solutions/sustainability-communication/carbon-footprint-monitor

http://www.siemens.com/sustainability/en/environmental-portfolio/products-solutions/building-technology/green-building-monitor.htm

http://www.neo-technologies.ch/index.php/en/metering/green-value.html

http://www.ecoreflect.nl/

http://www.enigin.com/eniscope

http://www.enigin.com/products/eniscope/public-display

http://www.enigin.com/products/eniscope/renewable-energy

http://www.qagraphics.com/interactive-development/energy-efficiency-education-dashboard.html

http://www.webeasy.nl/?module=blog&page=viewpost&post=webeasy-installatie-management.php&pageback=

http://dashboard.deltacontrols.com/delta-hq/

http://www.luciddesigngroup.com/

http://www.unica.nl/online/module/energie-greenscreen

Computer software or online only

http://cm.asu.edu/#

http://www.powerhousedynamics.com/

http://www.iconics.com/Home/Products/Building-Automation.aspx

Home displays

http://www.busch-jaeger.com/en/comforttouch.htm

http://www.exibea.se/en/home

http://www.theenergydetective.com/newhome3

Other links of relevance

http://www.theenergysavingcompany.co.uk/

http://www.eu-greenbuilding.org/

http://www.zeromission.se/en/