CHALMERS

A Refrigerator Concept Designed for Sustainable Behaviour

Master of Science Thesis in the Master Degree Programme,
Industrial Design Engineering

REBECKA LANNSJÖ
ANNA VIGGEDAL

Department of Product and Production Development
Division of Design and Human Factors
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden, 2012

A Refrigerator Concept Designed for Sustainable Behaviour

REBECKA LANNSJÖ
ANNA VIGGEDAL

Department of Product and Production Development
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden 2012

A Refrigerator Concept Designed for Sustainable Behaviour

REBECKA LANNSJÖ
ANNA VIGGEDAL

Published and distributed by
CHALMERS UNIVERSITY OF TECHNOLOGY
Department of Product and Production Development
SE-412 96 Göteborg
Sweden
Telephone +46 (0)31-772 1000

Cover: [The final concept Pompador; a refrigerator concept changing the user behaviour to be more sustainable.]

Printed in Sweden by
Chalmers Reproservice
Göteborg, 2012

Abstract

Eco-design usually focuses on eco-friendly materials, energy efficient technologies and design for disassembly. Regarding the use phase less has been done. The research field Design for Sustainable Behaviour (DfSB) highlights the important aspect of users' impact on product sustainability, and suggests strategies for changing the user behaviour through product design. However, there are few product examples on the market providing evidence of when such strategies have been applied.

The refrigerator is a product for which the user behaviour has great impact on the sustainability. Not only in terms of energy consumption, but also the related food waste. This Master Thesis Project was carried out in cooperation with Electrolux with the aim to develop a refrigerator concept that changes the user to adopt a more sustainable behaviour. Three concepts were developed based on the findings from a thorough literature review and user study with the aim to understand the problem situation and users' barriers to a sustainable behaviour. A finding from the study was that users' understanding of the connection between their actions, e.g. placing warm food in the refrigerator, and the consequences on energy consumption and foods durability often is low, so is the knowledge of good food preservation.

The project resulted in the final product concept Pompador; a refrigerator that strengthens the bonds between the product, user and the brand. Above all it can change the users' behaviour to be more sustainable - avoid wasteful consumption of resources. Pompador is a refrigerator with drawers customized for different foodstuff and a top surface to be used as a workbench. The concept is developed for 5-10 years ahead and strongly focused on the target user. It includes increased feedback and an interactive top surface that helps the user chill and thaw food efficiently. The concept was evaluated and assumed to change the user's behaviour successfully.

Acknowledgements

There have been many people supporting us in this Master's Thesis Project and we will start by thanking all people involved at Electrolux, who has been of great importance for the project. Firstly we would like to thank Per Börjesson who believed in our project proposal and offered us to do this Master's Thesis for Electrolux IDC in Porcia, Italy. Also thanks in particular to Thomas Johansson for all your help with access to in-house material, design guidance and practical things.

A great thank you to Simona Iuculano, our supervisor at Electrolux. Your knowledge of what "looks Electrolux", and your great sense of good design helped us to come as far in the form development as we did. Thank you for your supervision, always with a smile.

It has been a pleasure working at both IDC Porcia and Stockholm and all colleagues have been very supportive and available with good feedback. Among these people we would like to firstly lift forward Urban Wählby at Advanced Development and thank you for all the time you offered us explaining the technical aspects and introducing us to the advanced world of refrigeration. Thanks also to Trung Viet Pham for your assistance with energy efficiency estimations. Without you two, this report had been much less interesting and the concept less technically feasible.

The next person to thank is Rudy Bortolini. Thank you for driving us around at the Electrolux departments in Italy making sure we met interesting people and learned and saw important things for our project. Your support on interaction design was also of good help. Thank you also for showing us the nice villages surrounding Porcia and where the best coffee could be found!

Other people important to mention are Lennart Johansson for sharing your refrigeration knowledge and Johnny Karlsson and the other we met at Electrolux in Mariestad who helped us making our concept technically possible. We would also like to direct a great thanks to the air care guys at Electrolux IDC Stockholm for offering us time and advices when making the renderings. Finally a great thanks to all of you not mentioned by name that in some way supported us in the project and made us have a great time at Electrolux when working on this Master's Thesis.

Örjan Söderberg and Anneli Selvefors, our supervisors, thanks for being there for us and responding to our questions and thoughts. Thank you for your guidance, assistance with literature and help with limitations and the positive support. Finally, a great thanks to our examiner Ulrike Rahe who introduced us to the interesting area of Design for Sustainable Behaviour.

Contents

1. Introduction 1

1.1. Background 1

1.1.1. Problem Description 1
1.1.2. Purpose 2
1.1.3. Aim 2
1.1.4. Question Formulation 2
1.1.5. Deliverables 3
1.1.6. Limitations 3
1.1.7. Report Layout 3

1.2. About Electrolux 4

1.2.1. The Electrolux Group 4
1.2.2. The Electrolux brand 4

2. Theory 6

2.1. Design for Sustainable Behaviour 6

2.2. Habits and User Behaviour 8

2.3. Sustainability in Product Development 9

2.3.1. The individual and sustainability 9
2.3.2. Business and sustainability 11

2.4. Resource Consumption 11

2.4.1. The big picture 11
2.4.2. Food waste 12

2.5. The Refrigerator 13

2.5.1. Technical principle and construction 13
2.5.2. Materials, recycling and manufacturing 15
2.5.3. Energy efficiency and classification 16
2.5.4. Users' impact on refrigerator sustainability 17

2.6. Food Preservation 19

2.6.1. Cold preservation of food 19
2.6.2. Date labelling 20
2.6.3. Suitable storage for different foodstuffs 20

3. Method 22

3.1. Planning and structuring 22

3.1.1. Gantt chart 22
3.1.2. Mind maps 22

3.2. Data Collection 22

3.2.1. Interviews 22
3.2.2. Survey 23
3.2.3. Context mapping 23
3.2.4. Observation-self observation 24

3.3. Analysis 24

3.3.1. Function analysis 24
3.3.2. Persona 24
3.3.3. PrEmo 24
3.3.4. Mood board 25
3.3.5. PESTED-analysis 25
3.3.6. Future scenarios 25
3.3.7. Brand eye 25
3.3.8. KJ-analysis 25
3.3.9. Wordle 25

3.4. Idea generation 26

3.4.1. Brain storming 26
3.4.2. Brain writing 26
3.4.3. Morphological matrix 26
3.4.4. Sketches 26
3.4.5. Strategy cards from Brains Behaviour and Design 26

3.5. Evaluation methods ***26***

3.5.1. Matrix Evaluation 27
3.5.2. Hierarchical Task Analysis 27
3.5.3. Cognitive Walkthrough 27
3.5.4. Predictive Human Error Analysis 27
3.5.5. Focus group 27
3.5.6. Sketch models 27
3.5.7. Computer aided design 27

4. Project Process 29

4.1. First phase – Research ***30***

4.2. Second phase – Analysis ***30***

4.3. Third phase – Development ***30***

4.3.1. Concept development 30
4.3.2. Final concept and evaluation 30

5. Pre-study 32

5.1. Analysis of the Refrigerator ***32***

5.1.1. Function analysis 32
5.1.2. The role of the refrigerator 32

5.2. The context of use ***34***

5.2.1. Lifestyles and cultural differences 34
5.2.2. Usage situations 36
5.2.3. The kitchen environment 36

5.3. The Target User ***38***

5.3.1. Persona 40

5.4. Analysis of the Electrolux brand ***40***

5.4.1. Electrolux's professional heritage 40
5.4.2. Brand Eye 41
5.4.3. Design language 41

5.5. The Refrigerator Market ***43***

5.5.1. Benchmarking 43

5.6. The Future Context ***46***

5.6.1. Trends and influences shaping the future 46
5.6.2. Future scenarios 47

6. User Study 51

6.1. Why User Studies? ***51***

6.2. User study set up ***51***

6.3. Survey ***52***

6.3.1. Survey findings 53

6.4. Context Mapping ***55***

6.4.1. Workbook 55
6.4.2. Generative session 56
6.4.3. Context mapping findings 57

6.5. Reflections and Observations ***58***

6.6. Conclusions from the user study ***59***

7. Basis for concept development 61

7.1. Conclusion from the pre-study ***61***

7.2. Barriers and Behaviour improvement areas ***61***

7.2.1. Barriers for a sustainable *behaviour* *61*

7.3. Reflections on choice of strategies ***62***

7.4. Personality Change for the Refrigerator ***63***

7.5. Need and demand list ***63***

8. Development 64

8.1. Idea generation ***64***

8.2. Part concepts ***64***

8.2.1. The Efficient 65
8.2.2. The Organized 65
8.2.3. The Professional 67
8.2.4. The Communicator 69
8.3. Part Concept Evaluation 71
8.4. Focus of final concept 72
8.5. Development of final concept 73
8.5.1. Complementary research: dimensions and components 73
8.5.2. Physical model 73
8.5.3. Product architecture 74
8.5.4. Interior and insets 75
8.5.5. Food preservation enhancing technologies 76
8.5.6. Utilization of the warm air 76
8.5.7. Educating the user - product placement 77
8.5.8. Educating the user - refrigerator status and temperatures 77
8.5.9. Interface 78
8.5.10. Form, expression and context 78
8.5.11. Involving more sensory modalities 78

9. Final Result 79
9.1. Pompador 79
9.2. The Product 79
9.2.1. Temperature zones 81
9.2.2. The four compartments 81
9.3. Functions 84
9.3.1. Towel dryer and warm surface 84
9.3.2. Temperature status in the refrigerator 85
9.3.3. The display: information and support to the user 86
9.3.4. Chilling food support 87
9.3.5. Thawing food support 87
9.3.6. The EatSoonZone 89
9.4. Form Design and Expression 91
9.5. Technical Aspect 92
9.5.1. Manufacturing and recycling 94

10. Evaluation 96
10.1. How Pompador Can Make Users Adopt a Sustainable Behaviour 96
10.1.1. Place food as intended for improved preservation 96
10.1.2. Encourage thawing food in the refrigerator 97
10.1.3. Encourage chilling food before placing it in the refrigerator 97
10.1.4. Awareness of temperature status in the refrigerator 98
10.1.5. Use food close to go off: the EatSoonZone 98
10.2. How Pompador Attracts the Target User 99
10.3. Theoretical Evaluations and Focus Group 100
10.3.1. Evaluation with CW and PHEA 100
10.3.2. Evaluation with need and demand list 100
10.3.3. Evaluation with users 100

11. Discussion 102
11.1. Method 102
11.1.1. Planning and structuring 102
11.1.2. Data collection 102
11.1.3. Analysis 103
11.1.4. User study 103
11.1.5. Development 104
11.1.6. Evaluation 104
11.2. Pre-study and Development 105

11.2.1. Literature findings 105
11.2.2. User study findings 105
11.2.3. Concept development 106
11.3. Final Results 106
11.3.1. Adoption of sustainable behaviour 106
11.3.2. Usability 108
11.3.3. Estimations regarding energy efficiency 109
11.3.4. Technology and material 112
11.3.5. Pompador's relevance for the Electrolux brand 112
11.3.6. Is Pompador attractive to the target user? 113

12. Conclusion 115

13. Recommendations 116

1. Introduction

This chapter introduces this Master's Thesis Project and includes a description of the background and the problem situation, a presentation of the research question, the aim and purpose of the project and its deliverables and limitations. At the end of the chapter the structure of this thesis report is outlined, and a brief introduction to Electrolux is given.

1.1. BACKGROUND

Sustainable design is an area in which currently much research is performed, and a central topic within this area is Design for Sustainable Behaviour (DfSB). In the field of DfSB, several sets of intervention strategies for how to - by means of product design - change the users to adopt a more sustainable behaviour are suggested. Because in the end it does not matter how sustainable and energy efficient the technology in a product is if the users do not use the product in a sustainable way. This motivates to put effort on designing with the intent to change the user behaviour to be sustainable. According to research it has been claimed that DfSB not only leads to benefits for the environment, but also can result in an increased level of innovation for companies. Just as advancements in technology can lead to new innovations, user centred design with sustainability can also do (Selvefors, Blindh Pedersen and Rahe 2011; Nidumolu, Prahalad and Rangaswami, 2009).

The product in focus of this project has been the refrigerator and the cold preservation of food situation in the domestic environment. The project has its foundation in the DfSB approach, and has been carried out in cooperation with Electrolux in Stockholm, Sweden, and Porcia, Italy, and for the Electrolux brand. The project was initiated with a working period of four weeks at the Electrolux Industrial Design Centre (IDC) in Porcia in Italy, after which the Stockholm office was the workplace for the remaining period of time.

1.1.1. Problem Description

The refrigerator is a product found in almost every household and it is used daily. The usage implies resource consumption and thus the user behaviour has an impact on the product sustainability.

The refrigerator's evolution over the years has primarily been focused on the technology and its efficiency, and regarding design and interaction have not much been changed since its invention almost 100 years ago.

New refrigerators have relatively energy efficient technology and a refrigerator that is top rated in the standardized energy efficiency test consumes about 18 W, i.e. less than 0,5 kWh per day (Wählby, 2012). There is a continuous development towards better and more efficient solutions, but after all it does not matter if a refrigerator has the highest energy class if the door is left open, it is loaded with hot food and the food stored in it is wasted.

It can be argued that further improvements of its energy efficiency would lead to insignificant reductions of total domestic energy consumption, since the consumption already is comparatively low. On the other hand, one can argue that even incremental improvements have considerable positive impact, since the appliance is so common and in use 24 hours a day all year around. Then take into consideration that the measured energy efficiency improvements only applies when the refrigerator is left closed in standardized conditions, and not when it is "misused" as it commonly is in reality.

In addition to the unnecessarily high energy consumption due to the users' behaviour with the refrigerator comes food waste. Food waste might be an even bigger problem and today is almost a third of all food bought thrown away. The eatable food wasted equals 3600-5300 SEK per household and year (Modin, 2011). The reasons for food waste can be several: foodstuffs are not stored in the right way, too much food is bought, food is forgotten in the refrigerator and sometimes expiring dates are relied on instead of tasting or smelling the food. Since the refrigerator plays such an integral part in food preservation, much can be improved and the wasting subsequently decreased by changing how people use their refrigerators.

Today, many companies are competing with sustainability, but in a near future sustainability probably will not be a differentiating factor, but a prerequisite to at all be in the competition. The competition will rather be about the functionality, experiences, usability and design between the already sustainable products. Therefore sustainability is getting increasingly important in product development, and so does the demand for attractive "green products" that give added value to the user. Still, many users associate eco-friendly products with lower performance: less attractiveness and less fun to use; something that is not necessarily the truth. The refrigerator is a product associated with high resource consumption in the use phase. However, few users reflect on it. Therefore there is a significant potential for improvements towards more sustainable user behaviour.

1.1.2. Purpose

The purpose of this Master's Thesis Project was to explore the context of cold preservation of food in the domestic environment to develop a cold food preservation concept that is sustainable and affects the user to adopt a sustainable behaviour when using it. The purpose was also to suggest a new way for Electrolux to strengthen their profile as a sustainable premium brand and stand out in the competition.

1.1.3. Aim

The aim of the project was to develop a design concept for a cold preservation of food product that encourages sustainable user behaviour, i.e. offers energy efficient usage and prevents users from wasting food. The concept should be designed for the near future, i.e. 5-10 years ahead. In addition a number of other important factors have been targeted, namely:

- The product concept should be developed to attract the target group of the Electrolux brand with emotional benefits and associated added values – such as convenience or emotional benefits.
- The product concept should elaborate on and express Electrolux's brand identity, by means of aesthetics, usability and functionality.
- The product concept should strengthen Electrolux's position as an eco-friendly brand and fit with the Electrolux major appliances product portfolio.

1.1.4. Question Formulation

Based on the problem description, purpose and aim, the question formulation for the Master's Thesis was:

How can an attractive cold food preservation product be designed so it offers a meaningful added value combined with good usability, encouraging the user to utilize it in an optimal way regarding food durability and energy consumption, resulting in a sustainable user behaviour?

1.1.5. Deliverables

The deliverable of this project is a final design proposal of a product concept visualised with renderings. Besides the final concept proposal there are three less elaborate part concepts presented orally, visually and in writing. There is also this academic report, presenting the extensive research study, describing the project process and presenting and motivating the results and the project process in detail. Finally there will be oral presentations where the project and its results are presented at Chalmers University of Technology and at Electrolux IDC in Stockholm.

1.1.6. Limitations

Within the frames of this thesis project no new technology is developed. The results should be based on technologies existing today, or technologies that currently are under development. This means that the technological solutions included does not have to be in use or industrialized today, but be highly possible to use in 10 years' time. The proposed solutions should be realistic to produce within the set time span, but yet at a conceptual level. Thus the final concept should be feasible to be realised within 10 years, and every detail does not have to be defined. Choice of materials has been taken into consideration, but has not been in focus and neither the sustainability of them. The same goes for the pre- and post-use phases, which are outside the scope of the project. This is also the case for the product economy, since cost estimations for a future product concept would be approximate and the product concept was aimed at the premium segment where higher costs can be accepted.

Even though Electrolux is a global brand, the product concept developed in the project was targeted to the European market, focusing on Sweden. This because of the major cultural and local differences related to the food stored in refrigerators. However these differences mainly concern the design of the interior, why solutions to make user behaviour more sustainable can be expected to work globally.

The project focuses on a product that can replace a refrigerator; having the capability to preserve at least the same kind of food as a present refrigerator and the freezer has not be taken into account. Since the focus has been on design for sustainable user behaviour graphic design of the interface have not been elaborated on in detail, and existing symbols from Electrolux have been used.

1.1.7. Report Layout

This report consists of twelve chapters and each chapter starts with a brief introduction to its contents. This section is for the reader to better understand where to find what in this report.

After this first chapter introducing the project background and its aim, a rather extensive theory chapter follows. This theory chapter is here for any reader who wants to deepen the knowledge and have a better basis to understand decisions and turns made in the project. In Chapter 3 the methods used are described, and the short Chapter 4 presents an overview of the project process and when the methods have been applied. In the 5th and 6th chapter the findings and results from the pre-study and the user study respectively, are presented. The 6th chapter also describes the set up of the user study. Chapter 7 serves as a bridge between the pre-study and the concept development and summarizes the most important findings, the barriers and problem areas, to meet in the concept development. The 8th chapter describes the part concepts and the development of the final concept, before it is presented in Chapter 9. There is also a Chapter 10 in which further motivations and the evaluations of the final concept are presented for those who want to find out more about that. Finally, a discussion of the results and the project can be found in Chapter 11 before the conclusions and recommendations in Chapter 12 respectively 13.

If just being curious about the results of the project, the reader can go directly to Chapter 9, but to better understand them especially the last conclusions from Chapter 6 and the entire Chapter 7 are important to read. Moreover, a lot of complementary material can be found in the appendices.

1.2. ABOUT ELECTROLUX

Since this project was carried out for the company Electrolux and the Electrolux brand, follows a brief introduction to the company and the brand in focus.

1.2.1. The Electrolux Group

Electrolux is a global leader in household appliances and appliances for professional use, selling more than 40 million products yearly in over 150 markets (Electrolux Group, 2011b). The company was founded as AB Lux in 1901 in Stockholm, Sweden and AB Electrolux was established in 1919 after agreements between AB Lux, Electromekaniska and Electron (Electrolux Group, 2011d). In 2010 Electrolux had 52 000 employees and a turnover of 106 billion SEK. Electrolux product range includes dishwashers, washing machines, vacuum cleaners, cookers, air-conditioners, refrigerators and freezers (Electrolux Group, 2011a).

Apart from domestic appliances - major and small appliances, the Electrolux Company also offers products for professional use. Electrolux Professional is a business segment of the Electrolux Company focusing on professional products. With their professional products they are the world-leading supplier of total solutions of professional food service and laundry equipment. The professional and domestic two parts have historically been well separated

The core values of the Electrolux group are; *Passion for Innovation, Customer Obsession* and *Drive for Results* (Electrolux Group, n.d.). Their tagline is "Thinking of you", which refers to their ambition to place the user in focus. The Electrolux group has more than 50 different brands, as for example Zanussi, AEG and Electrolux.

Being innovative is a central role for the company, and that is one of the reasons why Electrolux Design Lab, an annual global design competition for design students, was established in 2003, (Electrolux Group, 2011d). Apart from innovation, the humanistic and the environmental approach are important for Electrolux.

The Electrolux logotype is an evolution E as can be seen in figure 1.1.

1.2.2. The Electrolux brand

The Electrolux brand is the flagship brand of the Electrolux Company and is one of the major brands on the refrigerator market, and one of the few with a global presence. It was up to 2010 a brand positioned in the medium segment with the profile to be caring for their customers. In 2010 Electrolux changed the positioning towards the high-end segment, and is now one of few global household appliance brands in the premium segment. Competitors to Electrolux on the refrigerator market are brands as Siemens, Bosch, Miele, Lg, Whirlpool, Polar, AEG (also an Electrolux company brand), Gaggenau and Indesit.

The brand values of Electrolux are *empathy, insightful, progressive* and *ingenious*. The aim is to be perceived as the "Thoughtful design innovator", and fulfilling the brand values is the way to achieve this statement. Empathy means to have compassion for others experiences, thoughts and feelings. Insightful is to be perceptive and anticipatory and to create meaningful value for the consumers. Progressive implies challenging conventions and deliver concepts shaping the future. Finally, ingenious means creating clever solutions and original experiences. (Electrolux, 2011c)

Fig.1.1: The Electrolux logo; an evoluted E.

The product design strategy is involving cross category thinking, where the products of the entire product range of the brand are aligned in their design and interaction instead of only in individual product categories. This in order to achieve a consistent expression integrating designs as well as emotional aspects. The Electrolux brand imparts Scandinavian values and the Scandinavian touch is noticeable in the choice of materials, the functionality and also in the stronger focus on making sustainable products.

2. Theory

This chapter presents and summarize a literature review of research and theory relevant for the project to give a thorough background and support the project and its results. It covers the fields Design for Sustainable Behaviour, Habits and User behaviour, Sustainability in Product Development, Resource Consumption, the Refrigerator, and Food Preservation.

2.1. DESIGN FOR SUSTAINABLE BEHAVIOUR

Design for Sustainable Behaviour, DfSB, is a field of research and an approach incorporating a behavioural perspective in the product development and design process - aiming to affect how users behave in the interaction with products. People tend to not act sustainable because there are barriers for the sustainable behaviour that are big, and the way to act unsustainable is easier. Therefore, to reduce the negative environmental impact in the use phase of products, researchers in DfSB propose that designers by means of the right design and use of intervention strategies can influence the user to act in a more sustainable way (Lilley, 2009).

Behavioural change, change of routines or the raise of new behaviours can occur when a product presents totally new functionality or when a product offers functions that will simplify the everyday life of the user (Selvefors, Blindh Pedersen and Rahe, 2011). Behavioural change can also occur when a product raise awareness of wasteful resource consumption allowing the user to react on it.

DfSB is a user centred design (UCD) approach focusing on minimizing the resource consumption during the use phase of products. In the industry is the knowledge on behavioural aspects and different strategies for influencing user behaviour generally low, and therefore little effort

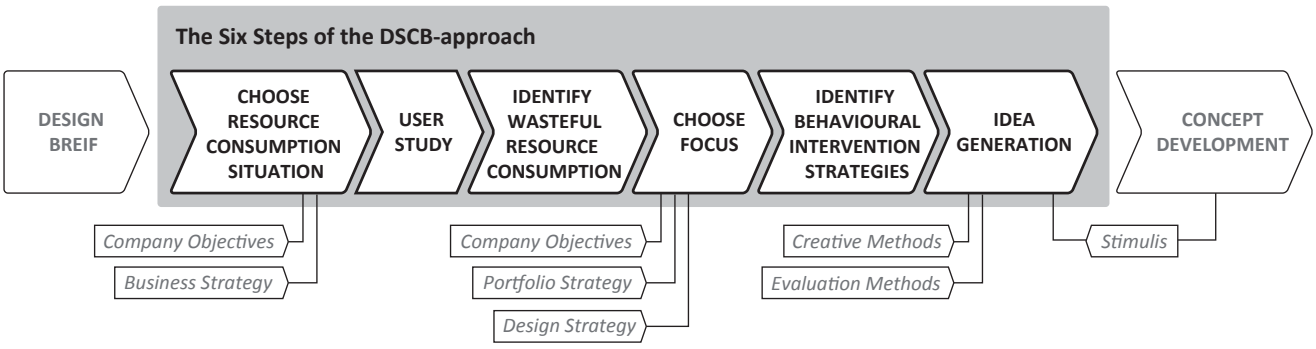


Fig.2.1: The DSCB design process; described in its six steps. (Selvefors, Blindh Pedersen and Rahe, 2011)

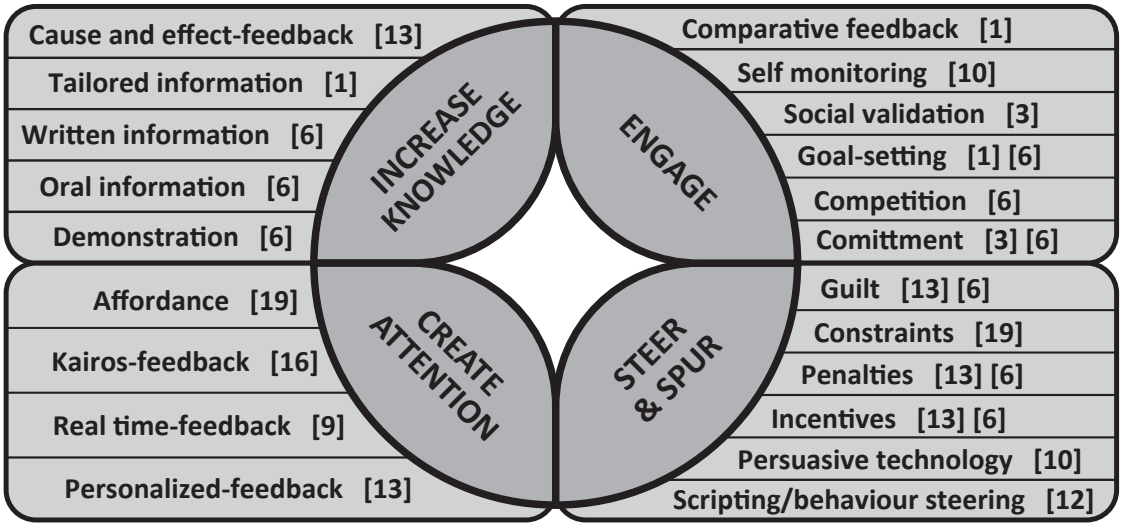


Fig 2.2: DSCB intervention methods (Selvefors, Blindh Pedersen and Rahe, 2011)

is put on it in product development. To ease the application of DfSB and intervention strategies product developers need guidance of which ways of influencing user behaviour that are effective for specific purposes and a map over what strategies are available (Selvefors, Blindh Pedersen and Rahe, 2011). Selvefors, Blindh Pedersen and Rahe (2011) also suggest a six-step process for how to apply the DSCB approach efficiently, including the steps showed in fig 2.1.

Different teams of researchers have presented various models and versions of intervention strategies, and here follows brief introductions to some of them.

In an approach called Design for Sustainable Consumer Behaviour Selvefors, Blindh Pedersen and Rahe (2011) present four groups of interventions: increase the user's knowledge, engage the user in a specific direction, steer and spur the user and create attention to a specific matter. In this model the strategies are categorised based on how they can evoke users motivation to decrease the resource consumption (fig. 2.2). The groups of interventions are best used in different phases of the product use. If the product usage is divided into four phases as in the wheel of consumption shown in figure 2.3, the user has diiferent needs why different types of interventions are more or less suitable to use. As an example is written information the most effective when used before the actual consumption of the resource. (Selvefors, Blindh Pedersen, Rahe, 2011)

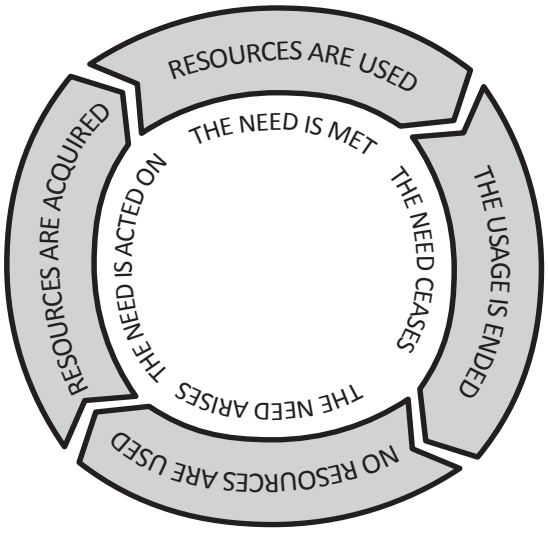


Fig 2.3: The cycle of consumption.
(Selvefors, Blindh Pedersen and Rahe, 2011)

Wever, van Kuijk and Boks (2008) and Lilley (2009) have divided strategies for design for sustainable behaviour into three different categories: *Eco-feedback*, *Behaviour Steering/Scripting* and *Forced functionality*, which are strategies that goes from being user empowered to being product empowered. Wever, van Kuijk and Boks (2008) add a fourth category to these three called *Functional matching*, which has the aim to just reduce the negative impact on the users' actions. This is not by changing the user behaviour, but by adjusting the function of a product to the user's old behaviour to make the outcome more sustainable than before.

Darby (2000) presents an approach of using feedback to change user behaviour, with direct, indirect or inadvertent feedback. She states that feedback plays an important role when it comes to energy consumption awareness and to reduce it. A study of the use of well-exposed, attractive and user-friendly displays where energy consumption was shown as feedback to the user, showed that it led to energy savings and increased awareness (Darby, 2000).

If a product is not used as the designer intended and it is instead used in an unsustainable way, and if furthermore the way the user interacts with the product is a highly habitual behaviour, it can be difficult to change it without making any radical changes in the product (Elias, Dekoninck, Culley, 2007). This especially applies when the products energy consumption is close to its theoretical minimum (when used "correctly"), and then Elias, Dekonick and Culley (2007) suggests to develop a new product concept that meets the real need of the user. They refer to this as an "Old behaviour - New Product" scenario that can create energy savings without requiring any major changes in user behaviour. To look at the theoretical minimum for the energy consumption of a certain product can help design teams with several options available and limited resources, to see whether the effort should be put on improving the efficiency of the existing product or to introduce new behaviour changing design features (Elias, Dekoninck, Culley, 2007).

Based on previous research in the area, Lidman and Renström (2011) have come up with a conclusive model of intervention strategies with five categories. The strategies are in this model grouped according to what degree the user or the product is in control of the behavioural change, from the product motivating the user to the product forcing the user, or even matching the existing behaviour. For the complete collection of DfSB strategies found in their literature review, see their Master's Thesis report *How to Design for Sustainable Behaviour?* (2011). Here follows a description of the categories of intervention strategies:

» *Enlighten* is when the product raises the users' awareness about their behaviour and its consequences, hence it relies on the user to change it. Examples of strategies are feedback, information and enlighten through interaction and experience.

» *Spur* is when the product encourages the user to change behaviour, for instance with incentives, competition or convenience.

» *Steer* is more relying on the product than the user compared to spur – the product is guiding the user to do "the right" thing through making it the evident choice. Strategies within steer are for example constraints in the product and scripting.

» *Force* is to by the design force the user to behave in a specific way. It can be done by functional limitation or habit intervention by radically changing how the product is used.

» *Match* is to adapt the product after current user behaviour. So it does not imply any change of behaviour but a more sustainable outcome of the behaviour by adaption of the product. (Lidman and Renström, 2011)

The DfSB-process should, according to several researchers, always start with user studies with the aim to find where in usage of the product the barriers for sustainable behaviour lie and which they are. This because sustainable behaviour tends to occur when the barriers to the action are few (Selvefors, Blindh Pedersen and Rahe, 2011). The choice of strategies also depends on what sort of behaviour that is to be influenced, if it is a habit or a routine, and what the target user is like. Several strategies could and should also be used in the same product to have the largest effectiveness - erase as many obstacles as possible towards the sustainable behaviour, making sustainable usage an effortless and natural behaviour.

2.2. HABITS AND USER BEHAVIOUR

This section briefly introduces the concept of habits, for more information about user behaviour see appendix I: User Behaviour.

Habits can be defined as "learned sequences of acts that have become automatic responses to specific cues, and are functional in obtaining certain goals or end-states" (Verplanken, 2004, in: Tang, 2010). Behaviours do not have to be habits only because they are frequently repeated; it is the automaticity that makes the habit (Tang, 2010). The three aspects of habits that make them strong and difficult to break are *frequency*, *automaticity* and *functionality*, and people who have developed strong habits are less likely to take in new information. This means that it is important to understand the strength of habits and to design the interventions for each level of understanding and awareness. To influence users to break their habits, two factors are suggested to consider: the repetition, i.e. how often the action is repeated, and the reinforcement, i.e. the strength and frequency of the received positive reinforcement received. (Tang, 2010)

In table 2.1 definitions of habits can be found. This table comes from Tang Tang's doctoral dissertation (2010), and is based on Verplanken's work (2004).

2.3. SUSTAINABILITY IN PRODUCT DEVELOPMENT

Sustainability often has different meanings to different people and in different contexts, why it is important to explain how it is defined and why is it important. To clarify the concept of "sustainability" it can be divided into three dimensions: Economical, Ecological and Social, which together form a system that should be maintained in a healthy state for an indefinite time (Lilley, 2009; Oehlberg, Agogino and Beckam, 2009). Oehlberg, Agogino and Beckman (2009) states that the ideal would be if engineers and product developers always aimed for products where all aspects of sustainability are cared for; ecological, economical and social - this would be called Sustainable design.

2.3.1. The individual and sustainability

When trying to make products more sustainable traditionally a lot of effort has been put on the supply side as for example DFD (design for disassembly), eco-friendly materials and recyclability (Tang and Bhamra, 2009; Wever, van Kuijk and

Table 2.1:Definition of habits. (Tang, 2010)

Habits	Explanation of the feature as opportunities to break
Learned sequences of acts	A certain degree of practice is required for a habit to develop
	Habits have a history of repetition, whether this history is long and painful or short and easy.
Automatic responses to specific cues	Habitual acts are instigated as immediate responses to specific cues. Such cues can be anything ranging from physical objects to time, geographical features, people, labels or internal cues like hunger or pain. Automaticity as a feature of habits is broken down into four possible components, i.e. a process or behaviour that: 1. occurs outside awareness 2. is difficult to control (but not impossible) 3. is mentally efficient (one can do other things in parallell), and 4. is unintentional (not so much in the sense of being consciously planned, but rather in the sense of not being goal directed)
Functional in obtaining certain goals or end-states	Habits are developed to serve us and make or lives livable. Establishment and maintenance of behaviour is a central theme.
	Habits are created and maintained under the influence of reinforcement
	Habits serve some goal

Boks, 2008). The missing part when only looking at these approaches is the use phase. Users might not utilize products as intended by the designer. There is a risk that they do not use the energy saving features or they might utilize eco-friendly technologies in unsustainable ways. Moreover there might not be any sustainable alternatives offered by the product. An example is the low-energy light bulbs, which many people think are so efficient that they can be on 24 hours a day without a big impact. This makes them less sustainable than the older versions because of the unsustainable user behaviour result in higher total energy consumption (Bhamra, Lilley and Lofthouse, 2005).

For many products it is well-known that the major part of environmental impact often is caused when they are in use (Lockton, Harrison, and Stanton, 2008; Wever, van Kuijk and Boks, 2008), embodying an important point to tackle in order to make a difference. A user-centred sustainability approach is therefore to change the users' behaviour to be more sustainable. This is an approach that well complement technological pro-environmental solutions (Wever, van Kuijk and Boks, 2008). Elias, Dekonick and Culley (2007) states: "*creating products where the most intuitive and comfortable way of using and interacting with a product or system is also the most environmentally friendly*". Here designers have the position to make a difference by designing products allowing users to lower the environmental impact during the use phase (Lilley, 2009). What is needed to achieve this is "*cross-fertilization between sustainable product design research and human-focused design disciplines like user-centred design and interaction design*" (Wever, van Kuijk and Boks, 2008).

There are many ways for individuals to contribute to a sustainable society, and minimizing the resource consumption is one. Most people have received the message that saving energy is good for the environment, but fewer think of their own household's energy consumption as such a great contributor to the negative impact on the environment and climate change (Tang and Bhamra, 2008; Darby, 2000).

What drives people to have a sustainable behaviour and buy sustainable products can be many different factors and not only ethical (Persson and Hemberg, 2010). Research show that many people react with guilt and a feeling of hopelessness when exposed to advertisements involving sustainability, and environmental-friendly products are by many seen as being more expensive products relative to their quality with the only added value "to save the environment" implying extra

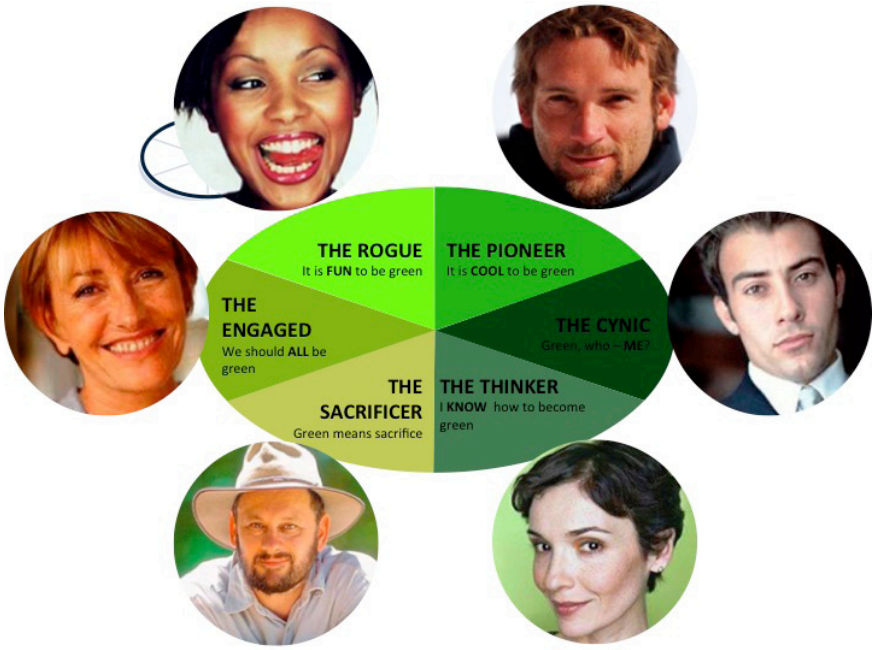


Fig 2.4: Eco-archetypes. (The Core Company, 2011)

costs (Oehlberg Agogino and Beckman, 2009). Products which gives no other benefits but being environmental friendly and are sold for a higher price than the alternatives not promoted as sustainable attract a small group of people; the ones who are willing to sacrifice (Persson and Hemberg, 2010). Whereas there are others who regard sustainable consumption behaviour as a way to save money through for instance lowered energy consumption costs.

Environmental and sustainability issues are present in the entire society and most people are in some way engaged in environmental issues; to different extent and of various reasons (The Core Company, 2011). As a designer it is beneficial to know which attitudes towards sustainability that the target customers have to be able to in the best way match their needs in-line with the company's values (Oehlberg Agogino and Beckman, 2009).

The Core-company suggests a model based on a model by The NeedScope. This model of so called Eco-archetypes has six categories that symbolizes six kinds of approaches to environmental issues; *The Rogue, The Pioneer, The Cynic, The Thinker, The Sacrificer* and *The Engaged*, see figure 2.4. All the archetypes are triggered by different kinds of arguments when it comes to environmental issues, from wanting to sacrifice all for saving the environment, to only care for the environment just if it results in benefits for oneself. The division into these six groups is however done by choice and the Core Company pinpoint that the wheel in reality is a continuum, where one person can belong to more than one category. It is important that the company communicates the arguments towards the archetype that corresponds to the brand's basic personality and towards the sector where the brand is supposed to be. (Torberger 2009)

2.3.2. Business and sustainability

It is common that companies just adapt their products to follow sustainability regulations and laws, and see environmental aspects as something costly they have to work with. Other acts sustainably only if there is a strong request for it from their customer. It can also be a wanted image leading to "green washing", i.e. companies showing an eco-friendly side towards the customers, which in reality are mostly empty words. Ecological thinking in business does not have to be difficult and can be a way to lower costs and increase revenues for companies (Persson and Hemberg, 2010). Nidumolu, Prahalad and Rangaswami (2009) write on the basis of their research that sustainability in fact is a key driver of innovation. For companies to have advantages in the future they should now act with highest possible sustainability as the goal and develop essential competencies that will be hard for competitors to match. (Nidumolu, Prahalad and Rangaswami, 2009).

2.4. RESOURCE CONSUMPTION

The ulterior goal of better product sustainability is to save resources. Concerning the refrigerator and the continuous consumption, the resources to save are primarily related to energy and food consumption and wastage, which are interrelated.

2.4.1. The big picture

The food industry including production, processing, transportation, consumption et cetera accounts for almost 30 % of global energy consumption. On top of that the food sector produces more than 20 % of global greenhouse gas emissions. (UN, 2011) Hence, when wasting food this accumulated energy is also wasted. However, there are great differences between the environmental impacts related to different kinds of foodstuff. The livestock and animal feed are great contributors to some of the most severe environmental problems, and corresponds to 18 % of the impact on climate change caused by humans. Additionally, it takes 16 times more fossil fuel to produce a certain amount of calories from beef in conventional food production, compared to the same amount from vegetables and grains. The water demand for production of 1 kg of beef is about 13 000-16000 litres, whereas only

160 litres of water is needed for 1 kg of potatoes. (Engfeldt, 2009)

These 30 % of global energy consumption coming from the food industry also takes the energy needed for cold preservation of the food into account. Keeping in mind that the residential sector corresponds to additional 11 % of the energy consumption globally (Verma, 2010) and 25,4 % in the European Union, with households' heating, lighting and appliances, one can understand that the refrigerator is a large contributor to energy wastage. Out of the energy consumed by households, the cold appliances, i.e. refrigerator and freezer, are responsible for on average 18 % (Tang, 2010).

2.4.2. Food waste

Of all food bought by the households almost a third is wasted (Modin, 2011). According to Konsumentföreningen Stockholm's research (KfS, 2009) more than half of the wasted food in Sweden is unnecessarily wasted, which means that it is wasted even though it have not gone bad and could have been eaten. The amount of food wasted per year in Sweden equals 910 000 tonnes (Modin, 2011). Young families and young professionals report higher levels of waste among socio-demographic groups, the latter often throw away unprepared food sometimes not even opened. (Lyndhurst, 2007)

Food waste is commonly not seen as having such a big negative environmental impact as for instance their packages, made of plastics or paper. (Corrado, 2007)

Everyone is not concerned with food waste. Among the ones who are common reasons to be bothered can for example be bad feelings of wasting money, throwing away good food and a general feeling of guilt. (Lyndhurst, 2007) Some of the key barriers to sustainable behaviour in food waste are according to Lyndhurst (2011):

- Lack of concern about food waste.
- Food practice that is unconscious and sometimes even irrational.
- Food practices are often a "sacred space" that is unquestionable and hard to change even with rational suggestions.
- Confidence in understanding but lack of real understanding of food labelling and food preservation.

Food commonly wasted

Food waste can be divided into edible food and inedible food like peelings. The edible food waste consists of pre-prepared (un-processed) food and post-prepared food (leftovers/meals). The post-prepared food can be leftovers from a meal on the plate, or leftovers that has been stored for a time but then not consumed. There are also leftovers that are never stored and thrown away because too much was prepared. (Lyndhurst, 2007) Different sorts of foodstuffs are more or less commonly wasted and among edible food is post-prepared food most likely to be thrown away (42 % of all food wasted) (Quested and Johnson, 2009). If the inedible foods like fruit peelings are taken into account, fruits and vegetables are most commonly wasted. (Modin, 2011; Lyndhurst, 2007). According to some studies, dairy products are also often thrown away. Meat, fish and eggs are not wasted as often and in as large volumes as other foodstuffs. However these foodstuffs have a larger environmental impact (sec. 2.4.1) than most other foods, why their contribution to the negative environmental impact is considerable. (Modin, 2011)

Reasons for food wastage

Different foodstuffs are best stored under different conditions, which is something that users have low awareness of. The specific requirements of every stored foodstuff are often difficult to meet at the same time with a normal refrigerator. In their research Geppert and Stamminger (2010) found that 10 % of the participants in their study, who set a specific temperature for their refrigerator, did it to protect their stored food. The participants chose to adjust the temperature to be between 8-12°C, which was probably done due to bad information or lack of knowledge about right preservation con-

ditions. (Geppert and Stamminger, 2010). Moreover, a significant number of the participants in a study by George et al. (2010) wrongly stated that they believed the refrigerator's interior temperature does not have much impact on how long food lasts.

In a publication by KfS (2009) it is concluded that unnecessary food waste can be prevented through better planning of grocery shopping, something that WRAP (n.d.) also suggests. In their research George et al. (2010) found that a great number of the respondents did not check their refrigerator before going grocery shopping, resulting in buying unneeded food. Grocery stores also play a great part in food waste through promotions, e.g. by two for the price of one, and big packs with lower price, which makes consumers buy more food than they will consume. (Lyndhurst, 2010)

A large part of food wastage could be prevented if people knew which of the products in their refrigerator that will expire first and used them before they went off (WRAP, n.d.). According to Lyndhurst (2010) one way to change people's food preservation behaviour is to in some way help and encourages people to rely more on their own judgement and common sense instead of completely trust date labels. (Lyndhurst, 2011)

As earlier mentioned people can have various reasons for wasting food, and these are common key drivers discussed in literature:

- Buying too much food, especially fresh/perishable
- Not consuming food with the shortest durability first
- Cooking too much food
- Clearing the shelves when cleaning the refrigerator
- Fear of eating unhealthy/bad food
- Untasteful cooking

(Lyndhurst, 2007)

2.5. THE REFRIGERATOR

This section gives an introduction to the refrigerator and topics related to it important for this project, but first a brief history of the product.

The first refrigerator cabinets were made in wood and cooled with ice blocks (Nickles, 2002). In 1923 the two Swedish students Baltzar von Platen and Carl Munters came up with a solution for how to use gas and an absorption technique in a refrigerator, which could replace the blocks of ice. This resulted in a patent that later was bought by Electrolux. During the 1920's Albert Einstein worked together with the Hungarian physicist Leo Szilard, a cooperation that resulted in several patents regarding improvement of Platen-Munters inventions. These patents were also bought by Electrolux to secure its superior placement on the refrigerator market. (Sempler, 2005)

In 1925 started the industrial production of the world's first practicable refrigerators without ice-blocks. These were produced by Electrolux in their factory in Motala, Sweden, and used the absorption technique.

2.5.1. Technical principle and construction

On the European market the so called combined bottom refrigerator with the refrigerator on top of the freezer is the most common model. This type is particularly common in central Europe, whereas full height refrigerator and full height freezers are more common in the Nordic countries. Refrigerators and freezers can either be free standing or built in, where the latter is hidden behind the kitchen cabinet doors. The freestanding model is the most common, but built-ins are getting more frequently occurring (Wählby, 2012).

The basic technical principle of a refrigerator (fig 2.5) is rather simple and has not changed very much since the 50's, except from the development to be more energy efficient and the addition of some new functions (Carlberg, 2005; Sempler, 2005). One important change made to improve the refrigerator sustainability were

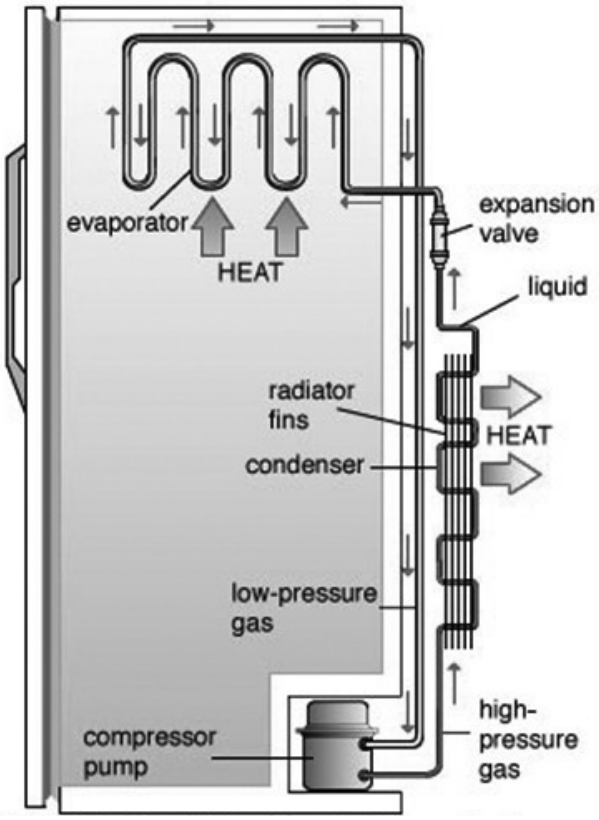


Fig 2.5: Technical principle of a refrigerator with static condenser.

the prohibition of the toxic coolant gas earlier used, the CFCs (Freons). Already in 1974 it was found that the CFCs destroyed the ozone in the Stratosphere, but not until 1992 the industrialized countries decided to cease the production of CFSs by 1995 (Diamond, 2005). In 1995 Electrolux had removed all Freon from their refrigerators (Grunewald, 1999).

Principally there are three main types of cold appliances in use today; the evaporation-condensation type according to the Rankine principle, the absorption cycle type and the thermo-electric cooling type by the peltier (Seebeck, Joule) principle. (Wählby, 2012)

The system includes a working fluid, called the refrigerant, a compressor, an expansion device (a valve or for domestic refrigerators more commonly called capillary tube), an evaporator and a heat exchanger. The refrigerant enters the compressor in vapour form, where it is compressed. In the condenser the high-temperature refrigerant is cooled by sending away heat to a high-temperature medium, T_H (the exterior air that gets warmed up), and condenses to liquid form. When the liquid refrigerant then enters the expansion device it is expanded and its pressure and temperature drop. When the refrigerant enters the evaporator it is a mix of a liquid and vapour. In the evaporator it absorbs heat from the low-temperature medium, T_L (the refrigerator), and boils forming vapour again, ready to enter the compressor anew. (Dinçer and Kanoğlu, 2010)

There are basically two different kinds of condensers: dynamic condensers and static condensers. The static condenser is the most used, except from in the Northern American (NA) market and it covers a large part of the back of the refrigerator. The dynamic condenser is primarily used in NA products which usually are larger. It is normally placed in the bottom of the refrigerator next to the compressor. The dynamic condenser is compact and therefore less material is needed. Since the dynamic condensers are compact they requires a fan to enhance the heat transfer. The fan demands additional energy compared to the static condenser, about 3 W. However, this fan does not have to run constantly, i.e. it is only employed when the cooling system operates. (Viet, 2012)

In most refrigerators the temperature varies vertically. The temperature can differ up to 5 degrees between the top and the in a full height 180 cm refrigerator of an older model. The difference is among other things due to the lower density of warm air compared to cold and the placement of the evaporator. In new refrigerators with a dynamic airflow thanks to internal fans the temperature gradient is normally much smaller or none at all. (Wählby, 2012)

When designing refrigerators three relevant aspects from the users' viewpoint are the volume, flexibility and cleanability. Regarding preserving the food quality and the refrigerators energy efficiency the stability in temperature respectively effectiveness of the insulation are two influential factors. The insulation should be as thin as possible to give the refrigerator an as large inner volume as possible, but must be thick enough to give good insulation and stability of the refrigerator. (Johansson, 2012)

2.5.2. Materials, recycling and manufacturing

A refrigerator consists of different materials: plastics, glass and metals. Beside steel, the material used most (about 8 kg) is the Polyurethane (PUR) foam used for the insulation. The insulation foam is injected between the inner liner and the outer cabinet and glues the walls together as it expands in the assembly. The foam makes the materials difficult to separate and recycle (Johansson, 2012). Usually high Impact Polystyrene (HIPS) is used for the liner and the white plastic insets and details. The transparent plastic boxes for vegetables are made of clear Polystyrene (GPPS). Besides the plastics are glass used for shelves and (stainless) steel for the external cabinet contributing about 50 to 60 % of the total weight to the refrigerator. (Johansson, 2012; Krische, 2012)

Recycled plastics from post-consumer scrap can get a greyish nuance, which usually is interfering with wanted white or light colours. If recycled plastics are intended for application with food contact, as for instance the inner liner of a refrigerator, it has to fulfil the demanding requirements of EU regulation 282-2008. This is a difficult and expensive matter also because even if the origin of containing plastics are all known, some of them might have taken up foreign matters that might render them unsuitable for contact with food. It is also difficult to keep track of the age of the containing plastics; making it hard to ensure high quality of the recycled material. A general problem with plastics is that they are less stable than for example stainless steel and glass, and lose their mechanical properties and often get brittle or change colour over time. Remelting aged plastics does not recover the initial properties as with metals or glass. When it comes to durability over time metal and glass are thus more stable materials. On the other hand can stainless steel get bumps and glass can be crushed.

What is important when it comes to choice of materials are to choose materials that can be recycled, to have as similar materials as possible, i.e. not a mix of different plastic sorts, and to design for disassembly.

The general problem with current mixed waste treatment praxis is that plastic recycling is often not feasible for cost and quality reasons. When it comes to refrigerators mainly the steel and copper is recycled. The polyurethane mixed with the other plastics in the refrigerator is hard to find usage for and therefore goes to energy recovery. If the refrigerator contains more valuable materials and components, such as vacuum panels for the insulation, it might be an idea to put effort and money on disassembly, recovery and re-use of these panels. (Krische, 2012)

Difficulties in making refrigerators of more sustainable materials are for example that many components are bought from suppliers, which complicate the control of the materials and manufacturing processes applied. The use of recycled material in the refrigerator is limited because it is hard to achieve the right quality and looks. Recycled materials are however seen as the best material to use if possible since it is cheaper. (Ohlsson, 2012)

All materials in a refrigerator could probably be sustainable if more effort was put on it and if cost was not an issue; if the customers were more willing to pay a higher price for a refrigerator made of only sustainable materials and which is totally recyclable. (Ohlsson, 2012)

Refrigerators are commonly manufactured in standardized processes and the efficiency of the productions lines is high. If a new refrigerator design differs too much from earlier designs, the present processes and the existing lines cannot be used. Machines and tools have to be replaced and the production lines adapted, which entail great expenditures for the company. When the company needs to make major investments that involve high risks, or the production has to be outsourced. That is why it is difficult to make major changes in the design that will reach the market; the company has to be sure the new design will pay back to be willing to take the risk. (Johansson, 2012)

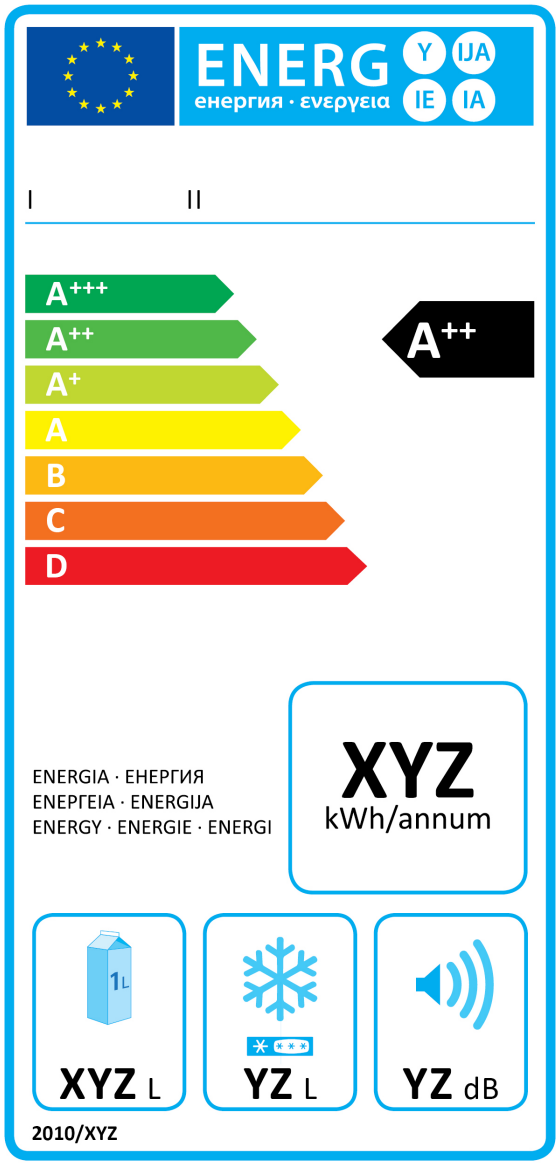


Fig 2.6: The standard energy label. As an example can an A+++ refrigerator of 300 l consume 150 kWh/year , and according to the index an A++ refrigerator consumes 30 % less energy per year compared to an A+ labelled refrigerator and 45 % less than an A labelled appliance.

2.5.3. Energy efficiency and classification

There are few appliances in the home that consumes energy 24 hours a day 365 days a year. Refrigerators and freezers are two such products and account for around one-fifth of domestic energy consumption and 25% of the average household bill (Tang and Bhamra, 2009). The best of modern refrigerators has a declared energy consumption of less than 0.5 kWh/day, i.e. when not opened, which is about the same amount of energy as one or two low energy light bulbs (Wählby, 2012). Refrigerators of larger dimensions consume more energy than smaller ones and thus the refrigerator should not be larger than the user actually needs to keep down the energy consumption (Geppert and Stamminger, 2010). However, the average size of the cold appliances has increased with on average 15 % between 1995 and 2001 (Tang, 2010) counteracting the total energy efficiency improvement.

According to the EU-legislation all refrigerators sold on the European market must have its energy consumption declared. The declaration is given an index to show how energy efficient the refrigerator is. Thanks to the implementation of the European energy label and minimum standards the energy consumption of a refrigerator was reduced with about 29 % between the years 1990 and 2001 (Tang, 2010). The energy efficiency index is constituted by letters, going backwards in alphabetical order starting from G (fig. 2.6). The more energy efficient a product is the earlier letter in the alphabet it gets. As the energy efficiency of appliances increased the scale had to be extended and the system was combined with "+", so today's best ranking is A+++. Currently A is the lowest approved rating but from next year on A+ will be the new lowest approved rating for refrigerators. (Wählby, 2012) The letter ratings are based on indexes that are calculated using the volume of the refrigerator and its energy efficiency.

The test for the classification for energy labelling is a standardized test, which then is compared to other products. The test is done in a controlled environment, which is not comparable with a real usage situation and has been criticized for not reflecting the actual energy consumption situation in a normal domestic context (Karlsson, 2012). The test does neither include door openings nor placement of warm or frozen food into the refrigerator, which makes the results differ a lot from the real life situation (Tang, 2010). Under the test conditions the refrigerator is standing closed in a room with an ambient temperature of 25°C. To be approved as a refrigerator and pass the tests its interior temperature has to be adjustable and with a temperature

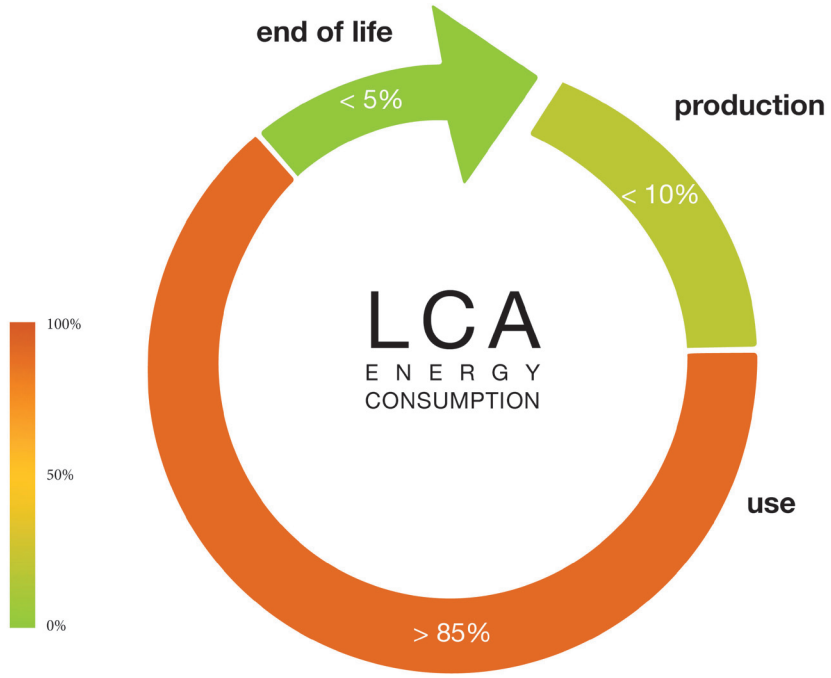


Fig 2.7: Simplified LCA for the energy consumption of a refrigerator during irs life time.

of 5°C or 4°C in the energy efficiency respectively the capacity test. For compartments to be classified as zero degree zone, or chill compartment, the test standards demands temperature in the interval -2°C to +3 °C, and to be a chiller 8-12°C is the needed temperature interval. (Karlsson, 2012)

2.5.4. Users' impact on refrigerator sustainability

Studying the Life Cycle Analysis (LCA) of a refrigerator (fig. 2.7), it can be seen that a significant part of its total energy consumption comes from the use phase - almost 90 % (ISIS, 2007). Thus refrigerators just as most electrical products have a significant environmental impact during the use phase of the life cycle. The impact is mainly determined by the user behaviour (Bhamra, Lilley and Tang 2008). Since most effort in the product development of refrigerators generally has been put on improving the energy efficiency the technologies; the insulation, compressor and fan, the use phase offers new opportunities of further sustainability improvements. Moreover, it does not occur to many users that the refrigerator can be such a high energy consumer (Elias, Dekonick and Culley, 2007).

A number of studies of user behaviour and sustainability regarding refrigerators can be found in literature where several interesting points are made. There are different factors influencing the energy consumption of refrigerators when they are in use, and ISIS (2007) have compiled this list:

- The settings of the temperature in the refrigerator
- The ambient temperature
- How much/often the refrigerator is loaded with food
- Frequency/length of door openings
- The ventilation around the refrigerator
- The condition of the gasket seals
- Placing warm food in the refrigerator

Regarding loading the refrigerator with warm food, almost 20 % of consumers in Europe do not cool down their hot food before putting it into the refrigerator. This action can lead to an increased energy consumption of 1,4 kWh/year for a single household, for calculations see appendix XVII. To cool down food in the refrigerator with a temperature of 50°C takes thrice as much energy as cooling down food with 20°C (ISIS, 2007).

Bhamra, Lilley and Tang (2009) have discovered that the limited storage space in many kitchens is

Table 2.2: Examples of findings from different studies on the effects of user behaviour on refrigerators' energy consumption. The differences in the results depends amongst other things on the type of refrigerator.(Tang, 2010)

User action with the refrigerator	Effect on energy consumption
Door openings	3 % of total electricity use
20 door openings 5s each	8 % increase i.e. 2,2 W
40 door openings/day	50-120 kWh increase of yearly energy consumption
Insertion of food into refrigerator	up to 10 % increase
Inserting food at 50°C in the refrigerator	3 times higher energy consumption than food at 20°C
Thawing frozen food in the refrigerator	Reduction up to 26%
1°C difference in interior temperature	4 % difference
Ambient temperatre 21-23°C	16% lower than in 25°C
Ambient temperature 17-20°C	32% lower than in 25°C

a common reason for refrigerating products that not need to be cold preserved. This motivates to look over the entire food storage system to facilitate a more sustainable energy and food consumption/preservation behaviour. In the same study they have also seen that food hidden at the back of the refrigerator is a large contributor to unnecessary food purchase and food waste. In the same study it was discovered that most of door opening time is spent on putting food into the fridge and freezer, and especially when making room for new items and transferring items between shelves.

More specifically Tang Tang (2010) presents in her doctoral dissertation an overview of the effects different user actions and behaviours have on the refrigerator's energy consumption according to different research communities and references. Some examples can be found in table 2.2.

Users can, as can be seen in the table above, save a significant amount of energy if thawing frozen food in the refrigerator. (Geppert and Stamminger 2010) Geppert and Stamminger (2010) conclude that only 15-25% of the participants in their study always thawed food in the refrigerator, and about the same percentage never used the refrigerator for thawing frozen food.

In order to reduce the door opening time and understand what optimal refrigerator interiors could be like, several research teams have studied how users organize foodstuffs in their refrigerators. This is one set of sorting principles presented by Bhamra, Lilley and Tang (2008):

» **Type of food:** Foods of similar kinds, like all dairy products or all vegetables are placed together.

» **Expiring date of food:** Foods with a longer "best before" date and new purchased items are placed at the far back while foods with shorter date are in front. Food that expires soon is also often placed so it is clearly visible (at eyes height).

» **Food packaging:** Sealed food and drink and packages such as ready meals, drink cans and

food boxes are placed overlapping each other while open items often are placed on the bottom shelf so it cannot drip on anything or be in contact with anything else.

» **Who the user is:**
Food and drinks that children should be able to take out themselves are placed clearly visible and a reachable level for them.

» **Weight of items:**
Heavy items such as potatoes are placed at the bottom, for instance in the drawer, whereas soft and fragile things as vegetables and fruits are placed on top of items preventing being squashed.

» **Door bins:**
The bottom door bin is almost always used for bottles and milk, which are high and heavy, the middle bin for small jars and bottles and in the top door bin are varied contents stored.

» **Temperature distribution in the refrigerator:**
The temperature differs inside the refrigerator and different foodstuffs have different temperature requirements. Thus things as minced meat, fresh fish and ham usually is kept at the back where the low temperature would freeze and damage vegetables.

Barriers for sustainable user behaviour

In an in-depth refrigerator user study presented by Bhamra, Lilley and Tang (2009) three possible main barriers for sustainable user behaviour were discovered from interviews with users. Below these three barriers are summarized and explained.

» **Lack of information:**
Users regard the refrigerator as a convenience product in modern life, and compared to its low running costs most users found it more important to lower the temperature to ensure the quality of food stored. Nevertheless, when measuring the temperature inside most users had the fridge operating on average 5°C higher than recommended. The energy consciousness was very low, and there was a lack of user awareness of the link between personal behaviour with the fridge use and the direct impact on energy consumption.

» **Lack of concern:**
In observation of product-in-use many persons left the door open while transferring items or for quick food preparation.

» **Lock in lifestyle:**
Users believed that the product is efficient enough by itself, thus that their behaviour has little influence, and there is no need for a conscious behaviour to improve the overall energy performance. They can therefore be fooled by high energy ratings.

(Tang, 2010)

Moreover, in the extensive refrigerator user behaviour study Tang (2010) presents in her Ph.D. dissertation it is written that most users have a positive attitude toward behavioural change in their refrigerator use patterns, and that the participants wanted to do the right things in order to reduce their energy consumption, act pro-environmentally and to save money. At the same time most people claimed they preferred buying a refrigerator with high energy efficiency rating, even though more expensive, rather than changing their habits.

2.6. FOOD PRESERVATION

This section explains what cold preservation of food is. It also gives an introduction to date labellings and a brief overview of the optimal storage conditions of different kinds of foodstuff. More details about appropriate storage conditions for different types of food can be found in appendix III.

2.6.1. Cold preservation of food

In Sweden is cold preservation of food (*kylförvaring*) per definition storage between 0-8 °C. The Swedish food agency (Livsmedelsverket) recommends a refrigerator temperature of 4-5 °C. Generally, the colder a foodstuff is stored, the slower is the growth of bacteria, mould and yeast fungus. Cold preservation also preserves the taste and consistency of food better.

Inside a refrigerator the temperature usually differs. How much depends on the kind of refrigerator and how it is designed, and therefore different foodstuffs are better preserved in different places in the refrigerator. There are basically four parameters that determine the durability of food: temperature, humidity, ethylene gas and handling (KES, n.d.). For most foods lowering the preservation temperature leads to prolonged durability, with the exception of some vegetables and fruits that can suffer from chilling injuries. Lower temperature slows down ageing processes and growth of bacteria and microorganisms. Moreover, a critical factor in cold preservation of food is to never break the cold chain from production to consumption in order to not affect the durability of the food in a negative way. In order to preserve a good quality of the stored food, i.e. taste, texture and nutritive content, it is important to keep the refrigerator temperature as stable as possible and without any fluctuations that have negative effects on the surface of the food (Whälby, 2012). Temperature fluctuations make especially vegetables give away moisture, leaving a wet spot in the refrigerator where mould can start growing (Whälby, 2012).

To preserve the humidity in the food is important, not only for its freshness, but also for its durability. The evaporation rate of the food should be kept down, and higher relative humidity around the foods surface slows down the evaporation and keeps it moisture. Ethylene gas (C_4H_4) affects some fruits and vegetables. It is a gas produced by all plant tissue speeding up the ripening. Some plants give away a lot of ethylene gas, and yet some are very sensitive to ethylene so the ripening is speeded up considerably, resulting in the food going off quickly. Thus it is important to separate vegetables sensitive to ethylene gas from the ones producing much ethylene. Finally, the handling of foodstuffs, the most basic of the four parameters, is important. Injuries from cuts and thrusts can reduce the durability remarkably, just as contact with items that can transfer or expose the food to different kinds of bacteria and microorganisms. (KES, n.d.)

The air inside the refrigerator is generally less humid than the surrounding air, why foodstuffs run the risk of drying up in the refrigerator. Moisture given away by for instance vegetables condensates on the inside surfaces of the refrigerator and is transferred away. When foodstuffs dry out they might look unappetizing, and therefore be wasted.

2.6.2. Date labelling

There are different kinds of date labelling with different meaning. The “best before” date indicates how long a product is expected to maintain satisfying quality if stored as recommended. Thus it does not say that it is not safe to eat anymore when the date is passed. The “use by” date on the other hand, indicates the last day the producer can guarantee the product is safe to consume and is frequently used on perishable foodstuffs. (USDA, 2011)

2.6.3. Suitable storage for different foodstuffs

Different foodstuffs have different demands on optimal storage conditions. There are different ways, storage methods, of prolonging the shelf life of food and thus minimizing avoidable food waste, and cold preservation is one such method. Avoidable food waste means food that would not have had to be waste if handled and stored better. Most foodstuffs last longer if preserved at a lower temperature and many foodstuffs can be frozen, which extends their shelf life considerably. There are yet some foodstuffs that are best preserved when stored below room temperature but not as cold as in the refrigerator.

Fruits and vegetables

Fruit and vegetables generally are optimally stored in the lowest possible temperature that not causes chilling damages, since cold preservation slows down the ageing process. When reaped, fruits and vegetables do not stop their life processes; they slow down but the metabolism and respiration continues. The respiration is vital for the durability, since carbons and carbon dioxide is consumed while water and heat is emitted, resulting in breaking down the vegetable and its

nutritive contents when stored. Thus, by slowing down the respiration the durability will be prolonged. This makes refrigeration good for many sorts of fruits, vegetables and berries, but there are some kinds, like tomatoes and bananas, which easily get chilling damages if cold preserved. If fruits and vegetables are stored too cold so they got chilling damages they will not necessarily get bad, their taste and quality will just be lowered. But the chilling damages can increase the risk of damages, such as growth of microorganisms.

The loss of water and the emission of ethylene gas that take place in the refrigerator, cause fruits and vegetables to deteriorate quicker. Most fruits and vegetables needs a high amount of humidity to stay fresh, but are sensitive to condense and lying in water since that causes growth of micro organisms. Fruits and vegetables contain 75-90 % water, and the water is necessary for preserving their consistency, which makes high humidity of the inside air important. Storing vegetables in half opened plastic bags or vegetable boxes prevents both drought and negative effects of ethylene gas, but can also lead to negative effects of getting too wet. Ethylene gas, which is emitted by some fruits and vegetables, speed up their ripeness process.

Animal-based products

Meat, fish, dairy products and eggs are sensitive to bacteria growth, which causes unpleasant odours and tastes. The propagation of bacteria is slower at lower temperatures, so by preserving animal based products at low temperatures, preferably right over their freezing point, they will not spoil as easily. The durability decreases with raised temperature, and minced meat, shrimps and fish are especially sensitive. Preservation in oxygen free packages prolongs the durability by minimizing the water losses.

Other products

Leftovers, just as animal product, are preferably stored as cold as allowed in the refrigerator to last longer. When post-prepared food is going off it is usually because of mould fungus - Penicillium. The durability can be considerably increased by shorten its time in room temperature and chilling it quickly. Cooking fat and nuts are optimally preserved in a dark and cool place whit low exposure to oxygen to prevent go rancid. Dry groceries are preferably stored in dark, dry and cool places, and soft bread should be stored at room temperature or frozen to stay fresh longer. If placed in the refrigerator the bread will deteriorate faster. Cans, bottles and jars with drinks, jam and sauces does not generally have to be refrigerated until opened, and then the warmer places in the refrigerator usually is cold enough. Temperature for storage and the durability depends on what amount of sugar and preservatives it contains. When going of it is usually because of mould. (Modin and Lindblad, 2010)

3. Method

In this chapter the methods and tools used in the project are described. The methods are organized according to in which phase of the project they primarily were used and what the outcome of the method or tool was. Apart from the described methods so called interaction sequences were used, which the project team come up with themselves. The interaction sequences were used to structure and specify scenarios in a timeline like format (sec.5.2.2).

3.1. PLANNING AND STRUCTURING

The planning and structuring methods were used throughout the project time line, but mainly in the early stages.

3.1.1. Gantt chart

Gantt charts are used when planning projects to visualize when different activities/parts of the project will start and finish. Each of the activities that will occur during the project is written on the right side of a chart and underneath the chart are the dates/weeks/months written. For each activity thick lines are drawn from where they will start to where they are supposed to be finished. The activity-lines sometimes run in parallel and helps out when planning the amount of work to do in each period of the project. The Gantt chart gives a good overview of a project that is simple to read and to communicate to others. (Maylor, 2010)

3.1.2. Mind maps

Mind mapping is a note-making tool combining visual and verbal thinking. It has a central word/picture describing the subject and radiating branches with related and/or relevant details or descriptions. Mind maps are useful in quick associative thinking, or when a group of people shall develop a shared vision. Its format allows showing relations and dependencies between words and provides a clear overview of the subject with a merge of variety of information. There should be no loops or unconnected branches in a mind map and the words should be written along the branches and not in boxes. (Stappers, 2005)

3.2. DATA COLLECTION

The data collection methods were foremost used in the research phase and during the user study, but also for complementary data collection during the entire project.

3.2.1. Interviews

Interviews are used for example to find the attitudes and opinions of users of a product. Interviews can be structured or un-structured. The first mentioned is totally structured when it comes to questions, time and order and the second is free in its character. The structured interview is fast and simple with the opportunity to get a quantitative result, while the advantage of the unstructured interview is the possibility to reach deeper

into the questions and to get better quality of the result. (Karlsson, 2007)

3.2.2. Survey

A survey is an indirect interview method where answers are collected from customers and users or other interests with a questionnaire. This method is mainly used to get quantitative data from a great amount of people, to get information from people who are difficult to reach with other means than mail or email et cetera, or to validate information collected from interviews. (Karlsson, 2007)

3.2.3. Context mapping

Peoples' experiences - what they know, feel and dream - are generally determined by tacit or latent knowledge, which is very difficult to express in words. Generative techniques are used to stepwise reach such knowledge in the users to build a better understanding. The basic principle behind generative techniques is to let people make things related to the topic that is explored and then let them tell a story about what they have made. (Fig. 3.1)

Sensitizing booklet

A suitable way to access insights about peoples' feelings, attitudes, experiences and needs is to take small steps into deeper levels of knowledge (Sleeswijk, Visser, Strappers, van der Lugt, 2007). Therefore participants in a context mapping study need to be sensitized before coming together in a generative session. This can be done by sending out sensitizing workbooks to the participants of the study about a week prior the session. The purpose of the sensitizing process is to enhance the quality and quantity of the results of the following generative session, and it should feel fun and professional at the same time. The workbook should include assignments allowing the participants to have time and freedom for self-reflection and become aware of their feelings, concerns and behaviours related to the subject. By doing the assignments in the real context they can feel more free and relaxed and easier bring their feelings and knowledge to the surface. The workbook can include open-ended questions, things to draw, stickers to place and so on. It is important that the workbook become personal to the owner and that there is space for impromptu comments; there should be room to surprise the researchers. The workbook can be disposed as a dairy with a task for each day to keep the participants continually reflecting. The subject of the sensitizing book should be the same as of the session but can be broader. (Sleeswijk, Visser, Strappers, van der Lugt, 2007) By collecting and analysing the workbooks prior the session also the moderators can be sensitized and better prepared.

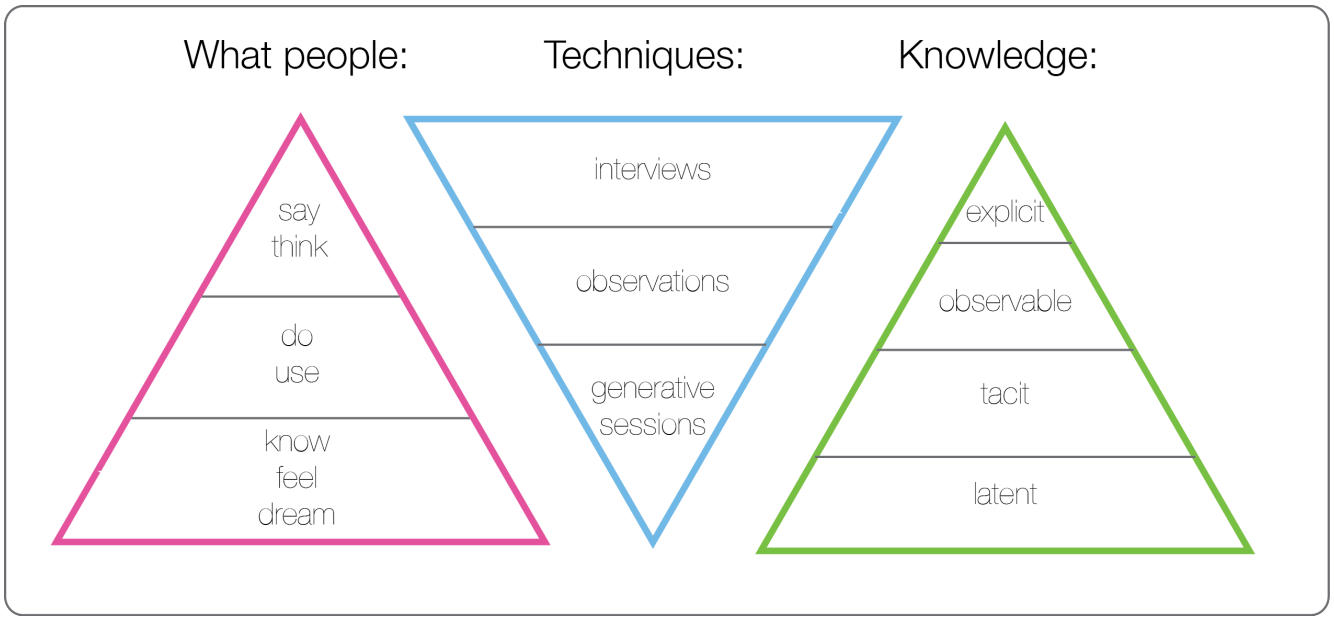


Fig 3.1: A model of how to reach people's knowledge and experiences on different levels.

Generative Session

A generative session is a group session where the participants make and say thing to reach deep insight about them on a chosen topic. The generative session can be combined with group discussions to reach more insights. In the generative assignments the participants are asked to organize expressive components; pictures, words or similar, to create an artefact which they then describe. The components should be ambiguous so they can be used and interpreted, and the resulting artefacts can be drawings, collages, story lines, maps or models. Group sessions generate much information since the participants can respond to each other's contributions. A group of four to six participants are good, and a length of about two hours is recommended. The sensitizing workbook can be used as a part of the group discussion and be referred to during the session. It should be analysed together with the session. The general layout of a generative session should be first a warm-up exercise, and then use of the generative technique followed by the group discussion. The session participants must feel that they are the experts on their experiences of the subject. (Sleeswijk, Visser, Strappers, van der Lugt, 2007)

3.2.4. Observation – self observation

Observation methods are used when studying users' behaviours and usage of products. Observations make it possible to get to know how the users actually use the product and where potential problems in the usage are. Observation methods can be divided into three different groups; direct observation, participating observation and self-observation. The self-observation is when the user writes for example a diary of his/her actions while using a product. Compared to interviews observations are good because they eliminate the eventual effect of the user consciously or unconsciously being steered by the interviewer. On the other hand writing the diary for self-observation might lead to that the user change his/her way of behaving in the examined topic. (Karlsson, 2007)

3.3. ANALYSIS

The analysis methods were applied in the analysis phase to filter, structure and understand the collected data and information to make it useful for the idea generation.

3.3.1. Function analysis

A function analysis is made to specify the intent of a product and to support the finding of how it can be met. Firstly the main function is defined - the reason of the product's existence. Thereafter are the part functions defined; the functions needed for the main function to be met. Thirdly the supportive functions are defined. These do not need to be met for the main function to be fulfilled, but they still give an important contribution. The functions can be arranged hierarchically with the main function in the middle, where a movement upwards gives the answer to *why* the functions should be fulfilled and a movement down explains *how*. (Österlin, 2003)

3.3.2. Persona

To create and communicate a common view on how the target users act and think a fictive character, a persona, can be made up. This persona can be of help in the idea generation –how the user wants the product to be, or for evaluation –what the user thinks of the proposed solution. (Karlsson, 2007)

3.3.3. PrEmo

People are generally very good at interpreting emotions and facial and bodily expressions, but not as good at expressing them verbally. PrEmo is a non-verbal self-report tool that is used to measure emotions that often are elicited by products. The toolkit consists of 14 figures expressing different emotions, seven are pleasant (desire, pleasant surprise, inspiration, amusement, admiration, satisfaction, fascination), and seven are unpleasant (indignation, contempt, disgust, unpleasant surprise, dissatisfaction, disappointment and boredom). (Desmet, 2003)

There is a scoring system as a part of the PrEmo tool, but in this project the figures were used alone without ratings.

3.3.4. Mood board

A mood board is a collection of images that represents for example an atmosphere, expressions, attributes and environments typical of the moods and values of the target group. An image board, a collage, can also be done to show typical details and wanted colours of the product in focus. The images can be used as inspiration and to steer the product development in the right direction. (Österlin, 2003)

3.3.5. PESTED-analysis

PESTED stands for Political, Economic, Societal, Technological, Ecologic and Demographic, and is a method or a checklist for exploring factors shaping the future. These factors are driving forces on a macro level and do not yet have a preset direction. (van der Lugt, 2004 p. 193)

3.3.6. Future scenarios

A future scenario is defined as "…a set of systematically developed and internally consistent - possible but not necessarily probable - images of future situations, developments or occurrences." (Van der Duin, 2002 cited in van der Lugt, 2004, p 190). Scenario making have primarily three functions: *cognitive*, *communicative* and *creative*. The cognitive function is to propose possible images of the future to trigger the receiver of the information. The future scenarios' communicative function is to create a shared mental model and to stimulate conversation, not in order to reach a consensus agreement but to understand different views and opinion on the subject. The creative function is to stimulate the exploration of the range of possibilities, and help to generate future concepts. (van der Lugt, 2004)

The construction of future scenarios follows a specific process; first the research is framed and the driving forces are analysed. Thereafter the main drivers are decided on and a scenario matrix is constructed so that possible scenarios can be built and fleshed out to picture the future states in lively ways. The four scenarios are then experienced in order to be useful for their initial purpose, whereupon the consequences for the product development can be interpreted. The scenario learning is not about choosing one scenario, but exploring forces that can determine future situations possible to affect the product under development. It is used to set a frame of mind and explore possible directions. (van der Lugt, 2004)

3.3.7. Brand eye

A brand eye is a method of deriving a coherent representation of a brand. It consists of images and words expressing the brand identity, the core values and the brand essence. It can be used to explore the brands values and establish a deeper notion of the brand. A brand eye consists of three layers, in the middle the *Brand Essence* - the brands ambition - should be stated, the second layer should represent the *Brand Values* with words and visuals and the third outer layer should be constituted by the brands *Characteristics* - important attributes of the brand and its products. By finding images representing the terms describing the brand, which often are abstract or can be interpreted in multiple ways, it helps to emotionally relate to the terms and it can be found inspiring. (Stompff, 2008)

3.3.8. KJ-analysis

KJ-analysis is used when an overview of a big amount of collected data is needed. The collected data is written down on post-its and each statement should be written on one paper. All post-its are then placed together on a big board where the post-its related to each other are grouped. The post-its will in this way create thematic groups and sub-groups. This grouped data can later on be formulated as demands for the future product. (Karlsson, 2007)

3.3.9. Wordle

A Wordle is a way to visualize a sum of words collected into a "word cloud", where the words

appear larger the more frequently they are mentioned. The Wordle can be made using a service on Internet. (Feinberg, 2011)

3.4. IDEA GENERATION

The following methods were used in the ideation and concept generation.

3.4.1. Brain storming

Brainstorming is an idea generation method aiming to make the participants come up with as large amount of ideas as possible. These ideas should have a great variance in type and it is good if some of them are a bit "wild". To come up with as great quantity of ideas as possible no criticism is allowed during a brainstorming session but the participants are allowed to further develop the ideas from the other participants. (Österlin 2003)

3.4.2. Brain writing

This is a method similar to Brainstorming, but instead the participants sit one by one and document their ideas. Thus canalization of all the ideas can be avoided. After 5-15 minutes, or when the creativity is slowing down, the ideas are shared for inspiration before continuing. The ideas of one group member can also be passed on to be further developed by another participant of the Brain writing session. Brain writing is also a suitable method to save and for the moment let go of earlier ideas to find new creative input.(Österlin, 2003)

3.4.3. Morphological matrix

Morphological matrix is a tool used to generate ideas for part solutions, which in different ways can be combined, to total solutions (Johannesson, Persson and Pettersson, 2004). Different categories or part functions are listed vertically in the matrix to the left, and the solution alternatives are filled in as either sketches and/or descriptive words horizontally. When all part solutions are generated and the matrix is filled, the ideas can be combined into different total solution alternatives.

3.4.4. Sketches

Sketches and two-dimensional renderings are suitable to relatively quick and easy generate, communicate or document ideas. They can also be photorealistic to present a final concept

There are different kinds of two-dimensional images with different detail levels with different purposes. *Idea sketches* are small, quick and sketchy to show thoughts and ideas. *Design sketches* are showing more explicit design alternatives, preferably with size references or usage examples. *Drawings* or *drafts* are technical visualizations with measurements, different views and maybe manufacturing details. *Sections* show cross sections of details, *explode views* displays how parts fit together and are related to each other's and eventual hidden parts. Finally *renderings* are very detailed and realistic presentation visualizations often used to sell in a product or concept. (Österlin 2003)

3.4.5. Strategy cards from Brains Behaviour and Design

A group of graduate students at IIT Institute of Design, Chicago, has found ways to connect cognitive psychology and behavioural economics to the design process. The group, which is called *Brains, Behaviour & Design*, has created tools like for example *strategy cards* and *reference cards*. The deck of cards, which can be downloaded at the their homepage, provides a guide to behavioural economics concepts and different strategies for how to change user behaviour. These cards can be of help in brainstorming and inspire to find design solutions for behavioural change. (Brains, Behaviour and Design, 2011)

3.5. EVALUATION METHODS

To test the feasibility of ideas, functions and total concepts, as well as selecting concept and functions the methods described below were used.

3.5.1. Matrix Evaluation

The ideas that are to be evaluated are placed along one axis of a matrix and the criteria of evaluation, requirements or demands on the other axis. The ideas are then given points for how well they fulfil the criteria. The sum of the points given to each idea can then be used for comparison. (Österlin, 2003)

3.5.2. Hierarchical Task Analysis (HTA)

HTA is a method used to break down a task into sub tasks, for example connected to a product. An HTA offers an overview of products different functions and relations. Firstly the user's main goal is identified and then is this goal broken down into part goals that are again are broken down in part goals forming a hierarchy of goals and operations. (Bligård, 2008)

3.5.3. Cognitive Walkthrough (CW)

A CW is can be done after an HTA, performed on the lowest steps of the HTA. CW is a method used to evaluate the usability of for example a product and to simulate the user's cognitive processes. In a CW the investigator asks four questions: "Will the user try to reach the right effect?", "Will the user note that the right action is available?", "Will the user associate the correct action with the right effect?" and "If the correct action is performed will the user understand that the action has led him/her closer to the goal?". The investigator can through these questions investigate both if the user probably understand what to do and how it is done and if the user is likely to get enough feedback when performing an action. If any of the questions is answered with a "no" the investigator reflects over the underlying problems which forms a base for a further development of the product. (Jordan, 1998; Bligård, 2008)

3.5.4. Predictive Human Error Analysis (PHEA)

CW and PHEA are two methods that complement each other and advantageously can be used in parallel after an HTA has been done. By using a PHEA the possible operational errors that might occur in the interaction with the product can be examined and their consequences investigated. PHEA is about answering the questions: "What might the user do wrong?" and "What will happen if the user act wrongly?" The investigator has to imagine the user's situation and the more innovative and imaginative the investigator is the more possible operational errors can be detected. (Bligård, 2008)

3.5.5. Focus group

A focus group is a group of people gathered with the purpose to discuss a certain matter. The topic discussed could for example be the user's experience of using a particular product, their requirements for a new product and attitudes towards a brand. The group is led by a moderator that has rather loosely structured pre-set questions and who make sure that all participants have a chance to voice their opinion and to stimulate the dialogue and interaction between them. The strength (but also the risk) of using this method is what one person says might initiate the others to make new associations. (Jordan, 1998; Karlsson, 2007)

3.5.6. Sketch models

A sketch model is a model of the product made in the early stages of the product development, made for internal evaluation and not for final presentation. This model is of a material and construction that is cheap and can be easy changed/modified. Making a sketch model or "mock-up" (sketch model scale 1:1) is a cheap way of evaluating and testing technical principles, building structure, ergonomics, usage, size, shape and proportions. (Wikström, 2008)

3.5.7. Computer aided design (CAD)

Computer aided design (CAD) is to by means of a software build three-dimensional models in the computer. CAD can be used for various purposes: form development, evaluation of form, colours, material, or preparing for manufacturing and above all for visualization. It is a comparably quick and easy way of displaying exploring views

and different variations of a product, but can also generate precise files for construction with exact measurements and tolerances. There are different CAD programs that are more or less suitable for different purposes. (Österlin, 2003)

4. Project Process

The project has been performed in three partly overlapping and iterative main phases (fig. 4.1), which can be seen in the Gantt charts (appendix IV). The first phase was the research phase, the second the analysis phase and the third the development phase - the idea generation and concept development. In addition there has been continuous writing on the report along the entire project process. The project has more or less followed the process of Design for Sustainable Consumer Behaviour (DSCB) suggested by Selvefors, Blindh Pedersen and Rahe (2011), presented in section 2.1. The DSCB process is divided into six steps: 1. Choice of product or resource consumption situation, 2. Investigation of user actions through an in-depth user study, 3. Identification of wasteful resource consumption, 4. Choice of focus and target behaviour, 5. Identification of suitable intervention approaches, 6. Development of product innovations through the use of intervention triggers, followed by continued development.

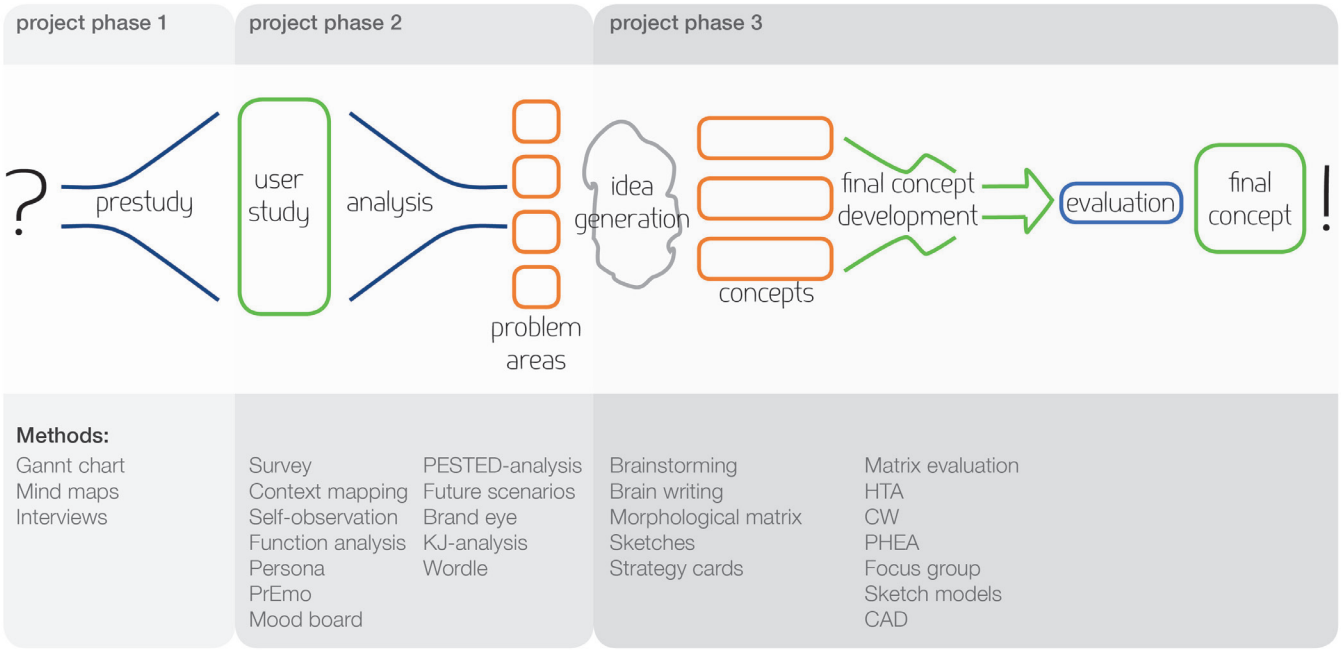


Fig 4.1: The project process with examples of methods used in each phase.

4.1. FIRST PHASE – RESEARCH

The project was initialized with a thorough pre-study including literature reviews and studies of material provided by Electrolux. In this phase, step 1 in the DSCB process was performed. During this first phase the project team studied foremost the field of Design for Sustainable Behaviour, articles and studies on the use phase of refrigerators, refrigerator technologies and energy consumption, food waste, the Electrolux brand et cetera. Most of these findings can be found in Chapter 2. Meetings and discussions with experts in different relevant fields and study visits to factories and showrooms were done. Another major part in this phase was the preparations and set up for the user study (methods sec. 3.2.2-3.2.4). During this phase the project team made several mind-maps (method 3.1.2) and other visual charts of related and associated words to organize information and establish an understanding of concepts, as for example what premium means and why people do not have a sustainable behaviour with refrigerators. Some of these mind-maps can be found in appendix V.

4.2. SECOND PHASE – ANALYSIS

In phase two the collected data from phase one was analysed, the user and context studies - the context mapping - was performed (Chapter 6) and future scenarios and a persona developed (method 3.3.6 and 3.3.2). The second, third and partly fourth step in the DSCB process were performed in this phase.

The user study consisted of first an online survey then a sensitizing booklet with a self-observation dairy for one week, distributed to five persons selected to represent the persona, followed up by and finalized with a generative session. The function of the current refrigerator was studied resulting in a function analysis tree (method 3.3.1). The brand was analysed by doing a brand eye (method 3.3.7) and by reading about Electrolux and discussing the brand with people in-house. A need and demand list was created at the end of this phase, and the main problem groups - areas of improvement - and barriers to a sustainable behaviour were specified.

4.3. THIRD PHASE – DEVELOPMENT

In the third phase of the project the two last steps of the DSCB process were performed. The third phase was the most extensive, why it was divided in two parts.

4.3.1. Concept development

In phase three the idea generation took place based on the analysed data. The idea generation started already in phase two with series of brainstorming and brain writing sessions (methods 3.4.1 and 3.4.2). The idea generation and concept development continued with sketching (method 3.4.4), and discussions and ideation workshops were held with people working at different departments at Electrolux. The first widespread ideas were after evaluations and further development more specified and formed into three concepts (sec. 8.2) with different focuses and some additional value-adding features and characteristics that could be implemented in any of the concepts. After presentations of these three concepts at the Electrolux Industrial Design Centres in Porcia and Stockholm, the feedback was considered and the concepts evaluated (method 3.5.1) before a direction for the final concept was chosen (sec. 8.4).

4.3.2. Final concept and evaluation

The chosen direction for the final concept underwent a thorough development process (sec. 8.5) initialized with complementary research; information gathered from for instance study visits and meetings with experts. The final development had a focus on the user behaviour and the interac-

tion with the product, but also the aesthetics and choice of materials, the technology and its placement et cetera was considered. A sketch model (method 3.5.6) was built to test dimensions and the handling, sketching and computer modelling (method 3.4.4 and 3.5.6) were done to develop the form and details. Another idea generation workshop about the chosen concept was held with two Australian designers. After the iterative development process into a more detailed level the concept was finalized (Chapter 9) and evaluated in different ways (Chapter 10). Evaluation methods used, apart from the sketch modelling, were for example a user acceptance test in a focus group with participants from the context mapping study, CAD and a Cognitive Walk-through (method 3.5.1-3.5.5, 3.5.7). Finally the final concept was presented and the project completed.

5. Pre-study

The pre-study consisted of, apart from the extensive user study described in Chapter 6, analysis of several influencing aspects; the refrigerator, the context of use, the market and the Electrolux brand, the target user and the future. This chapter presents important findings from the pre-study. Sustainability has not been designated a section of its own in this chapter, instead it imbues every part of the analysis phase.

5.1. ANALYSIS OF THE REFRIGERATOR

The function and meaning of current refrigerators were studied and analysed in order to form a basis and understanding prior the development of new concepts. An issue with refrigerators is that they are rather big investments and products people keep for a long time - normally until they break down. That is often for too long in order for the energy efficiency to be as high as when it was new.

5.1.1. Function analysis

Since the entire situation and concept of cold preservation of food was taken into consideration, except the freezer and not only the refrigerator as a single product, it was important to form an understanding of the purpose and basic function of the refrigerator. This to include the functionality of the traditional refrigerator and to help meeting the needs behind those functions in a new product concept. The function analysis shows the main function - to preserve foodstuffs - and necessary respectively desired part and supportive functions (fig. 5.1).

5.1.2. The role of the refrigerator

When buying a new refrigerator function often comes first. After all, buying a refrigerator is quite an investment and people tend to fall back on safe choices when choosing which one to buy since it is a very traditional product. This makes it important that the basic functions and features identified in the function analysis are met. Compared to a dishwasher people can make the washing up themselves but they cannot cool down food in the summer by themselves without a refrigerator. Kitchen trends changes from year to year the refrigerator market is slower and less trend sensitive.

The refrigerator has through the years changed is "personality". In 1935 the Coldspot refrigerator designed by Ramond Loewy made a great impact in the design and conception of the product; from being bulky, dark and non attractive to something simple, functional and attractive for the users. It had aluminium shelves to prevent rusting and a door that could easily be opened even though the user had the arms full of groceries and less noisy. It was advertised as: luxurious, modern, convenient and arrestingly beautiful. The Coldspot was a great success and sold more than 400 000 in two years. (Von Atta, 1986; Anon., 2007)

Function Analysis

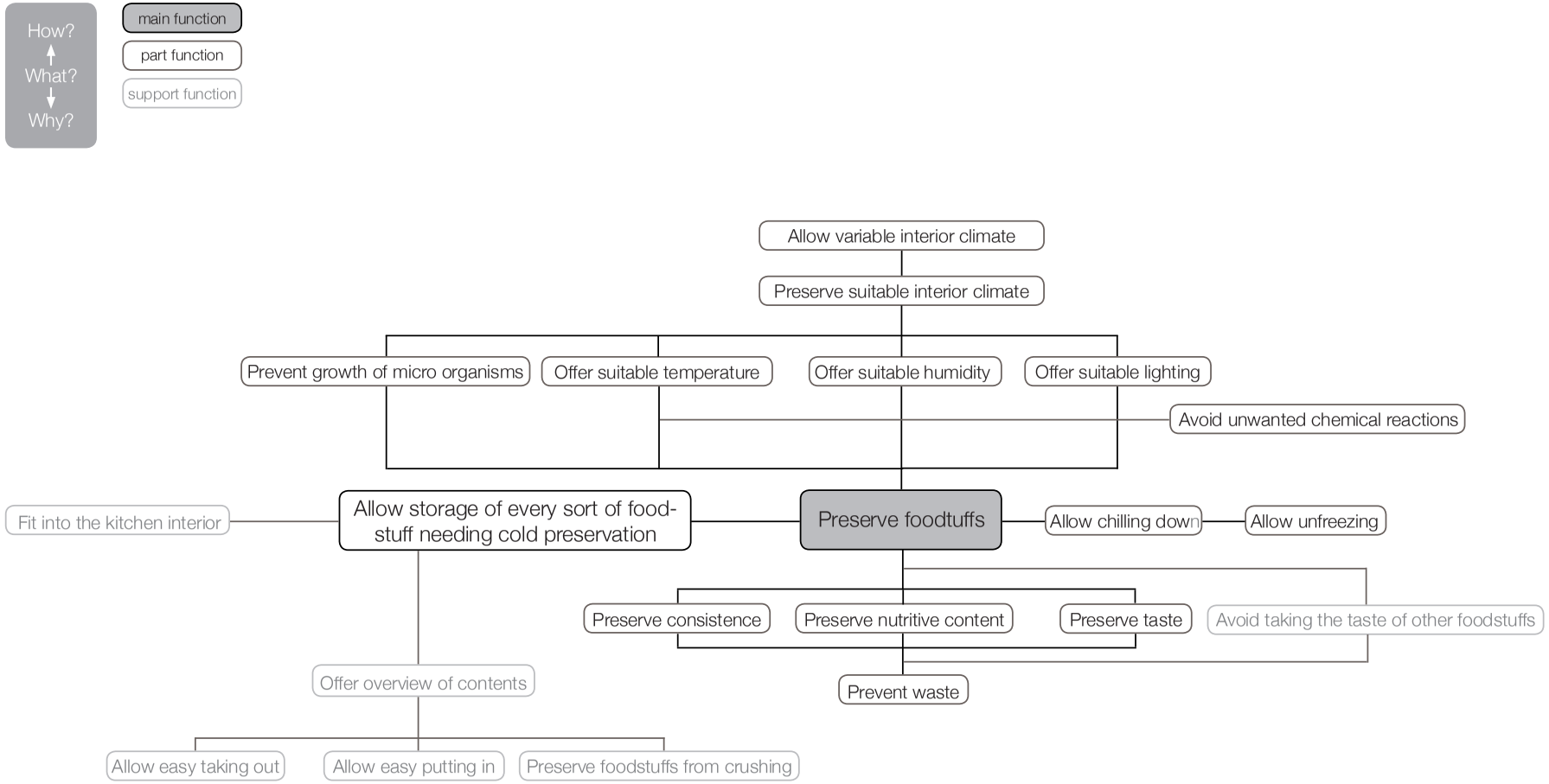


Fig 5.1: Function analysis. The main function is as can be seen to preserve foodstuffs.

Thus the refrigerator was changed from in the beginning being a luxury product only used by wealthy families, to become an essential and standard product of the modern home and was used by housewives. As the society changed, feminism for example, the refrigerator went to be used by more and more people and is now a product which is used by everyone and rather anonymous in its appearance. The refrigerator has now had this meaning for a long time, and maybe it is time for a new change? For theory about product attachment, design for emotions et cetera, please see appendix II.

Another relevant point from a sustainability perspective based on the literature review is that, referring to section 2.4.1 and the fact the refrigerators consume energy and food production involve major energy consumption, a significant amount energy can be saved if not wasting the food stored in the energy consuming refrigerator. Thus by strengthen the role of the refrigerator in a way making the user take better care of and understand the value of food, much energy and resources can be saved.

5.2. THE CONTEXT OF USE

As described in section 2.5.4 peoples' behaviour are very context dependent. Therefore it is crucial to understand and study the context of refrigerator use. A food flow chart was done to visualize the foods' way from entering the household to ending up in the trash bin. To structure the refrigerator interaction a number of and actions lines, *interaction sequences* (sec. 5.2.2), were made.

5.2.1. Lifestyles and cultural differences

The refrigerator is used in almost every household in everyday-life as well as for special occasions. Different cultures and lifestyles affect what kind of and how much foods that are stored, however refrigerators look more or less the same everywhere but the interior varies globally. The concept of food and dining has a very strong linkage to culture. Therefore the demands and expectations on refrigerators vary between different countries. Not only culture but also personal preferences and climate differences are related to what users of different parts of the world expect from their refrigerator. This because the durability of foodstuffs, what people eat and the energy consumption of the refrigerator depend on the temperature where it is placed. For instance in southern countries with a warmer climate or where the tap water is not drinkable, a lot more bottles of drinks has to be stored compared to in Sweden. In those countries they normally do not have the possibility to put the bottles outside to be chilled because of the climate. There are also often non-eatable things stored in the refrigerator. This makes it not only a food preservation product but hence also storage place (see the function analysis in sec. 5.1.1).

On top of the cultural differences come food trends and different diets making people wanting to store for instance extraordinary large amounts of fresh vegetables in their refrigerators, or not wanted space in the refrigerators customized for meat. Food is also associated with income and status as well as priorities in life and what is trendy. A refrigerator can speak tonnes about the owner's lifestyle, their approach to healthy eating, shopping habits, and daily routines and how they arrange their leisure time (Tang, 2010). So in one sense it is strange that such an important appliance as the refrigerator is not treated with more respect and more highly esteemed than it is by most people.

It is getting more common to do grocery shopping more frequently and buying less at a time, especially if living in the city and close to a supermarket. The living space is limited in urban areas and thus also the storage space for food. How many meals a day that are eaten and prepared at home, how many people living together and the food shopping frequency are consequently some of the determining factors of what kind of refrigerator is needed. On top of that comes the attitude towards sustainability and knowledge level concerning sustainability effects of food preservation and food storage in to consideration. For more details on users' attitudes towards their refrigerators and sustainability, see section 6.4.3 Context mapping findings.

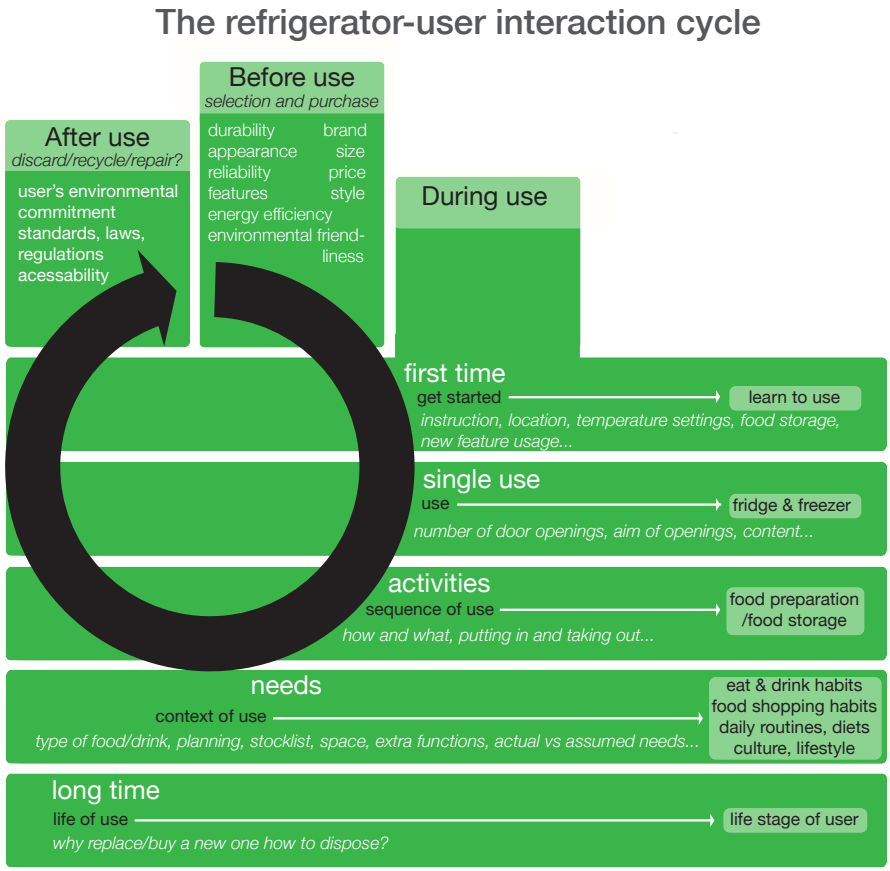


Fig 5.2:This model over different usage situations are based on a model presented by T. Tang (2010). Depending on the situation and the user's intentions, different time spans and different occurences in the context can be influential and relevant, and this model can help structuring the thinking and what to consider in the product development.

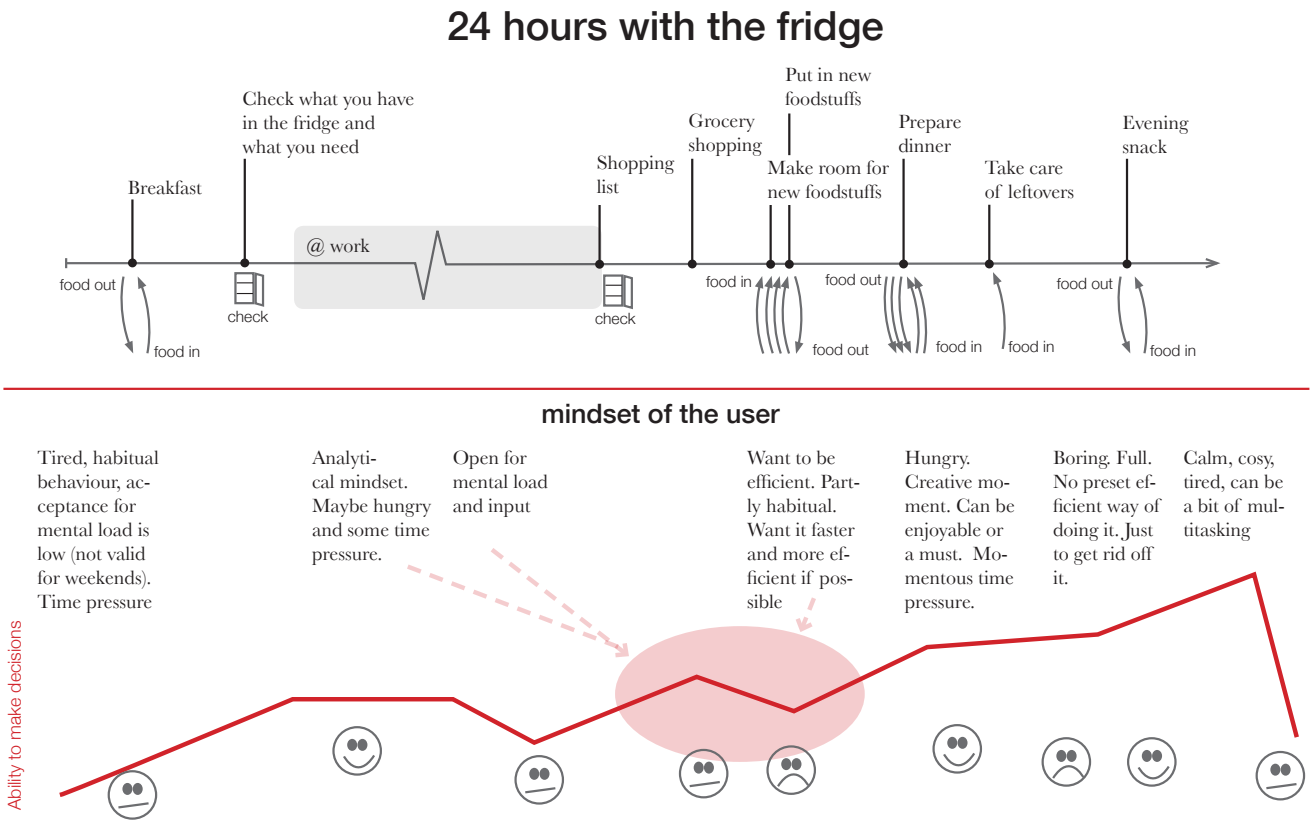


Fig 5.3: "24 h with the fridge". An interaction sequance with connection to the mindset and status of the user.

5.2.2. Usage situations

Children, elderly, men and women - every member of the household - use the refrigerator on daily basis. It might be the household product that is mostly interacted with by all members of the household and no introduction how it should be used is given, and should not be needed. The refrigerator interaction and the use phase can be looked at through different lenses, at different levels; on one hand there is the impact over the entire time span of the use phase, from point of sale until disposal. On the other hand particular single activities such as the interaction when preparing dinner can be looked at. The choice of strategies and the kind of solutions depend on the level of the focus in interaction. In figure 5.2 the user-refrigerator interaction can be seen. The figure is based on an overview of the three stages (before use, use and after use) were the refrigerator interaction has environmental consequences made by Tang and Bahmra (2009) for an observation study presented in the article *Understanding Consumer Behaviour to reduce environmental impact through sustainable product design.*

Interaction sequences

Problematic events, in the interaction with the refrigerator from a sustainable user behaviour point of view and the reasons behind them can be seen in the interaction sequences. A general interaction sequence shows the hypothetical standard interaction with the refrigerator during 24 h (fig. 5.3). The graph and the faces shown under the interaction sequence visualize the user's ability of decision-making respectively mind-set during the 24 h interaction sequence. The graph and mind-set mapping were made based on findings from the literature review and the project team's experience and assumptions. The aim was to find possible problems and barriers to sustainable behaviour, and the outcome was partly validated by the participants of the user study, see section 6.3.3 More specified interaction sequences taken from the 24 h interaction sequence, as for example grocery shopping, dinner and quick meal can be found in appendix VI.

5.2.3. The kitchen environment

Refrigerators are in most commonly placed in the kitchen, why the kitchen environment was important to consider when developing a new refrigerator. It is not only the visual appearance that has to fit with the kitchen design; dimensions, ways of openings etc. are also depending on kitchen layouts. Moreover, the kitchen environment can have an impact on the sustainability of the resource consumption associated with the refrigerator. The kitchen plan affects the number of door openings for transferring items between the refrigerator and the unpacking place or the dinner table. If there is a surface for loading and unloading nearby, the length of openings can be reduced. The placement of the refrigerator can also influence the energy demand, for instance if it is placed next to a heat source like the oven.

It is not only the logistics in the kitchen and the process the food and refrigerator is a part of that should work smoothly, the refrigerator also has to look good and fit into the environment where it should be for next coming years. That is the reason why the project team looked into kitchen interiors and kitchen trends in order to find out about the appearance of the context.

Food Flow

In the kitchen food flow chart the ways food is transported in the kitchen, which was investigated and mapped by the project team, is presented in figure 5.4. The food flow figure shows the total amount of food entering and exiting the household, where foodstuffs are stored or processed and where the transistions from hot to cold take place in the kitchen.

Kitchen trends

After having visited premium kitchen resellers, furniture fairs and performed a kitchen trend forecast on the Internet, the image board in figure 5.5 concluding the project team's impressions were put together. The final concept was not supposed to be trend sensitive but fit into a high-end kitchen environment for a long period of time.

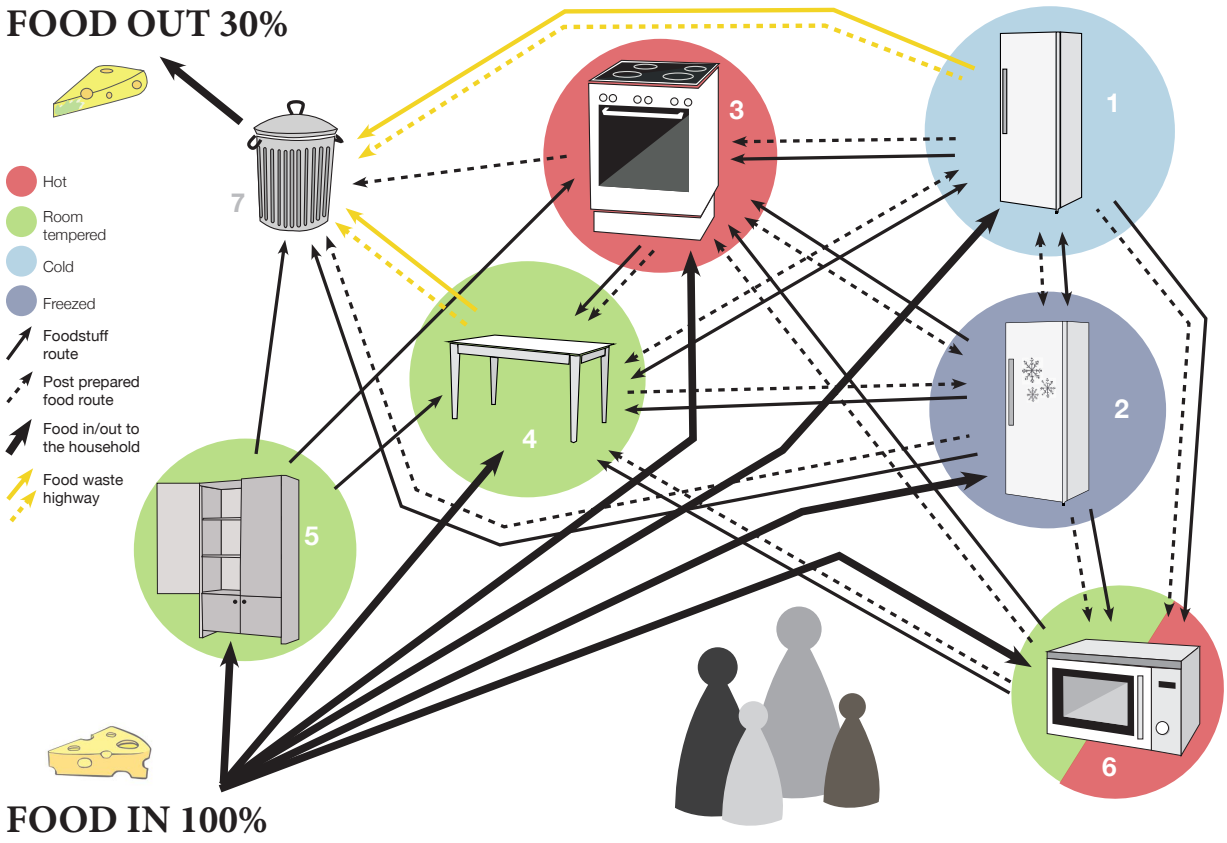


Fig 5.4: The food flow in the kitchen and a description of it below. Most of the wasted food comes directly from the refrigerator or from the dining table.

a. Food is bought, transported to the household and stored in the freezer (2), refrigerator (1) and in room temperature (5), or is directly prepared. A ratio of these foodstuffs is later placed in the trash bin directly from storage before it has even been used.

Problem: *Some foodstuff is wrongly preserved and goes off quicker than necissary.*

Underlying reason: Lack of knowledge of how to preserve foodstuff optimally, convinience, miss-placed by accident.

b. When cooking, foodstuff are taken out from the freezer (2), sometimes thawed in the refrigerator (1), in the microwave oven (6), in room temperature (4) and sometimes it goes directly to the oven or stove (3).

Problem: *Additional energy is consumed when cooking frozen foods directly on the stove or in the oven. Energy can "be saved" if frozen foodstuff is thawed in the refrigerator instead of in room temperature, in the microwave or in the oven or stove.*

Underlying reason: Time-pressure, laziness and planning issues. Forget to take out the foodstuff from the freezer in time.

c. Leftovers are directly placed in the refrigerator (1) or freezer (2) when they are still warm. Leftovers are wasted in the trash bin.

Problem: *The refrigerator (or freezer) get heated up inside which affects the foodstuff stored there. The cooling systems have to work harder which increases the energy consumption. Posr-prepared that could have been eaten later or used in new dishes are thrown away*.

Underlying reason: Laziness and convinience. Lack of knowledge of consequences. Lack of inspiration.

d. About a third of the bought foodstuff is thrown in the trash bin and removed from the household (Modin, 2011).

Problem: *A huge amount of food is wasted of various reasons.*

Underlying reason: Many different previous actions lead to the wastage, much is about bad planning.

The team found it important to get knowledge of looks of premium kitchens of today and possible long-term trends to be able to map out the context around the concept. Frequently occurring design features and possibly emerging trends in kitchen design that are considered to be relevant for the target user are listed below.

» Natural materials like wood and glass and sometimes even concrete.

» In kitchens as in many other fields trends are followed by contra-reaction trends. White and shiny surfaces that have been trendy for some years are more and more replaced with black and darker colours and matte surfaces.

» Another contra-reaction is that the appliances are more and more visible in the kitchens again instead of built-in behind cabinet doors. This is also a part of the professional trend.

» Freestanding units and kitchen islands.

» Stainless steel is still frequently seen. When it first became popular it was mostly on appliances to remind on the products from professional kitchens. Now it is becoming more frequently seen that the appliances reminds of professional products in other ways. Domestic users want to achieve results of highest class with their products why also functions and other design details are inspired by professional products.

» Simplistic designs with geometrical shapes and straight architectural lines. Hidden handles and clean surfaces.

» Inspiration taken from the furniture industry regarding ways of opening doors and drawers and other details.

5.3. THE TARGET USER

The Electrolux brand has a well-defined group of target users within the premium segment of the European market. The target user lives in an urban area, is a person with a dynamic life-

Fig 5.5: Image board for the kitchen context and identified trends relevant for the project.

Fig 5.6: Image board representing the persona Louise.

Louise is a 34 years old woman living an active **multi-faceted life** in a modern fast moving European capital. She lives together with her boyfriend, David, and their 11 months old daughter Ella. The apartment where they live was originally Louise's, and she has carefully furnished it after her taste. Thus there was not much room left for David's belongings when he moved in. Louise is at the moment on maternity leave, but otherwise she is working as a project leader and has an **income sufficient** to pursue her **interests with passion**. Louise is an attractive woman because of her strong and confident personality and elaborate style.

One of the main priorities in life for Louise is **style**. To her, style is so much more than a tool to impress on others (that is just an nice outcome of it). Style is an important **external expression of who she is**. The expression of her unique style comes to practice through **interior design** and her favour for **fashion**. Her role as a style leader makes her friends turn to her for advice.

Louise is a perfectionist and a **natural organizer**, which also is reflected in their home. She likes putting a lot of time in making it look beautiful and welcoming, and she wants **her home to reflect her personal style** and individuality. Home decoration is one of her foremost interests. A **healthy lifestyle** is important to Louise and David as well. Both of them likes doing fitness and eat healthy food. For Louise is the main motivation to **feel good and look good**.

Louise likes travelling a lot and wants to see and **experience** new things and cities, and especially go shopping. She really likes the pulse of big cities like New York. Besides leisure travelling she also does some work related traveling to events and fairs.

Louise is an **outgoing person** and likes partying and clubbing a lot. But since she recently became a mother she is not enjoying the nightlife to the same degree as she used to, and is more often having friends over for instead. She really enjoys **socializing** and likes to invite friends and family for dinner. Sometimes she is also going to the cinema and going to different event with her large group of friends.

With more frequently having people over her passion for **visually appealing appliances** has grown. When it comes to home appliances, and especially kitchen appliances the **style always come first**. But they have to do their job and be of a **high quality**, thus she often buy from **premium** brands. She is not very keen on learning complicated functions and does not have the patience to do a lot of settings. But still she wants to be the master of her products and they have to achieve the good results she wants.

Fig 5.7: Description of the persona Louise.

style and is keen on expressing her personality through her products and stylish home. She finds a great pleasure in home styling and is willing to put money in to get good looking and high performing appliances, especially if they reflect her personal style. The target user is a bit of an early adaptor and a trendsetter who others look up to, which imply that by targeting her it is also possible to reach the broader mass.

5.3.1. Persona

The persona, Louise, was made to represent and bring alive the group of target users. Louise was created based on a mixture of the Electrolux brand segmentation and the most suitable eco-archetypes from section 2.3.1. The persona is visualized in the image board in figure 5.6 and described with the text in figure 5.7.

As earlier mentioned people can be divided into different groups, archetypes, depending on their approach to environmental issues. When creating the persona, among the six profiles developed by The Core Company, a mix of The Cynic and The Pioneer was considered as the best match.

The Cynic likes glamour, fashion, elegance, and beauty, has a "better taste" and wants what is best. Environmental issues are often seen as a bit geeky, even though s/he is about to change attitude in this matter. Generally the cynic is not concerned with environmental issues and sustainability.

The Pioneer is a personality who wants to be first with things. The nature is seen as a source of power; filled with energy and adventures. The pioneer likes to provoke and to shock. (Torberger, 2009)

5.4.ANALYSIS OF THE ELECTROLUX BRAND

The three aspects of the brand identity considered being most important to express was premium, professional and Scandinavian. The project teams interpretation of these words can be seen in the expression board (fig. 5.11) and the brand eye (fig. 5.8).

Since the domestic range is moving its position towards being premium, the connection to and the heritage and influences from Electrolux Professional is becoming more important. For more detailed information about the Electrolux brand and the company, see section 1.2

However, Electrolux has apart from the professional products foremost its heritage in home appliances. Not cell phones or cameras as some other brands also making refrigerators. Therefore all functions of the concept to be developed should stick to the core and focus on food management, aiming to ease it and make it seamless, sustainable and enjoyable as possible.

5.4.1. Electrolux's professional heritage

The heritage from Professional products is strong and the appliances are the preferred brand by hotels, top chefs and institutional kitchens all over the world. The professional products form highly effective systems with the aim to deliver perfect results with high hygiene and low running costs. (Electrolux Professional, n.d.) In the Professional side the Electrolux brand is world leading and has a good reputation, which give a lot of credibility to the domestic products - the real professionals prefer products with the Electrolux name, Thus the professional heritage is an asset important to elaborate on and communicate in the concept.

To pinpoint the preference from professional users increase the credibility of Electrolux in the consumer market. Thus, to differentiate from other brands on the market and their competitive advantage, Electrolux emphasizes their "Professional Heritage" – *"Developed for professionals, now adapted for you!"* (Electrolux, 2011c)

Professional kitchen appliances are commonly made in stainless steel, because it is durable and easy to keep clean. Professional kitchens and kitchen appliances are deeply rooted in a traditional design, which have not been much changed over the past years when it comes to the expression. The appliances have to not only be, but also look hygienic and robust.

Fig 5.8: Brand eye for Electrolux.

Key characteristics for professional food preservation products are:

- » Stable temperature (no fluctuations) to preserve the food as good as possible
- » High durability
- » Low energy consumption
- » Easy to clean for high hygiene standards (Carlberg Felicetti, 2012)

5.4.2. Brand Eye

To capture the Electrolux brand and its essence, a brand eye (method 3.3.7) was created. The brand eye (fig. 5.8) served as base for common understanding of what the Electrolux brand stands for and a source of inspiration for the team. The brand eye shows the logo and value statement in the middle. In the second layer are the brand values and expressive images. The third outer layer features images and words describing and characterizing the Electrolux brand and its products.

5.4.3. Design language

In order to be able to fulfil the requirement of making the refrigerator concept visually belonging to Electrolux brand, make it look attractive to the target group and to have an overall aesthetically pleasant design the Electrolux design language was analysed. To facilitate the fulfilment of this a list of Electrolux explicit design cues, listed in next section, was set up and to consider in the form development process together with the expression board.

Electrolux design cues

After the analysis of existing Electrolux products, both on the market and new concept products, and discussion with the supervisor at Electrolux, similarities in the design and commonly reoccurring details and design features were found and listed (see examples in figure 5.9 and the logotype in figure 5.10). Design cues identified were:

- The "flow line" (1)
- Contrasts, in colours and in surface finish
- Sharp transitions between surfaces (3)
- Chamfers to emphasize material thicknesses (4)
- Visible material thicknesses (like a shell) (2)
- The Electrolux logo in a central position
- Slightly tilted surface towards the central axis (5)
- As materials: shiny white plastics, brushed stainless steel and glass.
- White and silver –premium colours, and silver painting under glass
- Clean, strong and simple design with architectural lines, but yet some softness
- White symbols on black displays
- Letters and symbols on glass, so the shadows gives a 3D feeling

Expression

The expression board, presented in figure 5.11, was done based on the Electrolux brand identity and the identified design language. It was made with the purpose to be an evaluation tool for the concept; if the expression board was done so that it truly expressed the wanted expression the fiwnal result should in the end fit in with the images on the board. It expresses the brand values of empathy, insightful, progressive and ingenious, and the environment to fit the concept in. It have

Fig 5.9: Design cues examplified in the Favola.

Electrolux

Fig 5.10: The Electrolux logo.

Fig 5.11: Expression board for the product to develop and for the kitchen context.

both a picture of the Electrolux “Aurora cook top” and “Favola espresso pod machine”, but is also expressing Scandinavian colours and materials with a premium feeling, also in design and surface transitions, and a professional cooking experience. The expression board thus features both explicit and implicit design cues to implement in the product design.

5.5. THE REFRIGERATOR MARKET

A brief market analysis was performed aiming to see what the current trends and the latest technologies existing on the refrigerator market are. This section provides with some examples from the market and an overview of emerging refrigerator and kitchen trends.

5.5.1. Benchmarking

Food preservation

In general it was seen that many refrigerator manufacturers are striving to find ways of either optimizing the preservation for every kind of foodstuff stored in the refrigerator, or to preserve all the food in the refrigerator at a lower and very stable temperature to last longer, and to achieve that in an energy efficient way. There are new refrigerators which include technologies allowing setting the temperature differently at different places in the refrigerator. This is achieved with a directed airflow in combination with sensors. It is also this airflow that enables having an even temperature in the entire fridge. The fan controlling the airflow is often equipped with a filter keeping the air clean and preventing spread of unwanted odours.

There are refrigerators with a 0°C compartment aimed for meat and fish to prolong the freshness with up to the double (fig. 5.14). Some manufacturers have focused on controlling the humidity rather than the temperature, like for instance the Smart Fresh zone in refrigerators from Miele. In this zone, which keeps a low temperature of 0-2 degrees, the humidity can be controlled by new functions and it has one dryer (45 %) and one more humid (90 %) zone. Some combined refrigerators/freezers do also feature a quick freeze box, like Samsung's RL52/55's Power Freeze function, where the temperature can be quickly lowered said to preserve the taste of the food in the best possible way.

Furniture market influences

Another tendency seen on the market is the resemblance of furniture products. There are for instance refrigerators with drawers (fig. 5.12-13), which also can be good from an energy efficiency point of view since the cold stays on the bottom of the drawer because of its higher density as it is open (Tang, 2010), and smaller compartments of the refrigerator can be opened at a time. The ways drawers are opened and closed, with soft close and rolling out smoothly on rails are also reminiscent of the furniture market.

For quite some years built in products with refrigerators hidden behind door panels in the kitchen has been trendy and there might be a shift going on towards users wanting their appliances to be visible and good looking as carefully designed pieces of furniture.

Professional products

Just like the trend in general on the market, not only considering kitchen appliances, consumers are often asking for products inspired by professionals. This especially applies for the premium segment, and there is a demand on also refrigerators offering more to the user than only the basic functionality. Another example with inspiration taken from professional refrigerators, though not a new trend is the stainless steel finish.

Displays

Displays on the inside as well as on the outside of the refrigerator door are more and more frequently seen. On the outside the trends are going towards bigger displays and touch-screen with endless amounts of functionality included like in the Samsung RL52/55 and Electrolux Infinity refrigerator (fig.5.16). Examples of functions which not always are directly related to the refrigerator are recipes, shopping lists, photos and even Internet browser or television possibilities, and Samsung are one of the brands offering Wi-Fi enabled LCD display, opening up for endless

Fig 5.12-13: Refrigerators with drawes from Fisher & Paykel and Norcool.

interaction possibilities. Just as with many other technological products there is a strive to create an interesting experience when interacting with the refrigerator

Experiences and connectivity

When it comes to creating a pleasant refrigerator experience, speaking to all sensory modalities becomes important, and light and sound are two aspects to care for, which some manufacturers have done. Refrigerators can be noisy, therefore sound reduction is often considered, and refrigerators are constantly becoming more silent. With the LED lights it is opened up for using light in new interesting ways both for decorative and functional purposes. Especially in premium products the LED lights are used.

The I-Fresh (fig. 5.15) is a refrigerator concept from Samsung that will not hit the stores before 2015, and will apply a so-called food ID recognition technology, allowing users to access food information such as purchase dates, production locals, nutrition data and expiration dates. It will also allow connection with up-to-date mobile technologies since it will be Wi-Fi-enabled, allowing the user to enjoy multimedia and interactive experiences in the kitchen.

With the constant connectivity, and refrigerators wired up with Wi-Fi, information can be transferred to, and the appliances can be managed from both smart phones with apps and from the computer. In such concepts the refrigerator often turns into a "food manager" more than just a food preservation appliance.

Eco-features

There are already some eco-design features existing on the market which might change the user's behaviour. Examples are doors alarm when the refrigerator is getting too warm or when a door has been opened for a long while. Another relatively new feature that has existed for some years is the possibility to set the refrigerator in different modes such as holiday mode, shopping mode, party mode or eco-mode. Electrolux has these features and basically they prepare the cooling system for less openings than normal, loading a lot of not chilled foodstuffs and long openings and a lot of extra food stored and frequent openings respectively, in order to optimize the energy consumption and keep the temperature as stable as possible. The eco-mode sets the interior temperature to be most energy efficient depending on how full the refrigerator is (Tang, 2010). The table 5.1

Fig 5.14: Siemens "FreshnessCentre" with the CoolBox for fish and meet 1-4°C below the rest of the refrigerator for meet and fish. Fig 5.15: Samsung I-Fresh. Fig. 5.16: The Brazilian refrigerator Electrolux Infinity has a touch screen display.

Table 5.1: Eco-features existing on the market.

Feature	Description
Automatic defrosting	Defrosting takes place independently and systematically
Frost free	Refrigerator or freezer incorporates technology to keep the unit from icing up automatically
Temperature display	Electronic panel shows the exact temperature
Through the door ice dispensers	Ice dispenser in the door to give easy access to ice cubes without door opening
Twin motor models with two thermostats	Electrolux' (2005), holiday/winter modes, the temperature of the fridge and freezer compartments are regulated separately and the compartments can be turned off independently of each other
Removable door seal (gasket seals)	The removable design makes the gaskets round the doors easy to clean and replace, limiting energy waste during use
DAC (Divide and Cool)	Divisible Cooling Technology from Arçelik (Beko) (2009) has managed to operate with one compressor per fridge split into seven sections that could work separately, consuming 30 % less power than a regular refrigerator compressor. This provides the technical possibility for further reduction in behavioural energy use of the module-designed fridge.

gives an overview of more eco-design features existing today. However, these features are technological innovations designed for energy savings during the use and not primarily made to change the user behaviour even though they sometimes do.

5.6. THE FUTURE CONTEXT

Since the product of this project was aimed for the future, approximately year 2020, the possible future state of the world had to be studied. A scenario matrix was created showing four possible future directions. The scenarios were constructed based on trend research and a PESTED-analysis (method 3.3.5). Initially the future trend study was kept open and looking at mega trends, then gradually focusing on kitchens, futures of food and grocery shopping, i.e. the refrigerator context.

5.6.1. Trends and influences shaping the future

As a base for the future scenarios a PESTED-analysis was performed, where different key influences and mega trends important for the domestic context and food preservation situation of 2020 were listed. Three central words for this future state were defined as: freedom, customization and awareness. The most relevant points from the PESTED analysis are presented below. In appendix VII all findings from the PESTED analysis can be found.

Political

- The world is more global with less borders and more global laws
- Demand for small scale

Economical

» Time and experiences the new luxury

» Services instead of products

Sociological

» Constant availability of things and services

» Urbanization leading to smaller living

Technological

» Virtual world

» Effortless to use and high customization

Ecological

» Climate changes effect the way of life

» Demand for locally produced and genuine products

Demographic

» Increased ratio of old people in the western world

» Life a is a linear process rather than built by life-stages

Future insights: food and kitchens

Today's experimental cooking might be the future's standard. Different traditional dishes from all over the world will get more popular spread. At the same time as the demand for far away dishes and import of ingredients from other countries increase, locally produced food will stay important. Manufacturing principles and cultivation of foodstuff will to a greater extent be steered by global laws to ensure human rights and environmental sustainability, and the marking of foodstuffs more clear and consistent.

Home delivery of foodstuffs or whole dinners by in a simple way using Internet services might be more common as there already is a trend towards that (subscriptions of food bags for instance). Especially since people are keen to eat healthy but seldom have time to put much effort in their cooking. The 24-7 access to food and the smaller households implies more frequent and smaller grocery shopping. Ready made and half fabrication with dubious origin is getting less common as natural ingredients and food experiences are of increased interest. People will want faster and easier ways of preparing food that is not ready made, especially in the weekdays. It will be important to cook food healthy fast and simple, but still with a homemade experience.

Questions that arise which a new product concept has to meet in a better way than today are:

» How to handle post-prepared food?

» What if someone in the household have to eat later than the others, how to keep the food fresh meanwhile waiting?

» What will the role of the kitchen be?

The kitchen is a central point where people come together, and is not necessarily a place to eat; it is where food is prepared and stored and a place to socialize. In this way it compete more with the living room and vice versa. The kitchen still has a more specific function than the traditional living room even though the role of the kitchen is getting more diffuse. Smaller living and less space and surfaces in the kitchen put demands on smarter more efficient solutions with multi-purposes.

5.6.2. Future scenarios

The axes of the scenario matrix (fig. 5.17) regarded the topics materialism and functions, which were found to be important factors from the trend study. The horizontal axis is going from Specialized to Multi-purpose and the vertical axis from Physical to Virtual, creating the four different future worlds: Stuffocation, Squeeze in, Customized and highly effective and "Everything is possible". The scenarios can be seen in figure 5.17 and are described in the subsequent text boxes.

The four developed scenarios are more futuristic and extreme than the project team believe the world will look like in 2020, but that is since they are foremost meant to indicate directions in which the society may develop, It is important the four scenarios are a bit extreme and not too similar to be useful in the idea generation. Below are the four scenarios presented and described in seven areas relevant for the refrigerator or its context: grocery shopping, cooking, kitchen layout,

connectivity, kinds of foodstuff, household type and sustainability approach.

Among the four scenarios Customized and highly effective was chosen as the most probable future scenario and the scenario to work after. This decision was made after a discussion with the following motives:

» Companies will keep on developing products and to sell as much as possible they will sell many products not few.

» Things are getting more and more virtual and connected.

» It felt as the most inspiring of the four scenarios.

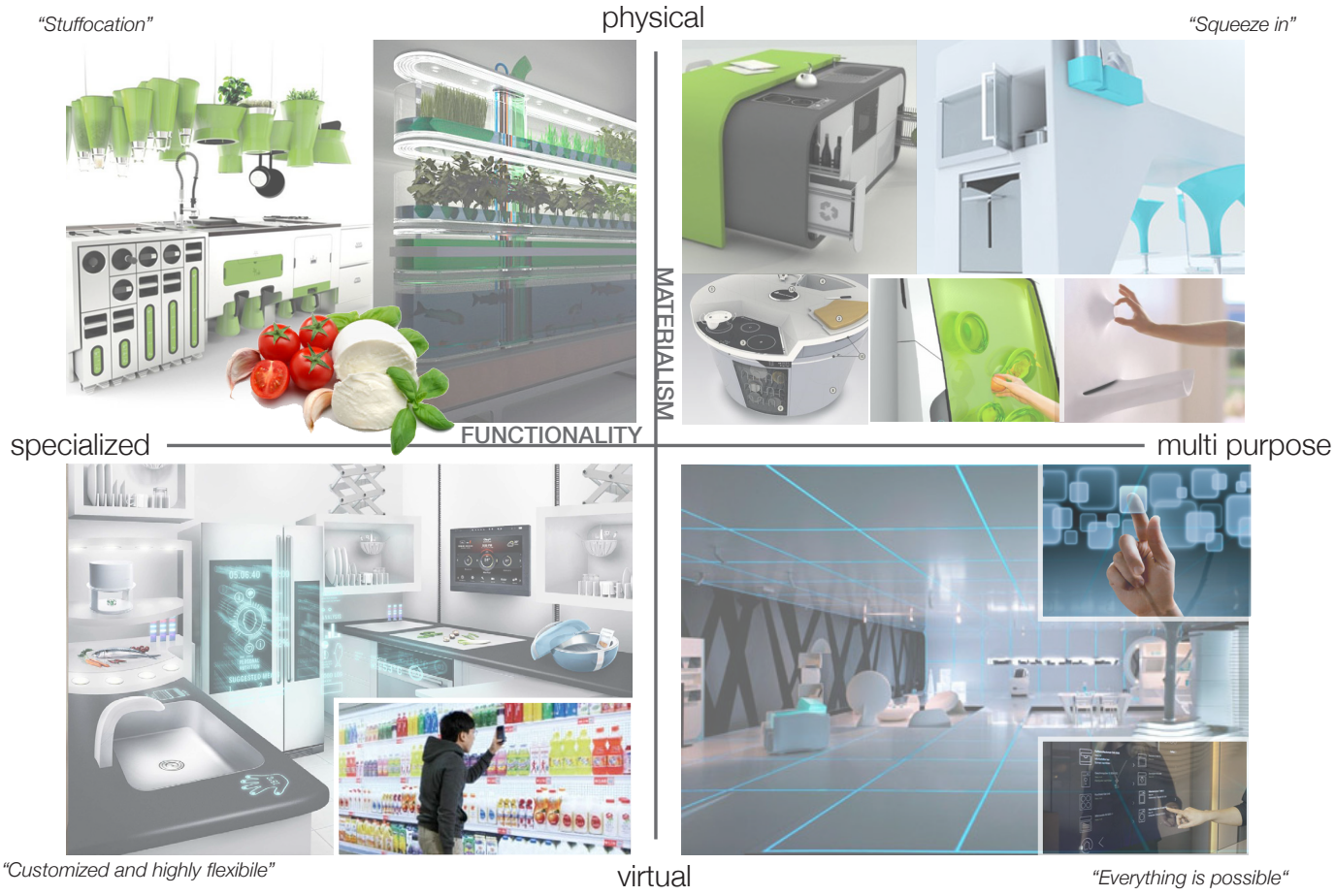


Fig 5.17: Future scenario matrix showing four possible future states

Scenario 1: Squeeze in

Grocery shopping: Shopping is done in huge supermarkets which has everything, and shopping is performed less often. Therefore the demands on long and good preservation of the foods freshness are high. In store there will be delicacy counters where you can ask for packages of fresh products for certain dishes, like an fish soup kit. The foodstuffs are put in the kits on demand, tailored for the user wishes such as number of portions, flavours and certain ingredients. Some products might even be cultivated in the store.

Cooking: The kitchen has just a few products which offers many different kinds of functionalities. Therefore one or two appliances are enough for preparing the meal. The products are intelligent in the sense that they have to know when to do what. When entering the room with the meal kit, the recipe will appear on your appliance and inform you how to cook.

Kitchen layout: The household is squeezed into a small space, why rooms as well as appliances has to be multi-functional.

Connectivity: Products does not have to be connected to such a high degree since a lot of functions are squeezed in to one product. There will be one preservation, one preparation and one disposal appliance which manage the food. Theses three appliances are connected and managed from an external product.

Kinds of foodstuff: Many and natural ingredients, but the amount you buy is always optimized and adapted for specific needs when bought in kits, this in order to save the precious space (and money).

Household type: It is small, it is efficient and it is full of smart solutions such as modularity allowing adaptation. The material and the technologies are very smart.

Sustainability approach: Products are difficult to disassemble for recycling because of all integrated functions and advanced materials. On the other hand fewer products are needed. People in general are not so concerned about sustainability since they feel a bit helpless and out of control. The central functions in the society such as recycling will be more elaborate

Scenario 2: Stuffocation

Grocery shopping: More small specialized shops with locally produced products. Shopping less at a time but more often. Pro-active. Easy access to genuine food from all over the world in specialized shops. The experience is very important and you can bring home traditional dishes from the show kitchen.

Cooking: Slow food and people do not hesitate to put time and effort into their cocking even though time is getting rare. But premium ingredients is important.

Kitchen layout: To make all special dishes a huge set of special appliances is needed. The kitchen features a lot of tools which makes it a bit crowded. Therefore in order to make it nice and organized good storage possibilities are very important. Smart solution for every appliance, foodstuff and product.

Connectivity: Most products are freestanding and not dependent on each other apart from physically (to nicely fit together and be stored in a good way). Many appliances are intelligent and have advanced features, but the physical dimension and hardware is always in focus.

Kinds of foodstuff: Organic food and excellent ingredients are important. Locally produced is preferred, but also from foreign countries but the origin has to be well known.

Household type: Space is needed to make room for all products, but as the population and cities are growing making smart use of space and good storage solutions are necessary.

Sustainability approach: Since very much natural resources are used because of all products and foodstuffs, people are very concerned about the origin and the recyclability of things.

Scenario 3: Customized and highly effective

Grocery shopping: The control is in the hands of the user, but shopping is managed by virtual means. Subscriptions of food from different shops/sites offering specialities such as locally produced foodstuffs or items from certain countries are common. You can manage the shopping virtually from home, and then pick up the groceries or have them delivered to your door.

Cooking: Cooking will still be important, but technologies, connectivity and virtual tools will play a larger role. Technologies will be smarter and be able to tell the user how to cook in order to achieve the best results.

Kitchen layout: More or less the same appliances as today will exists in the kitchen, but they will be connected to each other and able to interact in intelligent ways. The kitchen will still play an important role, but it will be much more interactive. Small appliances such as mixers, scales etc will be integrated in the kitchen just as microwave ovens and fridges can be today.

Connectivity: The kitchen will the households brain, and all appliances are intelligent and connected (also outside the kitchen). The products can be managed via a cloud, either from displays on products, apps on smart-phones or in other virtual ways.

Kinds of foodstuff: Food will be highly customized for everyone's personal needs, no matter what food is available depending on seasons - it is your personal needs for staying healthy that determines!

Household type: The household will have its different rooms for different purposes, but the rooms can easily transformed when it comes to appearance (projection of wallpapers, light settings etc). This could for instance be managed with apps.

Sustainability approach: There will be a lot of different products and stuff, but products are more and more replaced with services and virtual alternatives. Moreover products are easily updated and changed depending your needs and wishes.

Scenario 4: Everything is possible

Grocery shopping: Shopping, what is that? Food is automatically home-delivered as soon as it is needed. Standard products as milk are refilled as soon as there is too little left, and other more particular products has to be asked for manually.

Cooking: You can have an premium chef live cocking (virtually of course) in your kitchen. The total experience is of outmost importance when food actually is prepared at home. Because often ready made are eaten beacause of the lack of time. But again, speaking to all senses and creating an experience is central. Prepared food is taken to a new level!

Kitchen layout: Where is the kitchen? Everything is connected and the kitchen is rather a part of the living room - or the bedroom. The home is one multi purpose room.

Connectivity: A few appliances manage everything and the products are connected. Augmented reality is everywhere and the boarder between the physical and virtual reality merely does not exist.

Kinds of foodstuff: Less ingredients are needed since flavours and appliances can transform one product to another. The sensorial impressions of the basic foodstuffs are enhanced virtually.

Household type: You can live however you want, it is easily transformed. The only requirement is the limited space of the outer walls.

Sustainability approach: The dematerialized society offers a efficient resource consumption because so many products are replaced by services an virtual means. Nevertheless, the few products that are manufactured are not always the best for the environment...

6. User Study

This chapter is devoted the user study. It starts by explaining why studying the users are important in DfSB, and then describes the set up of the performed study. The study was performed in three parts, and the findings from each part are presented before some general reflections and the most important findings from the entire study conclude this chapter.

6.1. WHY USER STUDIES?

In literature it is stated over and over again that the users have to be studied and understood in order to, as a designer be able to change the behaviour in the interaction with a product. As an example Oehlberg et al. (2009) writes "It is important for designers to understand their customers' attitudes about sustainability in order to gauge how the final concept can best match customer needs while also addressing the company or designer's values". A product that includes an understanding of the person's behaviour portrays a more caring image. If the product knows what the user is doing and responds to her needs and reacts on behalf of her interests (i.e. saving money, saving energy), the user can assume that it is looking after both, the environment and her.

This is why in-depth user studies should be performed to gain a good understanding of how users interact with the product, just as hidden factors (barriers) behind why they act as they do, to be able to influence the user behaviour. After all, designing products means designing user experiences, which in turn determines the impact of the product experience (Tang et al., 2009).

Since this project is aiming to both change how the users act by changing the refrigerator, and make users more attached to their refrigerators - and thus hopefully care more for their food, - deep understanding of refrigerator usage and the target user is well motivated.

6.2. USER STUDY SET UP

The project team performed a rather extensive user study. On one hand aiming to find out more about fridge users' behaviour, attitude towards sustainability and food preservation habits in general. But also to go in-depth with the target group to see what emotional benefits would be for them and what strategies would be most suitable in order to change their behaviour to be more sustainable.

The study was divided into three parts; first the general more quantitative survey, then a self observation booklet and sensitizing work book for five characteristic persons from the target group, and finally a focus group discussion and generative session with the same five persons. The two latter parts were more qualitative with open-ended tasks and questions aiming to find deeper insights and valuable tacit and latent knowledge in the users, which are difficult to reach by interviews or observations (method 3.2.3).

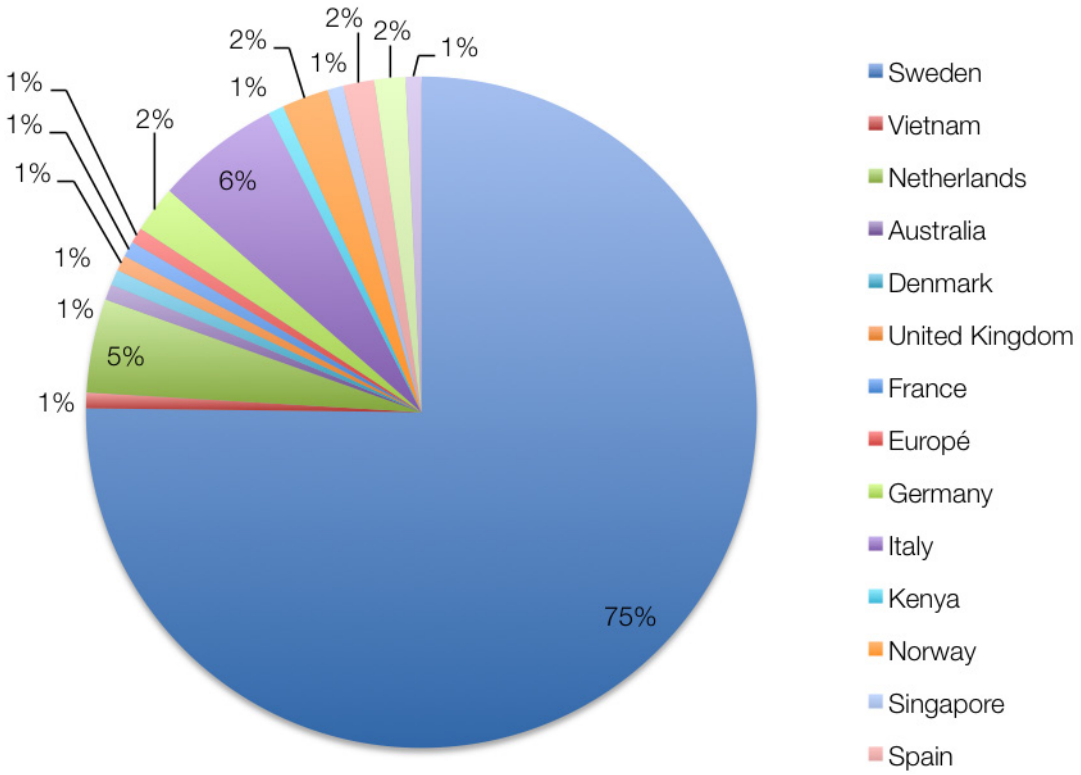


Fig 6.1: Survey respondents by country they live in.

The planning of the user study was initialized by mind mapping over what was desired to find out, and possible ways of reaching those insights. The aim and purpose of the study was set; to get to know the target to find out what their behaviour is like (what should be changed), why they behave in that way (what are the barriers) and what they do/do not appreciate in products and food management (value adding product attachment functions and strategies for behavioural change). Potential questions and tasks were formulated and the layout of the user study was decided on: a survey, a workbook and a generative session. Prior the user study an open pre-discussion interview was held with three refrigerator users in order for the project team to get more viewpoints and other perspectives in mind when setting up the study. At least one of the three participants in the discussion could be considered as typical for the target group. The discussion confirmed many of the team's hypotheses, but also provided some new input to bear in mind when setting up the study.

6.3. SURVEY

The survey, the first part of the study, was spread on the Internet via email and Facebook and everyone was welcome to answer it. The survey consisted of multiple choice and open-ended questions, as well as a couple of scales. There where three main parts; first some generalities (nationality, living situation, favourite product etc.), then questions about attitudes towards sustainability and sustainable behaviour, and finally some questions about food preservation and refrigerators, focusing on the conception of the refrigerator, food waste and keeping qualities of food. An additional scope of the survey was to explore how big the willingness for behavioural change and especially acting environmental friendly seemed to be.

The questions of the survey was created in a way making them easy to compare with similar statistics found in the literature, at the same time bringing deeper insights. The reasons behind having some open-ended questions were to have more qualitative data, which was considered as valuable for the project. For the complete questionnaire and responses see appendix VIII.

6.3.1. Survey findings

The survey had 133 respondents of different ages and genders from 14 different countries figure 6.1. Since the survey covered a more general and broader topic than the project itself, to collect background information and understanding, only the most relevant findings will be presented here. For the interested reader, the rest of the survey findings and information about the respondents can be found in appendix VIII.

Eco-friendly behaviour

When analysing the replies of the questions *How important do you find it to act eco-friendly?* and *How eco-friendly do you act in reality?* it became evident that a large majority ranked it far more important to act eco-friendly than they acted in reality. This shows just as Tang (2010) saw in her study (sec. 2.5.4), that there is a willingness to adopt a more sustainable behaviour. There where only 3 % responding that their behaviour was more eco-friendly than they found it important, and all these persons gave eco-friendly behaviour a fairly low score (under 7 on a scale to 9). Apparently there are barriers to why people are not as eco-friendly as they would like to be. In the question *What prevents you from acting more eco-friendly?* the most common reasons for not acting eco-friendly were time, money, laziness, convenience and lack of knowledge or feedback (fig. 6.2).

There were some respondents indicating they found either the impact of individual change too small to be significant, or the supply of eco-friendly products and services too limited (i.e. the problem is at an organizational/company level and not individual). Moreover there were some respondents saying they were not willing to compromise on performance or comfort in order act more eco-friendly.

Wasting food

The most common reason why people throw away food according to the survey that it does not smell/taste/look good anymore (57%). The next most common reason was past expiring date with 27 %.

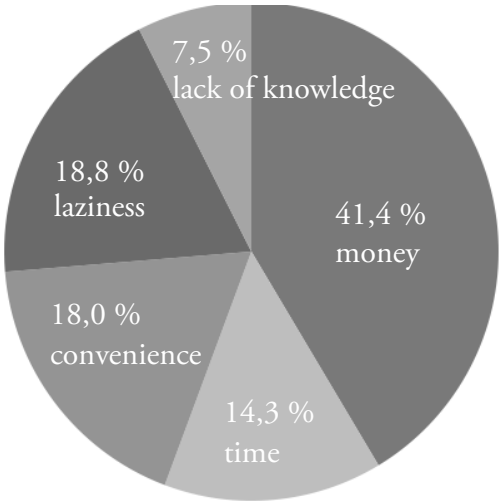


Fig 6.2: Reasons for not having an eco-friendly behaviour according to the respondents of the survey.

The participants in the group interview session prior the survey, said that they expected the refrigerator to keep the foodstuff fresh until the expiring date are passed but not much longer. A question that rose after the survey was if a refrigerator keeps the food fresh longer than to the expiration date would it make the users throw away less food, or if users still would throw away food just because the best before date is passed. If that were the case would only vegetables and other foodstuff without expiration date labelling be wasted less. There were only two respondents who said they do not throw away any food at all.

Door openings

The most common reason why the respondents open their refrigerator door for a long time is that they have done grocery shopping and are making room for/loading what they have bought, or when they are taking out foodstuffs to prepare a meal. Apart from the multiple choice answers participants could add other reasons for leaving the door open. Things mentioned there were by accident not closing the door due to the door does not close by itself when slammed, or that the user forgets to close it because of distraction.

Warm food

Regarding how the respondents treated warm food they want to save, 75 % answered that they

let it cool down before they put it into the refrigerator, and 20 % put it into the refrigerator when it is still a bit warm. In the research from ISIS (2007) a similar survey was done on how often people cool down cooked food before putting it into the refrigerator. In their results 20 % did not always cool it down before putting it into the refrigerator, in similarity with the 20 % in the team's survey who "put it into the refrigerator/freezer when it is still a bit warm". Another survey by Geppert and Stamminger (2010) shows similar percentages of people placing their warm food into the refrigerator.

Knowledge about food preservation

Most of the participants in the survey answered that their knowledge about under which conditions different foodstuffs are best preserved was 4 on a 6 graded scale (where 0 was very poor and 6 excellent). When comparing the ones who answered that their knowledge level were 5 or 6 with how they arranged the foodstuffs in their refrigerators, only 16,6 % ordered their items according to temperature differences inside. This result corresponds well to the findings in the literature study (sec. 2.6.4) where people tend to think they have better knowledge of food preservation better than they actually have.

To the question how they arrange foodstuff in their refrigerator, the three most common answers were: by food type, by packaging dimensions and by how often they are used.

Product preferences

On the question which electrical product in their household they liked the most, the majority of participants answered the computer (14%) followed by water boiler (9%) and stove (8%). At the subsequent question *why?* the answers of the respondents can be summarized with the following descriptions:

- energy efficient
- time saving
- the outcome is something pleasurable
- fun and easy to use,
- nice design
- flexible
- nice sound, smell and haptic feeling when using it
- allows multi-tasking
- gives a shimmer to habits
- keep order and things visible/accessible
- easy to clean
- creates cosy feeling
- support healthy living
- smart
- supportive
- looks after itself
- versatile
- genuine
- of good quality
- creative
- social connected
- adaptable
- substitutes boring actions

The last section of the survey treated the relation between the user and the refrigerator. The respondent had to rate their opinions between pairs of opposite words. The results of these ratings are shown in the chart in figure 6.3.

The last question was how the user considered "the personality" of their refrigerator and the answers were many and creative. To read some of the quotes see appendix VIII. The words the respondents used to describe their refrigerator were analysed in a Wordle (method 3.3.9) and the result can be seen in figure 6.5. Based on the Wordle a suitable personality was sketched symbolizing the present refrigerator, see figure 6.4. As can be seen, the general conception of the refrigerator is that it is boring, reliable, plain and anonymous. I.e. the user's relationship to it seems to be weak. Referring to section 5.2.1 where it says that the refrigerator tells a lot about the user and her/his lifestyle, it can be seen as remarkably that the bonds to the refrigerator are not stronger. Because there are not many people how speak proudly about their refrigerator as many do with other products.

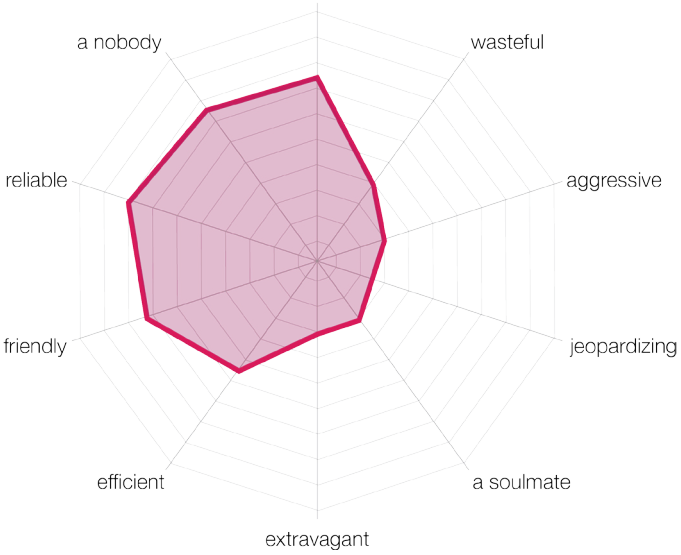


Fig 6.3: Survey responses, how users regard their refrigerator

Fig 6.4: Illustration of current "personality" of the refrigerator; boring, old and plain but reliable.

Fig 6.5: Wordle. result of the survey question regarding "the personality of the refrigerator".

6.4. CONTEXT MAPPING

The context mapping was supposed to answer how users act and why they do as they do, in order for the project team to be able to change the negative behaviours. The purpose was also to reach in-depth knowledge and the more fuzzy intangible insights that the users barely are aware of themselves. By performing the study the project team could also better understand what the target users' concerns, attitudes and values are and what makes them be attach to a product. The context mapping was initiated with a workbook followed up by a generative session.

6.4.1. Workbook

In the second part of the study were the participants a selected group of five persons, two men and three women, chosen to be representative for the group of target users. The five participants were all Swedes living in the Stockholm area and in the age 25-35 years old. Some lived in small student apartments, other in larger flats and yet some in villas. Two had recently become parents, one lived with her boyfriend and the other two lived alone. The participants of the study were chosen baring in mind that some of them should be in the life stage of Louise, the persona, today

and the rest in 5-10 years when the concept is aimed for.

The five participants received a personal booklet by mail, or it was delivered to them in person. The booklet was designed to be attractive and feel inviting for the participants to use, and was meant to be hung on the refrigerator door for easy access, see appendix IX.

The workbook was constituted by two parts; a self-observation diary and daily sensitizing tasks. The sensitizing tasks aimed to, apart from sensitizing the participants for the group sessions and allowing the project team to better adjust the set up of the session, to reveal information that could give hints for possible value adding functions and product characteristics. The purpose of the self-observation part was also to sensitize the participants prior the workshop and have them to start reflecting and become aware of their refrigerator behaviour. The second purpose of the self-observation was to let the project team study when, why and how often/long they interact with their refrigerators.

6.4.2. Generative session

The group session held when the workbooks were completed, collected and analysed, discussed the results of the self-observations and interesting parts of the tasks. Based on the workbook findings the aim was to go deeper and towards the future to find barriers for sustainable behaviour, ways of take away the barriers and strengthen the product and brand relationship. The set-up of the generative session can be found in appendix IX.

The session consisted of four parts; an introduction and warm-up exercise with statements allowing the project team to determine how well the participants corresponded to the group of target users, then a discussion of the results from the workbooks, aiming to find out about the problems and discussing why they do not have a more sustainable alternative of behaviour instead to discover the barriers. In this part the participants where given a timeline over a "standard day" from there self observation diary and the interaction sequences (sec. 5.2.2) and they were asked to place PrEmo stickers (method 3.3.3) describing their emotions in the refrigerator interaction there (appendix IX). In the third part of the session a future scenario was presented (appendix IX), focusing on the most critical situations from a sustainability point of view found in the survey and workbook. The participants were asked to create a timeline over how they would accomplish a specified task in the presented future context (fig. 6.6). They had papers, pencils, glue, tape, pictures and words at a hand, and were asked to describe what their kitchen and refrigerator would be like,

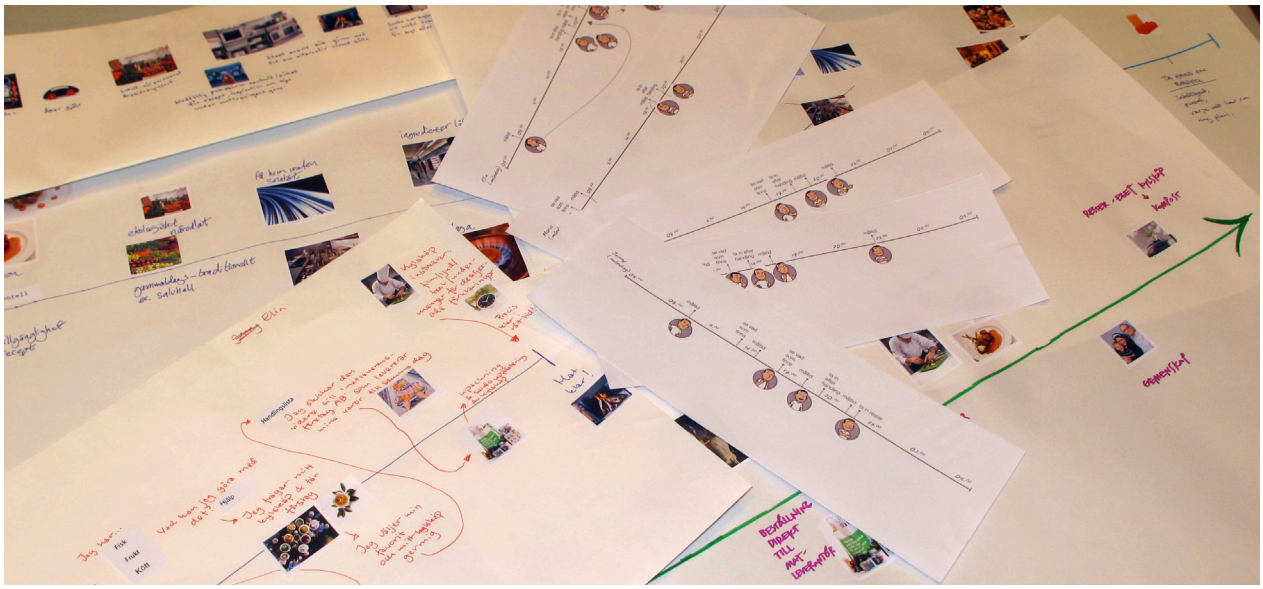


Fig 6.6: The timelines created by the participants in the context mapping study.

how they would act and behave in a desirable way in the given context. In that way the team could receive insights about what strategies that could be suitable for the target users as well as what they wish and dream about their future kitchen, that is potential value adding functions. The final part, after the presentation and discussion of the time lines created by the participants, was a discussion about product attachment and value adding functions based on the created future kitchens, the responses on the tasks in the workbooks and responses from the survey.

The result of the generative session was analysed through a KJ-analysis and then incorporated in the need and demand list (see sec. 7.5) and summarized in the next section.

6.4.3. Context mapping findings

In general people's awareness of their behaviour with the refrigerator seemed to be low, and the participants of the study were surprised over both how little and how much they interacted with their refrigerators. Only the workbook made them start reflecting over their behaviour, which is the starting point for making any behavioural change. Their view on their refrigerator was that it was a rather anonymous but vital household product. They said they had not reflected much over it before this study and found it quite well working.

None of the participants knew the exact temperature in their refrigerator and were not sure how to best preserve different foodstuff, however some said they believed they were confident and knew how to best do it. They were positive to be better informed about good food preservation and that a refrigerator customized for different foodstuff at different places depending on suitable temperature/humidity. There was however some who expressed a fear of being too steered and wanted to have flexibility.

When throwing away food date labelling was seen as important especially when it comes to meat. One participant said he was more careful with his child's food than with his own. Milk was often smelled or tasted before wasted. They said it was especially difficult to know when saved leftovers would go off.

There were mainly two parameters that over the years have changed the participants refrigerator usage; economy and change in daily routines (from student to worker, single to parent). All participants seemed aware of that hot food should not be placed in the refrigerator due to higher energy consumption, however they did sometimes put in warm food because they thought it was better for the hot food to be cooled down quickly. They did not reflect upon that warm food that was put into the refrigerator heat up the entire refrigerator and would affect the other foodstuff. They said it was sometimes difficult to remember to put the chilled food into the refrigerator when it had reached room temperature and difficult to know when it is enough chilled.

About thawing food some thawed in water and some in the refrigerator. The problem when thawing in the refrigerator was the uncertainty how long time in advance the frozen food needed to be put the refrigerator and to be thawed in time.

One of the participants said she sometimes held the door open for a long time when preparing a quick meal, like breakfast. The reason was to "save the effort" of opening the door again. Other times when they had the door open for a long time were when doing inventory before grocery shopping and when looking for something nice to eat.

None of the participants used a shopping list during the week they filled in the sensitizing booklet. Without a shopping list they said they often did not know what they had at home and sometimes they bought things just in case and by accident ended up with doublets of groceries.

Some of the future ideas and desires that came up during the generative session were:

» To shorten the time and way to get food to the house, since many of them found planning and shopping boring and wanted to put that energy on social cooking and dining instead.

» Some wanted the refrigerator smarter and someone to communicate with; it should know what it has and what could be done with it. The refrigerator could also be a door to a whole world with different foods and recipes available. In contrary to the refrigerator with more intelligence and more efficient shopping some people said they wanted better access to locally produced season dependent food, to go shopping good foodstuff themselves. A comment was that if an action demands an extra effort it leads to that the person in the end does not do it if s/he does not have any benefits from doing it

» The participants said they disliked refrigerators that are noisy. They liked to have large refrigerators with good overview and easy to organize and where everything is reachable.

» When the refrigerator is full and when there is good order in it, the participants said they were in a good mood. The times when they were most receptive for outer input differed but was not in the mornings, except from the one on maternity leave, when they were under time pressure and acted routinely.

6.5. REFLECTIONS AND OBSERVATIONS

Throughout the entire project process the project team reflected over their own refrigerator behaviour and observed people in their surrounding interacting with refrigerators in their everyday life in a spontaneous and unstructured way. Informal discussions were held about refrigerators and sustainable behaviour resulting in valuable reflections and insights in addition to the user study. These are some of them.

Insufficient temperature feedback

Sometimes the only way to control the temperature in the refrigerator is by rotating a wheel to where it for example can be adjusted from 1 to 5, with no feedback about what interior temperature each number corresponds to; does 1 mean the lowest temperature or the lowest chilling effect? Moreover, there is often no indication about the present temperature in the refrigerator unless a separate thermometer is put inside. This leads to deficient temperature feedback from the refrigerator to the user.

Lack of food preservation knowledge

The refrigerator does not offer optimal conditions for preserving every kind of foodstuff, but it is a good compromise. Few people seem to know the temperature variations in the refrigerator and where to best store different foodstuff and how the foodstuff would be kept fresh as long as possible in the refrigerator. The refrigerator is designed to keep foodstuff fresh until its expiration date labelling and as long as it does that no one will probably complain. However, referring to the information about date labellings presented in the theory chapter in section 2.6.2, foodstuffs last for longer if stored properly. There is thus room for improvement regarding the food preservation in the refrigerator and feedback to the user, but the reliance on date labellings can be a barrier.

Long door openings due to the refrigerator placement

The refrigerator is sometimes placed far away from a workbench or table, which leads to inconvenience when loading or unloading groceries. Long distance to a place to load and unload the groceries lead to unnecessarily long door openings.

Negative to computerized refrigerators

Some people do not want that the refrigerator, which is one of the few non-computerized products, become more digitalized with big displays and tonnes of advanced features. It also came up when speaking to people, more or less within the target group, that big displays or anything at all on the refrigerator door was seen as unwanted and ugly. Some also had the belief that the more functions a product has the higher is the risk that something breaks.

Poor looking display of groceries

A reason found to why people stand with the door open for a long time was because they searched for something tasty to eat but that the foodstuff in the refrigerator was so badly displayed in the refrigerator and looked too disgusting that they after a while closed the door without finding anything that tempted them.

Ignorance of energy consumption

A reason for standing with the refrigerator door open that was identified was that people are not aware of that they do it, when for example discussing with another person in the kitchen. One reason why people treat the freezer door with more care and quicker door openings might be that the cold freezer air gives feedback to the user that cold air is let out and energy wasted. It is also a more unpleasant feeling with the very cold freezer air compared to the refrigerator, something that is not as obvious with the less cool air from the refrigerator.

Random arrangement of foodstuff

How people arrange the groceries in their refrigerator differs a lot but often seems to be due to habits, what is learned from parents or totally random. If the refrigerator is full some people said that if a hole was found in the refrigerator it was quickly plugged when loading new groceries, despite eventual previous order, instead of rearranging the other foodstuff.

Date labelling reliance

There seems to be age differences in how much people rely on date labellings on foodstuff. When speaking with people of different ages a pattern seemed to emerge that older people who grew up before the date labelling on foodstuff was introduced tend to more often taste and smell the groceries before throwing them, while the younger generation tend to rely more on date labellings.

6.6. CONCLUSIONS FROM THE USER STUDY

These were the most important insights from the user study to consider in the concept development.

- People's knowledge about good preservation conditions for different foods is low, even though they often claim they have good knowledge.
- The feedback from the refrigerator is deficient. The user does not know if and/or where the refrigerator offer optimal preservation conditions for the foodstuffs, neither what the optimal conditions are.
- There is an ignorance about the effects of actions such as placing warm food in the refrigerator, and people tend to think it is bad for the energy consumption of the refrigerator but do not consider the consequence of heating up the rest of the food inside.
- People tend to leave the fridge door open for a long time when looking for something to eat, when making inventory before grocery shopping or when using the food while the door is still open. If the door is left open for a long time is generally depending on if the person finds the groceries looked for, and the awareness of how bad it is to keep it open.
- The reason why people do not thaw food in the refrigerator is due to bad planning and uncertainty whether the food is thawed in time.
- Packaging dimensions have a great influence on where people place their groceries in the refrigerator. Thus refrigerator designers play an important role in where people place their foodstuff.
- There is a gap between how environmental friendly people want to behave and how they actually do behave.
- The refrigerator is a vital product of the home but a rather anonymous and boring. People have faith in it keeping the groceries in the best possible way, but that is it.

» There is a big reliance on date labellings for expiration date. The refrigerator should keep the groceries fresh until then, but keeping it fresh longer is not expected. Some people throw away food directly if the date labelling has passed, especially when it comes to meet. Milk is often tasted before wasted.

7. Basis for Concept Development

This chapter acts like a bridge between the pre-study and the development phase; including conclusions, decisions of focus areas and a summary of discerned barriers to sustainable behaviour.

7.1.CONCLUSION FROM THE PRE-STUDY

After the analysis of the pre-study the project team could conclude that the worst sustainability issue related to the refrigerator is the extensive food waste, which in turn is highly dependent on bad planning and low consciousness of the bad effects of wasting food among people. The energy consumption of the refrigerator and the effects of long door openings turned out to be relatively low in comparison to the food waste issue, but yet an area of improvement. The placement of food in the refrigerator that is still warm appeared to be more common and worse from a sustainability perspective than first thought. The matter of bad food planning might be the biggest factor to food waste, but is a large problem that includes much more than just the refrigerator. The main barrier to meet in order to make the user behaviour more sustainable is the low knowledge and the ignorance among users; how food should be stored, the invisibility of the energy consumption, and the highly habitual behaviours with bad impact that most users merely are aware of that they have. Since the refrigerator is such a frequently used product and important in everyday life, it is very important for the users that the interaction with it is convenient and effortless.

7.2.BARRIERS AND BEHAVIOUR IMPROVEMENT AREAS

After the choice of product in focus and the conduction of the in-depth user studies, the next step to take, suggested by Selvefors, Blindh Pedersen and Rahe (2011) in the DSCB approach is to identify where, when and why the wasteful resource consumption is. In this step they also write that the barriers towards sustainable behaviour should be found, why the project team identified and listed eleven barriers related to the found behaviour improvement areas (appendix X).

7.2.1. Barriers for a sustainable behaviour

The two overall problems in the use phase of refrigerators regarding sustainable behaviour are food waste and waste of energy. Looking at the major causes and underlying barriers found in the interaction sequences presented in section 5.2.2 and in the user study (Chapter 6), supported with the findings from the literature review (sec. 2.6.4), important improvement areas from a behavioural point of view were found. By analysing them further the associated barriers for the targeted behaviours to be changed could be iden-

tified in order to be able to choose suitable DfSB strategies. These eleven barriers for sustainable refrigerator user behaviour were found:

1. Ignorance of how to – Ignorance that something can be done, lack of information
2. Ignorance of the actual consequences of the action
3. Hopelessness – ”it’s impossible”
4. It is too expensive
5. Too effort demanding (laziness, convenience)
6. High risk of accidentally doing wrong/forgetting to do right (it is easier to do wrong than right)
7. Takes too much time
8. Lack of inspiration to act sustainable/not (visually) appealing
9. Difficulties to plan
10. Lack in communication
11. Other things/actions comes first

After an initial idea generation and further analysis of the problem areas it was found that they were not optimal to use in the idea generation, why the areas was merged to four to be easier to work with and more relevant for the concept development. The four behavioural improvement areas were (figure 7.1):

1. Food placement (overview, best conditions for preserving the food)
2. Hot/frozen food transfer to the refrigerator
3. Take care of food before it goes off (leftovers, close to expiring date, knowledge)
4. Food planning (dinner planning, communication, shopping lists)

7.3. REFLECTIONS ON CHOICE OF STRATEGIES

After discussions and reasoning based on the user study, the DfSB literature review and with the persona in mind, a first selection of promising strategies for changing the behaviour in focus was done. Since the target group are not the ones with the strongest pro-environmental engagement and the willingness to compromise on either aesthetics, performance or result when using their appliances (sec. 5.3), the benefits of using the product as intended to change behaviour must be clearly communicated and greater than the potential additional effort demanded. Moreover, the target user do not want to be controlled, she wants the freedom to make her own decisions but yet like to have some guidance for making her choices. Therefore strategies from the category Enlighten might be to vague to use alone for a sustainable change, but promising if combined with other sorts of strategies. To force the user could on the other hand be perceived as too controlling and result in frustration if not used carefully. Different categories of strategies are often beneficial to mix in the product to be effective (Selvefors, Blindh Pedersen, Rahe, 2011), and the Spur and Steer categories can be assumed to be the most promising to use in this case.

Which particular strategies to implement in the final concept depend on what particular behaviour that is in focus. It always has to be taken into consideration whether behaviour is habitual or an occasional behaviour (sec. 2.2). Habits are more difficult to change and need certain strategies to be changed successfully. In the interaction with refrigerator many behaviours and actions are highly habitual, especially at breakfast time as the

Fig 7.1: The four focus areas; *Food placement, Hot/frozen food transfer, Take care of food before it goes off* and *Food planning.*

project team discovered in the user study, and this is something that has to be kept in mind in the development process. Concerning change of habits the user has to firstly be aware of his/her behaviour and be motivated to change it. The bad habit has to be broken and new better behaviours established.

7.4. PERSONALITY CHANGE FOR THE REFRIGERATOR

From the user study and especially the survey, it was seen that people's conception of their refrigerator is not very attractive, and probably neither the persona Louise has the most positive relation to her refrigerator. The idea of a personality change was born during the analysis of the survey, and based on the net chart visualizing the replies on how much the refrigerator is perceived in different ways, adjustment for how the refrigerator preferably should be perceived was done, see figure 7.2. The suggestion was to make the refrigerator more attractive by making it less plain, more "human" and to be perceived as more efficient. An idea of how to achieve this in a way attractive to the target user was to make the refrigerator more emotional in its communication and considering what sort of, and most importantly how feedback is given.

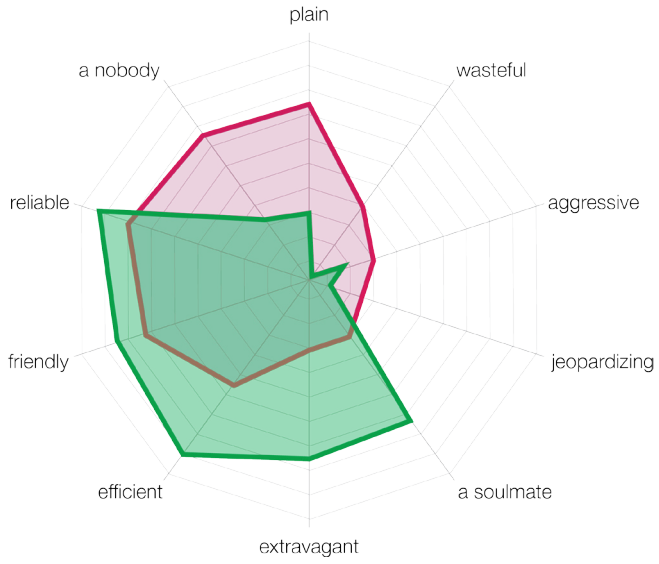


Fig 7.2: Suggested personality change for the new refrigerator (green), compared to survey responses in fig.6.3 (pink).

7.5. NEED AND DEMAND LIST

Since the project aimed to develop a concept and with the focus on the behavioural change for a pro-environmental behaviour, and was not limited by manufacturing, costs or other such specifications (sec. 1.1.6 limitations), there was no need for a strict requirement list. Instead a need and demand list was put together and updated throughout the project, to be used as a reference or checklist. The complete need and demand list can be found in appendix XI. The purpose of this list was to collect all the important aspects of the product concepts to fulfil, and to facilitate the evaluation of concepts. The listed needs and demands derived from the function analysis (sec. 5.1.1), the user study and discussions with experts. Specifications on the expression of the concept were also an important part mostly derived from the brand identity.

In the list the requirements were ordered in the groups: Sustainability, Technical aspects, Interaction, Functionality, Food management, Design demands (dimensions etc.), Customization, Expression and formal functions, Material and Market. Some of the most important requirements were:

- Preserve the freshness/condition of food
- Make the user act more sustainable than with a classic refrigerator, i.e. affect them to waste less food and consume less energy
- Be intuitive/easy to use
- Support thawing frozen food and chilling warm food in energy efficient and controlled ways
- Express premiumness

8. Development

The concept development was an iterative process, starting of early in the project with large quantities of wide spread ideas on different aspects of cold preservation and sustainable behaviour as well as how to make the refrigerator a more attractive product. Ideas were sorted out and the most interesting ones developed further resulting in three concepts. Methods used in the idea generation during the concept development were amongst others brainstorming, mind mapping, morphological matrix, sketching, KJ-analysis, workshops and the strategy cards from Brains Behaviour and Design. Throughout the concept development process meetings with experts on refrigeration from advanced development at Electrolux were held to verify the feasibility of technical aspects of the project teams ideas.

8.1. IDEA GENERATION

A large amount of ideas created from series of brainstorming, brain writing and idea generation sessions on topics such as optimal placement of foodstuffs, opening principles, awareness of contents without opening, knowing what to buy, taking care of leftovers and properties making the product more attractive to the target user. For more sketches and mind-maps see appendix XII.

Initially, much focus was on the technical feasibility of the concept. In meetings with experts from advanced development the technical possibilities of optimizing food preservation and keeping track of the refrigerator contents were discussed, serving as inspiration and indications of what could be realistic and promising directions for the coming concept development. Examples of possible utilization of such technologies were tracking the contents of the refrigerator by means of cameras and different sorts of sensors and RFID, and different possibilities of prolonging and enhancing the freshness of the preserved foodstuffs with light of wave lengths in the red and blue spectrum, boxes with vacuum and changing the gas composition of the air (more CO_2 or nitride gas).

8.2. PART CONCEPTS

Four directions of concepts were formed from further development of ideas from the clusters from the ideation, the workshop held at Electrolux (sec. 4.3.1) and the project teams qualitative evaluation in relation to the Electrolux brand and the target group. The concepts were given descriptive names according to the main focus of each of them. They were constituted so that they focused on different behavioural problem areas and had different sorts of functionalities, rather than offering solutions to the same problems in different ways. The concepts were also given different "personalities", and were described with three words. One of the four concepts, *The Efficient* (sec. 8.2.1) was eliminated as the focus behaviours of each concept had been defined. The reasons were it was narrower than the other concepts and that the technical possibilities of some

Fig.8.1. Sketches for the concept "the Efficient", a "double tray" with Peltier cell to insert in the refrigerator to thaw and chill food in

of the solutions were uncertain in energy efficient ways. Instead parts of the concept were integrated in the concept *The Professional* (sec. 8.2.3).

Beside the concepts there were yet some functions and features from the initial brainstorming that could be implemented in all of the concepts. These were grouped alone and saved for later on, in order to keep the concepts streamlined. These features were for instance better feedback on the temperature in the refrigerator, ways of informing about the effects of actions such as door openings or putting in warm food, making energy consumption visible and ways of making the refrigerator more human-like and personalized. Some of these "additionals" can be found in appendix XIII.

8.2.1. The Efficient

The Efficient was the early discarded concept that focused on making the handling of hot and frozen food in connection to the refrigerator more efficient and convenient, thus the category forming the base for this concept was *transfer of hot and frozen food into the refrigerator* (fig. 8.1). Energy and temperature feedback was central in this concept. The Efficient also offered special features allowing controlled thawing and quick chill inside the refrigerator in a convenient and energy efficient way. In this concept it can be said that the intervention strategy spur was used since it encouraged the user to act in a specific way, but it could also be seen as the intervention strategy match was used since the concept would offer a new function matching an existing behaviour.

8.2.2. The Organized

The Organized was a concept based on the behaviour improvement area accessibility and overview (fig. 8.2). The main purpose of this concept was to minimize door openings by providing a better overview so that products could be faster and easier found and accessed. The Organized was developed to be the *efficient, tidy* and *helpful* refrigerator (fig.8.3) who supports the user in organizing their food through its physical attributes (fig. 8.4-6). It also featured a system for managing leftovers with for example RFID tags. The aim was to minimize food waste by prohibiting the user from forgetting things back in the fridge or buying food in vain. Moreover, the good organization and quick access to frequently used products would decrease door openings and thus energy consumption. The Organized did not focus on preserving the food optimally, but allowed the user to access it in the easiest way so it would not be forgotten and the door not left open for a long time when not finding what is looked for. Therefore were features such as quick access to frequently used food, transparency in the door and ways of facilitating use of the stored food before going off appropriate, just as the system allowed the organization of leftovers and opened not finished packages of food. See figure 8.7 for the key functions from a DfSB perspective.

The Organized was to a great extent relying on the user to change the behaviour and the appliance was rather encouraging than guiding the user to

Fig. 8.2: The Organized, its size is lower and wider than a normal refrigerator for better overview and access.

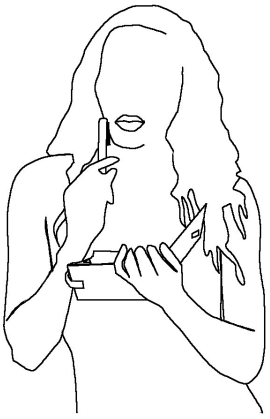


Fig. 8.3: The efficient, helpful and tidy personality.

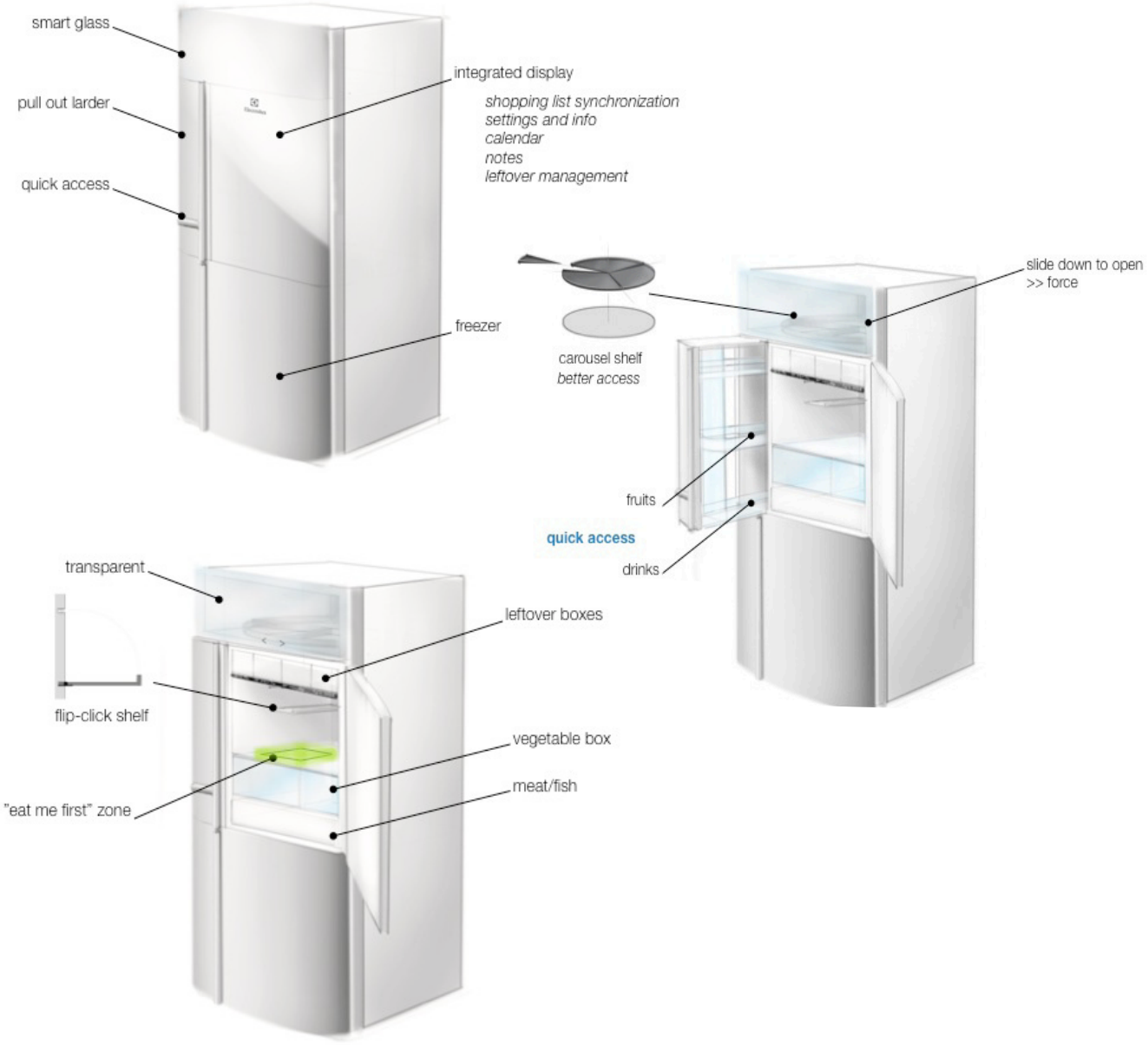


Fig.8.4-6: The Organized, closed and opened with its compartments and features indicated. Inside the top compartment with slide-down-to-open smart glass door, there is carusel shelf. The pull-out larder on the side is for quick access to fruits and drinks. In the large compartment there is an “eat-me-first zone“ and a system for post-prepared food.

Fig. 8.7: The key functions of The Orginized to make users adopt a more sustainable behaviour.

better organize and keep track of the food. Thus the kind of DfSB intervention strategies used in main was from the spur category (sec. 2.1).

Key functions from a sustainable behaviour perspective

» **Quick access and transparent door:**
Change of behaviour: Shorter door openings, keeping track of what is inside

» **Eat-me-first-zone:**
Change of behaviour: Eat food before it goes off by knowing what will soon expire

» **Leftover system:**
Change of behaviour: Saving and keeping track of leftovers.

Cons and question marks

» Difficult from an ergonomics point of view to lift out the trays from the top compartment, even though it is lower and wider.

» Will the user understand the many different features and part functions?

» Similar to a traditional refrigerator and some similar solutions have been suggested earlier in concepts which of various reasons have not been realized. Not differentiated and forward thinking enough?

For a detailed description of the functions and features of the concept The Organized, see appendix XIII.

8.2.3. The Professional

The concept The Professional was in the height of a kitchen bench (fig.8.8) and focused on optimizing the preservation of different kinds of foodstuffs (fig.8.10). The Professional's personality was *confident, competent* and *trustworthy* (fig. 8.9), and the concept elaborated on Electrolux's heritage and experience from professional products. By storing each kind of food in its optimal way, it can last longer before going off and is wasted. An important factor to succeed in that is to educate the user and to communicate the intended storage in an appropriate way. The behaviour this concept aimed to change was thus minimizing food waste through raising the awareness of how to take care of food by having the refrigerator offering the right conditions (8.10-12). The concept attracted the persona Louise because she knows her food can be optimally stored and she can put her time and effort on social and fun activities like cooking and dining. There could also be an application extending the functionality connected to The Professional since the refrigerator does not have a display (fig. 8.13).

Compared to The Organized, The Professional focused on preserving the food in the best way possible so it stays fresh longer instead of making it more visible and accessible. The second focus area it treated was hot/frozen food management. An aspect related to this was to communicate the effects of actions, like how a door opening of one minute would affect the temperature inside,

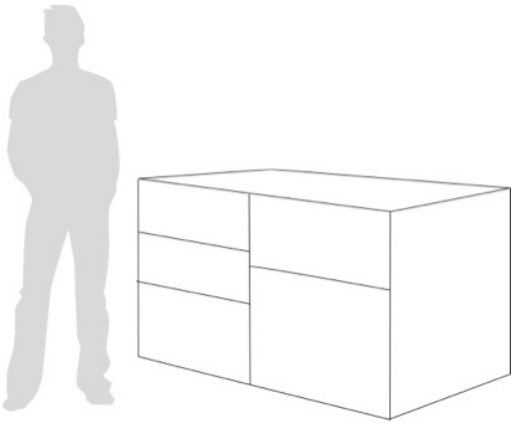


Fig.8.8: Size indication for The Professional.

Fig.8.9: The Professional's personality is confident, competent and trustworthy.

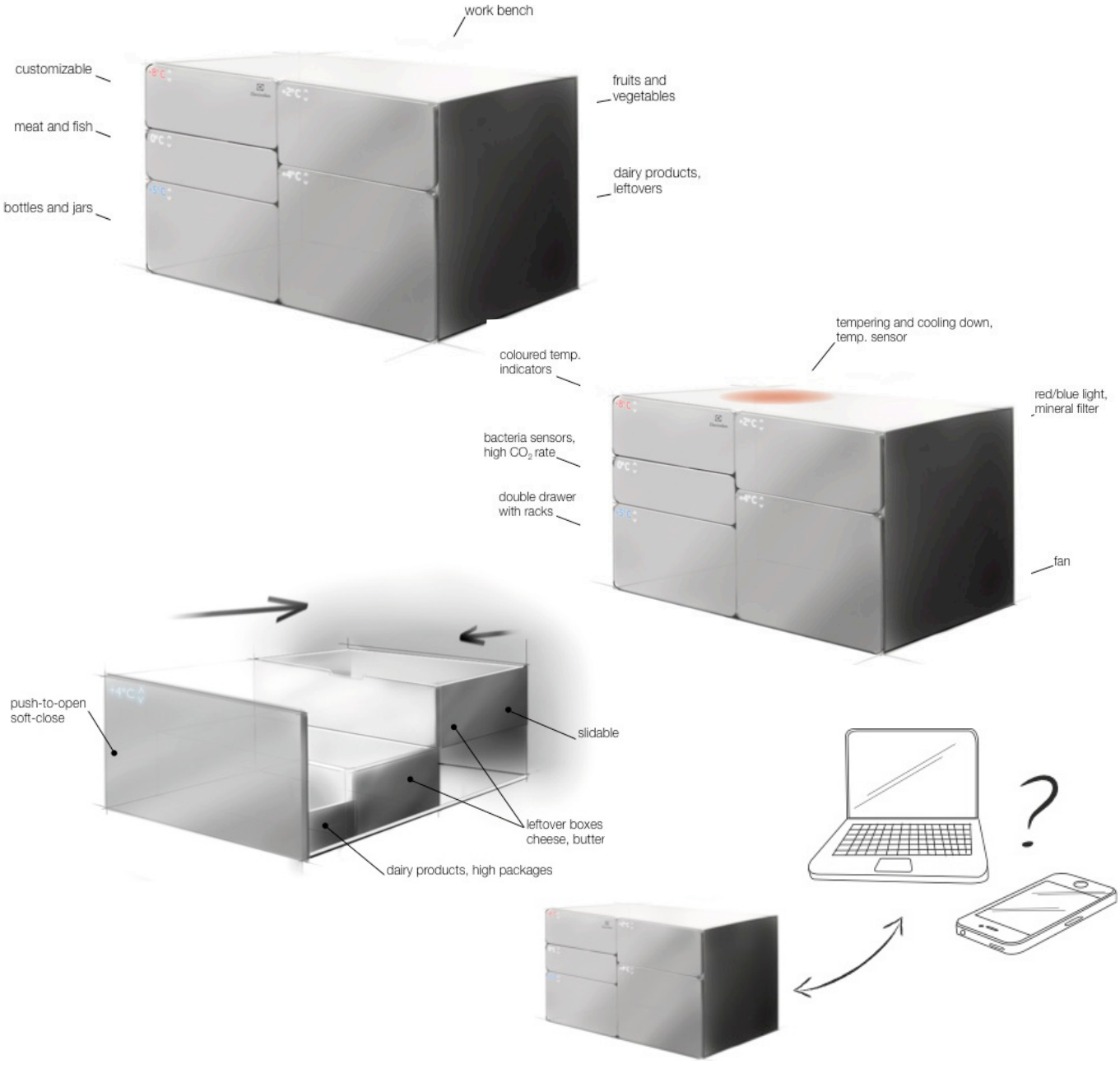


Fig.8.10-13: How food should be organized in The Professional. The Professional's functions and features. Example of a drawer offering good overview. The Professional could also come with an application.

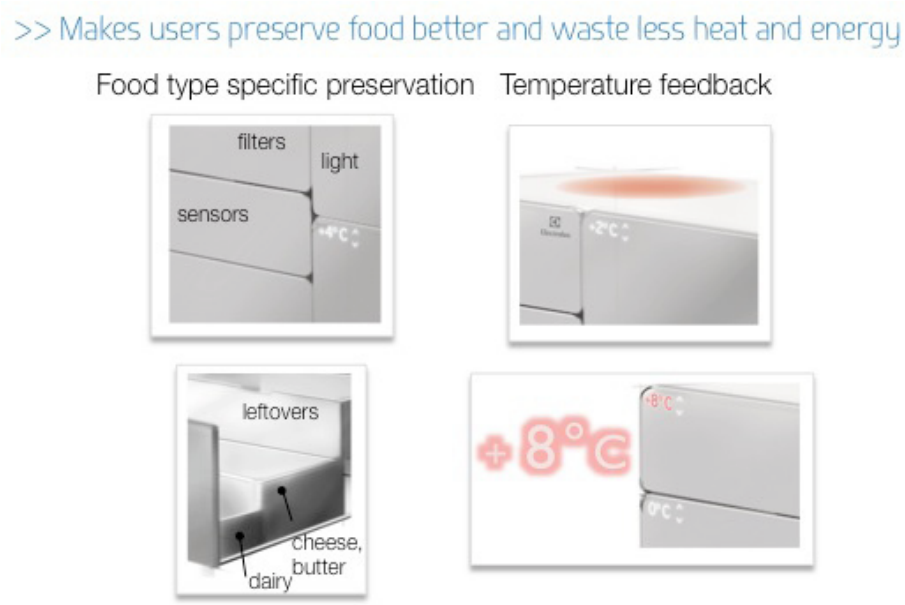


Fig.8.14: The Professional's key features from a sustainable behaviour perspective.

or what happens to food stored at wrong conditions. Since professional appliances inspired this concept it was suitable to make different modules with several doors and/or drawers suited for different sorts of foodstuff. The Professional involved system thinking in a way sharing standardized measurements with all major appliances of the Electrolux range, allowing transferring shelves, trays and insets between them seamlessly.

The DfSB category used the most in this concept was steer, because the appliance would not force the user to organize and put the food where it is aimed to be, but guide her/him to do so and let the user know it is the most beneficial way.

For a detailed description of the functions and features of the concept *The Professional*, see appendix XIII.

Key functions from a sustainable behaviour perspective

» **Food type specific preservation:**
Change of behaviour: Preserve food as good as possible

» **Temperature feedback on top surface**:
Change of behaviour: Not placing warm food in the refrigerator

» **Temperature feedback on drawers:**
Change of behaviour: Awareness of the status of the refrigerator, where specific conditions are met and the consequences of actions that increase the temperature in the refrigerator. See figure 8.14 for the key functions from a DfSB perspective.

Cons and question marks

» Not emotionally attractive enough for the target user, too technology and feature focused.

» Will the user know what food to place where?

» Are all the temperature and climate zones in the products possible without making it very energy consuming?

8.2.4. The Communicator

The concept *The Communicator* emerged from ideas of connectivity. Since many people find planning meals and grocery shopping time consuming and boring and wish for inspiration the project team explored how connectivity in different ways could facilitate that. The answer found was The Communicator, which was a somewhat more conceptual concept, focusing on the virtual. This refrigerator was transformed into an intelligent appliance, like the brain of the home, offering ways of connecting people, different appliances such as smart phones and computers and other kitchen appliances like the freezer, oven and dishwasher (fig 8.15, 8.17-20). On a larger scale connecting and communicating with the

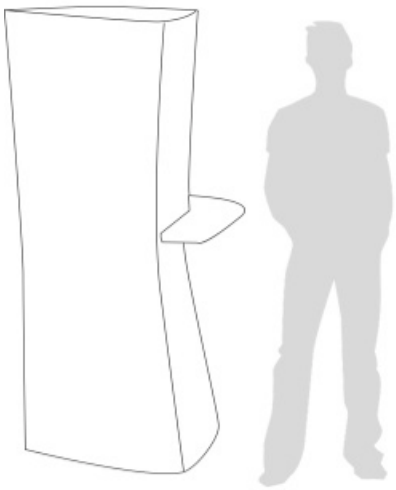


Fig. 8.15: Size indication for The Communicator.

8.16: The personality is social, inspiring and planning.

Fig. 8.17-20: The front view with a large integrated display on the door and a water tap to the right. The back view with a table and. The display and and cocking instructions from a virtual chef can be visible on the backside too. 18. The top view.

8.21: The Communicator's key features from a sustainable behaviour perspective. The focus is on planning through better overview and inspiration.

smart grid could open up for yet more possibilities. The most related problem area was food-planning focusing on providing information of what is inside the refrigerator, what needs to be bought and what can be cooked of its contents. So increasing the overview and awareness of contents was also related focus areas. Being a source of inspiration was a major characteristic of the concept.

The Communicator's personality was *social, inspiring* and *planning* (fig. 8.16), and it focused on making food planning easy and enjoyable so that no more food than needed was brought home and everything used. It also educated the user and increased the awareness. By making food management more enjoyable people would be more engaged in it and thus hopefully care more about treating their food better. Therefore The Communicator was made to inspire, to make planning easier and offer food related experiences.

For a detailed description of the functions and features of the concept The Communicator, see appendix XIII, and the key functions from a DfSB perspective can be found in figure 8.21.

Key functions from a sustainable behaviour perspective

» **Intelligent shopping list:**
Change of behaviour: Use shopping lists when grocery shopping to buy the right amount of food and no unneeded foodstuffs.

» **Find recipes based on refrigerator contents:**
Change of behaviour: Use foodstuff before they go off and not buy new food instead of using what already is at home.

» **Cooking inspiration trough interactive chefs:**
Change of behaviour: Caring about the foodstuffs and, be more involved in food management.

Cons and question marks

» Would it be effortless and intuitive enough for the user? If the user must scan or add the contents manually to the system, it would probably not be used.

» Is it to high-tech and different to be a refrigerator for the coming 10 years? Do the user want something simpler?

» The concept does not tell how the food is stored.

8.3. PART CONCEPT EVALUATION

The three part concepts were evaluated to find what direction and which features that were most interesting and promising to develop into *one* final concept. The concepts were evaluated against a revised version of the need and demand list (appendix XIV) and The Professional got the highest rating, which was the most favoured concept of the team.

Concept presentations were also held at Electrolux IDC both in Porcia and in Stockholm and feedback gathered and discussed. Based on these evaluations and feedback the direction of one of the concepts was chosen to develop further. The by most of the listeners preferred concept was The Professional, together with diverse functions from The Organizer and The Communicator, and the simple and smart solutions that are effortless for the user were favoured.

Important comments from the presentations were:

» The most important benefits for most users are convenience and time savings, it motivates them to buy new products

» Favourite features were: the eat-me-first-zone, the warm work bench, the support when thawing/chilling food

» The focus on the environmental impact improvement should be stronger. Include fewer functions and focus on a few strong key functions improving the user behaviour instead.

After discussions and more ideation the final focus for DfSB change for the final concept could be chosen, so it would be meaningful from all the important aspects. With the focus selected a list was done of all features from the three con-

cepts and the additionals. The ones relevant for the chosen focus and wanted DfSB changes, and promising features connected to the project focus were kept for further consideration and the rest discarded. In this list were indications of what behaviour improvement area each of the functions supported and which of the considered categories of DfSB strategies that were primarily implemented (i.e. enlighten, spur, steer or force) added. It was also indicated in which usage situation, referring to the refrigerator usage situations in section 5.2.2, each function would make a difference, and its assumed effectiveness. Examples of selected functions were the heat indication surface, but all planning and inspirations functions from The Communicator were left behind. (See appendix XIV for the evaluation matrix).

8.4. FOCUS OF FINAL CONCEPT

The concept chosen to be a base for the further development to one final concept was The Professional, the refrigerator with drawers in the height of the workbenches in the kitchen. The Professional's earlier sustainable behaviour focus was refined to be more relevant for the target user, Electrolux and the DfSB perspective. In the initial concept it was focused on the problem areas *food placement for optimal preservation* and *transitions between hot/cold transitions with temperature feedback*. The focus of the final concept was based on these, but more specified as described here.

When looking back on the pre-study, it was found that the major problem behind food waste is bad or lack of planning. What the refrigerator, as a product, probably can have the highest positive impact on would rather be the area of optimal food preservation, which can result in reduced food waste. Aid in planning could more efficiently be achieved with another product, or with an application to the refrigerator with functionalities as The Communicator. However, the project team thought that purely optimal food preservation is not enough to achieve sustainable user behaviour. This because the food will still run the risk of getting old and be wasted because it has been preserved for too long or forgotten, even though its freshness is very much prolonged. Therefore it is important to raise the awareness of using the food in the right moment, and not just to preserve it. The focus therefore became "keep the food fresh as long as possible, optimally until it should be used, so it is used it when it is still fresh", i.e. Professional food preservation. See figure 8.22.

To avoid that the improved preservation will be ruined by hot food placed in the refrigerator, and because of the low awareness of this action discovered in the user study a complementing target behaviour was chosen; the focus area of hot and cold food transitions. This was also motivated

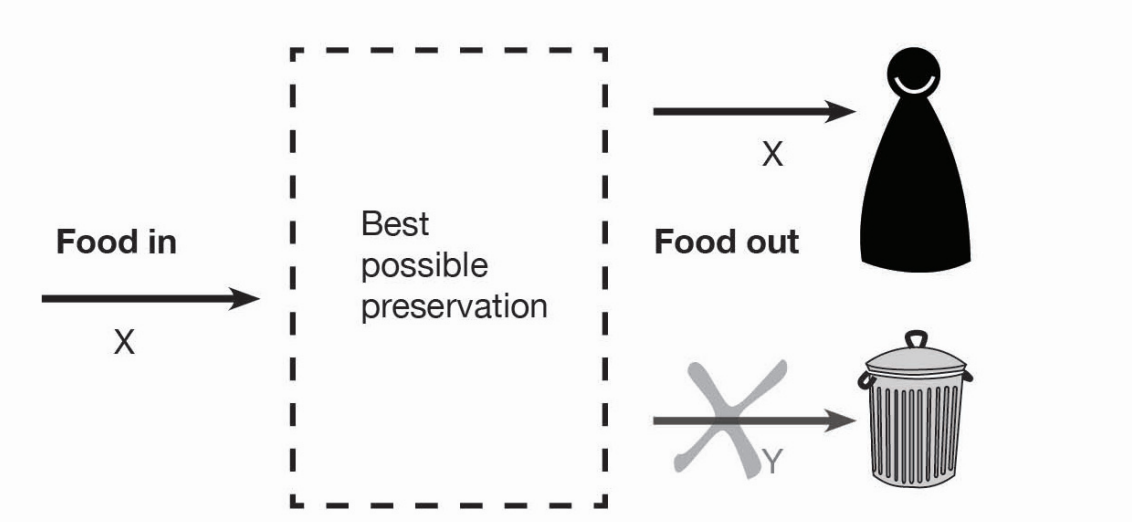


Fig 8.22: Schematic picture explaining the main focus of the final concept.

by the energy savings that could be made if this area was improved (see table sec. 2.5.4). Also because the awareness of temperatures related to food preservation and refrigeration is deficient, a barrier for sustainable behaviour. In this area the potential of improving the user behaviour from a sustainability point of view was assumed to be large through applying different DfSB strategies such as feedback.

8.5. DEVELOPMENT OF FINAL CONCEPT

When the core of the final concept and the user behaviour to focus on were defined, the chosen concept underwent an iterative development process. The functions chosen from the evaluation of the part concepts (sec. 8.3) were refined and further developed through sketching, modelling and discussions. The new set of functions and features taken from all three part concepts responding the focus was looked over and evaluated again in order for them to form a coherent and meaningful message from all the key aspects; the functionality, the DfSB approach, the attractiveness for the target user and the relevance for the Electrolux brand. When summarizing the evaluation the project team could see that all the four aspects had been considered to some extent, but the connection to the brand needed some more development. The evaluation list can be found in appendix XIV. The layout of drawers; appearance, dimensions and numbers was also elaborated on.

8.5.1. Complementary research: dimensions and components

As a kick off for the final concept development the project team went on a series of study visits to get inspiration and to collect important complementary information for the final development. The complementary information primarily considered dimensions, components and technical details. Resellers of tabletop refrigerators with drawers were visited, to not only see but also to feel what existing product are like and their pros and cons. The Electrolux refrigerator factory and development department in Mariestad was visited to discuss the technical and manufacturing feasibility of the concept and requirements for energy efficiency classifications.

In the next following sections the final concept development is described aspect by aspect pinpointing what was considered important for the final concept.

8.5.2. Physical model

A full-scale physical model built of foam board was used in order to evaluate and decide on the

Fig 8.23: The paper mock-up from different views. All the interior parts were built to try dimensions and handling.

dimensions of the product concept (fig. 8.23). When testing the model the project team could try out the handling to find suitable sizes and designs of each compartment to make enough space and good arrangement and overview for the intended groceries.

The interior was first built in foam board to be tested regarding size, ergonomics and functionality, and then modelled in the computer to develop the aesthetics and the construction. When all the refrigerator compartments were built, different ways of arranging the interior with subdivisions, boxes et cetera was tried and evaluated in order to find an optimal solution allowing flexibility yet restricted enough to be clear on where to place what. The project team strove to find a balance between flexibility for the user and yet make restrictions prohibiting wrong placement of the food in the refrigerator, and adjustments had to be made accordingly.

8.5.3. Product architecture

The idea of having the top surface of the product in line with a standard kitchen workbench, i.e. 90 cm high and 60 cm deep so it can be used as a workbench and extend the often limited work space in the kitchen, was kept and developed further. From building the sketch model and calculating the approximate volume, a width of 1 m was considered to look good, be spacious enough and the workbench seemed to be of a suitable size. The drawers should start 15 cm above the floor level, since that is a common height of the plinth, so the drawers can be in line with other cabinets in the kitchen. However, the product should have adjustable feet so it can stand straight even on a slanting floor. The product should be designed to be placed against the wall or in a kitchen island, but one of the sides was decided to be left free standing.

From looking at refrigerators with drawers currently existing on the market, it could be concluded that regarding the accessibility and overview aspects drawers are much better than doors, why an earlier idea of having one compartment with a door and extensible shelves was left behind. Another positive aspect regarding drawers versus a door is that the cold air stays in drawers and do not fall down as in refrigerators with doors. The drawers should however primarily be designed so that the user has good access to the groceries than for the cold to stay as much as possible.

The total volume of the refrigerator concept was estimated to be in between a normal full size refrigerator and the refrigerator of a combi-bottom appliance. The dimensions of wall thicknesses and the space needed for the opening mechanisms and the gaskets were measured to be used as a point of reference. However, the actual material thickness needed to insulate for the temperature difference between the different compartments was calculated (appendix XVII) and about 7 mm turned out to be enough for a temperature difference of 4 °C. Because of the space demand of the gaskets the actual wall thickness has to be considerably larger, at least 30 mm at the front surface where two gasket meets. However it can be narrower inside the cabinet.

When it comes to the rails and the mechanism for opening the drawer about 5 mm on each side, i.e. 10 mm per drawer is needed.

Different solutions for inset and subdivisions in the drawers where seen, and the project team could conclude that a solid bottom surface is preferred over a grid in order to prevent crumples to transfer between drawers, and the subdivisions has to feel rigid to give a high quality impression. Continuously movable subdivisions along the x- and y-axis are good from a flexibility and customization point of view, but their execution and the feeling of stability and durability as well as how easy they are to clean are very important factors for to be premium. However, this is something out of the project team's control to secure in this concept, since that is depending on the final choice of components and the manufacturing.

Since the chosen concept was a further development of the part concept The Professional the layout with drawers having different climate conditions adapted for various contents was kept. Also, the extended worktop was considered to suit the professional expression because as much

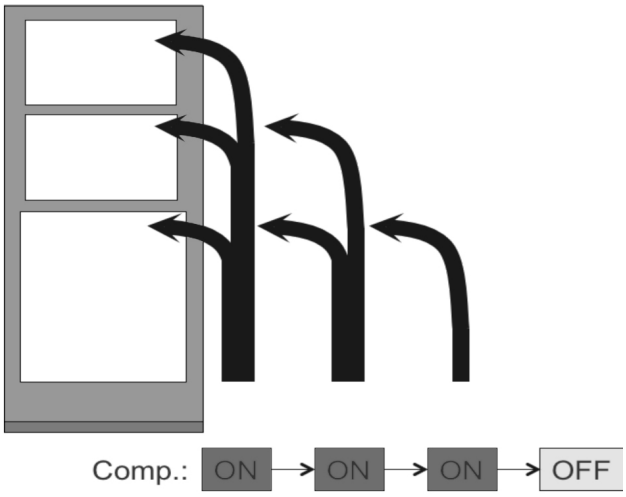


Fig 8.24 Schematic picture over how the distrubution of cold air can work with dampers if there are three compartments/zones with different temperatures.

surface to work on as possible normally is wanted in a professional kitchen. The distribution and number of drawers, and what food that should be placed in which drawer was optimized according to the demands. To make sure all groceries could be preserved in good conditions there should be many customized compartments as possible. But to make the arranging and un/loading of foods as little effort demanding as possible for the user and to keep down the heat leakage (which highly depends on the length of the gaskets) the project team after many iterations found that three different temperature zones and four compartments was a good trade-off. Because different foodstuffs, especially fruits and vegetables have different demands on temperature, humidity and ethylene sensitivity, compromises were needed to find a suitable grouping. Each of the temperature zones should have different boxes or insets for organizing different kinds of foodstuffs. For example vegetables and meat should be well separated even though they are stored in the same compartment and temperature zone.

Another aspect to take into account when distributing the temperature zones was the airflow in the refrigerator. The airflow should create a temperature gradient, from the coldest to the warmest compartment to allow the desired temperature differences. The airflow between the compartments can be controlled either by mechanical or motorized dampers. (Viet, 2012)

Many differently tempered compartments may cause complexity in air distribution and it is a challenge to control the different compartments at the right temperatures. The cooling system (evaporator) should operate upon the compartment that has a largest cooling capacity. For example, the airflow's distribution ways could be arranged as in figure 8.24 in case of three compartments with different temperatures.

8.5.4. Interior and insets

Since Electrolux Professional influences the chosen concept the outermost important aspect is that the refrigerator should be highly hygienic and easy to clean, and that the components have a durable design (sec. 5.4). Therefore the interior parts and insets should be removable and not have small spaces that collects dust, but be easily cleaned even in the dishwasher. Those parts that cannot be taken out should have rounded corners to be easy to clean with a cloth. Figure 8.25 describes the refrigerator's drawers and insets.

Insets and interior parts should be designed to support the user in organizing the food in the refrigerator and allowing the food to be better preserved (e.g. avoid spread of odours or drying out). Referring to the user study too many insets can feel a bit gadget-like and not premium, and they might not fit the users needs; it can be too restricted and the insets end up unused in a kitchen cabinet. On the other hand without any insets there will be little guidance for the user of where to put what and the insets can contribute to the improved food preservation. Therefore the project team wanted to keep down the number of interior parts and if possible make them transferable between drawers aimed for the same kind of food. More insets should be possible to buy from a VIP page. The dimensions of the groceries intended for each drawer should determine the appearance and size of each drawer. This to allow good organization of the groceries and make it possible to meet the common sorting principles (sec. 2.5.4).

When designing the interior the semantics of the parts was considered to let the design commu-

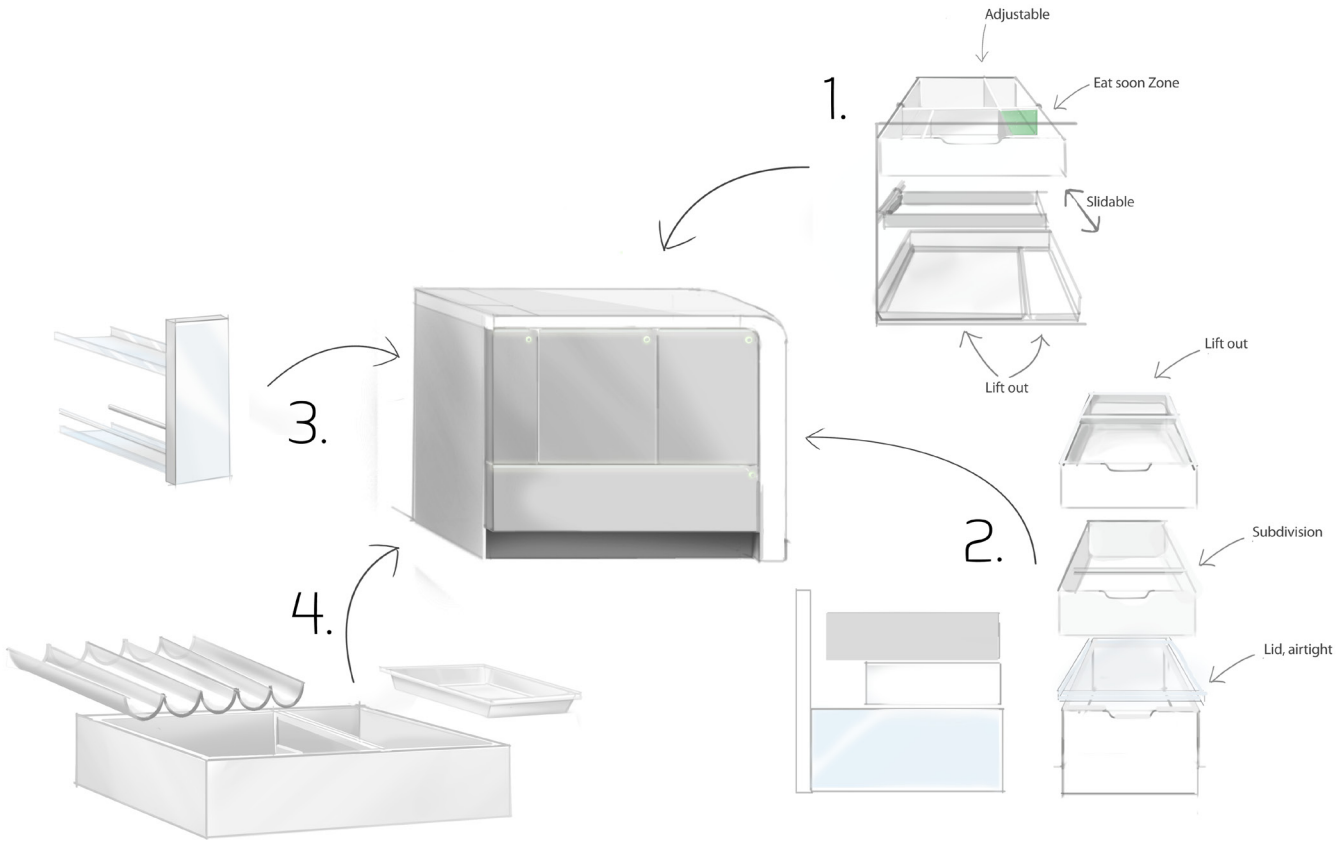


Fig 8.25: Overview of the concept's all drawers and insets.

nicate the placement different foods (sec. 8.5.7). This had a great impact on the visual appearance of the interior during the development - the choice of colours and material and form.

8.5.5. Food preservation enhancing technologies

To improve the preservation of foodstuff some of the features presented in the part concept *The Professional* was kept, but other discarded since all of them would not be attractive to the target user and not fit in the concept. The functions chosen to be implemented were mostly for fruits and vegetables, since these do not have any date labelling and the durability can be considerably prolonged.

8.5.6. Utilization of the warm air

If placing a fan next to the condenser there would be a possibility to either lead the warm air from inside the refrigerator to the side of the product or lead it up in the top surface. The technical feasibility of the idea was approved by several experts (Whälby, Viet, Karlsson, 2012). A warm top surface that can reach a temperature of 35-40°C is good for fermenting bread, when cooking and having to keep something a bit warm before serving, or when serving a buffet and having something to keep temperate. When the project team presented the idea of the warm surface for Klas Lindberg, winner of the Swedish chef competition "Årets kock 2012", he was very positive to the idea as such, and foremost regarded the surface as useful when baking bread. He also said it would generally be very nice to work on. He would not recommend it for tempering food like butter, since it would melt closest to the surface. But he, just as another professional chef the project team asked for a comment to the feature, found it useful for keeping food warm while cooking and waiting to serve it. However, he pinpointed that about 60°C is needed in order to keep food warm for longer time without increasing the speed of bacterial growth.

8.5.7. Educating the user - product placement

A key issue to solve in the concept was the communication to the user of the intended placement of foodstuffs in the refrigerator, and the communication of the temperatures inside. Regarding food placement the idea was to communicate the intended placement in several ways to guide the user and prevent wrong placement. Concerning communication of temperatures the project team wanted to do it as consistent and intuitively as possible, and go beyond only visual digits on displays.

The project team strove to make the placement of foodstuff as intuitive and little effort demanding as possible for the user, and therefore elaborated with both graphics and semantics; colours, materials et cetera. How each kind of foodstuff optimally could be presented depending on what it can be associated with was mapped out. An idea was to communicate placement with light of different temperatures in the drawers according to the temperature in the drawer, or to use colour coding connecting foodstuff with specific drawers. The ideas of having some sort of learning mode or even augmented reality projections to show what should be in each drawer were considered. The project team came down to that the concept should indicate the intended placement in three different ways; by information given on the display, symbols showed on the top edge of the compartment drawers and by semantics in the way the interiors of the compartments are designed.

Symbols

Symbols are often used in freezers printed on the door or on the drawers to show what could be placed there and for how long time different foodstuffs can be assumed to last. This chart, also called a "zoo-chart", is often left unnoticed or seen as a decoration, but could be a good guidance, especially if the symbols are more highlighted and one out of three features for placement guidance. The symbols that would be showed on the top edge of the opening to each compartment should display common and characteristic foodstuffs for the specific drawers. If not printed, these symbols could be on a display or lit up by LEDs to give a more premium and remarkable expression. Preferably they should also be colour coded.

Semantics

The semantics of the design of the interior describes their different purposes and is aimed to give a hint to the user of the intended placement of food; by its expression, the description of how it should be used and identification of what should be stored in it (appendix II Semantics). To find the right semantic expression for each of the drawers a brainstorming session was done creating mind maps with associations to the groups of foodstuffs. In these associations it was for example considered how the food normally is presented and with which materials, lights and textures. Regarding the design and semantics of the interior, areas intended for the same type of food should have reoccurring details and material in common, communicating their belonging. A summary of findings and ideas regarding the different drawers can be found in appendix XV.

8.5.8. Educating the user - refrigerator status and temperatures

Regarding communicating temperatures to the user it is important within two different fields. On one hand the actual temperature inside the refrigerator should be communicated allowing the user to know if it is too hot or too cold to be able to react on it and to know where to place different foodstuffs. On the other hand temperature communication is needed to let the user know if cooked food is too warm to place in the refrigerator and to give indications of how long it will take to thaw frozen food. When developing the communication in these two areas it was important to be consistent and clear. It was also important to think of in what way the target user wants the information to be presented. Louise is not a person very keen on numbers and precise measures, but rather wants to be informed in an intuitive and emotional way, and it has to be aesthetically pleasant. Therefore communication should foremost be through visual feedback with colour and light.

8.5.9. Interface

In order to be able to give proper feedback and information, make basic settings and so on the refrigerator need an interface. Whether it should have much functionality or if it should be totally managed from an external device was a big question. Even augmented reality and projections of the needed information was taken up as ideas. An alternative was to make the display very streamlined and only display the most important information like the temperature, and let all other information be accessed from a secondary device like a smart phone or a tablet.

8.5.10. Form, expression and context

Concerning the environment in which the product will be placed, the focus was on the kitchen the persona Louise might have in the future, and its appearance based on trend forecasts (sec. 5.2.3) was considered. Measurements and standards to adapt for, and the layout of the kitchen were also taken into consideration. The concept should fit into a kitchen environment and either be designed so it can be a completely free-standing unit or possible to placed by the kitchen workbench on one or on both sides. If having one side free and one next to another appliance or the workbench, it is important to make the free side symmetrical so it can be switched, i.e. either placed on the left or right side when installed. Regarding the situation of use, the interaction sequences presented in section 5.2.2 were kept in mind and looked over as an aid when designing the interaction with the product in order to achieve suitable communication between the product and user in each situation.

The refrigerator should have a design that do not stand out too much in the kitchen environment, yet is attention drawing and considered as unique to be attractive to the target user. It should express professionalism and premiumness and the expression ”classic with a twist” was used as a guideline. In appendix XVI some early sketches from the form development process and the form development from part concept to final concept can be found.

8.5.11. Involving more sensory modalities

The project team discussed different ways of involving more sensory modalities in the communication between the product and user, to increase the product experience (appendix II). Regarding temperature feedback mainly two possibilities were seen. Firstly the temperature of the front door of each of the four compartments could differ to involve a haptic experience. Secondly, as earlier mentioned, the lighting inside the compartments could correspond to its temperature.

9. Final Result

In this chapter the final results of the project - the proposed design concept Pompador - is presented and described in detail. First the product, its design and its functions, are described together with technical aspects and some thoughts on manufacturing. Then follows a description of the interaction with the product on the display, and the top surface and the signals given to the user elsewhere on the products are showed.

9.1. POMPADOR

Pompador is the *competent, confident* and *supportive* refrigerator. It has influences from Electrolux products for professional use, but is designed for the domestic environment in the next coming 10 years. It is made for a person who thinks that the appearance of appliances is important, is keen on home styling and highly prioritizes storing the food to preserve it with the highest quality, just like Louise. Above all Pompador allows this in a way that can affect the user to change unsustainable habits and start to behave in a more sustainable way when interacting with it, and in food management in general. Pompador is designed to overcome the unsustainable behaviours related to how to best preserve different foodstuffs by keeping food fresh optimally until it should be used, if it is placed in the right zone. It also increases the users awareness through feedback and support in for instance thawing and chilling food and remind of food that soon has to be consumed. Pompador adds a human touch to food preservation appliances and is a proposal of how to make the refrigerator more emotional as a product by being more supportive and by small details such as the light that slowly turns on when the product is waked up and the patterns that can emerge on the product after thawing food.

The name Pompador grew up along the development process and suits its appearance and the personality given the refrigerator. The name sounds confident, noble and premium, yet smooth and it emphases premium with "or" denoting gold in Latin languages.

9.2. THE PRODUCT

Pompador has four compartments as can be seen in figure 9.1, and there are three different temperature zones. All drawers are "touch to open", i.e. no handles, and are opened by pressing anywhere on the front. This is beneficial especially for the drawers at a low level and they can be opened even with hands full. The drawers cannot be left a few millimetres open by accident since they have "soft-close" function making it close the last bit automatically. The drawers run on rails so they can go in and out smoothly without any large force demanded from the user.

At the right side of the product there is a space for hanging kitchen towels and storing trays and similar. The glass coated top surface has an integrated scale and a display (fig. 9.3).

Pompador is designed to be placed in a kitchen island or against the wall with at least one side

Fig. 9:1: Pompador has four drawers. The left and the bottom ones are chillers, the middle one has normeal refrigerator temperature and the right one a is a chill compartment. At the right side is the kitchen towel hanger and the characteristic “flow line“ has the function to be the hanger.

Fig. 9.2: Pompador in the kitchen context. Optimally it is placed in a kitchen island, but it can also be placed against the wall. The white surface can be mirrored when installed if it fits the kitchen layout better.

Fig. 9.3: The display (at the front) and the scale is invisible until the refrigerator is interacted with - a drawer is opened, the surface is touched or something is placed on it.

Fig. 9.4: Size indication of the product.

free, the one with the storage and towel hanger (fig. 9.2). The white material surrounding the refrigerator body is designed symmetrical, so that the towel dryer/storage part can be mounted at the left side instead if that suits the kitchen layout better. The top surface, the workbench in immediate connection to the refrigerator offers a surface to use for loading and unloading of foodstuff, and to use when cooking (fig.9.4).

9.2.1. Temperature zones

Pompador has a cold compartment, a regular refrigerator compartment and two chiller compartments. The three temperature zones, which are chosen to be in accordance with the test standards (sec. 2.5.3) and to offer optimal storage conditions, are more specifically the following:

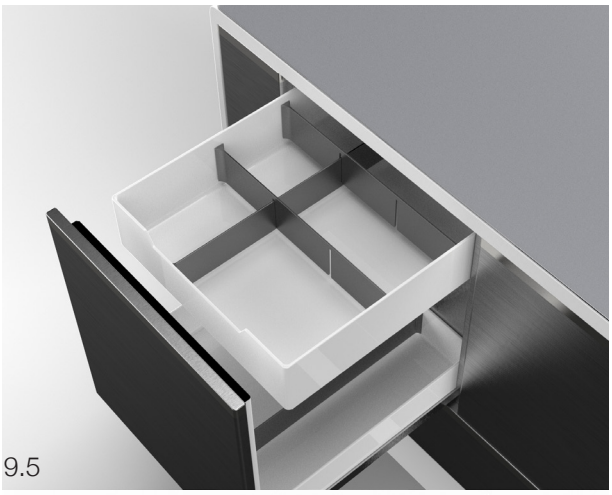
- 1°C in the right chill compartment
- 4-8°C in the mid compartment (with the recommendation to have 4°C) like in a conventional refrigerator
- 10°C in the two chiller compartments, the left and the bottom drawer

9.2.2. The four compartments

Pompador's four compartments has different interiors customized for the intended kinds of food, both in the ways they are designed and the food preservation enhancing technologies some of them features. Pompador's interior is designed in such a way that it should be easy to understand what food should be placed where for ideal preservation, but at the same time offer the user flexibility and the possibility to to some extent arrange the food as wanted.

The chill compartment to the right has three interior drawers (fig. 9.7-9). The uppermost is for meat and fish and made of stainless steel a hygienic and professional expression (fig. 9.7). The white plastic middle drawer is a "buffer box" for food that has an extended durability if stored colder (fig. 9.8). The transparent bottom drawer is for vegetables and fruits that are not sensitive to chill injuries, wants low temperature and high humidity (fig. 9.9). Therefore this drawer has, apart from the special features described in section 9.5, a lid to keep a constant high humidity level (fig. 9.8). When opening the chill compartment the vegetable box comes out completely, the buffer box half way and the meat drawer has to be pulled out manually since it would not be used as often and it is outermost important for the cold to stay in it (fig. 9.9).

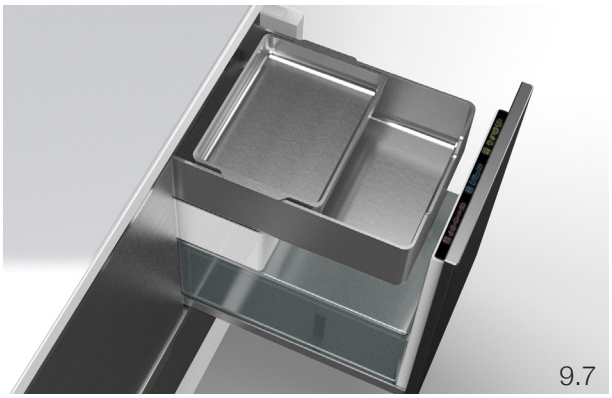
The flexible space in the mid compartment has two interior drawers; the bottom one for larger items and high packages and the top drawer that has to be pulled put manually (fig. 9.5-6). In this zone the temperature is adjustable. This compartment is designed to be spacious so it can be used for various kinds of foodstuff, but primarily dairy


9.5


9.6

Fig. 9.5-6: The mid compartment with two interior drawers with high flexibility, the bottom one is for tall groceries. Both have movable aluminum subdividers.

Fig. 9.10: The bottom chiller for larger things, fruits and vegetables in the plastic box and there is room for thawing food and a wine rack too.


9.7


9.8

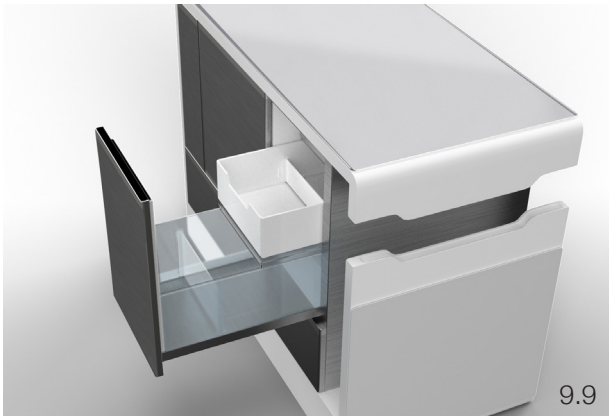

9.9

Fig. 9.7-9: The three interior drawers of the chill compartment: the meat/fish drawer has a removable tray/oven form on top. Close up of the buffer drawer, which has a movable subdivider inside and the lid enclosing the humidity in the vegetable drawer is also visible. A transparent drawer in the bottom for vegetables with a removable plastic box and movable subdividers


9.11


9.12

Fig. 9.11-12: The left chiller for bottles, jars and smaller things for quick and easy access..

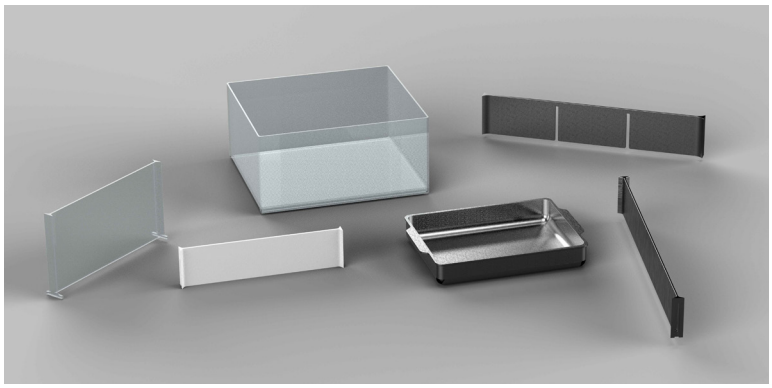
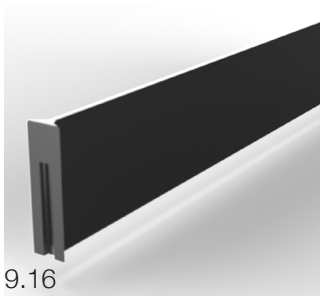


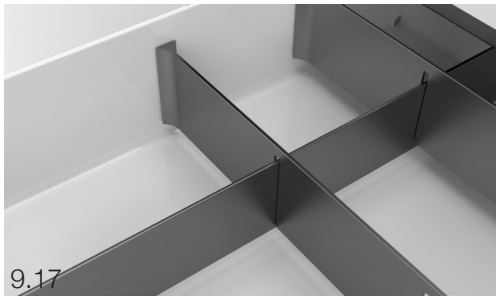
Fig. 9.13: All the loose parts; subdividers and insets that comes with Pompador but can be removed. Transparent subdividers for vegetable boxes (x3), fruit and vegetable box for the bottom chiller, white plastic subdivider for the buffer drawer, the metal tray that can be used when preparing meat/fish and storing it in Pompador before it is placing it in the oven and finally the two types of aluminum subdividers for the mid compartments (2x2).

Fig. 9.14: The vegetable boxes have subdividers which can be moved to any position and transferred between the two boxes. The boxes have tracks on the sides in the bottom. The subdividers have feet fitting into the tracks preventing the subdivider from falling and stabilising sides towards the side faces in the box.

9.15



9.16



9.17

Fig. 9.15-17: The metallic subdividers in the mid compartment and the buffer box are attached as can be seen in the figures. These dividers can be moved between specific position in one direction and moved without restrictions in the perpendicular direction.

products, but also leftovers, other packages et cetera. Since flexibility was a high demand seen in the user study it is also well motivated.

The chiller zone has as mentioned two compartments, the big drawer in the bottom (fig. 9.10) and the narrow at the left hand side (fig 9.11-12). Since this temperature zone contains things of very different sizes - from big bottles and heavy potato bags to small jars and stock cubes this division was needed. Because potatoes and drinks are heavy groceries not used too often the bottom drawer was customized for these. The leftmost drawer is intended for things that normally is placed in the refrigerator door shelves and should be preserved in about 10°C, like sauces, bottles, drinks and jars that for instance are frequently used while cooking, Storing these less cold and separated from other foods with the high frequency openings for these items in mind will thus save energy and not affect the other food stored.

Interior parts

Pompador's interior consists of boxes that can be lifted out if needed, and some more easy removable boxes and sub dividers, which either can be transferred between boxes or are tailored for specific ones (fig. 9.13). In the meat and fish drawer there is also a stainless steel tray/oven form, which can be lifted out and used in the oven or served from. In the bottom chiller compartment is there room for a bottle rack at the left side.

The interior has been designed to be hygienic and easy to clean with parts that can be lifted out and even washed in the dishwasher. Apart from the lose insets also the more fixed vegetable boxes, the plastic boxes and the metal meat drawer can be taken out to be properly cleaned and they have soft and rounded corners so that they easily can be cleaned without being taken out. The surface finishes and

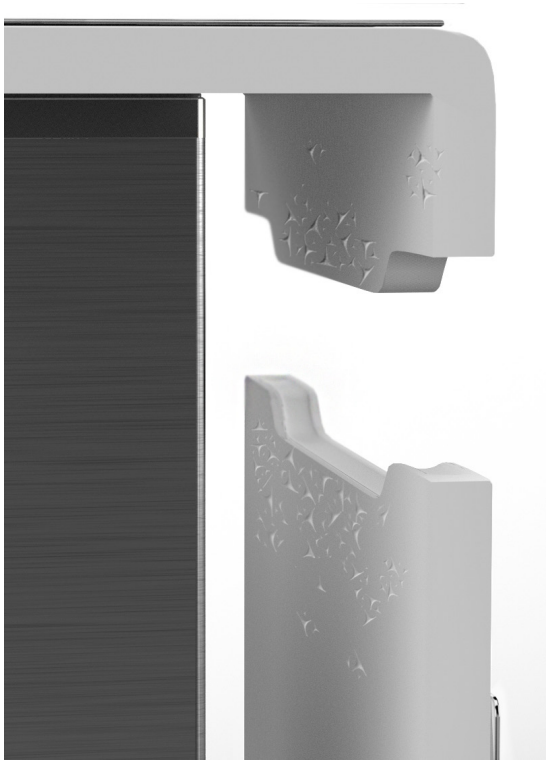


Fig. 9.18: Inside the towel dryer space there is an embossed pattern. There is also a cavity in the flow line where the kitchen towels can be hung and the cavity is for hangnig other things such as utensils.

Fig. 9.19: Corresponding pattern can also emerge on the glass surface on the side. This happens when food is thawed in Pompador.

choices of material also contribute to the cleanability. For more details and to see the design of the interior and insets, please see figure 9.15-17.

9.3. FUNCTIONS

In this section the functions of the product are described and also the interaction with it.

9.3.1. Towel dryer and warm surface

Pompador has a unique differentiating feature; it uses the warm air produced by the cooling system and distributes it either in the top surface or at the side space of the product. This function makes the product feel more outgoing and caring and not just focusing on cooling the enclosed foodstuff but also caring for the outside and the user.

The warm air from the back of the refrigerator is by means of a fan directed to the side where kitchen towels are supposed to be hung and can dry. This area also serves as a storage space either for trays or for the parts of the interior that can be taken out if they are not wanted to be used for the moment. Inside the space there will be an irregular pattern embossed to give the user a haptic surprise feeling (fig. 9.18), which can contribute to the emotional product attachment in a positive way (appendix II Design for Emotions).

Towel drying is the default mode, and if wanting to have the top surface of Pompador heated up instead it can be switched by changing in the display. The project team found it important to highlight that there is no additional heat produced for the heating function and to communicate that the warm air is coming from the refrigerator. This should be done more clearly in the product with something like a whirl moving over the glass surfaces as the fan is switched to show what happens.

Examples of usage areas for the heated up top surface are:

- fermenting bread
- keeping food warm while cooking or serving a buffet

Fig 9.20-21: If the temperature of a compartment is too high or low it is shown with a red or blue coloured line that is reflected in the blank line on the front

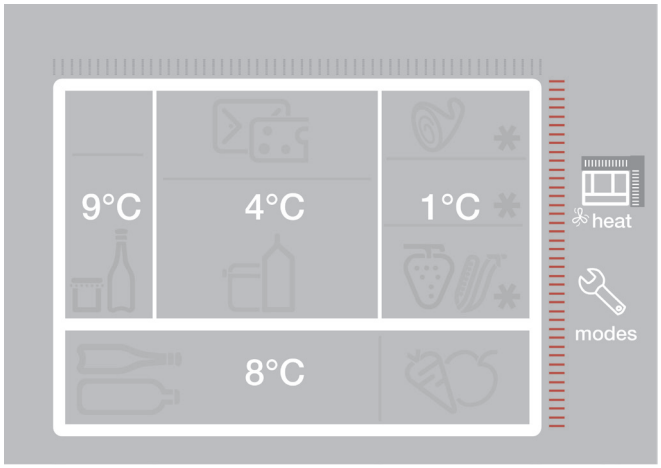


Fig 9.22: This is the first view of the display - all compartments and the present temperature in each. If the temperature deviates from what it should be the numbers are shown in red or blue.

- » it is generally nice to work to work on
- » tempering food
- » however, keeping food warm should be done with care since a temperature of 30-40 °C is not sufficient for keeping food warm safely (at least 60°C is recommended)

9.3.2.Temperature status in the refrigerator

Each compartment, apart from the adjustable mid compartment, has a fixed optimal temperature. If the actual temperature of any reason deviates with more than one degree it will be communicated to the user so s/he can understand and learn why the deviation has taken place (fig. 9.20-22). In that way it is possible for the user to react on it to re-establish the right conditions and to learn the effect of their actions. Pompador show deviations with either a red or blue light line that is reflected in the blank surface on the front of the drawers, depending on if it is too warm or too cold inside (fig. 9.20-21). To inform that the refrigerator is working on re-establishing the temperature conditions the light will after about ten seconds be exchanged to white pulsating light until the drawer has reached the target temperature, to communicate “work in progress”. When the temperature is re-established the white light shines with a firm intensity for a few seconds and then it turns off. The temperature in each drawer will also be showed in the default view of the display with red or blue colour if too high/low temperature. The refrigerator will always go to “sleeping-mode” after 30 seconds when not interacted with, except from when the refrigerators temperature is too high. Then the pulsating light will be shown on the drawer front until it is okay.

9.3.3. The display: information and support to the user

The top surface features an integrated display in the front corner that does not appear to the user until the refrigerator is interacted with. The display is there to give information, educate the user and to make settings and switch between different modes.

As soon as the display is activated it shows a symbol of the refrigerator with its four compartments where the present temperatures in each is displayed in white numbers if it is the correct temperature (fig. 9.22). In the default view there is also the possibility to switch from having the warm air directed to the kitchen towel hanger at the side or to the top surface. In the default view there will sometimes appear a green mark in the mid compartment representing the EatSoonZone. This green indication should only be there when there are many products in the EatSoonZone. There will also be the possibility to see if there are any notifications or reminders left by someone else the household regarding the food in the zone, like if something should be eaten (fig. 9.38).

When touching on any of the compartments on the display, the temperatures disappear and colour-coded symbols representing typical food that each drawer is intended for is displayed (fig. 9.24). If pressing again at one drawer it will be enlarged and a detailed list of suitable foods for the drawer is accessed (fig. 9.25). If wanting more information about specific food placement and preservation tips and suggestions, or just not wanting to stand by the product when looking up something, a search function in an application for secondary devices can be used. The interface is described in figures 9.28-9.33.

Fig 9.23-25: Apart from the design of the compartments, these are the placement guidances given by Pompador: The colour coded displays on each drawer with symbols of typical food, the view with the colour coded typical foods for each compartment in the interface that appears when pressing the first view and the more specified lists of foodstuffs per drawer shown when pressing one of the compartments in the prior view. The symbols on the top edge of the drawer light up gradially with a slight delay when the drawer is openend to catch the users attention.

The user is also supported in product placement by the symbols on the edge inside the drawers as shown in figure 9.23.

9.3.4 Chilling food support

The top surface of Pompador allows the user to see if the temperature of food placed on it is too high to be placed in the refrigerator. There are IR-sensors in the surface measuring the temperature in the core of what is placed on it. However, sometimes like when cooking this might not be wanted and therefore can the temperature indication be deactivated in the display, but the default is that it is turned on. When placing something on the surface that is too warm to be placed in the refrigerator, a red spot appear under it (fig. 9.26). The intensity of the red spot will be the same until food is cool enough to be put in any of the four compartments. The reason why the intensity of the red colour will not decrease as the food is cooling down is that if the user easily can see that the food is almost cold enough, the risk is immediate that s/he will put it in the refrigerator too early. It is better to not show any difference between "very hot" and "almost chilled", and just allow the user to see the approximate time left before the food is chilled when looking at the display.

On the display the temperature of the warm food is shown and an approximated time until it will be chilled enough to be put in the refrigerator is displayed in red digits. When the food is chilled to an acceptable temperature for the refrigerator, the red spot will disappear and all drawers' edges will shine in white. The light indications disappear when the food is taken away from the surface and placed in a drawer. An alarm and/or notification can be sent to a secondary device when the food is ready to be placed in the refrigerator (fig. 9.27). What happens in the display when chilling food is shown in figure 9.28-29.

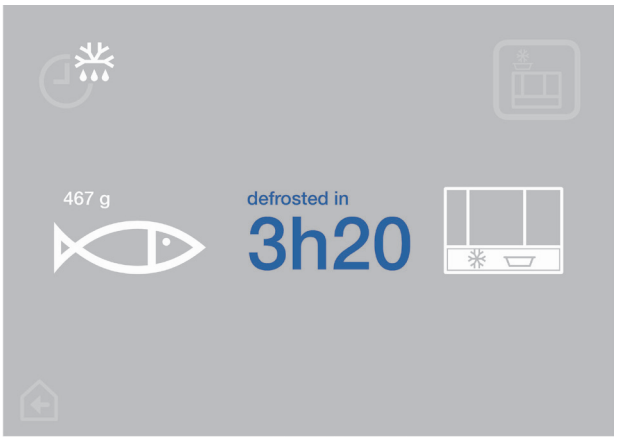
9.3.5. Thawing food support

When it comes to thawing frozen food, the top surface supports it in a similar way (fig. 9.30-35). To enable to estimate the thawing time, the surface features a scale. When the surface is activated, which it is as soon as some interaction/movement takes place on it, the scale is indicated with a contour line. By placing frozen food on the scale, and then on the display choose what category of food it is (meat, fish, vegetables, soup or bread), the estimated thawing time (if placing the food to thaw in the bottom chiller compartment) will be shown on the display. If the user for any reason does not place the food right on the scale the blue spot will point towards the scale, which contour is indicated. The led light line on the front of the chiller compartment where the frozen food should be placed is lit up in white to indicate it should be placed there, and it will also be indicated with a symbol on the display. If the food is left to thaw in room temperature instead it

Fig 9.26: When placing warm food on the surface a red spot appears under it and the estimated chilling time on the display.

Fig 9.27: When the food is chilled enough a notification can be recieved and it is indicated with lights on the fronts of the compartments.

Fig 9.28: The interface for chilling food. When hot food is placed on the top surface the display shows the time it will take before it is chilled enough to be placed in the refrigerator.
Fig 9.29: When it is cooled down it says “chilled” on the display and the light on the front is turned on.



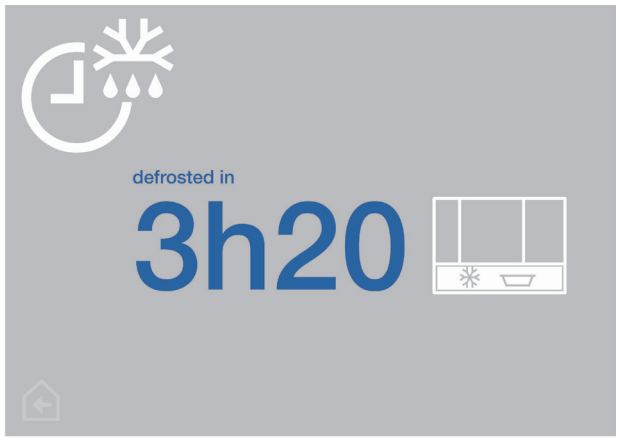


Fig. 9.30: The interface for thawing. When frozen food is placed on the scale its wheight is first shown.
Fig. 9.31: Then the user has to choose the food type.
Fig. 9.32: The time for thawing the food is shown and an indicatiion that it should be placed in the bottom drawer.
Fig. 9.33:.When frozen food is placed in the drawer the timer will start.

Fig 9.34-35: When something frozen is placed on the surface the blue spot indicates that it should be moved to the scale, whereupon the thawing timer can be set. When tha food type is chosen and the time for thawing the food in the bottom drawer shown. At the same time the bottom drawer is lit up indicating the food should be placed there.

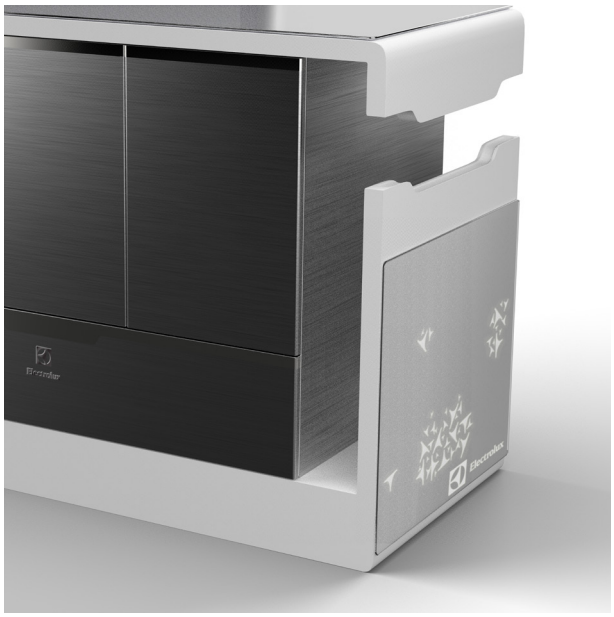


Fig 9.36: The pattern emerges on the side glass, piece by piece, each time the user thaws food in the refrigerator.

could be chosen on the display. Thawing in room temperature would be faster since the room air is warmer than in the refrigerator, but it should not be the default option since it is better from an energy consumption point of view to thaw food in the refrigerator. If the user anyway chooses to thaw the food in room temperature a new time can be calculated and a blue spot stay under the food on the surface. This blue spot decrease in intensity as the foods temperature is approaching the ambient temperature to disappear when the food is thawed. If not putting the frozen food in the bottom compartment after about 30 seconds and not have chosen "room temperature", it will automatically switch to room temperature thawing.

When the food is thawed according to the timer, a notification will be sent to the app, and the blue light that has been gently pulsating on the drawer throughout the thawing time (if not in "sleeping-mode") will shine solid in white.

Every time the food thawing function is used, a "point" will be gained resulting in an aesthetically pleasant pattern appearing on the glass on the side of the product as a bit of a surprise effect, indicating that thawing in the refrigerator is beneficial and encouraged (fig. 9.19 and fig. 9.36).

9.3.6. The EatSoonZone

The EatSoonZone (fig. 9.37) is a simple solution, earlier presented as a part function in the concept The Organized (sec. 8.2.2). It is designed to help users remember food they soon have to finish. It is an area in the middle compartment, which is highlighted with green light, where the user should place all foodstuffs that soon must be consumed. For instance, if having three packages of milk - one that expires tomorrow, one that lasts

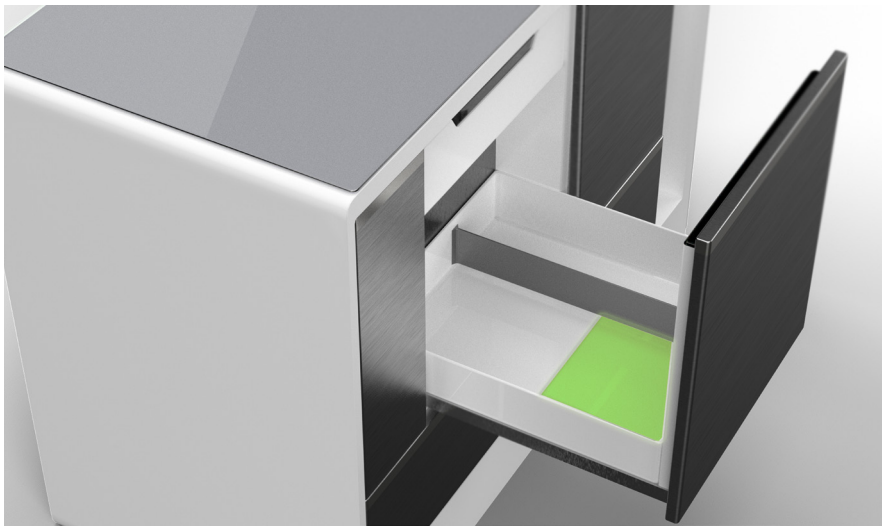


Fig. 9.37: The EatSoonZone is an area lit up with green LEDs where the user should place food that needs to be eaten soon.

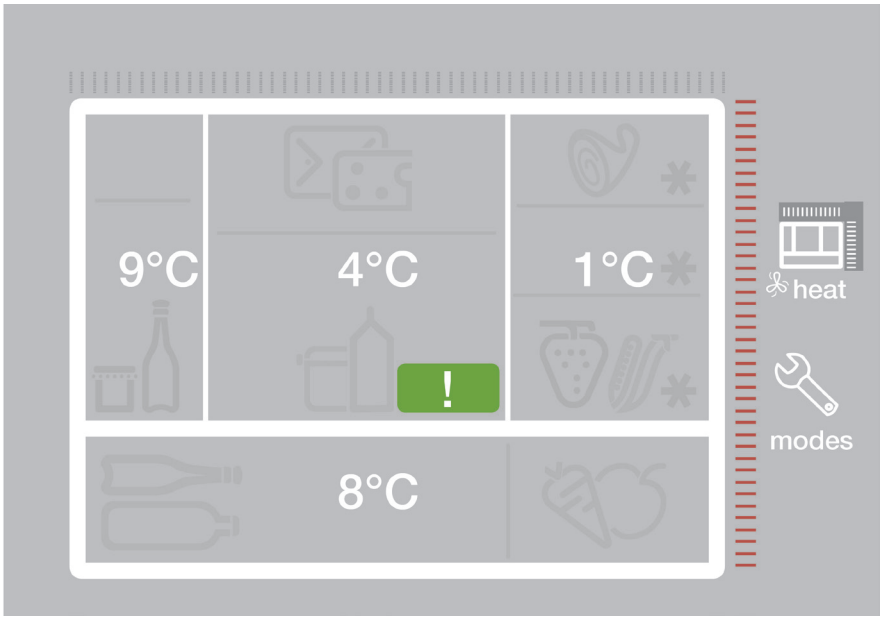


Fig. 9.38: The EatSoonZone is marked in the display if it is well loaded. The "!" denotes there is a notification for someone about something that has to be eaten. The red ldashed lines on the sides of the refrigerator icon indicates where the warm air is directed and it can be swithced by pressing on it.

Fig. 9.39: The design of Pompador is clear and distinct with architectural lines but yet soft.

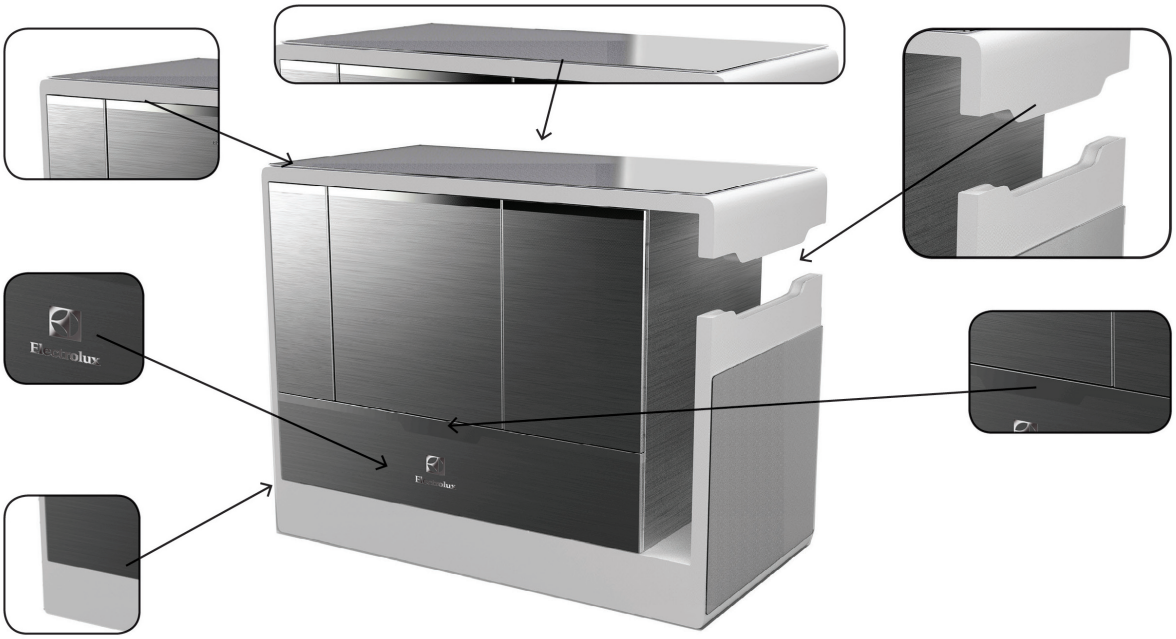


Fig. 9.40: The design cues implemented in Pompador.

for three days and one that lasts for one week, the one expiring tomorrow should be placed in the EatSoonZone to indicate that it has to be finished. The one lasting one week should then be placed in the buffer box to prolong its durability and the one lasting three days placed in the middle compartment to give it a nice temperature when consuming it.

The EatSoonZone has built-in sensors that can detect if a large part of the surface is covered with items (no light reaches the sensors where something is covering the surface). Thus it can be indicated on the display if the zone is very full to call for the user's attention (fig. 9.38). The user can also send notifications to smart phones to for example remind if there is a lunch box to bring or to communicate to another member of the household to use something from the zone. These notifications can also be indicated on the default view of the display with a "!" symbol.

9.4. FORM DESIGN AND EXPRESSION

In the design of Pompador some of Electrolux's explicit and implicit design cues (sec. 5.4.3) was implemented to achieve brand identification in the design (fig. 9.40). The overall design has a clear, strong and simple appearance with architectural lines but yet some softness (fig. 9.39). The characteristic flow-line can be seen twice at the right side and has the function of being the towel hanger. The flow-line is also present as a reflective marking on the front of the bottom chiller drawer. The characteristic visible material thickness can be seen in the entire white Corian part. The white Corian is also a contrast in colour and surface finish to the stainless steel refrigerator body.

The choices of materials are made to make the product "look Electrolux " and to give the premium expression strived for. The shiny white together with brushed metal is also identified Electrolux design cues used to make it look premium. The top surface and the left side where feedback and information are given is covered with a 3 mm thick glass layer and the top glass has silver coloured paint under it – an Electrolux design cue. Lastly, when it comes to design cues, the big Electrolux logo is placed at a prominent place. Shapes from the logo can also be found in the emerging patterns on the vertical glass.

To give an expression reminiscent of the professional kitchen appliances and to strengthen the expression of being competent, the refrigerator body is made of light brushed stainless steel. To

make Pompador look supportive and to give it the emphatic and natural Scandinavian expression, small radii are added on the transitions between surfaces to make it slightly softer and natural. The white Corian surface enclosing the refrigerator contributes to this expression by being like a protective shell around the refrigerator body, and by having a smooth surface. The open compartment allowing hanging towels and offering storage space is a bonus function that expresses its caring and supportive personality. The design of Pompador takes up elements from the kitchen trends and forecasts, above all the resemblance with furniture, but is yet classic enough to not be too trend sensitive.

Pompador can be offered in different combinations of colours and materials, but the project team suggests a refrigerator body made of brushed light grey stainless steel, enclosed in a surface of white Corian. Corian is a trademarked acrylic material that can be formed into more or less any shape. Different parts can be seamlessly melted together, which gives a large freedom and the possibility to interchange the placement of the side part when it is mounted. Corian is also available in recycled material (DuPont, 2012).

Concerning the interior, five materials are used: clear Polystyrene (GPPS) for the vegetable boxes, white Polystyrene (HIPS) for the inner liner and white plastic for the buffer, and flexible dairy compartments, stainless steel in the fish/meat drawer and also for the two chiller compartments and main structure of all compartments. There are also details as the sticks on the side of the chiller compartments and the wine/bottle rack made of black anodized or painted aluminium.

9.5. TECHNICAL ASPECT

To achieve the desired temperature zones and the needed adjustability (sec. 2.5.3) in the mid compartment, it is beneficial to have two evaporators, one behind the flexible space that also provides the chillers with cold, and one behind the cold compartment to the right that is just for that zone. The evaporator behind the mid compartment can control the flow of cold air to the chillers with dampers controlled by sensors. As described in section 8.5.3, these dampers are used for keeping the temperatures of the different compartments at the right degree. The use of vacuum panels in combination with the conventional insulation foam can improve the efficiency of the insulation, and thus the energy efficiency of the product. Figure 9.42 presents a feasible placement of the refrigeration technologies.

The warm surface and towel dryer at the side, and the possibility to switch between them, is enabled through a dynamic condenser (sec. 2.5.1) with a DC fan which make it possible to change the direction of the warm air. This fan and the condenser are placed in the bottom and back of the product, partly down in the plinth. For the warmth in the top surface there is a slit in the surface into which the warm air can be directed and flow in and out to warm up the bench (fig. 9.41). Concerning the towel dryer, the air can with the fan be directed to the side where the towel hanger is located, and the enclosure makes the heat stay better. The dimensions can be seen in the drawings in figure 9.43.

The temperature indications are possible thanks to IR sensors in the surface, which not only can measure the foods temperature on its surface, but also in its core to allow it to tell whether it is completely thawed/cooled down or not and how long it will take. The coloured temperature indications can for instance be enabled with a thermo chromic glass on the top surface.

Pompador has the following food preservation enhancing features that keep the food fresh for longer:

- In the vegetable box in the bottom drawer there is a mineral filter that reduces the amount of ethylene gas in the box and also superfluous humidity, preventing the vegetables and fruit from maturing and go off quicker. Such a filter is also said to decrease the energy consumption of the refrigerator (doppio, 2012)
- The vegetable box, in the cold compartment, features light of red and blue wavelengths.

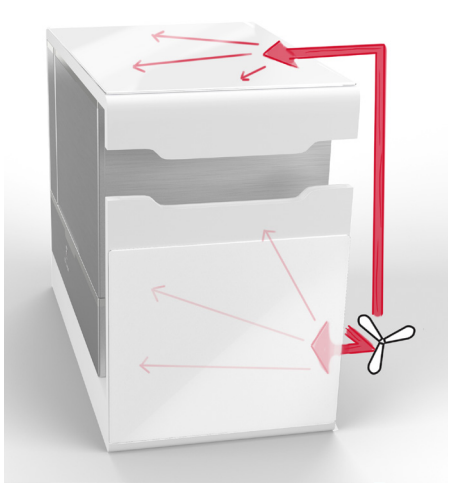


Fig. 9.41: The warm air is directed in the top surface or the side with a DC fan.

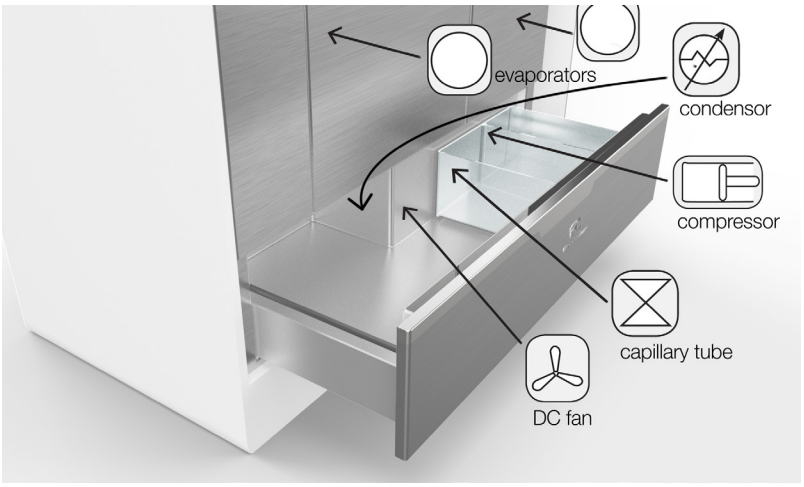


Fig. 9.42: Suggested placement of refrigeration technologies.

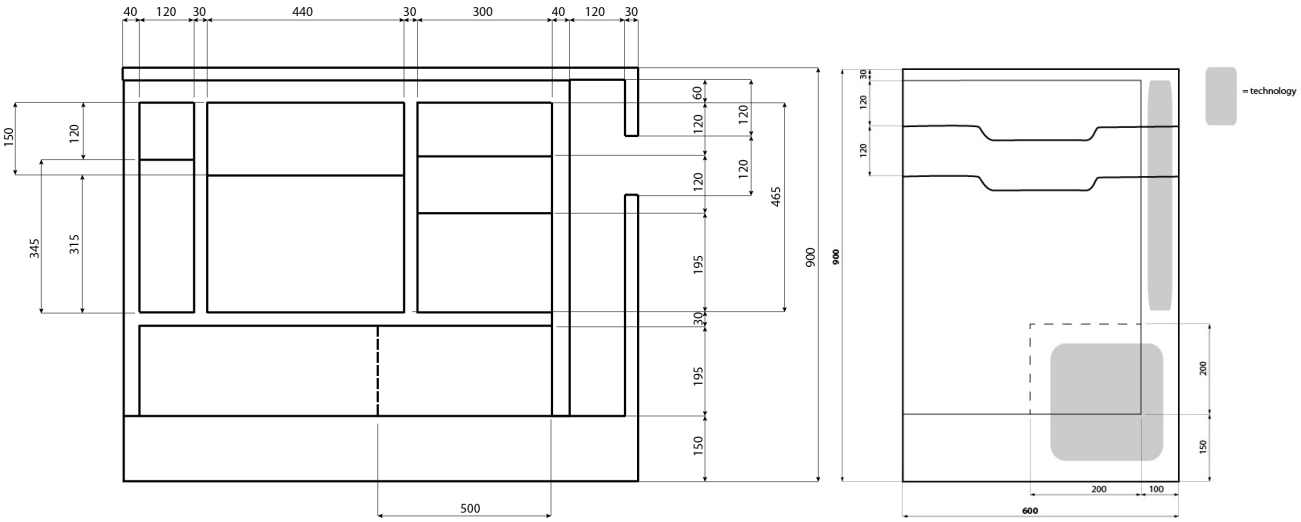


Fig. 9.43: Dimensions of all the compartments of Pompador.

Fig. 9.44: A simple sketch of the patterned inset with holes for the vegetable box in the cold compartment.

This light stresses vegetables so antioxidants are created and the photosynthesis affected, prolonging the freshness of vegetables and fruits. (Wählby, 2012)

» In the bottom of the vegetable boxes an inset is placed which has a structure with holes to minimize the fruit and vegetable's contact with the bottom surface, to avoid that they lie in possible condensed water, as illustrated in figure 9.44. The condensed water, if any is then collected under the inset, which can be lifted out and be cleaned. This prevents the growth of mould and bacteria and the vegetables and fruits to become rotten.

» A humidifier is added to the vegetable box in the cold compartment box to raise the humidity level.

» In both vegetable boxes there are also humidity sensors controlling the humidity to be at an as suitable level as possible for the different boxes.

» All boxes have sensitive temperature sensors controlling the current temperature in each compartment.

9.5.1.Manufacturing and recycling

According to the limitations of the project (sec. 1.1.6) materials, manufacturing and the pre- respectively post-use phase of the product lifecycle was not in focus of the project. However, the requirements in the need and demand list were that the materials used should not be worse than the ones used today, not harmful and to an as large extent as possible recyclable. The materials in contact with food have to be approved for that, so does paintings and surface treatments.

No materials that are worse from a sustainability point of view compared to today have been added, and most of the suggested materials can be recycled, if designed for disassembly and if Electrolux takes their responsibility of the end of lifecycle phase. The Corian material proposed for the surrounding white surface could be found containing 20% recycled material, but currently not in pure white. Probably there will exist such a flexible material that is totally recyclable in 10 years, to a reasonable cost. The glass (top surface) and aluminium (side lines in the pull-out side drawer and bottom drawer) are premium looking and recyclable materials but which need a lot of energy to recycle. These materials must be mounted so that they are very easy to disassembly, to make sure they will be recycled. Furthermore there is a certain degree of uncertainty in the construction of the top surface and the glass surface with the pattern on the right side, since it incorporates new functions and technology used in a new way. It is important that these technical components (microchips, sensors et cetera) can be separated from the Corian and glass surface since they often contain heavy and precious metals.

The ideal from a sustainability point of view would be to not use any material at all in the product, but that is impossible for a physical product. The product must be able to sell and is supposed to be aesthetically pleasant and look premium, which is difficult to achieve without the right choices of materials. Hopefully and probably will the development of sustainable materials make progressions in the next coming years so to find environmental friendly materials with the right properties, which fulfil the demands on a refrigerator, will not be a problem. An interesting way for Electrolux to go would however be if they collected and took care of the materials coming from their own old and used appliances to create a closed loop of fully recyclable but probably more expensive and high qualitative materials. This could be both economically and environmentally sustainable.

Since the construction of this concept has not been developed further development and evaluations of its possibilities to be disassembled and recycled is needed. The insets are however removable and made in one single material each and their fittings are simply constructed, e.g. a slit in the sub divider that meets a pointing part made of the same material as the box it is placed in (fig. 9.15-17). Most of the interiors parts of the drawers can be disassembled by the customers themselves and the materials separated. If Electrolux, or a partner company, would take care of the whole product when it is broken or discarded, or replace broken parts in a service system it would be preferable.

The demands to put on the materials used in this sustainable refrigerator concept and its construction is thus:

» Highest possible degree of recyclable materials, but not at the expense of the properties and durability of the material since that could shorten the lifetime of the product

» Parts should be replaceable in case anything would brake; therefore modularity as in the interior is favoured. There should be a service for replacing parts if needed

» Not mix materials; all materials should be possible to separate. Especially plastics usually contain such a great amount of additives and are often mixed, why they seldom are recycled and only used for making energy

» Not use any harmful or toxic glues, coatings or paints

» Finally Electrolux should through the product, the application or an Internet portal inform the user what to do with the product when its time in the kitchen is over

10. Evaluation

This chapter includes evaluations of the concept and further motivations for how and why the user would adopt a more sustainable behaviour by using Pompador and why the product will attract the target user.

10.1. HOW POMPADOR MAKE USERS ADOPT A SUSTAINABLE BEHAVIOUR

Pompador is designed to change the targeted unsustainable user behaviours in the identified focus problem areas. Besides the four key features that are described in the subsequent sections, these following functions and general aspects of the product design also contribute to a change towards more sustainable user behaviour:

- The surface contributes to shorten door openings since it can be used for to place things on when loading or unloading food, and not having to turn to another surface further away.
- The scale on the top surface supports and encourages the user to cook the right amount of food, and it is convenient that it is always accessible without scattering the top surface.
- Regarding the total concept the strategy of value adding design has been implemented and by offering a product the user will be more attached to, she will care more for it and hopefully behave in a more sustainable way when using it.

The key features to change the target behaviours and how the suggested functions will do it, will here be presented one by one in four steps: 1. The unsustainable behaviour in focus, 2. The three most prominent barriers, 3. The solution offered in Pompador and 4. The intervention strategies foremost used. Regarding the intervention strategies presented related to each function, more detailed descriptions of theses strategies can be found in the reference literature (Lidman, Renström, 2010)

10.1.1. Place food as intended for improved preservation

A problem existing today is that food often is badly organized in the refrigerator and not placed so it is best preserved. Referring to the barriers listed in section 7.2.1, foremost the following three lies behind this dilemma:

- Ignorance of best possible placement,
- The refrigerator does not communicate the best possible placement,
- The refrigerator does not offer optimal preservation possibilities

In Pompador this problem is solved as follows: *It has zones specialized for different sorts of food and multiple ways of communicating the intended placement to the user*.

More specifically this is achieved with the specific temperature zones and the food enhancing technologies in the different drawers meeting

the barrier that the optimal preservation conditions seldom are offered in current refrigerators. Secondly Pompador is designed to overcome the barriers that the user does not know where to place food for best preservation and the refrigerator does not communicate it properly. Pompador communicate the placement to the user with the symbols and lists in the display, the colour coding, the symbols on the drawers and the design and semantics of the drawers (dimensions, form colours and materials), making it easier for the user to know what to place where.

Implemented intervention strategies

Regarding the new grouping of food and the temperature zones the force strategy *Habit Intervention* and the spur strategy *Enhanced benefits* are used. When it comes to communication the primarily used strategies are *Simple information* from enlighten; through different ways of directly or indirectly display of the information, and *Enhanced benefits* through good order and overview.

10.1.2. Encourage thawing food in the refrigerator

The present problem when thawing food is that people in general does not know how long it will take to do it in the refrigerator, which is also hard to predict when thawing in room temperature. The awareness of the energy savings made when thawing in the refrigerator are low, and instead more energy is consumed, e.g. through thawing in the microwave oven. The most prominent barriers for thawing food in the refrigerator are:

» Ignorance of the energy savings that can be made and the time of food to be thawed

» It takes too much time

» The feeling of not being in control and not be sure of the results, resulting in difficulties to plan.

Pompador can change the thawing behaviour by: *Encourage a controlled way of thawing food and saving energy without jeopardizing the foods' quality*.

This is achieved with the interactive top surface indicating with a blue spot when something frozen is placed on the surface and the timer function based on the temperature, kind of food and its weight. The pattern on the side is an abstract way of visualizing energy savings.

Implemented intervention strategies

The coloured spot when food is frozen is an application of *Enlighten through interaction and experience,* the strategies *Immediate feedback (*turns blue when placed on surface*)* and *Simple feedback (*blue = cold, red = hot*)* also contributed in this function; all strategies which enlightens the user. When placing frozen food on the scale the strategy *Simple information* is used by information on the display letting the user know the thawing time. Making thawing in the refrigerator the default option is an application of the steer category. The entire food thawing control function is an application of the *Convenience* strategy; meanwhile the way to achieve the "thawing in the refrigerator behaviour" is through *Scripting. Support autonomy* is also used when looking to the long-term use - the user will learn thawing times based on former experience from the refrigerator and thus be more autonomous. The pattern is an application of the *Aesthetics and order* strategy and also allows *Self monitoring feedback.* Thus the thawing food function include enlighten, spur and steer strategies.

10.1.3. Encourage chilling food before placing it in the refrigerator

The current problem regarding chilling food is that many people tend to place warm food in the refrigerator affecting the durability of the food already in the refrigerator and considerably increased energy consumption. Yet some people leave the warm food to cool down but forget it so it is left in room temperature for too long. The barriers identified to be behind this unsustainable user behaviour is mainly the following three:

» Inconvenience/lack of time - when leaving the home or when afraid of forgetting the food in room temp (too effort demanding to wait)

» Ignorance if it is cool enough to be placed in the refrigerator; no indication of the temperature of the food.

» Ignorance of the actual consequences of the action.

The solutions to the problem offered in Pompador are: *To give clear and intuitive indications of when food is (and will be) cold enough to be placed in the refrigerator.*

This is done with the feedback from the red indications on the surface and the timer function described in section 9.3.4.

Implemented intervention strategies

Enlighten through interaction and experience and *Immediate* and *Simple feedback* is used through the red spot, and the numbers of the temperature and the chilling time on the display is an application of *Exact feedback*, i.e. Enlighten strategies. The indications with light when the food is chilled enough is mainly an application of *Feedback* - turned on light shows that it is okay.

10.1.4. Awareness of temperature status in the refrigerator

When it comes to knowing the status of the refrigerator, how cold it is and where the coldest respectively warmest spots are, the current problem is poor feedback on the temperatures and the consequences of long door openings.

The barriers for having better awareness and maintaining the right refrigerator conditions are:

» Ignorance of the consequences of actions (long door openings)

» Delusion of knowing the present and the suitable temperature in the refrigerator

» The refrigerator does not communicate its (negative) temperatures well

Pompador overcomes these barriers by the following solution: *Multiple temperature indications that are easy to see and understand and possible to relate to the behaviour with the refrigerator*.

Two features constitute this solution, firstly information about temperature in each drawer showed on the display (sec. 9.3.3). This part solution meets all three barriers. Secondly, there is feedback with red/blue/white light on the drawer fronts when the temperature deviates, which meets the barriers ignorance of consequences of actions and the refrigerators poor communication of temperature variations.

Implemented intervention strategies

The Enlighten strategies *Simple Information* and *Enlighten through Interaction and Experience,* and the Spur strategies *Immediate Feedback* and *Order and aesthetics* with the red light on the front among the white lights, are examples of DfSB strategies used in this function.

10.1.5. Use food close to go off: the EatSoonZone

One of major problem found was that users forget to consume food in the refrigerator that will soon expire, and it therefore has to be wasted. Barriers related to this unsustainable behaviour are:

» High risk of accidentally forget foodstuff

» Deficient communication between members of household and from refrigerator

» Lack of inspiration

The change of user behaviour regarding this problem can be achieved with Pompador through: *Providing the user a fixed and clearly visible spot in the refrigerator that highlights food that has to be eaten soon - an EatSoonZone.*

The EatSoonZone meets mainly the first two barriers mentioned above.

Implemented intervention strategies

The two spur strategies *Attention drawing design* and *Support autonomy* is primarily used. The user is encouraged to be autonomous and on their own learn to adapt their food purchases to their consumption.

10.2. HOW POMPADOR ATTRACTS THE TARGET USER

Pompador has, apart from its overall design and functionality, some certain features that are particularly developed with the target user, Louise, and creating added value for her in mind. These features are the following:

» Warm top surface for baking, serving buffets or brunch to friends (she is very social).

» The towel dryer allowing her to dry her kitchen towels in a smart way.

» The patterns, emerging at the vertical glass surface and embossed inside the towel hanger space indirectly communicating energy savings and add an emotional surprise.

» The flexibility and possibility for customization, through arranging and buying more insets and customize the theme of interface or the application.

» The feedback and information foremost given with symbols, light, sound and colours, instead of numbers and text to be more emotional.

» Concerning the four functions particularly developed to change the user behaviour presented in section 10.1, these also offer other benefits for the user like for instance the following.

» The guidance for, and the offered improved food organization together with the food preservation enhancing technologies offers better order and overview of the groceries. The food can be kept for longer in a better and tastier condition, and the doors can be opened for shorter times since the food will be easier to find and better organized, which the target user likes and can save both time and money.

» With the thawing timer function the user will be able to better plan and learn more about thawing times through the support, feedback and information given by the refrigerator. S/he will experience being in control of the process and feel more secure about the result, which is better convenience. By thawing the food in the suggested way good quality can be assured and energy saved compared to thawing in for instance the microwave oven. Also, the knowledge and autonomy will be increased over time if using the function. The user can then learn chilling and thawing times so s/he knows it even when not using Pompador, i.e. the product includes learning.

» The chilling feedback and guidance gives the benefits that less unnecessary energy will be wasted and less food damaged in the refrigerator, because less warm food will be placed in it, or food will not be forgotten for too long in room temperature (resulting in less food wasted). The guidance and showed temperature will help educating the user in how long time it will take for it too cool down. It will enable planning of thawing time and together with the temperature indications on the drawers highlight the consequences of actions. The user will experience being more in control and a better food manager which hopefully will make her/him more engaged in food management and find it more enjoyable.

» The light communication of temperatures in the refrigerator creates a “social bond” between the refrigerator and the user; the refrigerator starts talking to the user. The user gets feelings of having good control of what happens with the refrigerator and also trust in the refrigerator that it is competent to take care of the food.

» The EatSoonZone helps the user to not have to throw away old food, which is a great benefit. Since this function is relying on the user she can feel a greater responsibility and more in control over the refrigerator contents, which she is assumed to like.

10.3. THEORETICAL EVALUATIONS AND FOCUS GROUP

The results of the evaluations of the final concept from the Cognitive Walk through (CW) and Product Human Error Analysis (PHEA), the opinions from the consumer acceptance group and the evaluation of fulfilment of the need and demand list is presented in this section.

10.3.1. Evaluation with CW and PHEA

When using CW and PHEA (methods X and X) for examining three crucial scenarios from a usability and product-understanding viewpoint - the thawing food scenario, the chilling procedure and the organization of the foodstuff in the refrigerator - a few potentially critical events were found. These were for example unclear feedback if two events happen at the same time, like thawing two different things at the same time, or what happens when wanting to thaw and chill simultaneously. The potential problems found were either corrected or recommended to undergo further development. Example of an adjusted problem was in the chilling food scenario: If the user would like to place something hot to cool down on the top surface when it is heated up, this would obviously be a problem. Therefore it was added that a question would appear on the display when this happens; if the user wants switch off the warm top surface when placing something hot to be chilled on it. The complete CW and PHEA, together with HTAs for all the evaluated scenarios can be found in appendix XVIII.

10.3.2. Evaluation with need and demand list

From the evaluation against the need and demand list it was seen that the concept overall met it well, especially regarding the food management and functionality requirements. The two parts somewhat less fulfilled were the requirements regarding technology and materials. This was however expected because according to the limitations of the project these aspects should not be developed in detail, anyhow demands can be put on them. Yet some of the requirements could not be evaluated properly without making further user tests.

10.3.3. Evaluation with users

The evaluation focus group participants, who were persons from the context mapping study, were positive to the behaviour changing functions, not primarily because they could make them be more sustainable, but because they could simplify actions in everyday life like thawing and chilling food. They liked that the refrigerator did all the thinking. The participants thought they would change their refrigerator usage behaviour to the better when using this product and for example not placing warm food into the refrigerator. They expressed it as a "Big Brother see you" effect: If the refrigerator knows and tells what you are doing it might prevent you from doing wrong. The EatSoonZone was appreciated, especially if there were several members in the household. Other appreciated functions were the warm workbench and the scale.

The words describing the refrigerator's personality and the four Electrolux brand values were ranked on a scale from 1-10 evaluating Pompador, where all got high ratings; most 9 and 10 and none less than 7. Some comments were:

Confident:

"It reacts quickly, even before you react ", "It has control of the situation".

Competent:

"It has the expected functionality and contains even more". "The stainless steel gives it a competent appearance".

Supportive:

"Today the refrigerator does not offer any support, but with this it is a considerable difference!"

Progressive:

"The hot and cold functionalities are great!", "It

has a very classic look but on the other hand I do not want a spaceship in my kitchen".

Empathy:

"It is concerned about you and the environment"

Regarding if the product fitted into the expression board (sec. 5.4.3, fig. 10.1) it was highly ranked with comments that the materials were coherent and a classical look perceived. The concept was accepted and scored average 8 on a scale from 1-10 how desirable the participants found the product. To the question if they would buy the product the answer was more vague, this due to that they would have wanted to feel it and try it first. For example if the drawers would come out with good speed, if the overview would be as good as presented by the team and if the low placement of the drawers would be more effort demanding than the height of a common refrigerator.

Fig. 10.1: Pompador fits with the expression board.

11. Discussion

In this chapter the project and its results are discussed. The first section treats the methodology used followed by a discussion of the user study and its findings. Interesting points of the concept development is reflected on before the final result, Pompador, is discussed from relevant aspects - how likely it is to change the user behaviour, the potential improvements of the energy efficiency compared with a normal refrigerator, materials and sustainability, how it fits the Electrolux brand and finally a discussion about how it will attract the target user.

11.1. METHOD

Since the project team started off with a very open project scope, because of the complexity of the topic - designing behavioural change, it took a long time to find the focus of the project to not be too narrow neither to wide. This time was however important to get the entire picture of the studied situation. Nevertheless, the project could take up speed as the scope was narrowed down and more focused. Because the project treated a product concept for the future with many important angles to take into consideration and hardly any restrictions or specific wishes from the company, the team did not want to make too many limitations to early. However, it can be assumed that the final concept could have been more developed in detail and more evaluated if the target behaviour to change had been specified earlier in the process. On the other hand a thorough introduction to DfSB and related fields of research was needed in order to have knowledge enough to be able to achieve the goal of the project. This motivates why such a large part of the project had to be occupied by pre-study.

11.1.1. Planning and structuring

The project team made careful plans of each of the phases of the project in Gantt schedules, and complemented these with a daily agenda written in the morning each working day. Every week was wrapped up by writing a logbook. In that way both the long term planning of the entire project could be managed, and the execution of every activity on time assured in the daily plan, and followed up in the logbook. This strict yet negotiable planning and structuring of the project worked very well and came naturally for the project team. Moreover it was considered as important in order to manage the broad project scope in the beginning, to manage it in the set time and not get lost. However, the time plan did not work out as good in the final phase of the project as in the rest of the process. This mainly because major changes in the design was made very close to the end of the project. But these changes were on the other hand very valuable and considered to radically improve the results why it was worth it.

11.1.2. Data collection

The data collection started of widely, which was needed in order to be able to narrow down the project towards the right focus. Since there are

prior research made on refrigerators and designs for sustainable behaviour, these reports could be used as references and guidance for what other data and information that would be beneficial to collect. During the time in Porcia, very much information from people at Electrolux was received regarding for example on-going and past projects on related topics, and study visits to the refrigerator factory and R&D department in Susegana and to Electrolux Professional. At this time the project team was very open minded and wanted to collect as much input as possible because of the limited time in Italy, thus resulting in an overload of information. This was a deliberate choice to be that open and conduct interviews and to involve many experienced persons. When having structured and filtered all the data, most of it turned out very well and to be valuable. The focus of the project turned to be directed more towards food waste than solely energy consumption, as the starting point was.

11.1.3. Analysis

The analysis phase incorporated many different methods, and some of them are more worthwhile to discuss. The function analysis of the current refrigerator was done early in the project and then left unnoticed. Not until the evaluation of the chosen concept the project team realized how useful it was and that almost all functions from it had subconsciously been fulfilled in new ways. Similar applies for other methods, primarily the mind maps over information from the research phase and associations with "premium". They were performed early in the project and then not looked at for a long period of time. Then in the end the project team realized how much the concept development indirectly had been influenced by those findings.

The persona was of much help in the project and frequently used throughout the process as a sounding board to ask: *would Louise like this?* To both describe Louise in words and imagery made her accessible and useful in various situations and for various purposes. However, the images chosen to visualize her could have been even better. But since they foremost were for the project team to use internally, the project team considered them to be good enough.

Regarding the future scenarios one can question why all four of them have not been more used. The answer is that the future scenario method was applied primarily to; based on the PESTED-analysis, explore possible directions the refrigerator context could take in the future. The future scenarios served as binoculars directed towards the future for the project team and was primarily used to inspire in the generative session in the user study.

11.1.4. User study

The decision to make a large user study was well motivated by publications of other researchers within the field of DfSB (Tang, 2010; Selvefors, Blindh Pedersen, Rahe, 2011). The project team was very happy with both the set up, execution and results of the study. The decision to start off with a mind-opening discussion with some users, prior setting up the first part of the survey, was of good help to design the study in a rewarding way. To perform it as a three-stage rocket (survey, self-observation and sensitizing booklet and generative session) allowed the project team to go from general to specific, from structured to open-ended and from the present situation to the future context in a way that enabled both the team and the participant to be prepared and sensitized to collect and share valuable insights. The user study was probably the part of the pre-study bringing the project the most valuable input. To get to know and understand the target group, get their experiences, knowledge and inspiration apart from findings from literature. It served well to validate and broaden the assumptions regarding barriers and problem behaviours the target users have that the project team set up prior the study. Moreover the study was very fun to conduct.

Concerning the survey, it was very positive with so many replies - 133, which was far more than expected. The number of respondents and the spread in age and nationalities strengthen the reliability of the results. Most of the survey questions gave interesting results, but as always it is

easy to afterwards see how question could have been formulated differently to be more valuable, even though a pilot test of the survey was performed before it was spread. For instance 30 % replied with a food product on the question which energy consuming product that was their favourite. After all food is also energy consuming but not in the way the project team meant. The project team tried to formulate the questions so the replies could be compared with prior studies and statistics from various reports to validate the team's replies. However these questions, as for example the questions about food placement principles, turned out to not be the most interesting ones.

The self-observation using the sensitizing workbook was good to make the participants aware of their refrigerator usage, and made a foundation to the later workshop. One question is though if the participants during their self-observation missed out on some parts because the refrigerator usage is highly habitual; that they sometimes acted without being aware of it. This would have been solved if for example complementing the self-observation with a camera mounted in the kitchen of the participants, recording their actual actions.

11.1.5. Development

The idea generation and development process was mostly performed in systematic ways on specified topics and with morphological matrices, but also freely and on different levels reaching from technical aspects, emotional attachment to the target user and total concepts, individually and in pairs. The project team believe there was a good balance and that the process was comparably smooth. Moreover it was good that several iterations were made in each phase.

A specific method used for idea generation producing good and useful output was the two workshops, one with a group of designers and engineers at Electrolux in the concept development phase and one with two Australian designers during the final concept development. The structure of these workshop were the same; first a presentation of the project and then were statements and questions formulation with an adherent background briefing discussed and sketched on. However, a too short time was scheduled for the first workshop and there were several who could not attend because of the choice of day, affecting the outcome.

11.1.6. Evaluation

Regarding evaluation methods the mock-up was the most important method used. The physical testing made the project team really believe in the architecture of the final concept, however it also lead to that some major changes had to be done to improve the concept. Since the sketch model was made a long time before the end of the project, there was time enough to make the needed adjustments. The method of using 3D CAD was a good way not just to visualize the concept but also to evaluate and methodically try variations of the visual appearance of it, and to make fine tunings. The method was of great help when in Catia developing the insets where one solution often led to implications to the other parts it was interacting to, which quite quickly could be solved in the program. Some of the parts, like the top surface was however more time consuming than expected to make in CAD.

The CW and PHEA was helpful methods to use when evaluating the interface of the product and forced the project team to carefully think through each and every step of the interaction with the product in the chosen sequences. However, a CW and PHEA was difficult to perform on the less elaborated and more conceptual parts of the product, and the PHEA was considered as not worth to perform on the "get help through interactive guidance" task regarding food placement, since it would imply a lot of assumptions because the interface was not defined enough.

When evaluating the final concept with users only two of five could attend, which is not sufficient for being statistically and reliable material to present. Their response was anyhow of interest and mainly positive. The evaluation from the group might have been affected by that the final

renderings of the concept was not of good quality. Because they were friends of the team, there is also a risk that even though they are people that dare to say their opinion, might have given a more positive evaluation to be kind. A more veracious answer could have been received if the focus group was a collection of unknown people from the target group.

11.2. PRE-STUDY AND DEVELOPMENT

This part of the discussion treats the project process.

11.2.1. Literature findings

An issue to meet, discovered in theory (sec. 2.5.3), was that the average refrigerator size has increased with 15 % 1995-2001 and people keep on asking for larger refrigerators. At the same time the project team saw that people buy more food than they eat and like when their refrigerators are well filled, i.e. many people fill their refrigerators with unneeded food just because there is space, and more food is wasted. On top of that, as also seen in the trend forecast, the living space in crowded cities is getting smaller and thus also the room for the refrigerator. This is a bit contradicting, why the project team wanted to design a refrigerator that is smaller than a full size, but larger than a combined refrigerator and freezer. By dividing the refrigerator into several smaller compartments the user will not have the feeling that it is so empty even though it is little food in it.

The project was full of innovative thinking and idea generation but many of the favourite ideas that the team implemented in the part concepts were later on found in internal project reports at Electrolux and partly in the dissertation by Tang (2010). It was on one hand side boring to see that some of "the teams ideas" already had been thought of, but at the same time it was encouraging to see that designers and researchers with more participants in their studies and more experience in refrigeration and DfSB came up with the similar solutions as the team did. If the ideas that were similar to the project team's, which were later found in literature had been found earlier it might have steered the idea generation process instead.

11.2.2. User study findings

Survey

Most of the respondents in the survey were Swedes, but also originating from other countries. In the context mapping study all five participants were from Sweden, which might have affected the results and made the final concept specifically adapted for users with a "Swedish mind set" having common Swedish food in their refrigerators. These five participants were chosen to match the target group, but even though the project team evaluated how similar to Louise they were, it cannot be assured that they "were 100% as Louise". However the team considered them to be similar enough to be regarded as in the target group. If the team would have had the possibility to use a questionnaire and choose from a larger number of people, even more suitable persons for the user study might have been found. Nevertheless the input from the context mapping was very valuable, and matched with what the team would expect Louise to think and to a certain degree with the findings from literature

Some of the results from the survey were found more interesting than expected and came to play a greater roll in the project than anticipated in advance. As for example how the survey participants found the personality of their refrigerator. The result of the survey was in its entirety of great value for the project and primarily for the rest of the user study.

Context mapping

The close relationship between the refrigerator usage and the private life of the users might have prevented the participants of the study from being completely honest in what they tell and show. The project team noticed for instance that some participants arranged their food to be clearly visible

prior taking the photos of their refrigerators they were asked to hand in (appendix IX). Moreover, some participants in the user study confessed that they adapted their refrigerator use behaviour when working with the sensitizing booklet. This was interesting from a behavioural point of view. The change was probably because they felt watched, which they also told when coming back for the consumer acceptance test for the final concept. The change in their behaviour while filling in the sensitizing booklet could also be caused by the fact that they never before had reflected on their refrigerator behaviour. By this simple exercise they became enlightened.

11.2.3. Concept development

The project was targeted to the European market but had most input from Sweden since the project team is Swedish and the participants of the study, as earlier mentioned, were mainly Swedes. The feedback sessions held at Electrolux IDC in Porcia (Italy) and the workshops and feedback sessions held at IDC Stockholm however contributed with opinions, facts, reflections and ideas from people of different origins than just Sweden. The project teams time in Italy also contributed to a more European perspective on refrigerator usage. However, regarding the behaviour with the refrigerator it can be considered to be global and it is primarily the interior of refrigerator and what is stored in it that differs, why many of the project teams proposed functions would work globally.

A question the team worked with a lot was how intelligent and virtual the refrigerator should be and for example how much the users actually would like to know about the contents of their refrigerators. It might be possible to use RFID and always know what is in the refrigerator, but would the user want that? When working with a future concept the result can risk to be developed so that it in the end mainly does something else than the intended core function, or that it turns out to be a cool spaceship that none would like to have at home. However should a concept be somewhat futuristic and intangible with the ability to if wanted peel off a layer or two. This was one of the reasons why the concept "The Organized" was rated down, because it was too tangible.

One of the most interesting focus areas for behavioural change was "Planning". The team believe that this area might have the greatest impact regarding food waste but chose to not work on this focus area because this can as well be done by another product than a refrigerator. The reason to why the team discarded this focus area was in the end due to the question: "What behaviours can a refrigerator be most effective in changing?"

11.3. FINAL RESULTS

The purpose of the project was to answer the question formulation stated in (sec. 1.1.2). The project team believe this question has been well answered by Pompador, the final product concept. Since Pompador is a concept aimed for the future treating the rather complex topic of changing behaviour through design, DfSB, the effectiveness of the concepts behavioural changeability cannot be assured without testing the concept with a functional prototype on real users, preferably during a long period of time to see if the sustainable behaviour will remain.

However, when evaluating against the need and demand list most product requirements were fulfilled, and also the usability of the product was considered as high, even though further testing is needed and some improvements already suggested (Chapter 12). Pompador has many characteristics potential to both attract the target user and to above all change the user behaviour to be more sustainable than today. Regarding the aim of the Master's Thesis, the final concept is considered to fulfil it. More in detail how every aspect of the aim is met is discussed in this part of the discussion.

11.3.1. Adoption of sustainable behaviour

Pompador is different from a conventional refrigerator and cannot be used as such, therefore the user behaviour have to be changed. Then the question is whether it will be more sustainable?

The project team believe so, even though it have not been tested, and also the user's asked believed they would adopt a sustainable behaviour if using Pompador. Since the intervention strategy *Habit intervention* from the category force (sec. 2.1) was used, a new and different functionality and appearance will break the habits of the user and prevent him/her to act as previously. Especially since many of the unsustainable behaviours are habitual, force strategies and particularly habit intervention can be assumed to be effective.

Since the refrigerator, with current technologies, is a product approaching the theoretical minimum of energy consumption, it is difficult to change habitual behaviours with it without major changes in the product (sec. 2.1). As Elias, Dekonick and Culley (2007) suggests to meet the real user needs in order the successfully change the user behaviour related to the energy consumption of the product, the project team can be regarded as having done right when first conducting the user study, and then developing a product relatively different from current refrigerators.

On current refrigerators there is normally just one door and this is opened whatever foodstuff is searched for. This concept has four openings, which can be seen as quite a major change, and hopefully lead to less outlet of cold air and energy wastage because less is exposed to the warmer kitchen air when one drawer is opened. The cold air will also stay better in drawers than in a cabinet, because the colder air fall down which is prevented by the structures of the drawer. What however might happen is that the user does not know in which drawer the wanted food is placed and needs to open several drawers to find it. Since symbols of foodstuff are placed on display strips seen when opening the drawers, looking for right placement without looking at the display on the workbench, might lead to unnecessary drawer openings. This concept is nevertheless designed to support the user to keep good order of the foodstuff. The display on the top surface and the possibility to look in the application on a smart phone should prevent the unnecessary openings of drawers for placement guidance. Moreover, the foodstuff is intended to be organized in a way so that things commonly used together, such as yogurt, juice and cheese are placed together, why more door openings not necessarily are needed. But, if this really works cannot be assured until it has been tested in real life situation over a period of time. However the project team believes that learn how to use the product should not be difficult especially if the product comes with a demo video or similar for the application, of how it should be used, and because of the predicted high learnability over time.

Concerning placement of foodstuff and flexibility, a relevant question is: *How much effort can be demanded from the users?* This question comes down to whether the placement guidance will be used or if users are too lazy, and it is one of the reasons why the project team suggests to have the product placement guidance accessible on external devices - people might not want to stand by the product when looking up something. However, there is still a risk that users place their food so its not optimally preserved, but anyhow it will not probably be worse than today. It is a question if the user will be guided enough to adopt a better behaviour when it comes to food placement in the refrigerator, or if new bad habits will be formed. What also needs to be further investigated is if the users' benefits of good order and foods kept fresh for longer equals or exceeds the effort put on knowing good placement. However, from sustainability point of view it is better for sure because a smaller volume is chilled to a lower temperature and almost 50 % of the total volume is warmer than a conventional refrigerator (sec. 11.5.3).

An example of wrong food placement that might happen is that milk is placed in the left chiller compartment with shelves, where it might seem to fit well. 10°C might make the milk last even shorter than to its expiration date. Even today many people place milk in the refrigerator door, which is not good for it. The project team discussed if this wrongful placement could be prevented by round markings in the base of the shelf to indicate that no square packages should be placed there. This however does not work with milk bottles, with rounded bases, and there also exist square jars.

Especially the chilling hot food guidance and the EatSoonZone are regarded as strong functions likely to be effective in changing the user behaviour because they are so intuitive. The EatSoonZone is a new simple function that can create a change in behaviour that might endure even if the function is removed. According to the focus group evaluation both said that they thought they would change their behaviour to the better if using this refrigerator.

When it comes to the chilling and thawing food support, conventional refrigerators does not give any help at all, and chilling and thawing was identified as areas of problematic behaviours in literature as well as the user study. Therefore these completely new functionalities, which both demands very little effort from the user, is very likely to give a positive contribution to a more sustainable resource consumption with the refrigerator. However, the timer has to be activated manually and does not start by itself when placing something warm on the surface, which can be regarded as too effort demanding or unnecessarily complicated. This was a conscious choice by the project team since it was wanted to make the user *feel* the temperature of the food, *see* it on the display and *see* the thawing time to be able to associate it to each other and learn from experience to know when food is too warm even without the refrigerators support. Also, sometimes it is not wanted to set a timer for chilling but just place something warm on the surface for a while. It is also possible that the user for some reason do not want to see any red or blue coloured spots on the surface at all, why it has to be possible to switch it off. However, the indications cannot be active when the warmth in the surface is activated.

When it comes to the warm top surface a new possible behaviour is that it the user uses it to thaw food on, quicker than if placing it in the refrigerator. This behaviour would not be worse from an energy consumption perspective than using the micro, hot water or thawing in room temperature as commonly done today. But it is not good for the food's durability since it will be heated up on the surface speeding up the growth of bacteria. More importantly the warm surface would in this case counteract Pompador's thawing functionality. The warm surface might also tempt the user to keep food warm on it for a longer time, which would lead to bacterial growth making the food hazardous to eat. The warm top surface was a feature seen as important because it is a forward thinking feature that brings novelty to Pompador and gives it a more human and interesting personality. However it should be treated with care so it does not counteract good behaviours that Pompador can result in disregarding the warm surface. At the end of the day sustainable user behaviour and good food management is more important than the warm surface. On the other hand, the warm top surface might lead to that the product is more loved and therefore more taken care of and inspires to better food management.

Why the preservation of vegetables and fruit was so much focused on in the final result is not a coincidence. Because of the big reliance on date labellings the project team realised that focusing on the preservation of vegetables and fruits was a good idea, and vegetarian food was identified as the most commonly wasted. Also, the meat industry is the by far worst sector of the food industry from a sustainability point of view, which support the focus on enhanced vegetable and fruit preservation. It is also a way to encourage vegetarian food consumption. However, because of compromises one of the vegetable boxes meant mainly for fruits had to be placed in the bottom drawer where the accessibility is low.

11.3.2. Usability

Looking at the usability of the refrigerator concept the team would state that it is relatively good, especially the fact that it supports learning. Out of the ten design principles by Jordan (1998) (appendix II; Usability) most of them were considered and met, just a few were not elaborated on. The interaction with the product is made to be intuitive and quick to learn (Design rule: Explicitness). Similar tasks are presented in similar ways (Design rule: Consistency), as for example frozen and hot food management where both are placed on the surface, can be connected to a timer, get a light around them presenting its temperature with colour (Design

rule: Feedback). The red light is always used for hot and warning and blue for cold. Feedback is in general given to al larger extent than in today's refrigerators; on temperatures with numbers and coloured light and from the Eat-soon-zone and from the chilling/thawing timer.

Regarding the display; information can be easy accessed using few steps to reach what is wanted (Design rule: Prioritization of functionality and information) and the information of placement of foodstuff is described in several different, redundant and visually clear ways (Design rule: Visual clarity). However it can be discussed how willing the user is to interact on it when using the refrigerator and if it would be more suitable to move more or less of it to an external application.

The placement of foodstuff might be somewhat difficult in the beginning and more effort demanding than when using today's refrigerators, especially when it comes to the correct organizing of vegetables and fruit. The user has to be motivated to learn how it should be arranged in order to do right. This concept has however good learnability, meaning that the users will rather quickly learn where they place their common foodstuff and after a short period of time not have to look up placement more than for few new groceries.

Another question is if the user will understand that the heat transferred to the workbench and side is actually coming from the refrigerator, as waste energy from the cooling function. If this is not understood the user will think that this function is an energy consuming function, which will make the refrigerator look bad, effecting its semantic expression to give it a hypocritical personality. It is possible that this connection has to be better explained, either by using descriptive semantics or by marketing the product as a "heat-transition-system" where both cold and heat is used.

11.3.3. Estimations regarding energy efficiency

There is a difficulty in getting a high energy classification in the standard tests and at the same time have several different stable temperature zones which are well suitable for the food, since that is not the type of refrigerator that the tests initially were designed for. The standard test is criticized for being unrealistic since it does not represent usage of the refrigerator. Still the labelling is relied on by many people when buying a refrigerator, and companies can therefore generally not sell refrigerators with lower energy class rating than their competitors. It might be possible that less energy could be consumed if using a refrigerator with slightly lower energy class rating where less food was wasted and hot and cold food management improved, but this would have to be calculated on and tested. Because of the criticism towards the standard efficiency test it might be changed and improved in ten years. But if the energy class rating could not be as high as on an ordinary refrigerator one idea could be to change the name of this concept from a "refrigerator" to something else to make it attractive to the market. In that case could the specific standard fridge temperature zones also be disregarded and temperatures set freely.

Just a little difference in temperature settings in the refrigerator result in a rather big difference in energy consumption (sec. 2.6.4), why it is motivated to increase the temperature for the food that does not need very cold preservation as is done in the chiller compartments of Pompador. If the temperature in refrigerators in main would be set just a few degrees higher it would result in a large difference in energy consumption from households. But on the other hand the food in it would go off quicker, which would lead to increased food waste that is not a wanted consequence. That is why the chill compartment of Pompador meets this potential problem and offers preservation for food with demands on both high and low temperature.

The ideal to make more cold air stay in the drawers they should have higher sides. But this would be very bad for an ergonomic and handling point of view and also for the visibility. The project team believed that the accessibility was of great importance for to make the concept attractive to the target group, and if the sides had been higher it would lead to lower accessibility and overview, and the user might then not have wanted to buy the product.

Table 11.1: Energy consumption estimations.

	The concept Pompador	Size as the concept but 1 compartment at 4°C, as a normal refrigerator
(1) Maximal yearly energy consumption of the refrigeration technology to be approved as A++	84,5 kWh/year	94,5 kWh/year
(2) Heat load*	96 W	46 W
(3) Energy savings from increased operating temperature	13 %**	
(4) Additional energy consumption from decreased operating temperature	1,4 %**	
(5) Additional energy consumptions from placing warm food in the refrigerator		11 %**
(6) Energy savings from thawing food in the refrigerator	Up to 26 %**	
(7) Door openings	>0,12 %	<0,12 %

**Heat load is the total heat leakage in the refrigerator and depends on factors as the length and conditions of gasket seals, the leakage through the walls (i.e. the insulation and the construction) and holes (for cables and screws) et cetera.*

*** Of total energy consumption*

Table 11.1 summarizes the assumptions made regarding the energy consumption of the concept. Since it is a future concept and not any decisions on particular models of refrigeration technologies et cetera are made, the values are very approximate and based on assumptions and calculations based on standard formulas. The final concept is compared with a reference product, a refrigerator with one cabinet of the same dimensions as the concept but with only one temperature of 4°C. The reason why not an existing refrigerator is compared with is because declared values of energy consumption take more aspects into account than the project team can do in the approximations for the concept. So in order to make a fair comparison the concept is compared to a theoretical refrigerator to eliminate the influence of factors not taken in to consideration for the concept. However, to give an idea of the consumption of a good refrigerator currently on the market, there are A+++ refrigerators (i.e. the highest energy efficiency class) of 280 litres which consumes 124 kWh/year (0,3 kWh/day). The declared energy consumption of an A++ refrigerator can for instance be 158 kWh/year. The reason why it its so much higher then the 94,5 kWh/year in the table is because it is measured in test and not calculated. Thus more factors such as heat leakage are included in contrary to the number generated from the formula.

Description of the table

The values of (1) are calculated from the formula for energy efficiency classification (appendix XVII) and the maximal yearly energy consumption to be approved as A++, disregarding factors such as user behaviour and heat leakage.

(2) Shows the assumed heat load, i.e. the cooling capacity needs to cover up for. The cooling capacity in turn depends on the efficiency of the technology (the compressor, the condenser and the evaporator) and the efficiency of the technology is normally about 75 %. The difference between the concept and the reference depends on the length of the gaskets, based on a leakage of 2,13 W/m (Viet, 2012). The numbers are very approximate but give a hint of the impact. Since the concept has almost twice as long gaskets (48%) as the reference refrigerator its heat load is accordingly higher. The gasket leakage can be approximated to stand for about 15 % of the total heat load. However, since ΔT is different between the differently tempered compartments in Pompador, the heat load from the gaskets will consequently also differ which is disregarded in these approximations (appendix XVII).

Based on the volume operating at a 6°C warmer temperature in Pompador and the approximate 6 % energy savings (ISIS, 2007) made when increasing the temperature the percentage of (3) is calculated.

The percentage in (4) is calculated in a corresponding way but for 26 % of the total volume operating at a 3°C lower temperature (ISIS, 2007).

The numbers of (5) and (6) are found in literature (ISIS, 2007; Tang, 2010)

The effect of door openings (7) is found in the report by Stamminger (2011) The lowest declared value of effect of door openings from their study is 0,12 %. Since the effect of door openings on the energy consumption are highly dependent on the exposed volume and the ambient temperature, and a considerably smaller volume is exposed to the ambient temperature each time and the drawer structure prevents the cold interior air from being exchange with the warm air, the effect can be assumed to be even smaller, i.e. >0,12 % and therefore disregarded because of its insignificance.

However, all these numbers of the impact of user's actions with the refrigerator are very general indications. The exact numbers depend on many factors and especially which particular refrigerator and its cooling system, that is used. Nevertheless the project team believe that it gives a rather fair indication of that for instance thawing food in the refrigerator can save very much energy if done on regular basis, and that the impact of a decreased operating temperature is smaller.

Comments

Due to the several different compartments of different temperature the cooling capacity of Pompador has to be more energy efficient than a comparable normal refrigerator to be classified as A++. The biggest challenge in a further development to assure an A++ classification would be to reduce the impact of the heat load from the gasket seals. New improved gaskets seals are then needed. It would not be enough to improve the insulation because then would the gasket leakage correspond to an even larger ratio if the total heat load. With current design of gasket seals together with conventional refrigeration technology Pompador would not pas the test as an A++ refrigerator. However, there are new far more efficient technologies coming and the vacuum panels earlier mentioned would contribute to a decreased heat load.

What is not measured in the standard test is the influence of (3), (4), (5) and (6) in the table, which would radically decrease the energy usage of Pompador compared to a comparative normal refrigerator.

If summarizing the values presented as percentages of the approximated effects of user behaviour on the refrigerators energy consumption, it can be seen that based on these numbers with the functions of Pompador the energy consumption can be decreased to 65 %, but with the one cabinet refrigerator without the supportive functions the consumption would increase with 11 %. In addition to that come the positive effects of the better organized and preserved food and the eat zone soon potentially leading to less food waste. Also, the fact that the food preserved in Pompador will not suffer from the negative effects of warm food loaded in it, affecting its durability in a negative way.

So to conclude, the concept Pompador is demands higher cooling capacity than a refrigerator with one single cabinet. But, this is disregarding the improvements made concerning user behaviour. Taking user behaviour into account the difference is more evened out compared to a conventional refrigerator. With the improved refrigerator technologies, gaskets and insulation that are under development the future of the energy efficiency of Pompador is anyhow hopeful.

11.3.4. Technology and material

To make the warm surface possible to switch on and off (from/to the towel dryer side) a more energy consuming technology had to be used - the dynamic condenser with a fan. The choice to have the warm surface in the concept despite its not obvious connection to sustainable behaviour was because the it considered as innovative, novel and a fun feature and met by very positive feedback from people at Electrolux. Also the asked professional chefs, the people at the evaluation focus group and other random people spoken with very much liked the function. The team thought that if the function it was so well met the target group might also like it.

When it comes to sustainable materials and how to at the same time create a premium looking and a not too expensive product, it creates difficulties. Since new materials come to the market continuously, there will hopefully be better alternatives offered in a couple of years. Since this is a project about sustainability and a concept designed for sustainable behaviour the product has to be sustainable in itself and the choice of material cannot be disregarded even though being out of the scope of this project. Therefore the project team want to pinpoint the importance of carefully looking over the most sustainable choices of material having the desired characteristics if developing this concept further. When it comes to recycled materials they have, as earlier mentioned, often less good material properties and can be less durable. Using less durable materials would lead to shortened lifetime of the product which is not desirable. Therefore it is a balance between making a durable long lasting product and making it completely recyclable.

Another earlier mentioned drawback when it comes to recycled materials for refrigerators was the difficulty to ensure the hygienic factor. The white Corian material surrounding the main refrigerator body and therefore used to a great amount in the concept, is not in direct contact with food and could therefore, without great problems regarding food contact hygiene, be made of recycled plastics.

What however always is important no matter of what materials used, is the matter of disassembly and also if the company can take care of their old product's materials to create a sustainable loop. This is something the team wants to encourage Electrolux to work on and to be clear in the communication to the users about.

11.3.5.Pompador's relevance for the Electrolux brand

Electrolux is a premium brand and Pompador is designed to have a premium expression. However, being perceived as premium is very dependent on the final execution of details, something that is partly out of control of this conceptual project. The choice of material becomes important and the tactile feeling of robustness, the smoothness and speed when the drawers are pushed out should "feel right". A good service system and upgradeability is associated with premium products, i.e. the total brand and product experience. These are factors that have been thought of through out the project, but the concept is yet too conceptual to make sure they will be executed in a way achieving the premium expression sought for.

Important for the Electrolux brand is to elaborate on and strengthen its connection to professionalism. By highlighting this in Pompador with the approach to enhanced food preservation and the precise yet emotional control the professional and sustainability profile of the brand can be strengthened on the cold preservation side of appliances. A difficulty was however to mix the professional

expression and functionality with a domestic and more soft emotional expression from the Scandinavian and emphatic values in the same product in a natural way, attracting Louise.

More importantly, Pompador can contribute to strengthen Electrolux profile as a pro-environmental brand caring about the user by offering it in their product portfolio – it shows a, for Electrolux, new way to look at eco-design. Pompador is a good example of how user centred design with focus on sustainability can encourage innovation, referring to what was stated in section 2.3.2.

11.3.6. Is Pompador attractive to the target user?

The persona Louise is an emotional person and this was kept in mind when developing the concept. Information not needed or wanted at the moment is not visible or communicated in an intuitive or emotional way, e.g. in colours instead of numbers. A balance to find was how much colours and light that could be incorporated into the concept without disturbing the aesthetically appearance and get the expression of an 80's disco, but keep it tasteful and clear. The for a long time favoured idea of using differently coloured light inside the refrigerator to communicate different temperatures was therefore left. The reason was, besides the fear of using too much coloured light in the concept, which it would be too difficult for the project team to evaluate how it would be like. The food might look unappetizing and the appearance of the light would be dependent on the lighting in the room it is placed.

The project team believe the warm top surface adds value to Louise with emotional benefits - supporting her social lifestyle when for example dining in the kitchen and enhancing the experience of food preservation and management. It is a feature which makes the product unique and something to talk about with friends and can therefore be regarded as an application of the strategies *Attention drawing design* and *Value adding design*, which might lead to the spreading of sustainable refrigerator usage and a point of sales for Electrolux.

Since Louise is a trendsetter she likes having products that are new and different, and that is what Pompador is compared to existing refrigerators. She could be the first of her friends to have sustainable refrigerator behaviour and feel unique and smart when using the refrigerator heat in a clever way and thawing food knowing she saves energy. The form design was of great importance to make Pompador look unique and be a product people talk about in contrast to the anonymous approach most have to their refrigerators today. Pompador has a more furniture like approach in its design rather than a classical white goods design, which was seen as a coming trend on the market, This also make it differentiated from other refrigerators, and Louise is attracted by products that are unique and different without being extreme. However, the layout of the product has a downside; drawers on a low level do not offer good ergonomics for tall people. But when it comes to full height refrigerators shelves on low levels are not good either, they are even worse when it comes to loading, unloading and overview. Convenience is important for all people and some might discard this refrigerator because of the expected bad ergonomics. But on the other hand the overview of food is much improved, it is easier to keep good order and the drawers at the higher level are very accessible.

For the target group uniqueness, organization, a healthy life-style, high quality and premium appliances, socializing, experiencing new things and self-expression are important. Pompador meets many of these factors by for instance the unique appearance, the top surface, the new way of food management, the improved organization of foodstuff and the possibility to customize the interface. Pompador is also a product that involves more sensory modalities in the communication with the user and an enhanced experience when using it. This is achieved for example with the pattern that can emerge on the vertical glass and the hidden tactile pattern which surprises inside the towel hanger space. The target group will

probably find this attractive since it makes her product special. The ability to even more customize the product was discussed and for example a system where the exterior of Pompador could be connected to a service where it could be changed and updated. The team however discarded that idea, due to its complexity, since it would increase the demand of material used during the product's life cycle and due to the fact that it might not be used and not be perceived as premium. The team found it better to focus on a "classic look with a twist" to make it stand out.

12. Conclusion

The goal of this Master's Thesis Project was to develop a product concept answering the question: How can an attractive cold food preservation product be designed with a meaningful added value, where the good usability makes the user utilize its technological potential in an optimal way, resulting in a more sustainable behaviour?

The goal has been achieved and the question formulation answered through the final concept, Pompador. Pompador offers an improved way of preserving food and raises the users' awareness of storage conditions and energy consumption. Pompador enlightens the user of the consequences of the unwanted target behaviours. Thanks to the improved feedback on temperatures and the supporting features with high usability for thawing and chilling food, a convenient way of managing it with a more sustainable behaviour is encouraged, and unnecessary food and energy waste avoided. The design and the multiple communications of the correct food placement enables the user to preserve food better and therefore potentially waste less. To ensure that food will be consumed before going off, Pompador offers the intuitive EatSoonZone supporting the user to remember food before it is too late.

The total design of Pompador expresses Electrolux's brand and design values, and responds to the target users preferences. The warm surface and towel dryer are new unique features that contribute to make Pompador forward-thinking and different in a way that matches Electrolux professional heritage and gives emotional benefits to the target user.

The project team hopes that this product concept has inspired Electrolux to focus more on the sustainability of the use phase of products in the design and development, and wish that they would challenge the competition with at least some of Pompador's functions in the future.

13. Recommendations

Since this project has resulted in a concept that is for the future, mainly focused on changing the user behaviour to be more sustainable, there are some aspects that need to be further developed and/or tested. The project team has constituted this list of recommendations of aspects to consider if continuing the development of Pompador.

» All behaviour changing features such as the feedback with light on drawers, the thawing and chilling support and the different means of communicating product placement should be tested in user tests on a functional prototype for a period of time for the effectiveness to be validated and the functionalities to be optimized. More specifically it is recommended to evaluate the worst-case scenarios of wrong placement of food in the refrigerator to see if it can affect the foods durability in a worse way compared to current refrigerators.

» The thawing and chilling timer functions has to be developed more into detail so they work when several events take place simultaneously (see HTA in appendix XVIII). In this state there is no solution for how to use the two different timer functions at the same time and the chilling function is not functional when the warm surface is active. Thawing is possible, but not chilling, and this is recommended to find solutions for. Also the particular technology for the temperature indications, whether it should be thermocromic glass/paint or LEDs or a display reacting on data from sensors.

» The particular sound of the timer signal is important. It is recommended to make it very pleasant and not aggressive or irritating. Both how and when and with what frequency it should sound should be evaluated. For example could it be an alarm if too warm food is placed in the refrigerator. However, alarms are recommended to treat with care, since they can be very annoying.

» That the heat used for drying towels and for warming the top surface is produced by the refrigerator when cooling the refrigerator interior, and not generated additionally, should be communicated to the user in a clearer way to show the "direct use" of the heat.

» The choice of materials should be looked over carefully to find material with the lowest possible negative environmental impact and high recyclability. That the parts are mounted for disassembly should be ensured and as use of the most energy efficient technology possible to all functions.

» To further expand the connection to the consumers and increase the product sustainability, a well-developed service program is recommended. In this program should, apart from service of the product if anything would happen, for instance upgrades of the software be offered.

» Related to the service system a VIP-portal on the Internet, just as there is for Electrolux's

professional products, is recommended. This portal should offer the possibility to order additional insets such as special cheese boxes or water containers specially designed for Pompador. These additional features could also come in limited editions or be designed in corporation with different brands or famous designers. Other features of the VIP-portal could be the possibility to download new themes for the interface, to share and access recipes and food preservation suggestions from professionals et cetera.

» The look of the interface should be improved. Now has mostly existing symbols been used and little effort been put on the graphic design, choice of colours etc. Another idea to investigate is if the earlier mentioned application for external devices should be developed to incorporate more of the functionalities of the display so that the display on Pompador could be more streamlined or even removed.

» The application could possibly also involve food-planning aids, since bad planning was identified as a great contributor to food waste. The applications could help people to plan grocery shopping and how to use groceries about to go off. Similar applications already exist, but the project team recommend Electrolux to develop an own for the product with the possibility to be used with more Electrolux products. Make it fun to plan!

» An introduction demo video/augmented reality projection or some sort of movie introducing the product and its function should be developed to be displayed for the user prior the first use. This demo should highlight the most important functions from the sustainable behaviour point of view and above all explain the product placement and how more information about it can be found. There could also be a learning mode in the product, giving the user more guidance in the beginning, or even magnets or stickers for the user to put on the fronts to show what should be in each drawer until the user, especially children, has learned it by heart.

» There should also be a "child lock" on the drawer so that small children or the dog will not accidentally open them, since they are push-to-open. This lock should easily be managed from the display or application.

» For vegetarians and people who of any reasons do not eat meat, it is recommended to offer an additional fruit and vegetable drawer to replace the fish/meat drawer with. There should also be a special "vegetarian edition" of the interface without the animal products. Regarding the interface, the project team recommend to develop some different versions and settings for different geographical regions. For example do the characteristic foodstuff symbols differ locally.

» If Pompador would be sold outside Europe it would be important to develop an interface that is suitable for other countries food cultures and languages.

» All interior parts that are possible to lift out should be developed to be able to clean in the dishwasher.

References

von Atta, B., 1986. Raymond L., 92, a pioneer in design. Philadelphia inquirer, [online] Available at: <http://search.proquest.com/docview/293868964?accountid=10041> [Accessed 24 February 2012].

Bhamra, T, A., Lilley, D. and Lofthouse, V., 2005. Towards Instinctive Sustainable Product Use. Presented at: *the 2nd International Conference: Sustainability Creating the Culture.* Aberdeen, Scotland 2-4th November 2005. Leicestershire: Loughborough's Institutional Repository.

Bhamra, T, A. and Tang, T., 2009. Understanding User Behaviour to Reduce Environmental Impacts through Sustainable Product Design. In: Undisciplined! Design Research Society Conference 2008, Sheffield Hallam University, Sheffield, UK, 16-19 july 2008.

Bhamra, T, A., Lilley D. and Tang, T., 2008. Sustainable Use - Changing consumer behaviour through product design. Proceedings of: *Changing the Change*, Torino, 10th-12th of july 2008: Publisher: Changing the change, Pages: 1-13

Bligård, J-O., 2008. Teoretiska metoder för utvärdering av användargränssnitt, *MMT030 Usability*. PPU Chalmers University of Technology, unpublished.

Brains, Behaviour & Design, 2011. *Brains, Behaviour & Design Group*. [online] Available at: <http://www.brainsbehavioranddesign.com/> [Accessed 4 March 2012].

Carlberg Felicetti, A. (Regional Category Manager, Nordic Region, Electrolux Professional AB), 2012. *Presentation of Electrolux Professional*. [conversation] (Personal communication, 11 January 2012)

Corrado, M., 2007. *Understanding Consumer Food Management Behaviour*. UK:WRAP (the Waste & Resource Action Program).

Darby, S., 2000. Making it obvious: designing feedback into energy consumption. Proceedings of the *2nd International Conference on Energy Efficiency in Household Appliances and Lighting*. Italian Association of Energy Economists / EC-SAVE programme.

Desmet, P.M.A., 2003. Measuring Emotions: Development and application of an instrument to measure emotional responses to products, in: M.A. Blythe, A.F. Monk, K. Overbeeke, & P.C. Wright (Eds.)

Diamond, J., 2005. Collapse; How societies choose to fail or succeed. [Online] London: Penguin group. Available at: http://www.revalvaatio.org/wp/wp-content/uploads/diamond-collapse-how-societies-choose-to-fail-or-succeed.pdf [2011-12-09].

Dinçer, I., Kanoğlu, M., 2010. *Refrigerator systems and applications.* 2nd Edition. Chichester: John Wiley & Sons, Ltd.

Doppio, 2012. Doppio fridge. [online] Available at: <http://www.doppiohome.com/swe/product/fridge/doppio_fridge_press.pdf> [Accessed 14 January 2012].

DuPont, 2012. *Corian® - En värld av inspiration*. [online] Available at: <www.corian.se > [Accessed16 February 2012].

Electrolux Group, 2011a. About Electrolux. [online] Available at: http://group.electrolux.com/en/about-electrolux-492/ [Accessed 17 October 2011].

Electrolux Group, 2011b. Company overview. [online] Available at: http://group.electrolux.com/en/company-overview-271/ [Accessed 17 October 2011].

Electrolux Group, 2011c. Electrolux a Premium brand. [Online] Available at: http://group.electrolux.com/en/electrolux-a-premium-brand-510/ [Accessed 29 November 2011].

Electrolux Group, 2011d. History Timeline. [online] Available at: http://group.electrolux.com/en/category/about-electrolux/history/history-time-line/ [Accessed 17 October 2011].

Electrolux Group, n.d. Our Values. [Online] Available at: http:// group.electrolux.com/en/our-values-2619/ [Accessed 17 October 2011].

Elias, E., W. A., Dekoninck, E. A. and Culley, S., J., 2007. The Potential of Domestic Energy Savings through Assessing User Behaviour and Changes in Design. In: EcoDesign 2007: 5th International Symposium of Environmental Conscious Design and Inverse Manufacturing, 10-13 December 2007, Tokyo, Japan.

Engfeldt, C., 2009, Boskapsuppfödningen, [Online] Stockholm: FAO Nordic, available at: http://www.fao.org/liaison/nordic/67545/se/ [Accessed 20 February 2012].

European Environment Agency (EEA), 2011. *Final energy consumption bu sector in the EU-27, 1990-2008.* [online] Available at: <http://www.eea.europa.eu/data-and-maps/figures/final-energy-consumption-by-sector-4> [Accessed 27 January 2012].

Feinberg, J, 2011. *Wordle*. [online] Available at: <http://www.wordle.net/> [Accessed 4 March 2012].

George, R. M., Burgess, P. J. and Thorn R. D., 2010. Reducing food waste through the chill chain. *Waste & Resources Action Programme*, [online]. Available at: <http://www.wrap.org.uk/downloads/Reducing_food_waste_through_the_chill_chain.e 9074f03.9600.pdf> [Accessed 4 April 2012].

Geppert, J. and Stamminger, R., 2010, Do consumers act in a sustainable way using their refrigerator? The influence of consumer real life behaviour on the energy consumption of cooling appliances. *International Journal of Consumer Studies,* 34 pp. 219–227

Grunewald, P, 1999. Environmental report 1999. [Online] Electrolux group. Available at:<http://group.electrolux.com/en/wp-content/uploads/2010/03/Electrolux-Environmental-Report-1999-Swedish.pdf> [Accessed 21 December 2011].

ISIS, 2007. Preparatory Studies for Eco-design Requirements of EuPs. LOT 13: Domestic Refrigerators & Freezers. Final Report, Draft Version Tasks 3-5. [online] *ISIS*. Available at: <http://www.ebpg.bam.de/de/ebpg_medien/013_studyf_08-12 _part3-5.pdf> [Accessed 4 April 2012].

Johannesson, H., Persson, J.G., Pettersson, D. 2004. *Produktutveckling - effektiva metoder för konstruktion och design.* Stockholm: Liber AB.

Johansson, L. (Senior Designer IDC EMEA), 2012. *Information about manufacturing and materials*. [letter] (Personal communication, 21 March 2012)

Jordan, P. W., 1998. *An Introduction to Usability.* London: Taylor and Francis.

Karlberg, L.A., 2005. Det tysta kylskåpet från Motala fyller 80 år. Ny Teknik, [online]_3 Oct. Available at: http://www.nyteknik.se/popular_teknik/kaianders/article244709.ece [Accessed 30 November 2011].

Karlsson, MariAnne (2007). Lyssna till kundens röst. Appendix till kurskompendium. Chalmers Tekniska Högskola, inst. för Produkt- och produktionsutveckling, avd. Design, 2008.

Karlsson, J. (Laboratory Manager at AB Electrolux Mariestad Factory), 2012. *Discussion about refrigerator energy efficiency and the technological feasibility of the project teams concept.* (Meeting during visit at the Electrolux manufacturing facility in Mariestad, 9 February, 2012)

KES Science and technology, Inc, n.d. *KES ethylene technology.* [pdf] s.l: KES Science and technology, Inc.

Krische, B. (Dr., Global Advanced Development Dish Care Electrolux), 2012, *Discussion about materials and recycling and refrigerators.* [interview] (Personal communication, 22 March 2012)

Konsumentföreningen Stockholm (KfS), 2009. Släng inte maten, en liten guide för plånboken och miljön. [pdf] Available at: <http://slangintematen.se/> [Accessed 13 April 2012]

Lidman, K. and Renström, S., 2011. *How to Design for Sustainable Behaviour? A review of design strategies and an empirical study of four product concepts.* M.Sc. Chalmers University of Technology.

Lilley, D., 2009. Design for Sustainable Behaviour: Strategies and Perceptions. *Design Studies* (30), p. 704-720

Lockton, D., Harrison, D. and Stanton, N., 2008. Making the user more efficient: design for sustainable behaviour, *International Journal of Sustainable Engineering*, 1:1, p. 3-8

van der Lugt, R., 2004. A quick and dirty introduction to scenario learning **In:** Strappers, P. J. et al. eds. 2007. *Context and Conceptualization ID4215.* Delft: TU Delft Faculteit Industrieel Ontwerpen. pp 189-197.

Lyndhurst, B., 2007. Food Behaviour Consumer Research: Quantitative Phase. *Waste & Resources Action Programme*, [online]. Available at: <http://www. wrap.org.uk/retail_supply_chain/research_tools/research/report_food_waste_.html> [Accessed 4 April 2012].

Lyndhurst, B., 2010. Helping Consumers Reduce Food Waste – a Retail Survey. *Waste & Resources Action Programme*, [online]. Available at: <http://www.wrap.org.uk/downloads/Summary_report_-_a_retail_survey.67111af5.9623.pdf> [Accessed 4 April 2012].

Lyndhurst, B., 2011. Consumer Insight: Date Labels and Storage Guidance. *Waste & Resources Action Programme*, [online]. Available at: <http://www.wrap.org.uk/downloads/Technical_report_dates_final.caeb040c.11175.pdf> [Accessed 4 April 2012].

Maylor, H., 2010. *Project Management*, 4th edition, England: Pearson Education Limited.

McMahon, J.E., 2008. *Appliances: Designs and Standards for Sustainability*. Berkeley (California), 1-2 March 2008, Berkeley: AIP (American Institute of Physics) Conference Proceedings.

Modin, R., 2011. Livsmedelssvinn i hushåll och skolor–en kunskapssammanställning, *Livsmedelsverkets rapportserie*, [online]. Available at: <http://www.slv.se/upload/dokument/rapporter/mat_miljo/2011_livsmedelsverket_4_livsmedelssvinn_i_hushall _och_skolor.pdf > [Accessed 4 April 2012].

Modin, R., Lindblad, M., 2010. Förvara maten rätt så håller den längre- vetenskapligt underlag om optimal förvaring av livsmedel, *Livsmedelsverkets rapportserie* [online]. Available at: <http://www.slv.se/upload/dokument/rapporter/matforgiftning_ mathantering/2011_Livsmedelsverket_20_forvaring_och_hallbarhet.pdf> [Accessed 4 April 2012].

Nickles, S., 2002. "Preserving Women" Refrigerator Design as Social Process in the 1930s.Technology and Culture, 43(4), p. 693-727.

Nidumolu, R., Prahalad, C.K., and Rangaswami, M.R., 2009. Why Sustainability Is Now the Key Driver of Innovation. *Harvard Business Review.* Vol. 87, No. 9, 57-64.

Oehlberg, L. A., Agogino, A. M. and Beckman, S., 2009. Framing Sustainability in Human-centered Product Design. Proceedings of the ASME 2009 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference IDETC/CIE 2009 August 30-September 2, 2009, San Diego, California, U.S.A.

Olsson, S. (Industrial Designer Colors and Materials Electrolux IDC), 2012. *Discussion about materials and recycling*. [conversation] (Personal communication, 22 March 2012)

Persson, M., Hemberg, S., 2010. *Eco-Branding : lyft ditt varumärke med ekologisk kraf*t. Liber AB, Malmö.

Quested, T. and Johnson, H., 2009. Household Food and Drink Waste in the UK. *Waste & Resources Action Programme*, [online]. Available at: <http://www. wrap.org.uk/downloads/Household_Food_and_Drink_Waste_in_the_UK_Nov_2011. 280df559.8048.pdf> [Accessed 4 April 2012].

Selvefors, A., Blindh Pedersen, K. and Rahe, U., 2011. Design for Sustainable Consumption Behaviour - Systematising the use of Behavioural Intervention Strategies. Proceedings of *DPPI 11, the 5th conference on Designing Pleasurable Products and Interfaces.* 22-25 June 2011, Milan, pp. 19-26

Sempler, K., 2005. Einstins kylskåp. Ny Teknik, [online] 25 May. Available at: http://www.nyteknik.se/popular_teknik/kaianders/article242878.ece [Accessed 30 November 2011].

Sleeswijk Visser, F., Strappers, P. J. and van der Lugt, R., 2007. Context mapping: a hands-on introduction **In:** Strappers, P. J. et al. eds. 2007. *Context and Conceptualization ID4215.* Delft: TU Delft Faculteit Industrieel Ontwerpen. pp 25-50.

Stamminger, R., 2011. *Modelling of domestic refrigerators' energy consumption under real life conditions in Europe*. Ph. D. The University of Bonn.

Stappers, P. J., 2005. A miniature motion to mindmaps **In:** Strappers, P. J. et al. eds. 2007. *Context and Conceptualization ID4215.* Delft: TU Delft Faculteit Industrieel Ontwerpen. pp 115-118.

Stompff, G., 2008. Embedded Brand: The Soul of Product Development. *Design Management Review,* Vol. 19 (2), p. 38-46.

Tang, T., 2010. Towards Sustainable Use: Design Behaviour Intervention to Reduce Household Environmental Impact. Ph.D. Loughborough University.

Torberger, P., 2009: Miljömärk varumärket rätt. *Resumé 1-3*, 15 jan 2009. (Pdf: core company archetypes.pdf)

UN (United Nations)., 2011. *UN urges food sector to reduce fossil fuel use and shift to 'energy-smart' agriculture.* [online] UN News Centre. Available at: < http://www.un.org/apps/news/story.asp?NewsID=40579> [Accessed 14 January 2012]

USDA, 2011. *Food Product Dating.* [online] (16 Sept 2011) Available at: <http://www.fsis.usda.gov/Factsheets/Food_Product_dating/index.asp#4> [Accessed 12 March 2012].

Verma, S., 2010. Energy-Efficient Buildings - A Way To Break The Deadlock. [online] Available at: <http://youthconnect.climateofconcern.org/cc_blog/article.php?a=235&section=youthvoice> [Accessed 14 January 2012].

Viet, T.P. (Project Manager, Advanced Technology Electrolux), 2012. *Discussion about refrigerator technology and construction*. [conversation/letter] (Personal communication, 1 February, 21 March, 5 April and 12 April 2012)

Wever, R., van Kuijk, J., and Boks, C., 2008. User-centred design for sustainable behaviour. *International Journal of Sustainable Engineering*. Vol. 1, No. 1, 9-20.

Wikström, P-O. 2008. Models, *MMF220 Skiss och modellteknik*. Industrial Design Engineering, Chalmers University of Technology, unpublished.

WRAP (the Waste & Resaouce Action Program), n.d. Simple tips for reducing food waste at home. UK: WRAP.

Wählby, U. (Global Primary Development Food Preservation Electrolux), 2011. *Introduction to refrigeration*. [conversation] (Personal communication, 8 November 2011)

Wählby, U. (Global Primary Development Food Preservation Electrolux), 2012. *Discussion about technical feasibility and possibilities*. [conversation/mail] (Personal communication, 12 February and 2012)

Österlin, K., 2003. *Design i fokus för produktutveckling*, Malmö: Liber AB

Anon., 2007. The new ice age. *Prince George citizen,* [online] Available at: <http://search.proquest.com/docview/361837291?accountid=10041> [Accessed 24 February 2012].

IMAGE REFERENCES

** Image belonging to Electrolux*
*** Image made by and belonging to the team*

Images Chapter 1

Fig.1.1: Evoluted E*

Images Chapter 2

Fig.2.1: DSCB intervention methods (Selvefors, Blindh Pedersen and Rahe, 2011
Fig.2.2: The cycle of consumption. (Selvefors, Blindh Pedersen and Rahe, 2011
Fig.2.3: The DSCB design process; described in its six steps. (Selvefors, Blindh Pedersen and Rahe, 2011)
Fig 2.4: Basic model of product emotions. (Desmet, 2003)
Fig.2.5: Eco-types. Image received by the Core Company.
Fig.2.6: The refrigerator; technical principle. (http-//www.solarpowerwindenergy.org/wp-content/uploads/2009/06/refregiratorparts)
Fig.2.7: Energy efficiency labeling. (http://ec.europa.eu/energy/efficiency/labelling/energy_labelling_en.htm)
Fig.2.8: Simplified LCA.**

Images Chapter 3

Fig.3.1: Model of how to reach peoples' knowledge. **

Images Chapter 4

Fig.4.1: Project process.**

Images Chapter 5

Fig.5.1: Function analysis.**
Fig.5.2: Usage situations.**
Fig.5.3: 24h with the fridge.**
Fig.5.4: Kitchen context:

1. Poggenpohl (http://www.poggenpohl.de/en/)
2. Gaggenau (http://gaggenau.com/)
3. Gaggenau (http://gaggenau.com/)
4. Bulthaup (http://www.en.bulthaup.com/)

5. Siematic (http://www.siematic.com/Startseite_Corporate_EN.htm)
6. Alno (http://www.alno.com/)
7. Poggenpohl (http://www.poggenpohl.de/en/)
8. Siematic (http://www.siematic.com/Startseite_Corporate_EN.htm)
9. Bulthaup (http://www.en.bulthaup.com/)
10. Poggenpohl (http://www.poggenpohl.de/en/)
11. Franke (http://www.franke.com/kitchensystems/uk/en/home.html)
12. Siematic (http://www.siematic.com/Startseite_Corporate_EN.htm)
13. Bulthaup (http://www.en.bulthaup.com/)
14. Siematic (http://www.siematic.com/Startseite_Corporate_EN.htm)
15. Siematic (http://www.siematic.com/Startseite_Corporate_EN.htm)
16. Siematic (http://www.siematic.com/Startseite_Corporate_EN.htm)

Fig.5.5: Food flow.**
Fig.5.6: The persona:

1. http://www.deviantart.com/download/212644950/starbucks_coffee_by_saldon-d3ilpw6.jpg
2. www.shoeperwoman.com/2009/09/chloe-frill-back-court-shoes.html
3. http://www.thewildercoast.com/2011/08/nyc-writers-conference.html
4. http://www.homedosh.com/zero-g-lighting-a-unique-lighting-design/
5. www.designscene.net/2010/10/wallpaper-november-2010-bianca-balti-gianluca-fontana.html
6. http://www.poshtots.com/gear/strollers/single-strollers/bugaboo-cameleon-sand-stroller-with-pink-fabric/21/1523/1115/11330/poshproductdetail.aspx
7. http://motorride.net/bwm/bwm-2011-activehybrid-750li-owners-manual.html/
8. http://thepwpfamily.myfullseat.com/events/653501-PUNKS-WEAR-PRADA-PRESENTS-PWP-MOUSTACHE
9. www.daytondailynews.com/blogs/content/shared-gen/blogs/dayton/loungelizards/entries/2010/02/10/10_perfect_pink_cocktails_for.html
10. http://www.norway.org.uk/NR/rdonlyres/10EA85CF5010436CB6FDC6B5539407C1/97843/Copenhagen_TveitTornoeblac.jpg
11. http://dansaskrattaleva.blogspot.se/2010/05/steppad-och-klar.html
12. http://www.belowtheclouds.com/2008/07/03/brunopasso-pd-1/
13. http://bästa.nu/mobilen/

Fig.5.7: Louise.**

Fig.5.8: Brand eye:

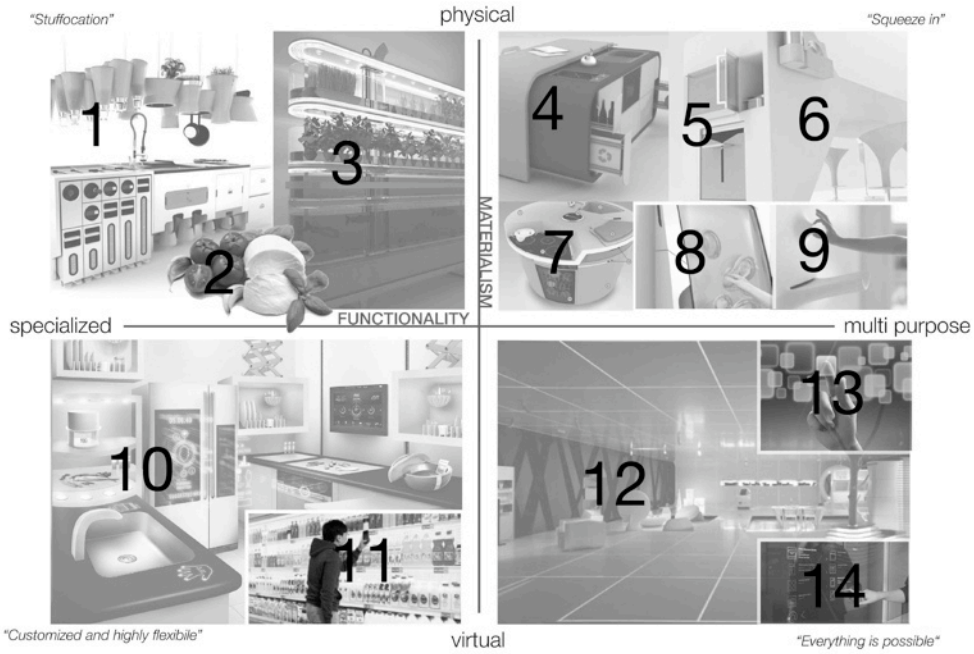
1. *
2. **
3. *
4. http://5election.com/2011/01/21/what's-in-your-glass-of-water/
5. *
6. http://wakefieldcommunications.com/wp-content/uploads/2012/03/ear.jpg
7. *
8. *
9. *
10. http://www.sxc.hu/browse.phtml?f=download&id=1108601
11. http://farm4.static.flickr.com/3276/2867735314_087feb1f0a.jpg
12. *
13. http://qblc.queensu.ca/qblcBlog/plantInHand.jpg
14. *
15. *
16. *
17. Source the same as nr.3 in the Expression board
18. *
19. *
20. *
21. *
22. *
23. http://www.flickr.com/photos/cornelluniversitylibrary/3857207084/
24. *

Fig.5.9: Design cues.** (Image used; http-_newsroom.electrolux.com_se_wp-content_common_photos_sweden_favola-plus-beige)
Fig.5.10: The Electrolux logo.*

Fig.5.11: Expression board:

1. http://www.designboom.com/weblog/cat/8/view/12677/emma-nilsson-johanna-westin-lisa-frode-pa-sofflocket.html
2. http-_2.bp.blogspot.com__Dwex9AQ8IuA_SfIwEqHTmCI_AAAAAAAAFNY_V3EhJM-NK6A_s400_beet-avocado-salad-400-8
3. http://www.digsdigs.com/electrolux-aurora-illuminated-induction-cooktop/
4. http://blog.incipeindustries.com/wp-content/uploads/2010/07/Bang-Olufsen-BeoSystem-3-1024x782.jpg
5. http-_newsroom.electrolux.com_se_wp-content_common_photos_sweden_favola-plus-beige

Fig.5.12: Siemens ”FreshnessCentre”. (www.siemens.com)
Fig.5.13: Samsung I-Fresh. (http://www.globaltimes.cn/attachment/110422/fde51db49c.jpg)
Fig.5.14: Infinity.*
Fig.5.15: Fisher & Paykel. (http://kitchendesign.ie/wp-content/gallery/cooldrawer/fisher-paykel-cooldrawer-inside-view.jpg)
Fig.5.16: Norcool.**
Fig.5.17: Future scenario matrix:



1. http://theidesignbox.com/wp-content/uploads/2010/07/Picture1.jpg
2. http://elenasc.wordpress.com/2010/09/02/italian-food-stereotypes-no-grazie/
3. http://ecogadget.net/wp-content/uploads/2009/10/article-0-06C868E4000005DC-24_468x5371.jpg
4. http://www.visualsupercomputing.com/wp-content/upload-images/future-kitchen-3.jpg
5. http://www.dexigner.com/news/12854
6. http://www.dexigner.com/news/12854
7. http://img.weburbanist.com/wp-content/uploads/2010/01/modern-all-in-one-kitchen-concept.jpg
8. http://www.philippawagner.co.uk/uploads/article_1277801347_screen-shot-2010-06-29-at-09.11.38.png
9. Intuitive features. 2011. https://www.lsnglobal.com/
10. http://homesandtravel.co.uk/wp-content/uploads/2010/08/IKEA-Skarp_plain.jpg
11. http://yinnyang.co.uk/wp-content/uploads/2011/09/Tesco-HomePlus-Virtual-Subway-Store.jpg
12. http://www.increaseroom.com/wp-content/uploads/2011/10/Futuristic-Interior-Tron-Legacy-Movie.jpg
13. http://www.prometheanlight.com/wp-content/uploads/2011/09/advancement-of-technology.jpg
14. http://itechfuture.com/kitchens-of-the-future/

Images Chapter 6
All images **

Images Chapter 7
All images **

Images Chapter 8
8.24: Distribution of cold air. (Trung, 2012)
All remaining figures **

Images Chapter 9
All images **

Appendix

I. User behaviour

II. Product experience

- Sensory perception
- Design for emotions
- Semantics
- Usability

III. Food storage specifications

IV. Project planning: Gantt charts

V. Mind maps

- Premium
- Barriers, problems etc.

VI. Interaction sequences

VII. PESTED-analysis

VIII. Survey:

- Online form
- Responses
- Additional findings
- Quotes about refrigerator personality

IX. Context mapping:

- Workbook
- The participants' refrigerators
- Generative session set up
- PrEmo assignment
- Future assignment

X. Barriers matched with problems

XI. Need and demand list

XII. Idea generation: early ideas and sketches

XIII. Part concepts

- The Organized
- The Professional
- The Communicator
- Additionals

XIV. Evaluation

- Functions vs focus area for sustainable behaviour
- Part concepts vs. need and demand list
- Functionality, Electrolux, persona & DfSB

XV. Semantics and food associations

XVI. Form development

- Sketches
- From part to final concept

XVII. Calculations

- Wall thickness
- Placement of warm food
- Energy consumpion

XVIII. Final concept evaluations

- HTA
- CW and PHEA

APPENDIX I: **User behaviour**

In order to change users' behaviour it is needed to have an understanding of how behaviours arise and what the influencing factors are, or as Klöckner and Blöbaum (2010) puts it: "Understanding, explaining and changing human behaviour are the main objectives of psychology in general". Behavioural and social psychology is a large field of science on its own, and therefore will only some important facts and models be briefly presented in this report. In psychology are human behaviour often divided into internal aspects, such as attitudes, values, habits and personal norms, and external aspects, like incentives, institutional constraints and social norms. In addition there are also the key influences, which do not fit into these two categories, and therefore often missed out in models of behaviour (Zachrisson and Boks, 2010). These casual influences are important to focus on because they are active when the user interacts with a product, and have thus to be considered in design for behavioural change. There are many models attempting to include several of the mentioned influences, but these are often too complex to be effective. Triand's theory presented by Bhamra, Lilley and Tang (2008) is one of the more successful models including several influences.

How the user act depends on what intentions and habits s/he has and what is in the control of the user (Bhamra, Lilley and Tang 2008). According to Andersson's theory three stages of the development of cognitive skills can also be identified, these are the Declarative stage when facts about the skill domain are interpreted, the Knowledge compilation stage when knowledge is converted into procedures that can be applied without any further interpretation and the Procedural stage, which is where the processes can be speeded up because the knowledge is applied more appropriately (Zachrisson and Boks, 2010).

Intentions are made up by three factors. The first is the users' attitudes, which in turn depends on what knowledge and beliefs they have. Secondly are social factors, such as norms, roles and self-concepts. Lastly there is the affect, which depends on emotions. (Zachrisson and Boks, 2010) Emotions can be elicited by products and also depends on the context. Habits are formed depending on the frequency of past behaviour, and it is important to point out that habits are only one of several factors affecting the behaviour (Zachrisson, Boks, 2010). Triand's theory also encompasses strategies for changing behaviour ordered on a scale from "user in control" to "product in control" and can be found in figure AI.1.

Another model explaining behaviour, which is easier to grasp but has been criticized for being too simplified, is the Comprehensive Action Determination Model (CADM) by Klöckner and Blöbaum (2010), fig.2. The model is based on three theories (the theory of Planned Behaviour, the Norm-Activation model and the theoretical concept of habit and Ipsative Theory of behaviour) and aimed to remove the limitations and to create a model including external as well as internal factors.

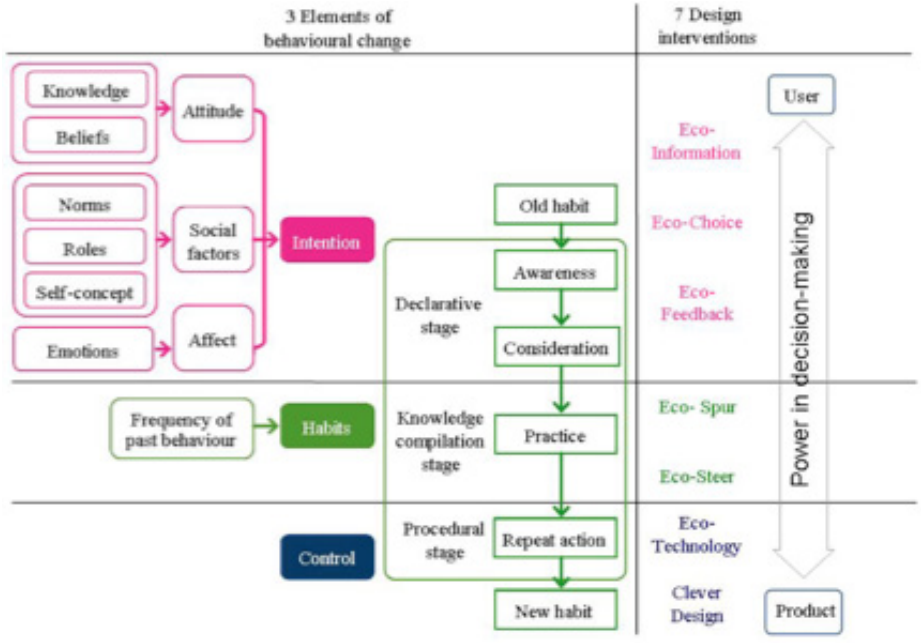


Fig.AI.1: Triand's theory (Bahmra et al. 2008)

(Zachrisson and Boks, 2010). The CADM explains that individuals' sustainable behaviour is directly determined by influences from three sources, namely habitual, intentional and situational. (fig. AI.2)

When looking into the theory of planned behaviour, where cognitive self-regulation is an important part (Ajzen,1991) there are some critical issues to be aware of. Intentions are central also in this theory, and Ajzen (1991) defines intentions term capturing the individuals' motivational factors influencing the behaviour. That is an indication of how much effort the person is willing to put down in order to perform the behaviour. Thus stronger intentions imply higher likelihood to perform the intended behaviour.

Ajzen (1991) also presents the old idea of that behavioural achievements depends on intentions (i.e. motivation) and behavioural control (ability). The perceived behavioural control plays an important role since if not the opportunities available to a person indicate the likelihood of a behavioural achievement, the behaviour will not probably be achieved. Therefore perceived behavioural control together with behavioural intention can be used directly to predict behavioural achievements (Ajzen,1991). However, in different situations and applications either perceived behavioural control or intentions can be more significant for the behaviour prediction, and sometimes only one of the predictors are enough (Ajzen,1991). As an example and a general rule it has been found that when behaviours do not pose any serious problems of control they can be predicted from intentions with good accuracy, for instance when having choice among a set of alternatives (Ajzen,1991).

Intentions are made up by three independent determinants according to the theory of planned behaviour. First is the attitude towards the behaviour, referring to the degree of favourable/unfavourable evaluation of the behaviour. The second predictor is the subjective norm, which is a social factor referring to the perceived social pressure. Finally there is the degree of perceived behavioural control referring to how difficult or easy a person perceive the performance of a behaviour. Each of these three predictors can also be regarded as a point of attack in attempts to change behaviour. (Ajzen,1991)

A rule of thumb is that the more favourable the attitude or subjective norm is towards a behaviour, the greater the behavioural control is and the stronger the individuals' intentions to perform the behaviour are. (Ajzen,1991)

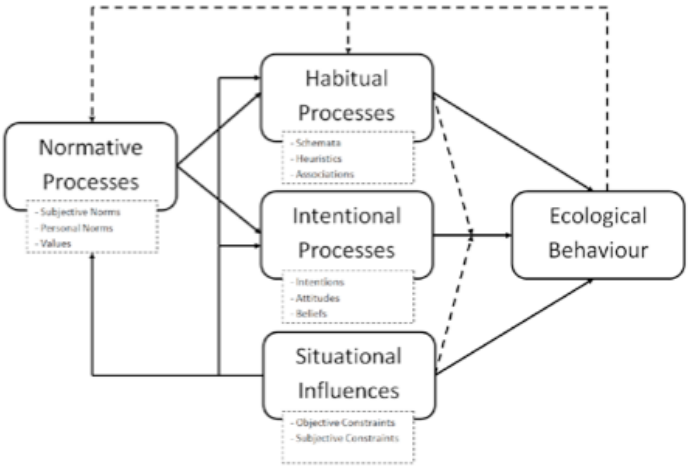


Fig.AI.2: The CADM model, (Klöckner and Blöbaum, 2010)

References

Ajzen, I., 1991. The Theory of Planned Behavior, *Organizational behaviour and human decision processes*, 50, p. 179-211, *University of Massachusetts at Amherst*.

Bhamra, T., A., Lilley D. and Tang, T., 2008. Sustainable Use - Changing consumer behaviour through product design. Proceedings of: *Changing the Change*, Torino, 10th-12th of july 2008: Publisher: Changing the change, Pages: 1-13

Klöckner, C. And Blöbaum, A., 2010. A comprehensive action determination model: Toward a broader understanding of ecological behaviour using the example of travel mode choice. *Journal of Environmental Psychology*, Vol 30 (4), p. 574-586

Zachrisson, J. and Boks, C., 2010. When to apply different design for sustainable behaviour strategies?. In: *Knowledge Collaboration & Learning for Sustainable Innovation ERSCP-EMSU conference*, Delft, The Netherlands, October 25-29, 2010, Trondheim: Norwegian University of Science and Technology

APPENDIX II: **Product experience** - *sensory perception*

In order to influence users' behaviour there are several different interrelated factors which affect how the user will act and how s/he will experience a product. In the context of product use, the user through stimuli perceived by the sensory modalities experiences the product. These stimuli can elicit emotional reactions and result in different kinds of behaviours. Thus, the usability, the semantics, sound, touch, smell, looks and taste of the product together with the concerns of the user evoke different behaviours and reactions in the certain context. The user experience is particularly central when it comes to designing a product with a strong user attachment.

Sensory perception

Designs intended to be perceived by several sensory modalities simultaneously, known as multisensory product experience or multimodal interaction is key to create rich product experiences. Schifferstein and Hekkert (2007) states that by designing products stimulating several of our sensory modalities at the same time the product experience is likely to be richer, but it is important that the messages sent out by the product is congruent enough. A bit of in-congruency might be welcomed in some cases. Because sometimes the designer may not want to communicate the same messages to all of the senses in order to evoke for instance surprise. In such cases the challenge is to combine familiarity with originality. Then it is important to assure that the product communicate the same message to most of the senses and that only one modality is responsible for the surprise effect to avoid confusion and misunderstandings.

Certain senses are more dominant and receptive for certain kinds of stimuli and types of information, and certain stimuli are typically perceived by multiple modalities. For instance there is commonly an overlap between vision and touch. Size just as shape can be perceived with both touch and vision and therefore it is beneficial if there are no contradictions or conflicts between what messages are sent to touch and vision. If the users expectations are not matched, disappointment may occur and therefore a coherent multimodal product experience can be linked to users product preferences. (Schifferstein and Hekkert, 2007)

Activating more sensory modalities in the product interaction has also become a usual way of communicating brand identity as an experience (Schifferstein and Hekkert, 2007). Moreover, it is not solely the sensory experience and physical interaction that determines the product experience. Sensory imagery and prior experiences in the mind of the user are also influencing how products are perceived.

APPENDIX II: **Product experience** - *design for emotions*

Design for emotions

Designing with the intention to evoke or prevent certain emotions, i.e. design for emotions, is facilitated by understanding the processes behind the emotions (Demir, Hekkert and Desmet 2009). Emotions are complex and their arousal is influenced by many factors. The same product in the same context can elicit different emotions in two persons depending on previous experiences and their concerns, for instance attitudes and values (see appendix II). Emotions can also be the reasons behaviours; for example a person who is very angry might shout and fight. Therefore design for emotions might be a good way to design in order to encourage certain behaviour, and in fact emotions include a strong behavioural component (Desmet, Hekkert, 2009).

Desmet and Hekkert (2009) define emotions and the function of emotional behaviour as "to safeguard our well-being in our relationship with the world and with everything that happens in it". People are constantly interacting with things and others in the surrounding, and in these interactions occurrences that might endanger the well-being can happen. The emotional behaviour is to adapt towards these occurrences aiming to strengthen the relationship with the things contributing to the well-being, i.e. positive emotions, and weaken the relationships with what is threatening the well-being, i.e. negative emotions. This implies that there is a relational aim oriented towards an ideal future state behind every emotional behaviour. (Desmet and Hekkert, 2009)

Desmet (2003) has made a basic model of product emotions (fig. AII.1). The model implies that there are four main parameters eliciting emotions, which are appraisal, object (product), concern and emotion. The first three of them and the interplay between them determines if and what emotion that is evoked. The appraisal is an automatic and non-intellectual evaluation of stimulus relevance for the personal well-being (Desmet, 2003). Emotions always come from a relation between an experience and a person. The object, also called the product in the model can be the object of the emotion sending out the stimulus. The stimulus can also be an event like someone telling someone something.

Concerns lie behind every emotion and could be for instance attitudes, values and self-images the user has, and concerns can be context dependent. Concerns can be defined as individual more or less stable points of reference for certain states of the world. When a stimulus is perceived from an object, its significance for the well-being is determined by if the appraised concern is matched or not. If the there is a match between the object and the concern it is appraised as beneficial; positive emotions are elicited, and if there is a mismatch with the concern are appraised as harmful, i.e. negative emotions are elicited. (Desmet, 2003)

Finally the fourth parameter - the emotion itself. As all affective concepts, emotions are intangible and therefore difficult to lay ones finger on. Emotions are often confused with moods, but the fact is that the two conceptions refer to different experiential phenomena. Moods have a long-term character whereas emotions often are limited to seconds. Another important difference between emotions and moods is that emotions unlike moods are involving one certain object that the person is experiencing, but emotions are also strongly influenced by moods and vice versa. (Desmet, 2003)

Based on the model of product emotions there are classifications of different types of product emotions such as aesthetic, social, interest, surprise and instrumental. Hence product emotions do not only rely on the aesthetics, as there is a common belief of, but also on functionality. These types of product emotions correspond to several kinds of appraisals, which can be associated with different sorts of emotions, and if the appraisal (and related concern) is known the emotion can be predicted. (Desmet, 2003)

Products that for the user have an attached value are often more respectfully treated than value-less things, and products are usually kept longer if it has an emotional value. (Lilley, Lofthouse, Bhamra, 2005) There are four product meanings that can be regarded as possible determinant factors of product attachment of ordinary products (Mugge 2007, Schifferstein and Hekkert 2008):

Self-expression: Expressing the consumer's unique identity

Group affiliation: Expressing the consumer's belonging to a group

Memories: Reminds the consumer of the past

Pleasure: Provides the consumer with pleasure

If a product conveys one or more of these meanings it can be regarded as having a special meaning compared to similar products that does not, and it

has the possibility to create a special bond to its user (Schifferstein and Hekkert 2008).

In her report Mugge (2007) writes that to evoke product pleasures that last for a long time the designer can incorporate surprise into the product. Pleasure eliciting surprise attributes can be particular for a specific product variant that no other variants can match completely. Past research shows that products that surprise the user are more enjoyable. (Mugge, 2007)

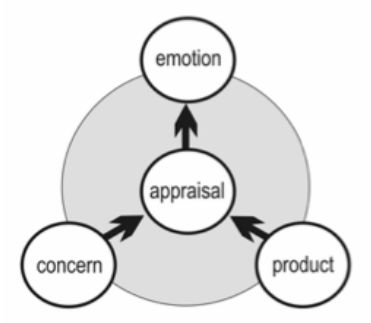


Fig.All.1: Basic model of product emotions. (Desmet, 2003)

APPENDIX II: **Product experience** - *semantics*

Semantics

Semantics comes from the science of Semiotics that can be explained as the study of signs, sign systems, their structure, properties and roles in socio-cultural behaviour. Signs could be more than just seen, they could also be heard, felt, smelt and tasted. Semiotics has three corner stones; syntax, semantics, and pragmatics. Where syntax is the context and the components surrounding the product, semantics is study of the message communicated by the product and pragmatics the physical and mental interaction with the product. (Wikström, 2007; Monö, 1997)

Aesthetics is the science of beauty and the experience of it, while semantics is the science of an object's significance. Semantics can be described by four functions:

Express. This is expressing a product's characteristics and properties though appearance and function. Form can be manipulated to express a quality a product does not posses. It is important to incorporate the company's business concept, the expectations from the targeted group and the product's purpose and function in its expression. It is important that the expression is in harmony with the other technical and semantic features of the product to not express characteristics as "dishonest".

Describe. This is describing a product's mode of operation through the product gestalt, totality of form, colour and surface structure for example.. Often it is more important to not make the description of operation unclear than to actually show the exact mode of operation.

Exhort. This is the signal message from a product. The function to exhort is always aiming at triggering a reaction in the user. Sometimes the exhort function is well disguised, other times is it obvious like an order on a display. An exhortation should be clear and does only function in the right situation.

Identify. The identification function can make the product tell what is its purpose, what is its origin, what brand it is and to what product category it belongs for example. The products of a company brand can by design strategy be given the same design language to show the customers the product origin. (Monö, 1997)

In his book Verganti (2009) states that change of "meaning" of a product to a user can lead to benefits for the company implementing the change. As an example he mention the introduction of the iPhone on the market; being not just a new more high-tech cell phone to use when for communication with people far away, but a product which is not primarily a cell phone but a entertainer or enabler which people can use to socialize with friends even in the same room. Nokia had earlier introduced the Smart phone but referred to it as a cell phone with more high-tech functionality. When not just upgrading the cell phone to be more high-tech, but changing its meaning, Apple got great revenues. (Verganti, 2009)

APPENDIX II: **Product experience** - *usability*

Usability

Usability can be described as: "...the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in particular environments" (ISO DIS 9241-11 cited in Jordan, 1998, p.5). The effectiveness is about to which extent the goal is achieved, efficiency is about how effort demanding it is to receive the goal and satisfaction is about the level of comfort when using the product. If all these three parts are highly fulfilled the product has good usability. Usability is, a bit simplified, how user-friendly a product is to a user.

As the products become more and more complex with more functionality, the importance of usability increases accordingly. Usability is of great importance from a sales perspective because people are increasingly unwilling to use products that are difficult to use. Therefore companies can have advantages over the competitors when offering "user-friendly" highly technical products.

These following 10 design principles can affect the usability of a product (Jordan, 1998):

1. Consistency: Similar tasks are designed so they are performed in similar ways.
2. Compatibility: The design of how the product is operated meets the users' expectations liked to the knowledge they have from other products and experiences.
3. Consideration of user resources: The product should be designed so the way the user operates with it are chosen with respect to the demands placed on the users' resources during interaction.
4. Feedback: The users get meaningful indications so they are information of the results of their actions.
5. Error prevention and recovery: The product is designed so the risk of making errors is minimized and if an error occurs it can be recovered quickly and easily.
6. User control: Designing so the user has as much control over the interactions with the product as possible.
7. Visual clarity: The information given by the product is displayed in such a way that it is easy and quick to read meaning it is big enough and not too cluttered for example.
8. Prioritisation of functionality and information: When designing the interface the most important functionality and information are given prominent place and are easy to access by the user.
9. Appropriate transfer of technology: If using technology developed for other application areas or contexts, the transfer of it should be appropriate to enhance the usability of the product.
10. Explicitness: The design of the product makes it clear how to use it.

References

Demir, E., Desmet, P. M. A., and Hekkert, P., 2009. Appraisal patterns of emotions in human-product interaction. *International Journal of Design*, 3(2), 41-51.

Desmet, P.M.A., 2003. A multi-layered model of product emotions. 4 The Design Journal. In press

Desmet, P. and Hekkert, P., 2009. Nine Sources of Product Emotion, Working document for PUUE. *ID4210 Product Usage Understanding and Experience*, Industrial Design Engineering Delft University of Technology, unpublished.

Jordan, P. W., 1998. *An Introduction to Usability*. London: Taylor and Francis.

Lilley, D., Lofthouse, V. and Bhamra, T., 2005. Towards Instinctive Sustainable Product Use. Presented at: the 2nd International Conference: Sustainability Creating the Culture. Aberdeen, Scotland 2-4th November 2005. Leicestershire: Loughborough's Institutional Repository

Monö, R., 1997. *Design for Product Understanding*. Stockholm: Liber AB

Mugge, R., 2007. *Product attachment*. Delft: Technical University. (Thesis to obtain the degree of doctor within the School of Technology, industrial design engineering)

Schifferstein, H.N.J., Hekkert, P., 2008. *Product experience*. Oxford: Elsevier.

Verganti, R., 2009. *Design-Driven Innovation: changing the rules of competition by radically innovating what things mean*. Boston, MA: Harward Business Press.

Wikström, L., 2007. Semiotikföreläsning, MPP071 Chalmers University of Technology. Unpublished.

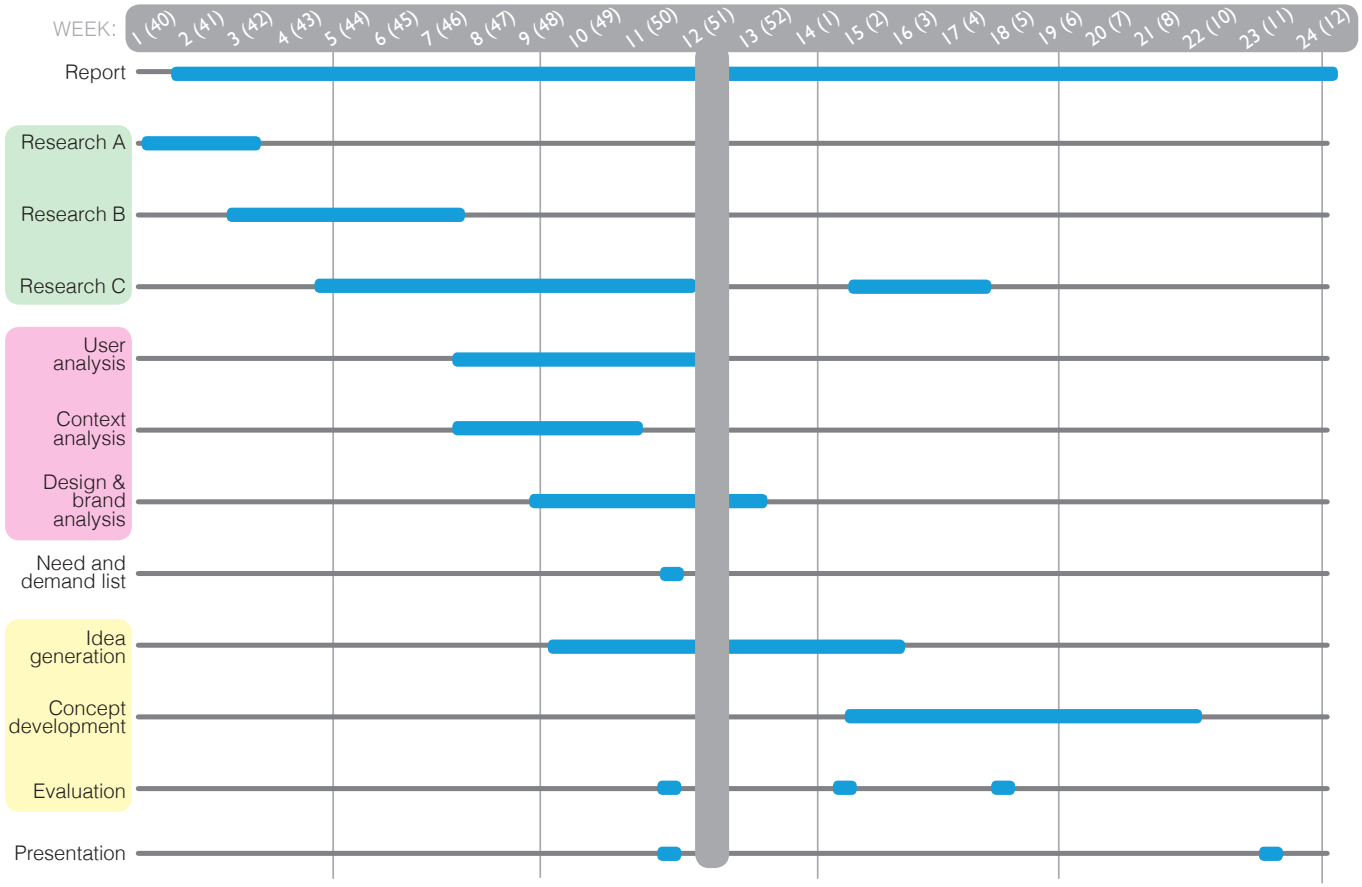
APPENDIX III: **Food storage specifications**

Special demands per type of foods

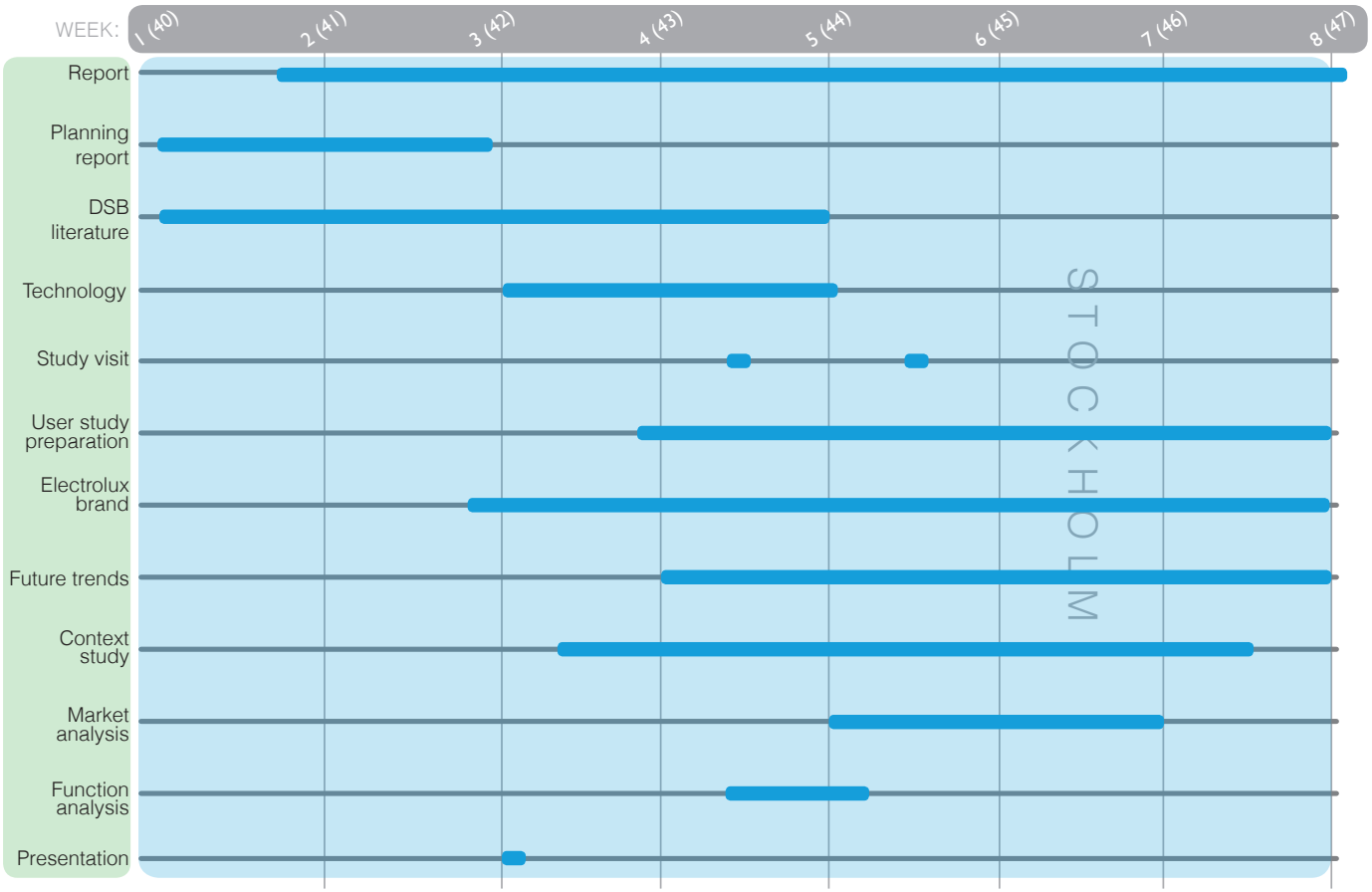
type	temperature	dimensions (min-max)	wheight	humidity	spread of odour/gas	sensitivity
Potatoes	>4°C (6-8°C)	Bag size=	heavy		-	To light and bumping
Tomatoes	>13°C			70-75%	Some ethylene	To cold
Cucumber	10-12°C	length=		90-95% (Keep the plastic wrapping)		To ethylene, humidity and too high or low temperatures
Eggplant	7-12°C					To ethylene, cold.
Pumpkin	6-8°C	diameter=	heavy			
Zucchini	5-10°C	length=				To cold
Carrots	0-5°C	Bag size=	heavy	98-100% (without condense)		To wetness
Onion	-2-0°C (OK in room temp.)		heavy	70-75%	Some ethylene	
Lettuce	0-2°C		light	95-98% (Keep in plastic perforated bag)		To ethylene, too high/low temp.
Pepper	7-13°C			High, keep in plastic wrapping		To ethylene, bumping, cold
Bananas	12-14°C					To ethylene and chilling damages
Lemon	10-15°C					To ethylene and cold
Leek	0°C	length=				To ethylene and humidity
Apples	0-6°C (OK in room temp.)		heavy	95%	High amount of ethylene	
Cabbage	4-8°C (2-4°C)	diameter=	heavy	90-95%		
Rocket sallad	0-1°C		light	95-98%		Light and too much moisture
Strawberries	2-6°C					To crushs and bumps
Mushrooms	0°C		light			Very sensitive to moisture, store in open paper bag
Herbes in pot	8-12°C		light			chilling damages
Milk	<5°C (higher temp. shorter durability)	height=25 cm				
Meat	Slightly under 0°C					Sensitive to high humidity
Fish	0-2°C				Odour	
Butter						Oxygen, light and high temp.
Cheese	4-8°C				Odour (keep each cheese separated)	Odour from other products
Egg	0° (if stored in room temp. shorter durability)					Porous, sensitive to odours and bacteria
Yoghurt	4°C (higher temp. shorter durability)					
Leftovers	<8°C					<2h in room temp.
Bread	>4°C (should be in room temp. or freezer)					

APPENDIX IV: **Project planning** - *Gantt charts*

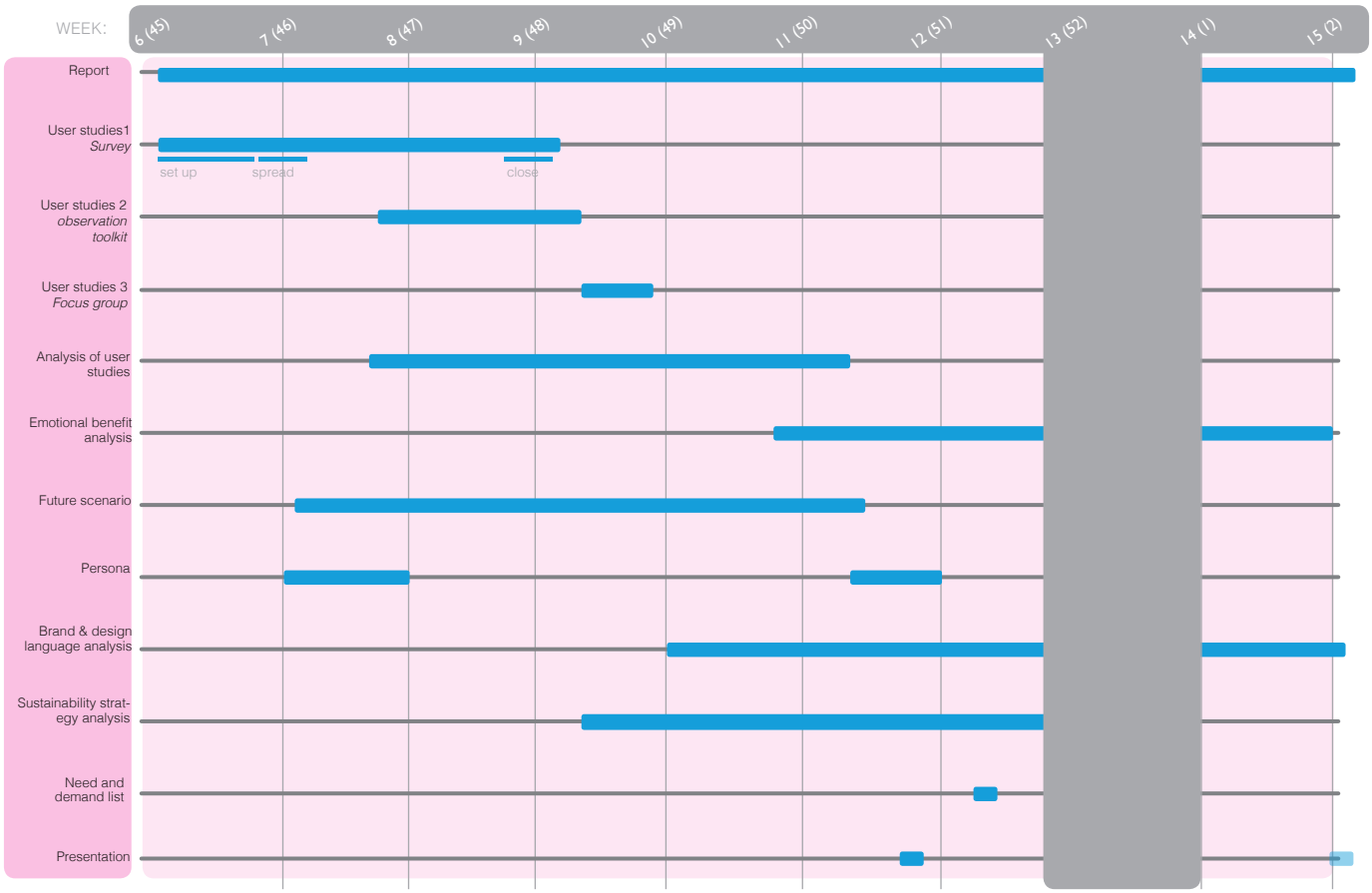
GANTT SCHEDULE



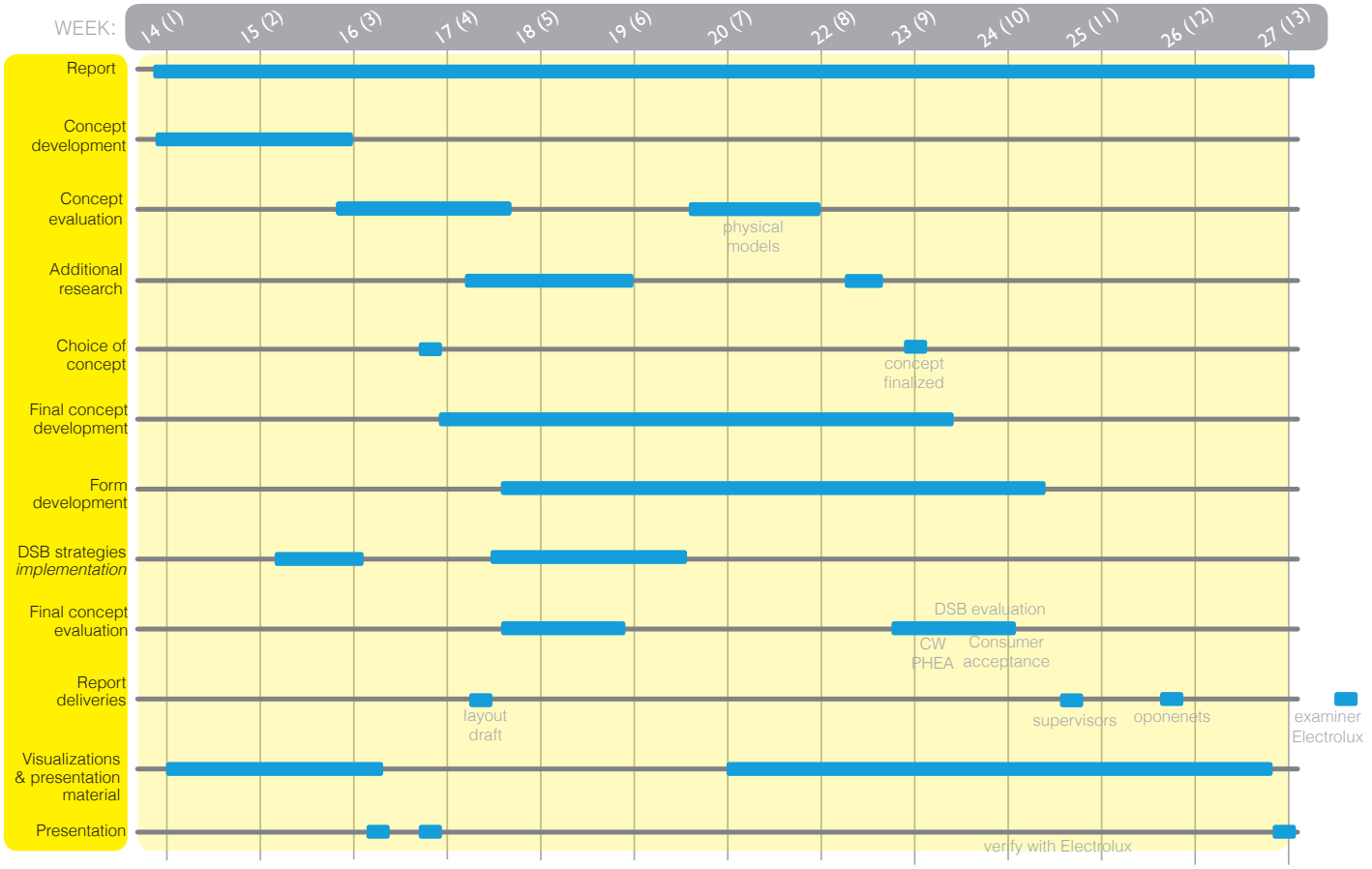
GANTT SCHEDULE PHASE 1: RESEARCH



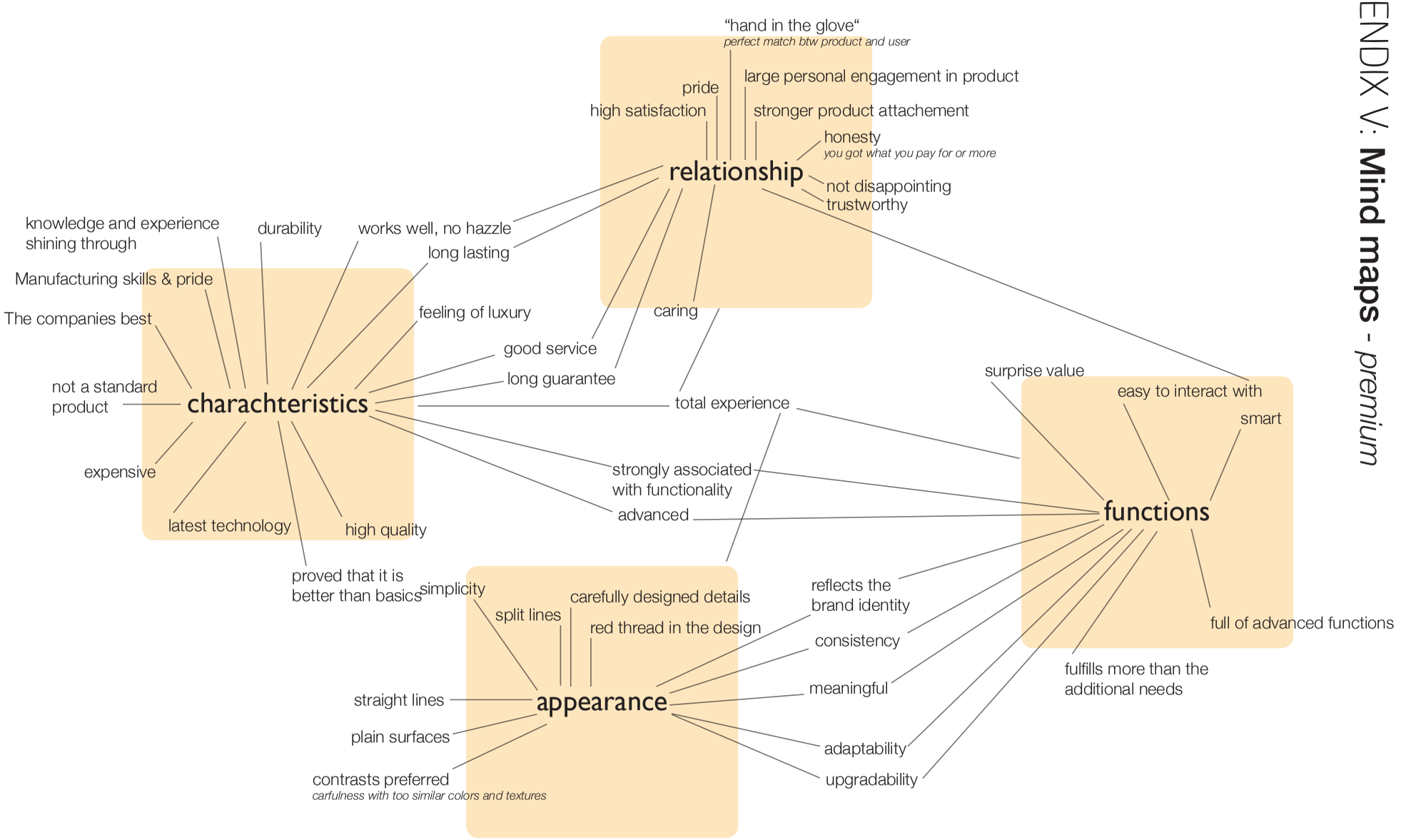
GANTT SCHEDULE PHASE 2: ANALYSIS



GANTT SCHEDULE PHASE 3: CONCEPT DEVELOPMENT



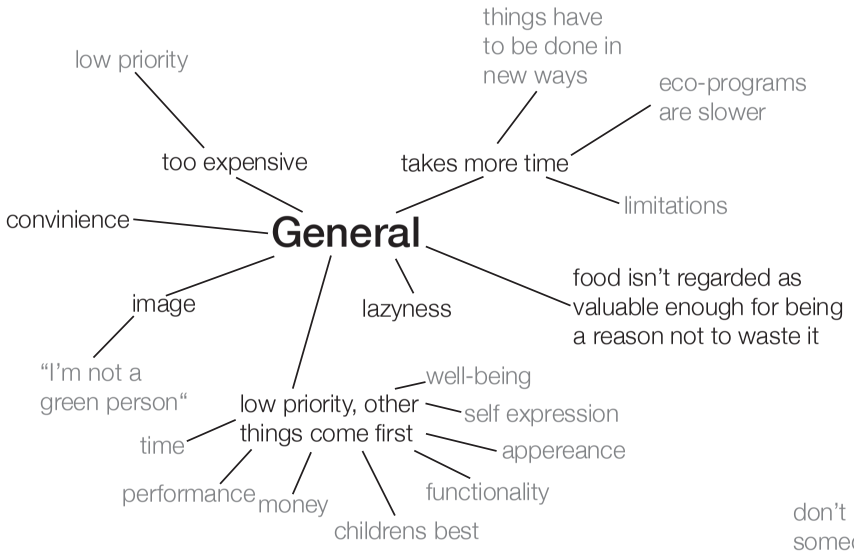
Premium - what is that?

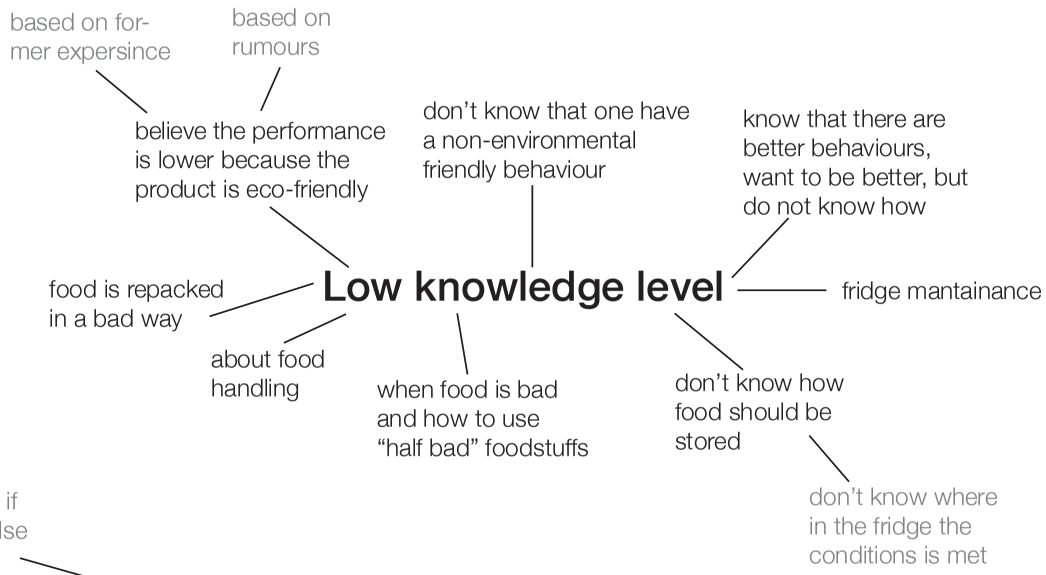


Barriers to sustainable behaviour

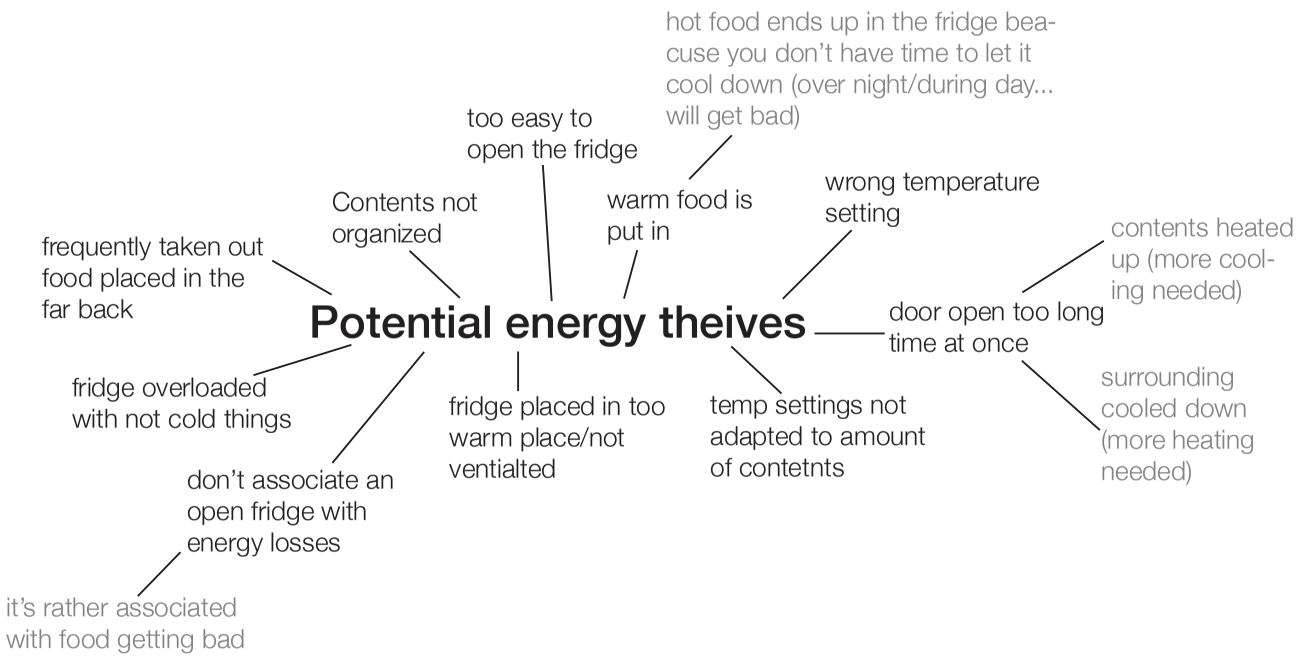
- Why people in general do not do "the right" thing

PERFORMANCE VS. ENVIRONMENT
VALUE FOR ME VS. ENVIRONMENT
MONEY VS. ENVIRONMENT
SMALL IMPACT VS. SOCIETAL GUILT





APPENDIX V: **Mind maps** - *barriers, problems etc.*


Potential energy theives
frequently taken out food placed in the far back
Contents not organized
too easy to open the fridge
hot food ends up in the fridge bea-cuse you don't have time to let it cool down (over night/during day... will get bad)
warm food is put in
wrong temperature setting
contents heated up (more cool-ing needed)
door open too long time at once
surrounding cooled down (more heating needed)
fridge overloaded with not cold things
don't associate an open fridge with energy losses
it's rather associated with food getting bad
fridge placed in too warm place/not ventialted
temp settings not adapted to amount of contetnts

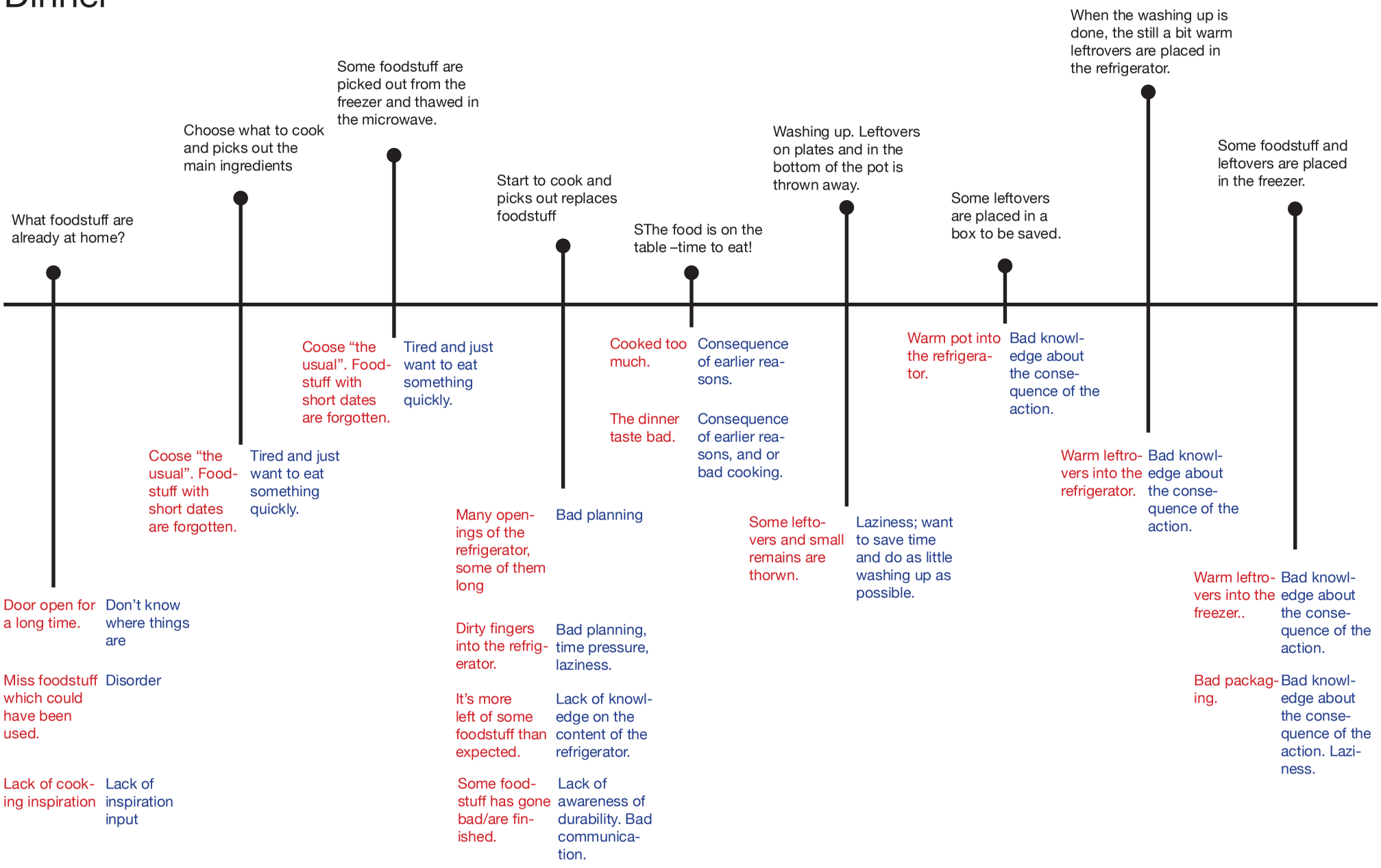

What do your fridge say about you?
eating habits
healthy
eating home or out
vegetarian
special diet
gourmet
fast food
economy
wealthy
poor
lifestyle
communication
organized
priorities
personlaity
household size
many
children
alone
culture
heritage
traditions
origin
favours

Quick meal

Keeping the door open for a long while when deciding what to pick out.	Bad knowledge of refrigerator content.
	Tired; low energy for desicion making.
Opening and closing many times.	Same as abowe.
Holding the door open while e.g. pouring out milk.	Laziness.
Throw away small remains.	Laziness.
Holding the door open for a long time when replacing foodstuff to their right place.	Wish for order in the refrigerator.
Holding the door open for a long time while e.g. pouring out water.	Laziness.
Holding the door open for a long time while deciding what to eat.	Lack of inspiration.
Throw away small remains.	Laziness.

Grocery shopping

Dinner


What foodstuff are already at home?
Door open for a long time.
Don't know where things are
Miss foodstuff which could have been used.
Disorder
Lack of cooking inspiration
Lack of inspiration input
Choose what to cook and picks out the main ingredients
Coose "the usual". Foodstuff with short dates are forgotten.
Tired and just want to eat something quickly.
Some foodstuff are picked out from the freezer and thawed in the microwave.
Coose "the usual". Foodstuff with short dates are forgotten.
Tired and just want to eat something quickly.
Start to cook and picks out replaces foodstuff
Many openings of the refrigerator, some of them long
Bad planning
Dirty fingers into the refrigerator.
Bad planning, time pressure, laziness.
It's more left of some foodstuff than expected.
Lack of knowledge on the content of the refrigerator.
Some foodstuff has gone bad/are finished.
Lack of awareness of durability. Bad communication.
SThe food is on the table –time to eat!
Cooked too much.
Consequence of earlier reasons.
The dinner taste bad.
Consequence of earlier reasons, and or bad cooking.
Washing up. Leftovers on plates and in the bottom of the pot is thrown away.
Some leftovers and small remains are thorwn.
Laziness; want to save time and do as little washing up as possible.
Some leftovers are placed in a box to be saved.
Warm pot into the refrigerator.
Bad knowledge about the consequence of the action.
When the washing up is done, the still a bit warm leftrovers are placed in the refrigerator.
Warm leftrovers into the refrigerator.
Bad knowledge about the consequence of the action.
Some foodstuff and leftovers are placed in the freezer.
Warm leftrovers into the freezer..
Bad knowledge about the consequence of the action.
Bad packaging.
Bad knowledge about the consequence of the action. Laziness.

APPENDIX VII: **PESTED-analysis**

Political

The world is becoming more global and the borders and differences between countries and region is decreasing. But at the same time is the demand for small scale and locally produced products increasing. Also, with the more wide spread online community new common global laws and regulations, stretching over the boarders between countries will be needed.

Economical

Time and experience is the new luxury, and in the fast moving and always connected everyday life having time off for an interesting experience will be the most valuable. The access to services instead of materialistic products will grow, and very much depend on the new technologies

The competition between companies is getting tougher and it is a must to find new ways to differentiate. The key will be experiences and emotional attachment, and sustainability will rather be a basic requirement than a factor to compete with. Brands will have more niched target groups and the role of strong and trustworthy brands will grow. This is also connect to the higher demands from the consumers who is getting more sophisticated and want more professional products.

Societal

Consumers want more ways of expressing themselves through the products and services they use. Therefore adaptability and personal customization, preferably automatic without any effort from the user, will be more important. Demand for convenience.

The barriers from the real world to the virtual world are getting fuzzier, so there will be two parallel realities. With the constant access to the virtual dimension where people do not have to meet in real life, the longing and strive for genuineness and honesty is increasing. Since the society gets more and more individualized all people want to clearly make up a picture for themselves and others of who they are and what they stand for, creating clear personal boundaries.

With a more wired up, high-tech and superficial virtual society, the search for the simple, genuine and natural increase. Therefor things such as urban farming and farm holidays are getting more common, which makes contrasts a central concept describing a possible future.

Accessibility is also a central word. Everything should be available all the time. With shops and services online, date and time will no longer matter when it comes to shopping and access to services. The same goes for information.

Because of smaller living spaces, due to urbanization, the categorization of the rooms in the apartment gets fuzzier. The rooms can be transformed to serve different needs. With higher personalization and more constant access to everything, higher living standard and the deemed for good foodstuffs, with declared and good origins, manufacturing process and ingredients are of greater importance.

Technological

The technological advancements will continue. But as technologies are getting more advanced the demands on ease of use and intuitivity is increasing. Also the social life and everyday life will be depending on the technologies, why they cannot be barriers. Multi functionality might get more important due to the growing population, urbanization and more people sharing less space. Therefore products and appliances will be more connected, and augmented reality letting us experience more in our surroundings than what the human eye can see will be common. Reality and the virtual world will be seamlessly integrated.

Ecological

Ecological and fair trade products will be more common if not the new standard. The demand of locally produced and genuine products will continue to increase. Climate changes will affect where and how people live in the future.

Demographic

Big cities are getting bigger and small cites are becoming big cities as the urbanization boosts again. Life-stages dissolving, and life can rather be regarded as a continuous linear process. With the medical advancements and higher living standards, an increased ratio of the (western) world's population will be old.

Consumption, behaviour and sustainability

We are very thankful that you are helping us by answering this survey for our master's thesis project! The survey consists of three parts and will take you about 5 minutes to answer. Let start with some generalities.
* Required

Age *

Sex *

Nationality *

In which country do you live? *

How big is your household? *

What applies to your kitchen? *
Choose all the alternatives applying to you

- [ ] it is small
- [ ] it is big
- [ ] it is an open plan kitchen
- [ ] it is a separate kitchen
- [ ] it is a pentry
- [ ] I have no kitchen
- [ ] I rent a room and share the kitchen with others
- [ ] Other:

What applies best to your grocery shopping habits? *
choose the alternative applying best to you

- [ ] daily shopping
- [ ] small shopping 2-6 times a week
- [ ] big shopping once a week only
- [ ] big shopping once a week and complementary shopping in between
- [ ] big shopping once a month and complementary shopping in between

- [ ] subscribed home delivery
- [ ] self scanning
- [ ] Other:

Which is your favorite product? *
Please choose one of your energy consuming products

Why is this your favorite product? *
Mention a few characteristics

Continue »

Consumption, behaviour and sustainability

* Required

Sustainability

How important do you find it to act eco-friendly? *

	1	2	3	4	5	6	7	8	9	
Not important	○	○	○	○	○	○	○	○	○	Very important

How eco-friendly do you act in reality? *

	1	2	3	4	5	6	7	8	9	
Not at all	○	○	○	○	○	○	○	○	○	Very much

What prevents you from acting more eco-friendly? *

Which household appliance do you think is the least environmental friendly? *

Have you adapted your behavior when using it to make it more environmental friendly? *

If yes, how? If no, why not? *

If you throw away food, what is the most common reason? *

- ○ It has past the expiring date
- ○ It does not smell/taste/look good anymore
- ○ I took a too big portion to finish it
- ○ It is too little leftovers to be worth saving
- ○ It has been frozen in the refrigerator
- ○ there is no room for it in the refrigerator/freezer
- ○ Other:

Consumption, behaviour and sustainability

* Required

Refrigerator habits

How many meals do you normally prepare at home on weekdays? *
Snacks not included.

When you open your refrigerator a normal weekday, how full is it usually? *

If you leave the refrigerator door open for a while, what is usually the reason? *
Choose the alternatives that applies to you

- ☐ I cannot find what I am looking for
- ☐ I rearrange to make room for food
- ☐ I am taking out to prepare a meal
- ☐ I am looking what I have at home/need to buy
- ☐ I feel hungry and do not know what to eat
- ☐ I leave it open all the time
- ☐ I have done grocery shopping and have to put in a lot
- ☐ Other:

How do you treat warm food you want to save? *

- ○ I let it cool down to room temperature before putting it into the refrigerator/freezer
- ○ I put it into the refrigerator/freezer when it is still a bit warm
- ○ I never save it
- ○ I have not reflected over it
- ○ Other:

How would you rate your knowledge about under which conditions (i.e. temperature, humidity, light) different foodstuffs are best preserved? *

	1	2	3	4	5	6	
Very poor	○	○	○	○	○	○	Excellent

How do you arrange items in your refrigerator? *

- ☐ by how often they are used
- ☐ by product type
- ☐ by expiring date
- ☐ by temperature differences in the refrigerator
- ☐ by packaging dimension
- ☐ by weight
- ☐ to avoid leakage
- ☐ to avoid odour spread or contact with other items
- ☐ no certain order
- ☐ Other:

When buying a new refrigerator, what is most important to you? *

- ○ Aesthetics and design
- ○ Brand
- ○ Volume
- ○ Price
- ○ Energy efficiency rating
- ○ Interior layout
- ○ Extra features
- ○ Other:

What do you think of your refrigerator? *

Please mark on the scales where you would place your refrigerator.

	1	2	3	4	5	6	7	8	9	
Plain	○	○	○	○	○	○	○	○	○	Extravagant

*

	1	2	3	4	5	6	7	8	9	
Wasteful	○	○	○	○	○	○	○	○	○	Efficient

*

	1	2	3	4	5	6	7	8	9	
Aggressive	○	○	○	○	○	○	○	○	○	Friendly

*

	1	2	3	4	5	6	7	8	9	
Jeopardizing	○	○	○	○	○	○	○	○	○	Reliable

*

	1	2	3	4	5	6	7	8	9	
A soulmate	○	○	○	○	○	○	○	○	○	A nobody

If your refrigerator was a person, how would you describe its personality? *

Please describe briefly

What's your favorite colour?

If you want to participate in a competition for a nice price, send an email to: rebecka.lannsjo@gmail.com with your name and the answer to the question, as a subject write: "Survey contest". After the survey is ended there will be a lottery between the participants and the winner will receive a price announced on the Facebook event page and by email.

○

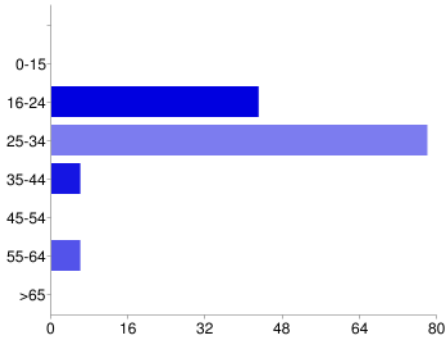
« Back Submit

APPENDIX VIII: **Survey -** *responses*

133 responses

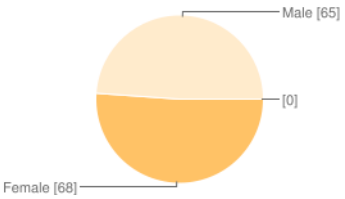
Summary See complete responses

Age



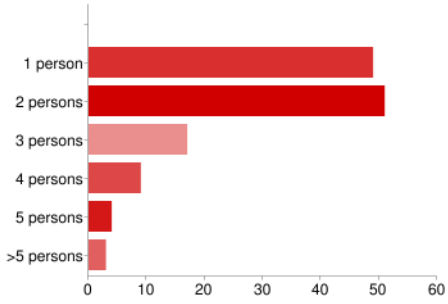
	0	0%
0-15	**0**	0%
16-24	**43**	32%
25-34	**78**	59%
35-44	**6**	5%
45-54	**0**	0%
55-64	**6**	5%
>65	**0**	0%

Sex



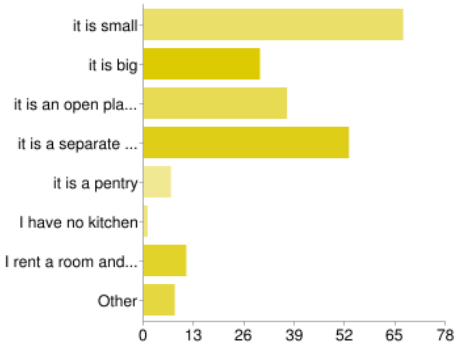
	0	0%
Female	**68**	51%
Male	**65**	49%

How big is your household?



	0	0%
1 person	**49**	37%
2 persons	**51**	38%
3 persons	**17**	13%
4 persons	**9**	7%
5 persons	**4**	3%
>5 persons	**3**	2%

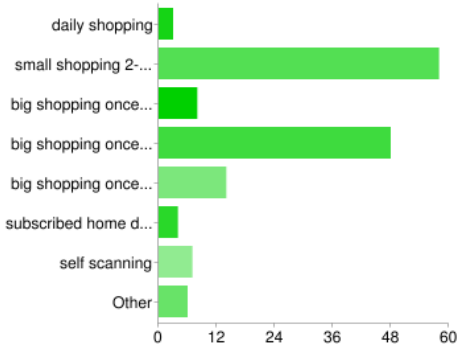
What applies to your kitchen?



it is small	**67**	50%
it is big	**30**	23%
it is an open plan kitchen	**37**	28%
it is a separate kitchen	**53**	40%
it is a pentry	**7**	5%
I have no kitchen	**1**	1%
I rent a room and share the kitchen with others	**11**	8%
Other	**8**	6%

People may select more than one checkbox, so percentages may add up to more than 100%.

What applies best to your grocery shopping habits?

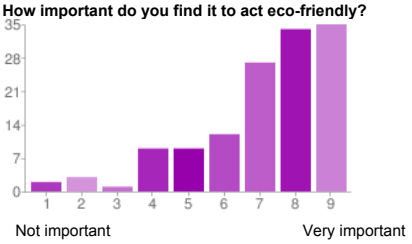


daily shopping	**3**	2%
small shopping 2-6 times a week	**58**	44%
big shopping once a week only	**8**	6%
big shopping once a week and complementary shopping in between	**48**	36%
big shopping once a month and complementary shopping in between	**14**	11%
subscribed home delivery	**4**	3%
self scanning	**7**	5%
Other	**6**	5%

People may select more than one checkbox, so percentages may add up to more than 100%.

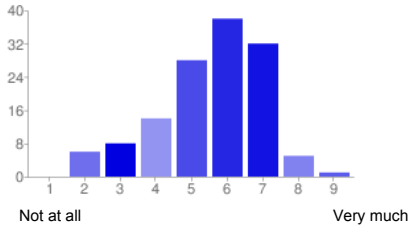
Sustainability

How important do you find it to act eco-friendly?



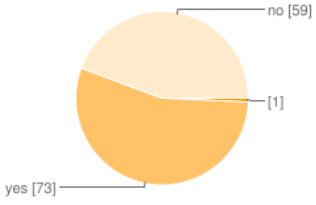
1 -	Not important	**2**	2%
2		**3**	2%
3		**1**	1%
4		**9**	7%
5		**9**	7%
6		**12**	9%
7		**27**	20%
8		**34**	26%
9 -	Very important	**35**	26%

How eco-friendly do you act in reality?



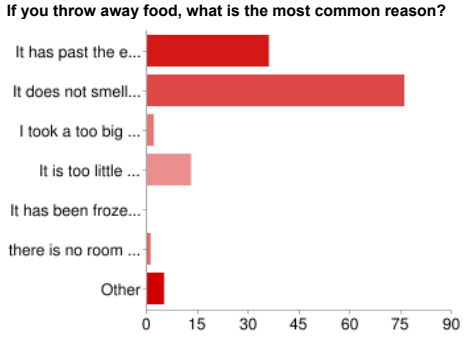
1 -	Not at all	**0**	0%
2		**6**	5%
3		**8**	6%
4		**14**	11%
5		**28**	21%
6		**38**	29%
7		**32**	24%
8		**5**	4%
9 -	Very much	**1**	1%

Have you adapted your behavior when using it to make it more environmental friendly?



	1	1%
yes	**73**	55%
no	**59**	44%

If you throw away food, what is the most common reason?

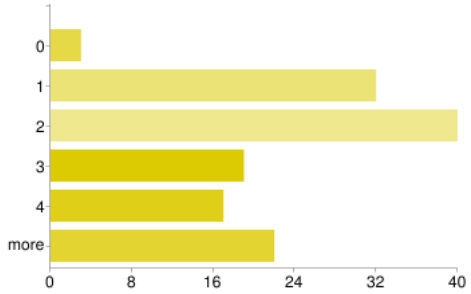


It has past the expiring date	**36**	27%
It does not smell/taste/look good anymore	**76**	57%
I took a too big portion to finish it	**2**	2%
It is too little leftovers to be worth saving	**13**	10%
It has been frozen in the refrigerator	**0**	0%
there is no room for it in the refrigerator/freezer	**1**	1%
Other	**5**	4%

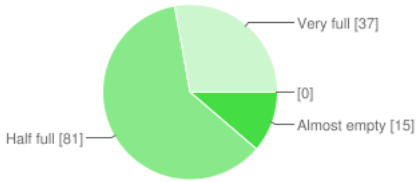
Refrigerator habits

How many meals do you normally prepare at home on weekdays?

	0	0%
0	**3**	2%
1	**32**	24%
2	**40**	30%
3	**19**	14%
4	**17**	13%
more	**22**	17%

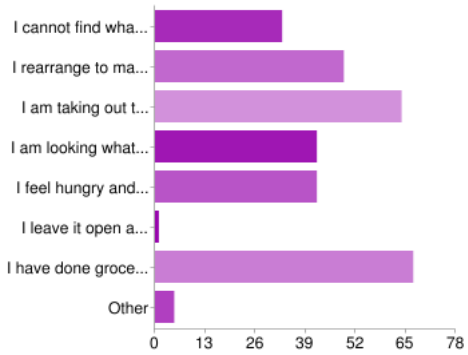


When you open your refrigerator a normal weekday, how full is it usually?



	0	0%
Almost empty	**15**	11%
Half full	**81**	61%
Very full	**37**	28%

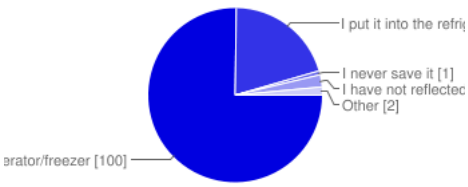
If you leave the refrigerator door open for a while, what is usually the reason?



I cannot find what I am looking for	**33**	25%
I rearrange to make room for food	**49**	37%
I am taking out to prepare a meal	**64**	48%
I am looking what I have at home/need to buy	**42**	32%
I feel hungry and do not know what to eat	**42**	32%
I leave it open all the time	**1**	1%
I have done grocery shopping and have to put in a lot	**67**	50%
Other	**5**	4%

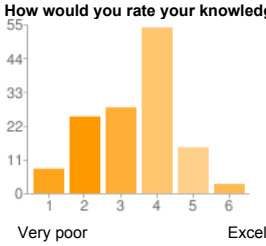
People may select more than one checkbox, so percentages may add up to more than 100%.

How do you treat warm food you want to save?



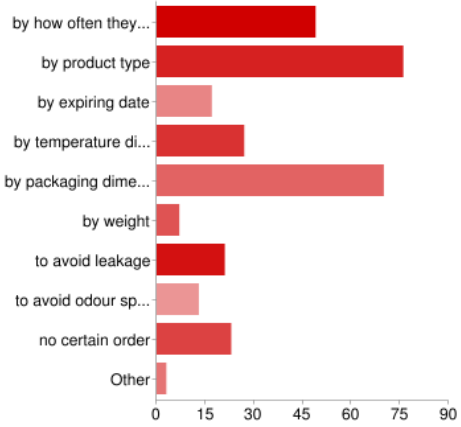
I let it cool down to room temperature before putting it into the refrigerator/freezer	**100**	75%
I put it into the refrigerator/freezer when it is still a bit warm	**27**	20%
I never save it	**1**	1%
I have not reflected over it	**3**	2%
Other	**2**	2%

How would you rate your knowledge about under which conditions (i.e. temperature, humidity, light) different foodstuffs are best preserved?



1 - Very poor	**8**	6%
2	**25**	19%
3	**28**	21%
4	**54**	41%
5	**15**	11%
6 - Excellent	**3**	2%

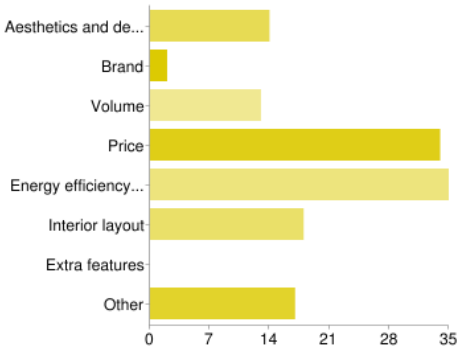
How do you arrange items in your refrigerator?



by how often they are used	**49**	37%
by product type	**76**	57%
by expiring date	**17**	13%
by temperature differences in the refrigerator	**27**	20%
by packaging dimension	**70**	53%
by weight	**7**	5%
to avoid leakage	**21**	16%
to avoid odour spread or contact with other items	**13**	10%
no certain order	**23**	17%
Other	**3**	2%

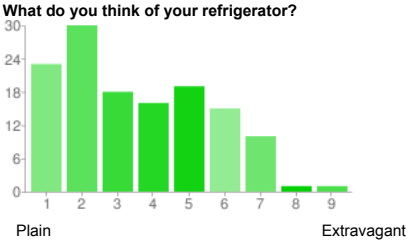
People may select more than one checkbox, so percentages may add up to more than 100%.

When buying a new refrigerator, what is most important to you?

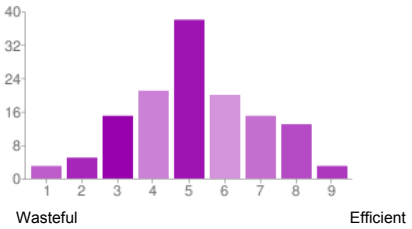


Aesthetics and design	**14**	11%
Brand	**2**	2%
Volume	**13**	10%
Price	**34**	26%
Energy efficiency rating	**35**	26%
Interior layout	**18**	14%
Extra features	**0**	0%
Other	**17**	13%

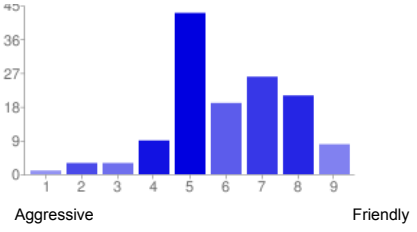
What do you think of your refrigerator?



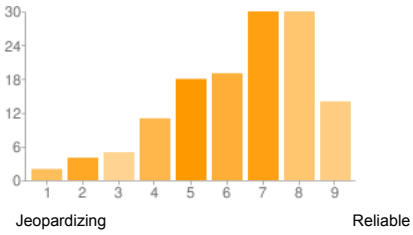
1 -	Plain	**23**	17%
2		**30**	23%
3		**18**	14%
4		**16**	12%
5		**19**	14%
6		**15**	11%
7		**10**	8%
8		**1**	1%
9 -	Extravagant	**1**	1%



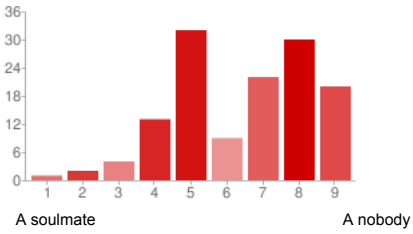
1 -	Wasteful	**3**	2%
2		**5**	4%
3		**15**	11%
4		**21**	16%
5		**38**	29%
6		**20**	15%
7		**15**	11%
8		**13**	10%
9 -	Efficient	**3**	2%



1 -	Aggressive	**1**	1%
2		**3**	2%
3		**3**	2%
4		**9**	7%
5		**43**	32%
6		**19**	14%
7		**26**	20%
8		**21**	16%
9 -	Friendly	**8**	6%

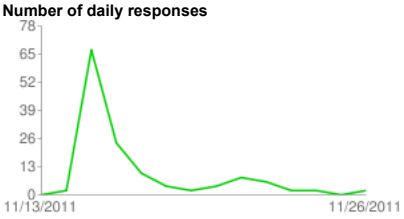


1 -	Jeopardizing	**2**	2%
2		**4**	3%
3		**5**	4%
4		**11**	8%
5		**18**	14%
6		**19**	14%
7		**30**	23%
8		**30**	23%
9 -	Reliable	**14**	11%



1 -	A soulmate	**1**	1%
2		**2**	2%
3		**4**	3%
4		**13**	10%
5		**32**	24%
6		**9**	7%
7		**22**	17%
8		**30**	23%
9 -	A nobody	**20**	15%

Number of daily responses



APPENDIX VIII: **Survey -** *additional findings*

The respondents

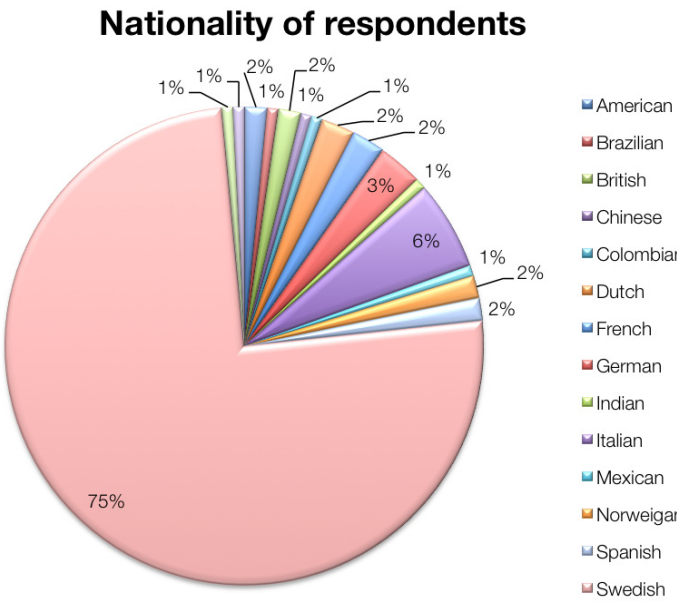
The survey had 133 respondents, ad the majority of them were in the age 25 to 34 (59%), and 32% between 16 and 24. Almost half of the respondents were male and slightly more than half were females. A majority of the respondents were Swedes or people living in Sweden. Still there where a fairly high ratio of respondents of different nationalities; 24% where not from Sweden, and among these Italians were most common nationality (6 %). There where also 24 % of respondents not living in Sweden; some persons of other nationalities than Swedes living in Sweden and some Swedes living abroad.

Most respondents lived in single or two persons households with a small separate kitchen. Most went for small grocery shopping 2-6 times a week or big shopping once a week with complementary shopping in between. The 11% who answered that their refrigerator was almost empty might have a too big refrigerator for their needs.

Buying a new refrigerator

When asking about what people consider as most important when buying a new refrigerator the majority said price (26 %) and energy efficiency rating (26 %). After these came interior layout with 14 % and "other" with 13 %. Most of the ones who replied "other" said that they had never thought of it or they had never bought a refrigerator. Furthermore, some replied with a combination of the given alternatives. Aesthetics and design and volume was considered as moderately important with 11% respectively 10 % of replies. Brand did only get 2 % of the responses and extra features apparently did not mater at all (0%). What can be concluded from this is that when all comes around cost is most important to the consumers, since the energy efficiency rating is closely associated with the energy costs.

In other studies other researchers also came to the conclusion that the most important matter for the consumers when buying a new refrigerator is low energy consumption. On a second place they had good performance, on the third place low operating noise emission (as one in the team's survey also added even though it did not exist as an option) and on fourth place was the purchasing price. The reason to why people rank low energy consumption so high might be because the energy consumption of a product that is running 24h every day have great impact on the monthly energy bill even though the kW consumption/hour is relatively low.



APPENDIX VIII: **Survey -** *quotes about refrigerator personality*

Somewhat smelly, with lots of strange stuff inside.. amazingly i don't mind eating the stuff Friggo had in the stomach.. (10)

Someone who does not stand out that much, quite anonymous. He/she performs the tasks which are given, but nothing more. Does not try to show off but still confident in itself. (13)

He´s the smelly guy that no one wants to talk to and that makes annoying sounds at night. Still you need him desperately.. (14)

His name is Cliff, friendly and helpful but a bit stupid - a few sandwiches short of a picnic. (18)

A shy hardworking person. The kind that never complains, although it has to endure long shifts and sometimes smelly cheeses. (19)

A bitter and complacent middle aged man, doing his job but without immediate hopes or dreams for the future. Sad, but true. (20)

Plain, effiecient enough but not extravagant (svensson). A bit boring but at the sametime someone you can trust. (21)

A old and very simple person who is happy he is hidden behind an extra door. He is not concerned about the environment and he like to make sounds in the night. (39)

Completly unrealible asshole who sometimes hides my food in his pockets, sometimes freezes it just for fun. He also soils himself and leak fluids all over the place. (46)

En stor vit fyrkantig och bufflig svensk! Pratar inte mycket, men han svänger rejält när det kommer mycket folk och det vankas fest! Öppen mot alla! Inte alls skygg och nudist. (48)

An old gentleman with no complaints about his life. (49)

Silent but kind. Keeps a cool head, patient and the one person I can really rely on freshing up my day even when I've forgotten about items from long ago. A good buddy :) (55)

A cold person that knows how to take care of itself. A person that is usually well dressed (for its external aspect) and the belly full (for the interior aspect) :) (62)

standing there reliable, allways at your service, melting in, discrete (64)

Really effective, modern, good looking, a person you could depend upon and smart, i think he/she would be smart. (71)

A middle aged or older person I don't notice very much. Reliable and mostly does what it is expected. I think it would be called Norm. (73)

A boring, beige person feeling a little bit tired. A quiet guy without much personality or substance. (78)

Not so clever, light up when you say hello, but turns grumpy if you talk too long and pretty silent general. (83)

A boring old man, sitting in a corner, making strange noises (93)

lyssnar på lugna favoriter, är trygg och nöjd i sitt hörn men vill egentligen se världen. vågar inte. klär sig i beige loafers. (100)

Den ställer alltid upp, är pålitlig. Den är lugn, passiv och tystlåten. (107)

My refridgerator is shy, doesn't stick out or draw attention to itself, but now and again I hear it whining. Maybe it doesn't like the decorations (reminders, shopping lists, newspaper articles, photos, etc.) we fasten to it with magnets. However, I think its also tired and worn out from so many years of faithfully serving us and others before us. It has a few scars, but is still hanging in there, I think its probably on its last leg 'though. It could go any time now. That would actually probably be for the best, evironmentally speaking, because then we would be forced to buy something new and energy efficient. (110)

Simple and not very concerned about fashion, a bit old-school, you-know-what-you've got kind of person. (128)

It's a cold, anonimous personality that stands all days in a corner. From a professional perspective is organized and reliable, he never does anything wrong. (133)

APPENDIX IX: **Context mapping -** *workbook*

1(19)

Min kylskåpsdagbok

Namn: .....

Workshopkväll 8/12 på Electrolux Sit Göransgatan 143 kl 18-21!

2(19)

Har du några frågor eller funderingar? Tveka inte att kontakta någon av oss på telefon eller mail.

Rebecka
tel. 0730-582155
rebeckalannsjo@gmail.com

Anna
tel. 0708-614687
annavig@hotmail.com

3(19)

Hej & välkommen till din bok!

Först vill vi tacka dig för att du ger oss ca 15 minuter av din tid varje dag under en vecka för att hjälpa oss med vårt examensarbete.

Det är viktigt för oss att du utför uppgifterna så sanningsenligt du kan, dvs att du dokumenterar så som du vanligen agerar utan att förändra något. Kom ihåg att det här är din bok och att du är fri att kommentera/skriva/rita så som det känns bäst för dig!

Boken består av två olika delar; din kylskåpsdagbok där du markerar varje tillfälle och antal gånger du öppnar kylen. Den andra delen innehåller olika småuppgifter, en per dag, på baksidan av varje dagboksblad. Dessa uppgifter önskar vi att du utför i lugn och ro.

Hoppas att du finner uppgifterna lite roliga att göra, och ännu en gång tack för din hjälp!

/Rebecka & Anna

Uppgifter

När du öppnar kylskåpet:

- *Notera det på dagbokssidan*

Varje dag:

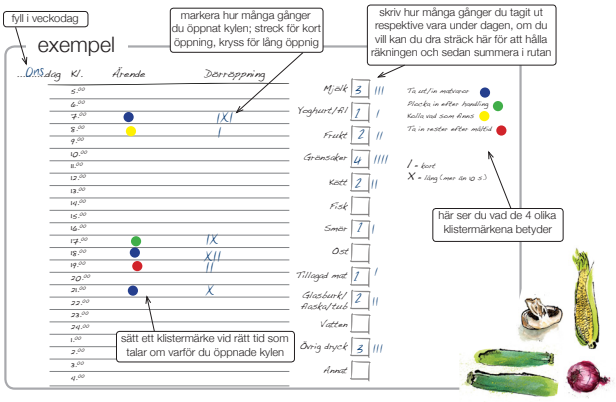
- *Gör uppgiften du finner på baksidan av varje dagboksida*

Första och sista dagen:

- *Foto insidan av ditt kylskåp*

Lycka till!

4(19)



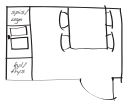
5(19)

mitt kök

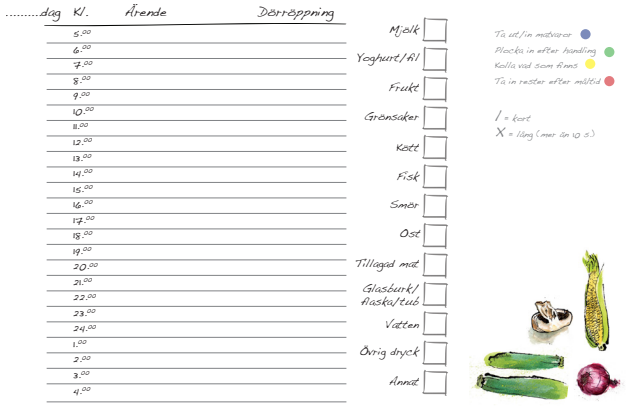
Innan du börjar fylla i kylskåpsdagboken i morgon finns här en förberedelseuppgift för dig att göra nu:

Skissa upp ditt kök och indikera var kyl/frys, spis, diskho etc finns!

exempel

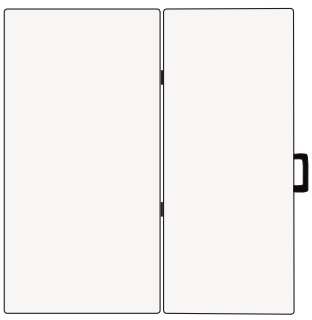


6(19)



7(19)

Dag 1. mitt kylskåp



1. *Rita ut hyllor och lådor såsom det ser ut i ditt kylskåp i skissen intill.*
2. *Klistra in matvaruklistermärkena där du brukar förvara varorna i din kyl.*

Är det någon av vara du aldrig har hemma, hoppa då över att placera in den. Är det något du ej förvarar i kylen, sätt den då utanför. Rita gärna in fler varor själv.

exempel

Subsequently every second page is th self observation sheet above (one for each day of the week)

Dag 2. min kylskåpsdörr

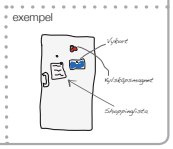
1. Vad finns utanpå ditt kylskåp? Skissa upp din kylskåpsdörr och vad som är fäst på dess utsida. Använd gärna färger och beskrivande ord.

2. Inköpslista? Om du har en inköpslista för den här veckan vill vi gärna att du tejpar fast den här eller målar den till:

rebeckajannsjo@gmail.com

Använder du ingen inköpslista kryssa här ❑

exempel



Dag 3. fräscht

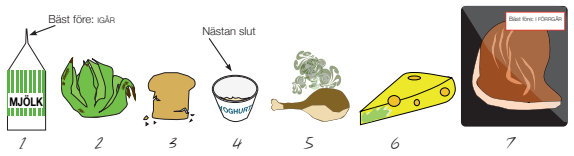
Vad innebär fräschhet för dig när det handlar om kylskåp, och vad gör att kylskåpet inte känns fräscht och inbjudande?

Skriv, rita och fyll det gröna fältet med sådant du förknippar med ett fräscht kylskåp, och använd det röda fältet för ord och bilder som du finner typiska för ett ofräscht.

Dag 4. att slänga mat

Placera in nummerna för matvarorna på linjen, sorterade i den ordning du skulle ha slängt bort dem.

Slänga direkt



1 2 3 4 5 6 7

Dag 5. det jag gillar mest

Vilket är ditt favorit tillfälle/upplevelse i köket?

Vad tycker du allra bäst om att ha i ditt kylskåp? Rita och beskriv!

Vad gillar du mest med ditt kylskåp?

Dag 6. framtidens kök

Föreställ dig ditt kök år 2020. Tänk på vart teknikutvecklingen är på väg; appar, connectivity, scanning och "smarta funktioner... eller kanske något helt annat, något som inte involverar teknik?

Nämn 3 saker du önskar att ditt kök skulle kunna göra år 2020!

Rita gärna!

1.

2.

3.

Dag 7. skicka in

Det här är den sista uppgiften i din kylskåpsbok: Skicka in fotona på insidan av ditt kylskåp som du tog den första dagen och idag till:

rebeckajannsjo@gmail.com

Vi kommer inom kort att samla in din bok enligt överenskommelse.

Sedan ser vi fram emot att träffa dig vid Electrolux huvudentré på Sit Gärnsgatan 143 (T-bane station Stadshagen) den

8/12 kl. 18.00 för en trevlig diskussionskväll!

Vi räknar med att det kommer att ta ungefär 2 timmar, och vi bjuder på fika och en gåva som tack för hjälpen.

APPENDIX IX: **Context mapping -** *the participants' refrigerators*

U1 day 1

U1 day 7

The photos from day 1 and 7 from the participants using the sensitizing workbook.

U1 = user study participant 1

U2 day 1

U2 day 7

U3 day 1

U1 day 7

U4 day 1

U4 day 1

U4 day 7

U4 day 7

U5 day 1

U5 day 1

U5 day 7

U5 day 7

APPENDIX IX: **Context mapping -** *generative session set up*

1. kl. 18.00: Fika och Introduktion – *15 min*

Presentation av oss och kort om projektet - ***2 min***

Låt deltagarna presentera sig med namn, sysselsättning, hur de bor (boendeform, typ av kök och personer i hushållet) - ***3 min***

Uppvärmningspåståenden (ställa sig upp när det stämmer in) - ***10 min***

Presentera sig med namn, sysselsättning och familjeförhållande och kökstyp….

1. *Jag bor i lägenhet*
2. *Jag bor i hus*
3. *Jag är en romantiker*
4. *Jag är en logisk analytiker*
5. *Jag är något av en perfektionist*
6. *Jag är en slarver*
7. *Jag är intresserad av mode och inredning*
8. *På lördagkvällar föredrar jag hemmamys*
9. *På lördagkvällar är det fest som gäller*
10. *När jag köper nya hushållsprodukter är det viktigt att de uttrycker min stil*
11. *För mig går alltid prestanda och funktion före design*
12. *För mig är det viktigt att mitt hem reflekterar min personliga stil*
13. *Jag brukar ta med mig hemlagad lunchlåda till jobbet*
14. *Mitt drömkök är en maskinpark med de mest avancerade funktionerna*
15. *Mitt drömkök är välmatchat och välkomnande*
16. *Jag gillar exprimentiell matlagning och testar gärna nya saker*
17. *Jag lagar middag hemma varje dag*

2. kl. 18.15: Diskussion om vanor – *31 min (Utifrån workbooken)*

I syfte att hitta barriärer och se om problemhypoteserna stämmer

a. Hur tyckte ni det vara att fylla i boken - ***3 min***

Var det lätt/svårt, roligt/tråkigt? Upptäckte ni något som ni själva gör som ni inte var medvetna om tidigare? Har det gett er någon tankeställare eller fått er att vilja förändra ert beteende på något sätt eller vis?

b. Har ni reflekterat över varför/när ni har kylskåpet öppet länge? - ***3 min***

Har det med dålig översikt eller placering av matvaror att göra? Jocke, vad är "annat" för vara som ni tar ut ofta?

c. Har ditt sätt att använda kylskåpet förändrats under åren? - ***2 min***

Med ändrade levnadsförhållanden, familjekonstellation, ålder, ekonomi el dyl

d. Vad har kylskåpet för roll/betydelse för dig? ***- 4 min***

e. Humörslinje uppgiften: Vad känner du när du interagerar med ditt kylskåp och hur är ditt humör? - ***2 min***

Få en individanpassad 24h tidslinje och sätt ut humörsgubbar

f. Diskutera vilken ”status” de är i och jämför svaren - ***3 min***

Gällande informationsmottaglighet i de olika skedena...

g. Inköpslista: Ni som inte använder förskriven inköpslista hur planerar ni era inköp?

Planerar ni dem alls? Hur bestämmer ni vad ni ska äta och när planerar ni det?

h. Matflöde; Hur gör du för att tina mat från frysen? Hur hanterar du varma matrester? - ***5 min***

Varför, varför, varför, varför inte?

i. Har du reflekterat kring vad som är orsaken då du slänger mat? - ***5 min***

Hur mycket influerar datummärkning? Oftast från kyl, matbord, skafferi, ugn eller frys till soptunnan? Otillagat eller tillagat?

j. Anser du att du kan tillräckligt mycket om hur olika livsmedel bör förvaras? - ***4 min***

Koll när det gäller temperatur och fuktighet m.m.? Skulle du uppskatta om ditt kylskåp gav dig feedback/information om det?

Upplever ni ”felplacering” som ett problem? Hur skulle du vilja få sådan information? Genom kylskåpets utformning och eller skriven information?

3. kl. 18.50: Framtidsscenario och fika – *20 min*

Läs upp framtidsscenariot och beskriv uppgiften de skall utföra. Visa dem materialet och be dem att göra en egen action line (eller cirkel om de hellre vill) med bilder ord och valfritt material.

Påminn efter 15 min om att avsluta!

4. kl. 19.10: Presentation av framtidsscenario, diskussion kring mervärden – *40 min*

Låt var och en beskriva vad de har skapat och förklara varför/hur de tänkt. ***12 min***

Diskutera: ***28 min***

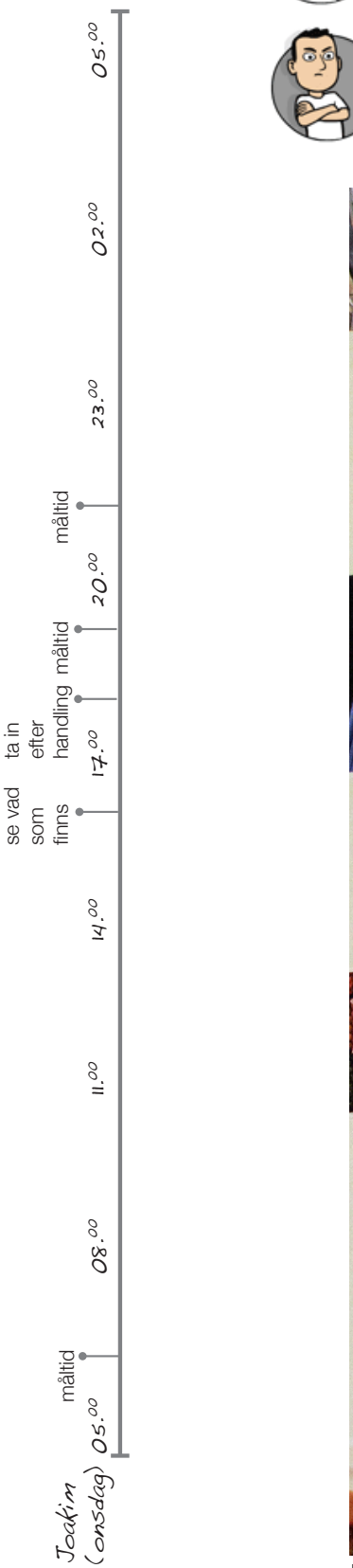
Hur kan planering av inköp och kommunikation underlättas? Hur handlar ni maten? Hur kan ni få bättre koll på kylskåpets innehåll? Hur vet ni vad för mat som ni ska laga och hur går ni till väga? Kommer ni ens att laga mat? Var sitter ni och äter? Tillsammans med vem? Vad gör att ni skulle tycka om just de produkterna och funktionerna ni beskriver? Vad i allmänhet gör att man blir fäst till en produkt?

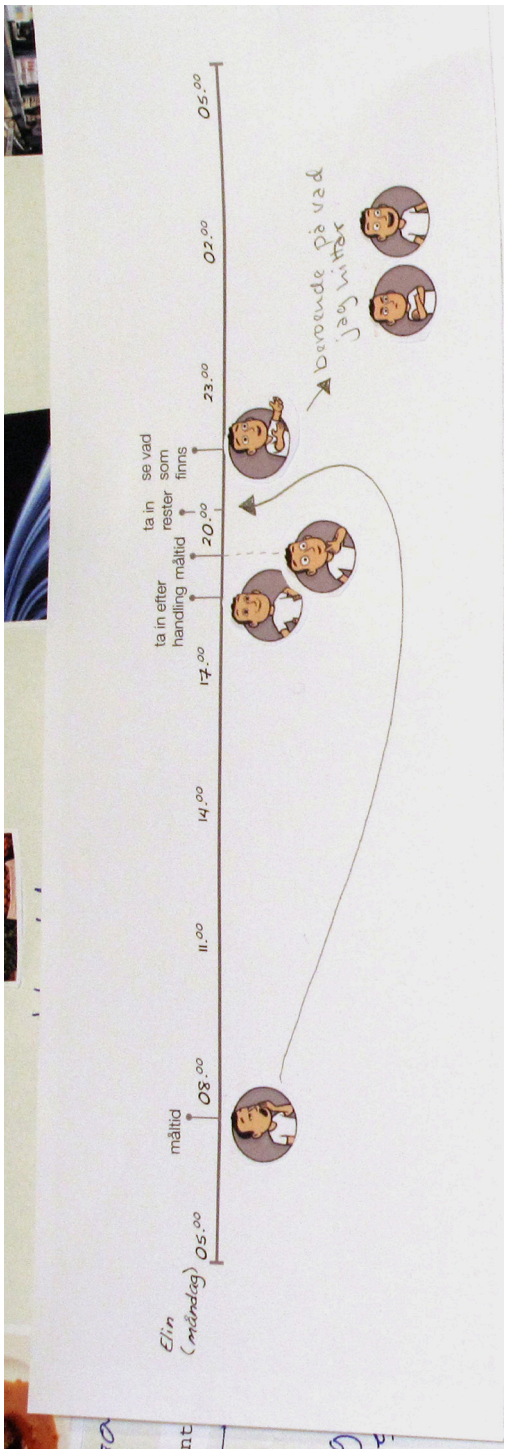
Påståendena från enkäten……diskutera och rangordna vad som är viktigast! Hur viktigt är det att produkter uttrycker den ni är? Hur stor roll har varumärket i det?

5. kl. 19.50: Avslutning, tack och utdelning av presenter

Förfrågan om de kan tänka sig ev ställa upp på utvärdering av slutkoncept.

APPENDIX IX: **Context mapping -** *PrEmo assignment*





Filled in assignment

APPENDIX IX: **Context mapping -** *future assignment*

Framtiden.

Välkommen till år 2020....
Världen är globaliserad där gränser mellan länder och regioner allt mer blir utsuddade. Du kan höra från yngre som växer upp att de ofta säger sig vara europeer snarare än svenskar. Även gränserna mot den virtuella världen har suddiga kanter, till vilken du alltid är uppkopplad och där du har en utvecklad egen personlighet som liknar den du har i verkligheten. Av och till får du en känsla av dubbla verkligheter. Virtuella möten mellan dig och vänner och arbetskamrater är vanligare än verkliga möten. Synen på livsstadier i livet har mer eller mindre försvunnit och barn som växer upp vet inte vad ord som ”medelåldern” betyder. Livet ses mer som en linje, utan uppdelningar. Forever young.

Fler och fler människor flyttar till storstäder. Konkurrensen mellan företag är stor vilket tvingar dem till att hitta nya mer emotionella vägar att skilja sig från varandra och tilltala dig och dina önskemål. Tjänster ersätter och kompletterar produkterna du köper och de produkter du köper är speciellt anpassade för just dig och dina behov. Produkter blir smartare och kan kommunicera med varandra. De blir mer ”mänskliga” och kan utvecklas, uppdateras och med tiden anpassas bättre till dig som användare. Tillgänglighet är ett ord som ligger i tiden; allt är tillgängligt alltid. Andra viktiga uttryck som speglas av samhället är frihet och ständig medvetenhet.

Din framtida dröm-mathantering

Du har bjudit hem några vänner på middag. Föreställ dig att året är 2020 och att samhället ser ut så som du just fick beskrivet i framtidsscenariot.

Hur skulle du gå tillväga för att planera, handla och förbereda måltiden? Hur ser ditt drömkök, och framförallt ditt optimala kylskåp ut? Vad kan det göra och hur interagerar du med det? Är det ens ett kylskåp eller hur förvaras maten, och hur sker inhandling av matvaror?

Gör en tidslinje över hela förloppet med fokus på interaktion och kommunikation med ”kylskåpet”, och beskriv med ord och bilder så som du tror att det hade gått till i de bästa av världar!

Beskriv gärna vad du upplever och vad som gör det till det bästa kök/kylskåp/ mathanteringsprodukten/tjänsten du kan föreställa dig inom de givna ramarna!

Här är lite stödord som är bra att beskriva i förloppet:

planera och kommunicera – handla – få hem och packa in varorna – hitta och ta ut ingredienser och tillaga – ta hand om rester

APPENDIX X: **Barriers matched with problems**

Barriers											
Areas of behaviour change	1	2	3	4	5	6	7	8	9	10	11
Food placement (overview, best conditions for preserving the food)	X	X	X		X		X			X	X
Hot/frozen food placed in the refrigerator		X			X	X	X		X		X
Taking care of food before it goes bad (leftovers, close to expiring date, knowledge)			X		X			X			X
Food planning (dinner planning, communication, shopping lists)			X		X	X			X	X	

1. Ignorance of how to – Ignorance that something actually can be done, lack of information
2. Ignorance of the actual consequences of the action
3. Hopelessness – ”it’s impossible”
4. It is too expensive
5. Too effort demanding (laziness, tired, convenience)
6. High risk of accidentally doing wrong/forgetting doing right (it’s easier doing wrong than right)
7. Takes too much time
8. Lack of inspiration to act sustainable/not (visual) appealing
9. Difficulties of planning
10. Lack in communication
11. Other things/actions comes first

APPENDIX XI: **Need and demand list**

Any of the needs and desires should not compromise on sustainability

1. Sustainability

1.1 Make the user act more sustainable than with a classic refrigerator, i.e affect them to waste less food and consume less energy.

1.2 Utilize the technology in the most sustainable way (so the energy efficiency reach its full potential)

2. Technical aspects

2.1 Possible technology

2.2 Top class energy efficiency

2.3 Possible to integrate with/adapt for smart grid

2.4 (Feature a display/touch screen)

2.5 Not be noisy

3. Interaction

3.1 Be intuitive/easy to use

3.3 Not overload the user with information

3.4 Offer an interesting experience

3.5 Be supportive

3.6 Feel nice to touch

3.7 Advice cooking

3.8 Enhance the experience and the social aspects of food

3.9 Not demand more effort than present refrigerator without clearly communicated benefits

4. Functionality

4.1 Offer temperature and humidity conditions so products of the following categories last at least to the declared expiring date:
dairy products, meet and fish, vegetables, eggs, fruits, drinks, jars and cans, post-prepared food, etc
...

4.2 Allow adaptation of interior climate

4.3 Support thawing food in energy efficient and controlled ways

4.4 Support chilling down food in energy efficient and controlled ways

4.5 Allow easy taking out of foodstuff

4.6 Allow easy loading

4.7 Offer overview of contents

4.8 Give information/feedback on energy consumption

4.9 Offer suitable lighting to see inside

4.10 Support food planning (shopping and meal planning)

4.11 Guidance in what to stored where

4.12 Support keeping good organization

4.13 Facilitate knowing status of food (including left overs)

4.14 Allow flexibility and meet needs of different occasions

4.15 Offer cooking inspiration

4.16 Help saving time

4.17 Be easy to keep clean

5. Food management

5.1 Preserve the freshness/condition of food

5.2 Preserve consistence of food

5.3 Preserve nutritive content of the foodstuff

5.4 Prevent growth of microorganisms

5.5 Preserve taste of the foodstuff

5.6 Minimize waste of foodstuff

5.7 Support utilization of leftovers

6. Design demands (dimensions etc)

6.1 Meet dimension and weight requirements of foodstuffs and packagings needing cold preservation (see specification)

6.2 Offer overview of contents

6.3 Preserve foodstuff from crushing

6.4 Fit into the kitchen interior

6.5 Easy to keep clean

6.6 Flexible for shifting needs

6.7 Support organization of foodstuffs

7. Customization

7.1 Attract the target by being:

- Flexible for shifting needs
- A way of expressing themselves through the product
- Supportive to their social lifestyle
- Fun to interact with

7.2 Upgradeable

7.3 Adaptable for the users needs and preferences

8. Expression, formal functions

8.1 Express premiumness

8.2 Carefully designed details

8.3 Unique (i.e not mainstream, too ordinary)

8.4 Perceived as fresh

8.4 Perceived as reliable and competent

8.5 Emotionally attractive

8.6 Fit into the Electrolux brand product range.

8.7 Change its “personality” from anonymous and boring to attractive and confident

8.8 Invite to consume the contents

9. Material

9.1 Use, in comparison with other materials on the market, sustainable materials

9.2 Not use environmentally harmful materials

9.3 To an as high extent as possible use recyclable materials

10. Market

10.1 Be designed for the European market.

10.2 Strengthen the bond between the consumers and Electrolux

APPENDIX XII: **Idea generation -** *early ideas and sketches*

Vid höjd temperatur i kylen och sänkt i rummet visas detta som färgskiftning/ljus i rummet

När kylskåpet blir för varmt/ ökar energikonsumtion skiftar handtaget gradvis färg*

Subtil ljus/färg/mönster förändring på kylen när energiåtgången ökar

Användning av termofärger

Electrolux loggan ändrar färg beroende på energiförbrukningen*

Indikations(färg)lampa som visar på energiförbrukningen*

Feedback
på energiförbrukning, temp., status etc.

En sensor känner av om temperaturen stiger och kör då igång kompressorn med adderat ljud för att uppmärksamma användaren

ar hur man ligger til jämfört med
dra i energiförbrukning/pengas-
eri/matslöseri

Displayen visar med siffror hur temperaturen stiger hela tiden då dörren är öppen

Svårare och svårare att öppna dörren/dörren åker igen fortare och fortare vid många på rad följande öppningar

Kylskåpet låses då ett för varmt objekt kommer nära/alarm avgår

Ljuset avtar ju längre dörren är öppen (och slocknar helt till slut) för att visa på hög temp./energiförbrukningen*

Sätt att få info för planeringshjälp:
- scanna vid inplacering
- scanna kvitto
- våg i hyllplan
- kameraigenkänning
- 3D scanning
-programera via menysystem
- smartglas så att man kan se utan att öppna
- taligenkänning

Självscanningssystem i affären är kopplat till kylen så att ett varningssystem aktiveras om man köper varor som redan finns hemma*

Utnyttja handlingskvitto eller självscanning i affären för att få information inköpta varor till kylen, indikera var i kylen varan placeras

Skicka veckomeny till kylskåpet, famijen kan komma med synpunkter, kylen gör an shoppinglista av menyn*

mataffär

årstidsberoende

Matkalender på displayen. Årstidens varor, receptförslag, synka med nära och kära, dela med sig av matupplevelser*

kommunicera med mataffären genom kylen

Rfid/kamera/vikt/scanning för att få information på kylskåpsdisplayen/i smart phonen

connectivity och igenkänning

connectivity, avläsning av kylens innehåll och dess bäst före datum som kan ses i telefon

Planering

receptförslag för årstider, för se rester (om lagat från tidigare förslag finns lagrat, annars lätt att knappa in)*

receptförslag

Rfid och app: fråga via smart phone “finns mjölk”, få svar (ja 1 l bäst före...)

viktsensorer i hyllplanen som kan avgöra hur mkt som finns kvar av varje vara så att du vet det när du handlar och listan autouppdateras*

“dinner app“ - alla i hushållet måste attenda middagen, de kan önska måltider, och menyn sänds till mataffären så att matkassen kan hämtas upp där

Slumprecept efter de ingredienser som finns i kylen och behöver konsumeras

Inköpslista på displayen som är synkad med mobiler och datorer i hushåller,

listor

Inköpslista som tar hänsyn till vänner och bekantas middagsplaner , kollektivhandla

info om mats status

Inköpslista som automatiskt påbörjas av kylen, baserat på vad som finns och dess status, samt om varor tar slut*

Den automatiska inköpslistan är baserad på årstidensvaror och tillgång, föreslår även recept*

Förenklad info (typ mejeri 8 prod. *i*) viasas på displayen. klickas i kan mer info fås

Info om hur mkt det är kvar av olika rester och vad som behöver läggas till för att få god måltid

Varmt/kallt –temperaturövergångar

Ge dörren mer isolering för att skydda varorna i dörren bättre

Transferzone – varmt till kallt, kallt till varmt, övrig tid?*

Peltiercell

Upptiningsrådgivning - säg till när en rätt ska lagas och hur, kylen säger när maten bäst skall tinas och hur (direkt frys stekpanna eller 2h i rumstemp först?)*

Planering av matlagning i smartphone – kopplad till kylen – ställer automatiskt larm för när något ska tas ut och tinas – meddelas till användaren*

snabb nedklning med Peltier och skydd över så att värmen ej sprids*

Quick chill; en avdelning i kylen som kyler direkt och fort

Tining av mat på alt. sätt. Utnyttja värme från elementet.

Kall mat in

En stekpanna/gryta som kan ställas in i kylen med varma rester och där kopplas så värmen går ut ur kylen till rummet

När varm mat ställs in i kylen isoleras den av en isolerande bubbla

Då fryst mat placeras i kylen avges ökat ljus/trevligt ljud och på displayen står uppmuntring/feedback om "tjänad" energi*

Varm mat in

Isolerande "cooling box" som kan placeras i kyl/frys med varm mat i och transportera värmen ut ur kylen/frysen

En metallhylla fastkopplad i dörrhantaget som visar OK då maten i den är sval nog för att gå in i kylen

mat kan distanstinas via dator/telefon. säg när den ska vara tinad och kylen fixar*

Sensorer runt dörren som känner när för hög temperatur närmar sig och ett alarm (ljud/ljus) sätts igång*

En stekpanna/gryta som kan ställas in i kylen med varma rester och där kopplas så värmen går ut ur kylen till rummet

En hopfällbar metall/hårdplastpåse finns i kylen där varm mat kan placeras och värmen effektivt föras ut

Defrost compartment i kylskåp. bra idé, detaljer på blad E *

liten hylla som sakta rör sig in i kylen så maten kommer in först när den är kall

Kylen är indelad i temperaturezoner (varmast överst). varm mat placerasi liten hiss över och sänks sakta ned till rätt nivå allteftersom den svalnar

---

Utformning (av öppning)

"Kylbok" - hyllorna kan bläddras mellan som i en bok

Rörelsesensor som vid "viftning" öppnar kylskåpsdörren

2 dörrar, en stor och en liten

utfällbar hylla på handtaget som är en avlastinings yta som förkortar öppningstiden /antalet öppningar

kylutrymmet sluts till när maten dras ut*

Gummistripes som stänger in kylan istället för dörr

många fack och dörrar avsedd för specifika varor*

Skjutdörr i glas, som i butiksfrys

roterbar dörr som en lönndörr

olika tätslutna fack optimala för maten , vakuumfack, korta hyllplan som är obegränst flyttbara, interiöra lådor*

minska öppningstid/underlätta öppning

Skjutdörr på höjden (som arkivskåp)

Transparent eller smart glass dörr*

låda som tillsluts bakom så att kyla ej läcker ut när kylen öppnas

Lådor som öppnas med en knuff

Flera lådor och längsgående handtag - när motsvarande del av handtaget vidrörs öppnas de lådorna*

dörrar

Byrålådeöppning*

Lucka uppåt/nedåt

Låda som kan öppnas i 1 och 2 steg

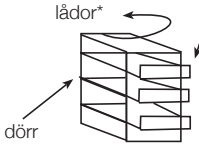
uppbyggnad

kyl-köksö
känsla av professional

Öppning från två håll; skåp och lådor*

lådor

door-in-door



Runt och roterbart

Modulärt så att utrymmet kan tillökas/minskas efter behov. Flera dörrar/lådor och ev även utspridda enheter*

Utsnurrbara hyllor som i ett hörnskåp

Utdragbar kryddskåpsliknande burkhylla****

Roterbar kyl med olika typer av öppningar från olika håll, lättillgänglighet och häftigt

runda/roterand hyllplan inuti för att öka översikt och tillgänglighet

Kylsåpsskåp hängandes över diskbänken som ett köksskåp i ögonhöjd*

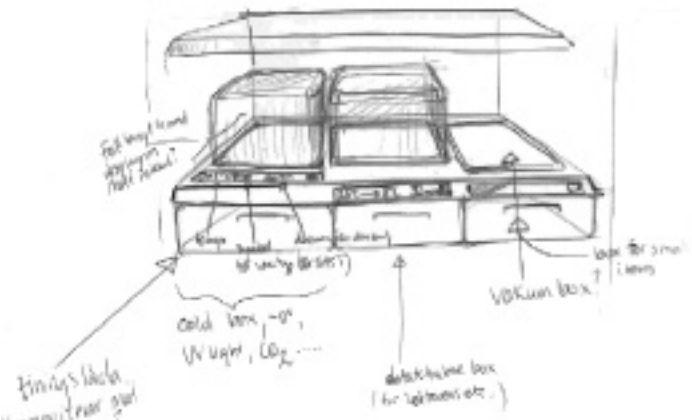
dörr/låda två öppningsmöjligheter i en

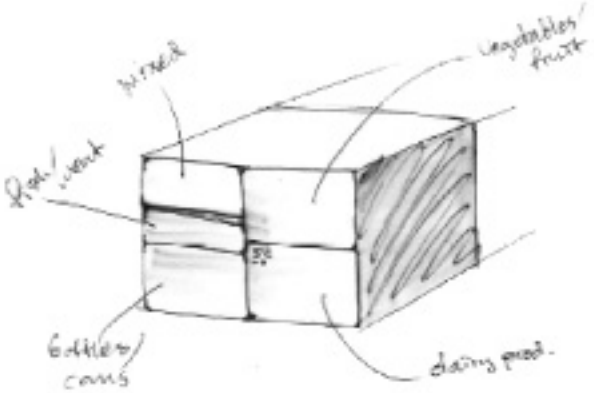
stänga inne kyla

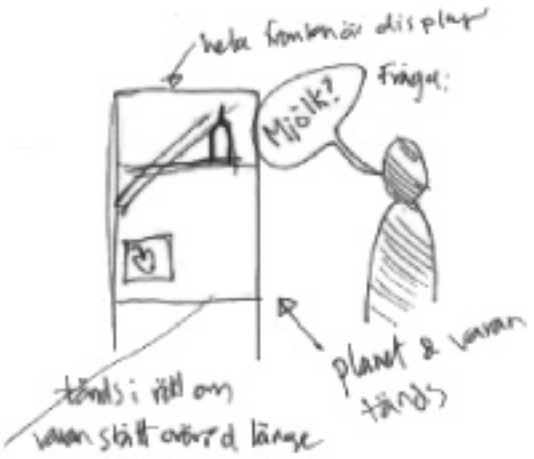
Ett mindre kylskåp så att man måste köpa hem mindre

Luftgardin som barriär* även feedback på att det är en barriär

spärr som förhindrar frekvent öppning

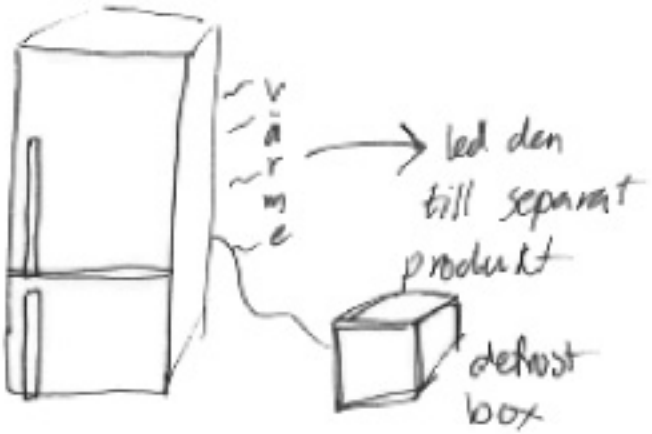

cold box
UV light
detachable box

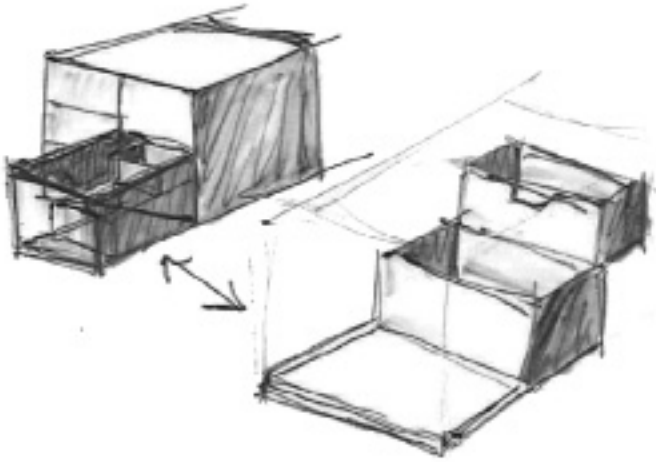

vegetables/ fruits
dairy prod.

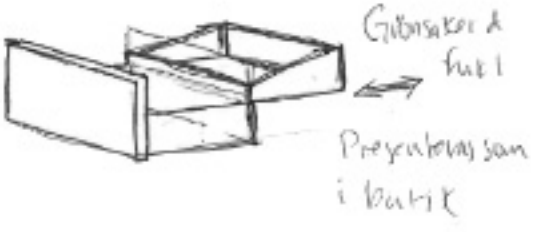

Mjölk?
Fråga:
plant & leaves


Lucka

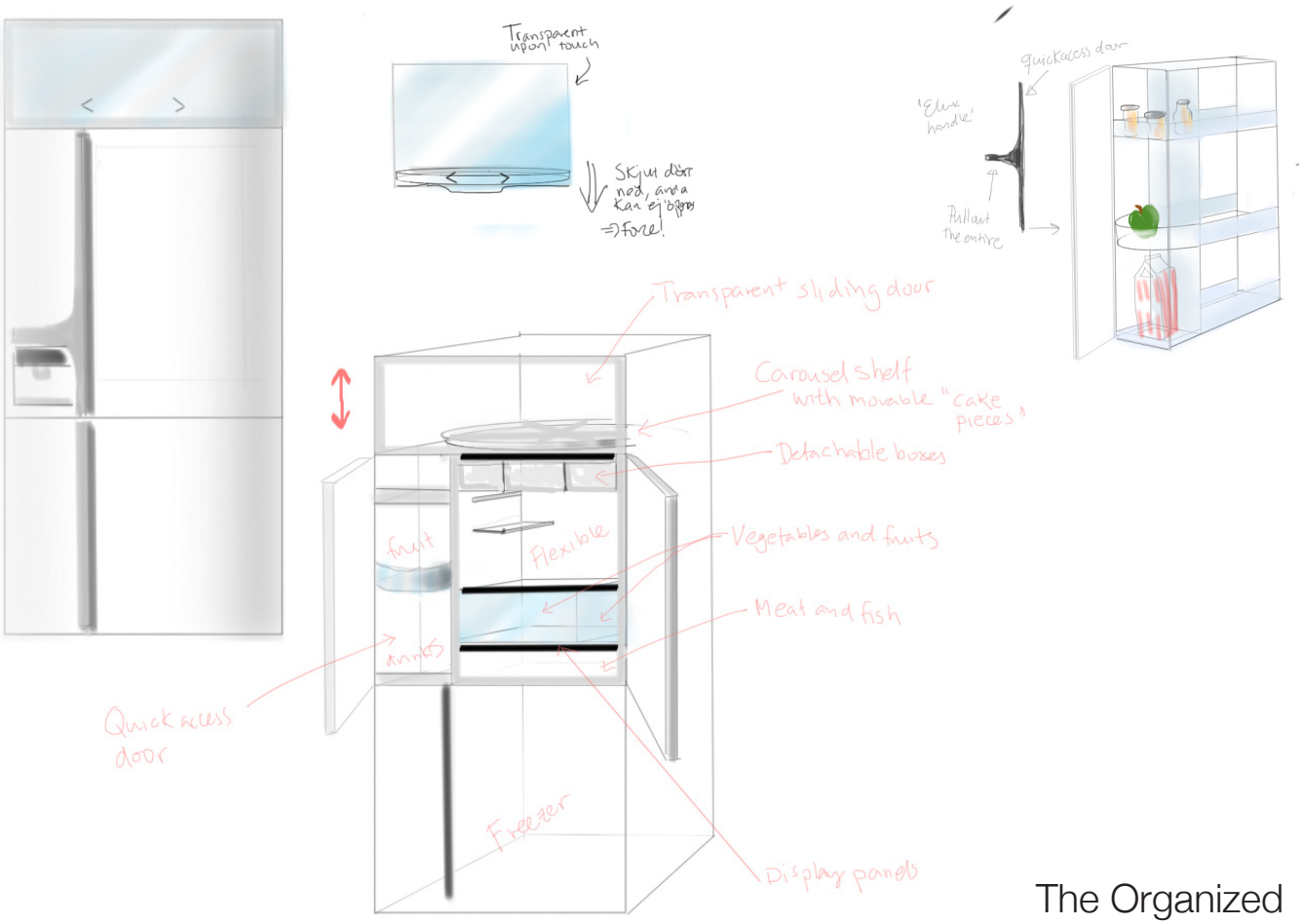

Varm


värme
led den till separat produkt
defrost box




Grönsaker & frukt
Proyektorn sam i kylen

APPENDIX XIII: **Part concepts** - *The Organized*



The Organized

Functions and features

The Organized was a combi-bottom refrigerator with the freezer in the bottom. The entire front was glass coated and its dimensions were slightly lower and wider than most refrigerators in order to make it easier to reach the top compartment.

The top door of the top compartment was made off Smart glass, so it was opaque until it was touched and turned transparent, so the contents could be seen without opening the door. The door to the large compartment had an integrated display, which was invisible until it was interacted with. In the interface it was possible to write a shopping lists that were synchronized with for instance smart phones to facilitate planning. Settings of the refrigerator could be made and information about how different foodstuffs should be preserved accessed. The refrigerator could also remind the user of products which had not been moved for a long time, or give notifications to for instance bring the lunch box.

The Organized also aimed to change the user behaviour in placing warm food into the refrigerator by giving immediate feedback on the action. It would by means of IR sensors around the opening detect instantaneous temperature increases and then turn the interior light redder, communicating that the temperature in the inside would raise affecting the food in a bad way.

To the left of the large compartment there was a pull out larder, which also could be opened as a small quick access door for frequently used products.

In the flexible large compartment there was a system of detachable boxes for leftovers. It included boxes connected to a display strip on which date labelling, contents and special storage settings could be

accessed. Thus, taking care of leftovers and broken packages was encouraged and facilitated.

To encourage the user to finish the oldest food first, an eat-me-first zone was suggested. In this zone lit up by green LEDs, products close to expire could be placed to highlight and remind that they had to be consumed. In the same compartment were also "flip-click shelves" suggested to further increase the flexibility and possibility to customize the space. These shelves could be flipped down or up against the wall depending on the dimensions of the stored items. There was also a dividable box for vegetables and a cold compartment for eat and fish, which was about zero degrees.

The top compartment covered with smart glass could be opened by sliding down the door, making it impossible to open the other doors at the same time by force. The carousel shelf behind the transparent door facilitated reaching things at the back, and gave easy access to products often used together. The carousel shelf had "cake piece trays" where entire kits of products such as the breakfast kit could be placed on one tray so they could be taken out all at once, and the opening time hence shortened. The carousel could be turned from the outside by swiping on the glass door, and it could learn its usual position at a certain time of the day to then auto turn.

When opening the quick access door at the side frequently used drinks could be reached and there was a fruit bowl encouraging users to more eat fruit. If using the horizontal handle instead of the vertical the entire larder could be pulled out. In the larder the was space for storing bottles, cans, jars, tubes etc. with good overview, and it was less cold than in the large and the top compartment.

APPENDIX XIII: **Part concepts** - *The Professional*

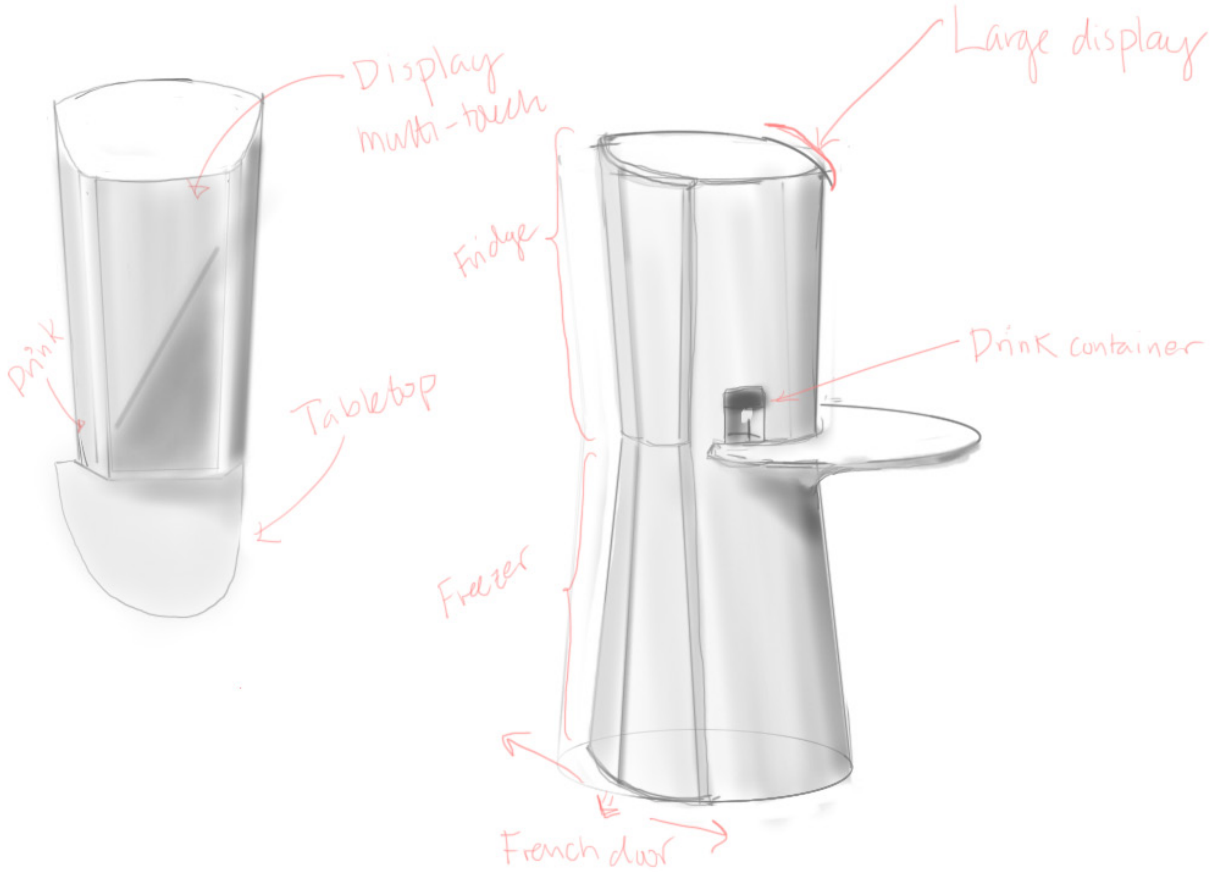
Functions and features

The Professional was placed under/in line with the kitchen worktop and had several compartments and drawers tailored to optimally preserve different foodstuffs, i.e. food was placed according to type and what temperature and humidity demands. The top surface could be offered in different colours so Louise could choose the one she fancies. The top surface was not only decorative but also functional, since it could be used as a working bench. There was a fan at the back of the refrigerator that led up the heat that otherwise is spread in the room. With the fan turned on the surface could be used for tempering food, fermentation of bread or to speeding up thawing (which better should be encouraged to do in the refrigerator). If the fan was turned off the top surface was suitable for cooling down food before putting it in the refrigerator since it featured temperature sensors. If something too hot to put in the refrigerator was placed on the surface indicators would turn the surface red around the food and the intensity of the colour would decrease until it disappeared and the food was cold enough to go into the refrigerator.

Each and every drawer would have sensors and special features prolonging the durability of the food, like a mineral filter reducing ethylene gas and moisture, and light of red and blue wave length making vegetables mature slower. There would also be a specified temperature interval adapted for each drawer's contents, and a temperature indicator on the outside showing the temperature in absolute numbers when the surface is activated (touched). Otherwise only a small circle would be visible. The temperature indications would inform the user if the temperature in the drawers are in the right interval; if any happened to be to high the indicator would lit up in red instead of withe and if it were too cold it would turn blue to give feedback. Apart from the special functions the drawers interior and size were designed to offer good overview and space for different groceries, and to keep good order.

The Professional did not have a multifunctional display; instead it should come with a special application with a clear and stylish interface. The application would have functions that expanded the professional experience and educated and engaged the user in the food management. There would be recipes from the professional chefs working for Electrolux all over the world, giving the persona Louise the possibility to find the latest professional trendy recipes to cook for her friends, increasing her interest in food and thus start caring more about the foodstuff. There could also be information about foodstuffs; how they are best taken care of and their contents, advices how and when to chill and thaw food connected to a timer function and the possibility to make personal settings and adjustments.

APPENDIX XIII: **Part concepts** - *The Communicator*



Functions and features

The looks and the appearance of the interior were undefined. Instead the focus was on the virtual functions. The concept was visualized with a more unique form than the other concept, mostly to show that it could be very different from the conventional refrigerator. It was completely freestanding with a small table around it on the back. The table could be used when having a snack or interacting on the display, which could be visible on both sides of the refrigerator. Since it had eye tracking it could detect where the user stood and turn up there with customized settings to make it more personal. The table had a part sticking out by the door that could be used when loading/unloading the refrigerator, so the door did not to have to be kept open for as long as when having to turn to another surface.

To prolong the durability of foodstuffs The Communicator could have a larger freezer compared to refrigerator. It also featured a built-in water dispenser by the table to eliminate door openings for taking out water.

The interface off the Communicator offered functions within three areas - overview of contents, assistance in planning and recipes et cetera for inspiration. It had content awareness, which means that it by means of cameras and sensors, or possibly RFID tags, could keep track of its contents and share the information with connected devices. This allowed the user to know what they had at home and what were soon to go off without having to check in the refrigerator. If knowing what there is in the refrigerator when being at the supermarket the user could avoid buying doublets. S/he could also have suggestions of what to cook based on what there already were at home.

When the user opened the door products needed to be consumed soon could be highlighted. Since the Communicator had voice control it could also be possible to ask for products and they will be highlighted to be found faster. In the interface informa-

tion about food storage, different foodstuffs, their nutritive contents, their environmental impact and so on sould be presented in an engaging way to educate the user. Pinpointing the effects of actions such as putting warm food into the freezer could also be suitable.

Competition is a strategy for changing behaviour, why allowing the user to compare statistics over food purchases and energy consumption could be a good way to encourage a more sustainable behaviour. Based on the content awareness were the shopping list and the support to choose dishes to cook two key functions. The shopping list could either be written right on the display, as it had been a real piece of paper hanging there, or things could be added by the voice control. The list could be synced with other devices and it could even be sent to the food store for the groceries to be pick up or delivered to the door. Based on the weekly menu planned on the Communicator, the ingredients from the chosen dishes that were missing in the refrigerator could be automatically added to the list. When planning for the entire week in advance less food is bought in vain, and the quantities needed can be optimized. The refrigerator could send a reminder of what to buy by whom and when in order to have the ingredients fresh at home when they are needed.

In order to make the planning more enjoyable and engaging users in caring for the food and the environment, there were the inspiration functions, where the bank of recipes was the core. The Communicator could easily adapt for the users demands; special diets, budgets, desired ingredients, what they got at home, cooking time, flavours etc., to find suitable recipes. Thus the Communicator would serve as a moderator when the user runs short of inspiration. There could also be seasonal suggestions and maybe also where to buy the ingredients nearby, or with good offers based on the present supply. The cooking instructions were shown on the display as an interactive video with a chef or a friend cooking. By navigating on a world map the user could connect to friends and share recipes and other food related things, something the target user would like since she is a social person who likes trying new things. If having near and dear far away there could also be a possibility for co-cooking or dining together via the Communicator.

To conclude this concept it offered endless possibilities of functions since it had the content awareness and the Internet connection. But it was important to pinpoint that it should not have any features that did not encourage a pro-environmental behaviour or were very relevant and meaningful for the Electrolux brand and its heritage, or for the target user.

APPENDIX XIII: **Part concepts -** *additionals*

Extras: Expression, character, customization, awareness...

- Wake up/fall asleep when starting stopping interaction. Light up slowly, pulsating light heartbeat breathing, noises, vibrations Communicator
- Voice recognition so it is personally customized for each user (foremost the communicator) The interface is adapted for each user and learns how you interact and creates shortcuts for you
- Turn the shelf according to who uses it and when Organized
- If the display is large notes can be written there and only shown when desired (like dashboard) Communicator/Organized
- Patterns and light with meaning – all of them giving some sort of feedback all but differently
- Change colour and appearance of the entire front as the user likes to have it (if all is a display or lit up with LEDs for instance, or projection) Communicator

Immediate connection btw action and consequence:

Door openings - decreasing light intensity inside Proffesrional
changed colour of the light Organized (synced with the coloured temperature zones)
increasing light signal
very subtile countdown/alarmclock signal Organized
air stream starting when opening (the heat from the back?)
termometer/numbers showing temperature incease all but differently
a meter showing increased cost, kWh, or anything else
handle gets warm (tactile feedback) Organized/Communicator (not necissarily handle)
colour change of handle

Momentanous temperature changes - measured with IR sensors Proffesrional (Organized)
frozen food -> reward (points, symbols ratings, vouchers..)
Telling in advance what will happen if you do this and that incentive will come so the user can change her mind
hot food -> warning Communicator
point deduction
suggest alternative action that is good

- The handle is very hot/cold depending on the temperature conditions inside (unpleasantness, direct feedback)
- Triggering reminders -> make it emotionally affective to do wrong (kill the frog...) create bad conscience from wasting food all but differently
- Reference objects/indicators to show the status the food should have in the present climate of the fridge.
- Hot food: light turns read
- Frozen food: blue light Organized

Also communicate in numbers: degrees all, durability off food Professional, electricity bill, compare with oneself Communicator (earlier)

Communicate visually: patterns for instance

- Tactile surprises on handle Organized
- Hidden surprises/new occurences in the fridge Communicator, carusel shelf in Organized
- Light up items not used for a long time Communicator

Interior modules: Organized

- Special porcelain (or plastic) trays, forms, plates, boxes etc produced by designers/other brands as co-branding limeted editions, tailored to fit in the fridge. Also fit with other appliances (dishwasher, freezer...prof.)
- Vaccum box, defrost box, hot food box etc to place over on an designated place on the shelf with little display for settings

APPENDIX XIV: **Evaluation** - *functions vs focus area for sustainable behaviour*

Evaluation of concepts and features with derivation of used intervention strategies

*highly promising
*promising

OK1 = fit focus 1, optimal preservtion
OK2 = fit focus 2, temperatures

Concept	Focus area	Adopted DSB categories	Adopted DSB strategies	Usage situation*	Expected effectiveness
The Organized	Increase overview and accessibility -> waste less energy Save leftovers -> waste less food	1. Spur 2. Steer		Primarily single use, secondary needs	Education and communication of intended usage needed
The Professional	Improve preservation and awareness of contents-> waste less food	1. Steer 2. Enligthen		First time and activities	High, long term. Raised awarness of preservation. Placment have to be communicated.
The Communicator	Encourage and facilitate planning -> Buy less and use everything. No waste	1. Enlighten 2. Spur		Needs	Change in lifestyle, product dependent, behaviour gone if product gone
Features					
* Eat me first zone	Use before going off	Enlighten, Steer	Exhort behaviour, Scripting	Needs	Immediate, long term if becoming a habit
* Kits of products used together	Shorter/less openings, less energy waste	Spur	Convinience	Activities	Must be evaluated physically
* OK2 Encourage thawing in fridge	Hot/frozen management-> gain energy	-----	-----	Activities	-----
Transparent door	Overview, less openings -> less energy used	Spur	Convinience	Single use	Convenience is determining.
Inviting fruit quick access	Eat more veggies, accessibility -> less waste	Spur	Convinience, Incentives...	Needs	Lifestyle change, over time
Quick access door	accessibility, less long openings -> waste less energy	Spur	Convinience	Single use	Doubting. Depends on organization
* OK2 Direct feedback on hot food (light)	Hot/frozen food management, invisible energy -> less waste	Enlighten	Immediate feedback	Activities	High but annoying
* OK1 Leftover system	Take care of leftovers ->less food waste	Spur Enlighten	Enhanced benefits Information	Needs, activities	Long term ,life style change

*See the irefrigerator-user nteraction cycle

Features	Focus area	Adopted DSB categories	Adopted DSB strategies	Usage situation	Expected effectiveness
* OK1 Durability enhancing technologies	Placement for better preservation-> less food waste	Spur	Incentives	Activities, first time use	No direct behavioural change
Pull out larder	Placement for better overview-> less food waste	Spur?	Convinience?	Single use	Low, but good overview and organization
* OK2 Chilling down temperature indication surface	Hot/frozen food -> less energy and food waste	Enlighten	Immidiate feedback, Support relatedness, Enlightment through interaction and experience	Activities, needs	Immediate, educates!
* Warm surface using waste heat	Hot/frozen food	Spur, but not obvious	Enhance benefits	Needs	Benefit for the user, use waste Energy. Little behaviour change.
* Kitchen/food management seamless system with trays etc	Additional benefit	Spur	Enhance benefits, convinience	Activities	Benefit for the user, convinience
* OK1 Local temperature zones	Placement for better preservation	Spur, Enlighten	Incentives	Activities, first time	Good if communicated, otherwise terrible
* Shopping lists and synchronization	Planning -> waste less	Enlighten Spur	Support Autonomy, Convinience	Needs	If effortless, very effective
Recipie bank	Planning (inspiration) -> waste less through finding ways of using	Spur	Incentives	Needs	Indirect and low, inspirational
Reminder of products to consume	Use before going off	Enlighten	Information for sustainable behaviour	Activities	Depends. Easily ignored
* Competition, compare with the past	Decrease consumption	Spur, Enlighten	Competition, feedback for self monitoring	Needs	Most effective in the beginning, then the change might be sustained
Carousel shelf	Food placement (accessibility and overview)	Spur	Fun theory, convinience	Single use	Better control, relatively high

*See the irefrigerator-user nteraction cycle

Evaluation of concepts and features with derivation of used intervention strategies

	Features	Focus area	Adopted DSB categories	Adopted DSB strategies	Usage situation	Expected effectiveness
	Recipe suggestions based on contents	use food before going off	Enlighten, Spur	Engaging information, Convinience	Needs	Dependening on the function, effective when in use
	Self-closing drawers	Prevent heat leakage	Force, Match	Forced functionality	Single use	Good result, BUT when using another fridge it can have negative effect
OK1	Numerous customized compartments	Food placement for accessability and preservation	Force, Spur	Habit intervention, Order and aesthetics	Activities, single use	Immediate, but items has to be orginazed properly ☆
	Loading/unloading surface	Decrease door opening time -> less wasted energy	Spur	Convinience	Activities	High ☆
	Cooking instruction videos	(Engage and inspire)	Enlighten	Guidance from authority, Modelling	Needs	None, just inspirational and engaging
	Colour coded interior	Food placement, organization and preservation	Enlighten, Spur	Information, Order and aesthetics?	Activities	Uncertain
	Know contents away from home	Planning, use before going off	Enlighten, Spur	Information, Convinience	Needs	Excellent ☆
	Purchase optimization and weekly meal planning	Planning, less food waste	Spur	Goal setting, Enhanced benefits	Needs	If becoming a routine, high ☆
	Visible energy consumption	(Decrease energy consumption and increase awareness)	Enlighten	Enlightenment through Interaction and Experience	all	High, especially if directly associated with actions ☆
OK2	Visible absolute temperature and interval accordance	Educate to right preservation (food placement) -> less waste	Enlighten	Exact feedback	Single use	High ☆
	Storage/preservation suggestions	Food placement for preservation and overview	Enlighten	Information	Activities	Little, demands effort from the user
OK1						

**See the irefrigerator-user nteraction cycle*

	Features	Focus area	Adopted DSB categories	Adopted DSB strategies	Usage situation*	Expected effectiveness
OK2	Thawing/chilling timer	Hot frozen food and planning	Enlighten	Information, Feedback	Activities	Helpful, medium effectiveness ☆
	Food information (contents, impact, heritage, nutrition...)	Education and awareness	Enlighten	Engaging information, Enhancing resource value	Needs	Long term lifestyle change ☆
	Patterns emerge connected to energy consumption	Education and awareness	Enlighten, Spur	Enlightment through interaction and experience, Order and aesthetics	Needs	If well communicated; Long term lifestyle change
	Flip-click shelves	Organization for overview	Spur	Order and aesthetics	Activities	Helpful, medium to high effectiveness
	Mirrors on inner walls	Overview and awareness	-----	------	Activities, Single use	Uncertain, needs to be physically tested
	Additional modules for organization from other companies	Overview and awareness	Spur	Order and aeathetics, Affective design	All	Uncertain

APPENDIX XIV: **Evaluation** - *part concepts vs need and demand list*

Need and demand list extract for evaluation

1. Sustainability

-

2. Technical aspects

2.1 Possible technology

3. Interaction

3.1 Be intuitive/easy to use

3.4 Offer an interesting experience

3.5 Be supportive

3.7 Advice cooking for sustainable inspiration

3.8 Enhance the experience and the social aspects of food

3.9 Not demand more effort than present refrigerator without clearly communicated benefits

4. Functionality

4.1 Offer temperature and humidity conditions so products of the following categories last at least to the declared expiring date:

dairy products, meet and fish, vegetables, eggs, fruits, drinks, jars and cans, post-prepared food, etc

...

4.3 Support thawing food in energy efficient and controlled ways

4.4 Support chilling down food in energy efficient and controlled ways

4.5 Allow easy taking out of foodtuff

4.6 Allow easy loading

4.7 Offer overview of contents (a. know what there are inside b. know where what is placed)

4.8 Give information/feedback on energy consumption

4.10 Support food planning (shopping and meal planning)

4.11 Guidance in what to store where

4.12 Support keeping good organization

4.13 Facilitate knowing status of food (including leftovers)

4.14 Allow flexibility and meet needs of different occasions (modes)

4.16 Help saving time

4.17 Be easy to keep clean

5. Food management

5.7 Support saving/utilization of leftovers

6. Design demands (dimensions etc.)

6.2 Offer overview of contents

6.3 Preserve foodstuff from crushing

6.4 Fit into the kitchen interior

6.5 Flexible for shifting needs

6.6 Support organization of foodstuffs

7. Customization

7.1 Attract the target by being:

a. A way of expressing themselves through the product

b. Supportive to their social lifestyle

c. tempting to interact with

7.2 Upgradeable

8. Expression, formal functions

8.3 Unique (i.e not mainstream, too ordinary)

8.5 Perceived as reliable and competent

8.9 Invite to consume the contents

9. Material

10. Market

10.2 Strengthen the bond between the consumers and Electrolux

Category	The Organizer		The Professional		The Communicator		Comment
2.1		2		1		0	
3.4		0		1		2	
3.5	placering, rester	1	varm/kall mat	1		2	
3.7		0		1		2	
3.8		0		0		2	
3.9		2		1		1	
4.1		1		2	undefined		
4.3		0		2		1	
4.4		0		2	undefined		
4.5		2		2	undefined		
4.6		2		0		1	not a big difference!
4.7a		1		0		2	
4.7b		1		2	undefined		
4.8	indirect	1	indirect	1		2	
4.10		1		0		2	
4.11		1		2		2	
4.12		2		1		0	
4.13		1		1		2	
4.14		1		1	undefined		
4.16		0		1		2	
4.17		0		2	undefined		
5.7	save	2		0	use	2	
6.2		2		1	undefined		
6.3		1		2	undefined		
6.4		1		2		0	
6.5		2		1	undefined		
6.6		2		2		0	
7.1a		0		1		2	
7.1b		0		1		2	
7.1c		1		0		2	
7.2		1		1		2	
8.3		0		1		2	
8.5		0		2		1	
8.9		1		1		1	same same but different
10.2		0		2		1	
Summary:		**32**		**41**		**38**	

Functions of final concept

An evaluation which key aspect each feature satisfies the most and how

Key aspects:
a. Functionality
b. Sustainable behaviour
c. Target user
d. Electrolux

Hot food indication on top surface

a.– b. Yes, preventing loading of warm food in fridge. Learning user when food has ok temp.c. ? depending on how d. –

Working bench/(un)loading surface

a. Facilitate b.Shortening door opening time c.– d. –

Warm top surface

a.– b.Yes, if communicated where the heat comes from c.? Makes it unique d.Seems innovative, differentiate, professional?

Kitchen scale in the top surface

a.– b.Yes, encourages cooking the right amount of food c.Convenient, unique, better than others, advanced but simple d.Professional

Thermometer on the scale

a.– b. Help the timer function to work, learn temperature and thawing times c.– d.Ingenious

Thawing timer

a.– b.Yes, change behaviour to thaw in fridge c.Yes, in control, feel good etc. Important that it is easy d.Yes, communicate professional expertise

Storage/placement guidance on the display

a.Yes b.Yes, the food is placed where it should c.– d.Professional knowledge with ability to guide

Kitchen towel dryer

a.– b.Enlightment of energy usage –if communicated c.? uniqueness, should be nicely looking to attract d.Environmental thinking, strenghten eco-friendly image – if communicated

Indication of temperature accordance/deviation on the outsides

a.– b.Yes, enlightment of actions and educating about what's suitable c.– d.–

Indication of "work in progress" when the refrigerator is readjusting to the right temperature

a.– b.Yes, feedback on that energy is needed to meet the previous action c.– d –

Detachable interior for increased cleanability

a.Yes, preventing growth of micro organism and make it easy to keep clean b.– c.Yes, convenience (can put the parts into the dishwasher) d.Professional, important to keep clean and hygienic

Self-closing drawers

a.Yes, keep suitable indoor climate b.? awareness of long door opening if closing after a while c – d.–

Eat soon zone

a.– b.Yes, encouraging and informing of food that needs to be eaten. c.Uniqueness, she can use it as she pleases d.User in focus, "Thinking of you"

Big graphic symbol on each interior compartment

a. –b. Informing of right placement c.– (simple information) d. –

Small graphic symbols, digital on "display strip", lit up on the edge of each exterior compartment, showing examples of stored items

a. – b.Informing of right placement c.– (simple information) decorative/ aesthetically pleasant
d. –

Cold vegetable compartment with red/blue light and sealing lid (to keep humidity). Maybe mineral filter too

a. b.c.d. Premium feeling

Pattern in the bottom surface of the vegetable drawer minimizing the contact surface

a. Makes vegetables last linger
b.c.Something special, aesthetically pleasant
d.

Cold meat compartment with extractable trays

a. Hygienic, minimize risk of odour and bacteria transferal
b.c.d. Professional feeling

Cold drawer for long-storage of dairy products etc

a.b.? Encourage users to keep the food for longer c.d.

Highly adjustable drawer for smaller items in the mid-compartment

a.b.c. Yes, flexible d.

Pull out compartment for bottles/ jars

a.b. Quick access – less cold compartment that is separated matches the current behavior of taking jars in and out when cooking c.d.

Pantry compartment for drinks, potatoes etc.

a. Have to chill less for the things not having to be as cold preserved -> energy savings b.c.
d.

Additional storage accessories to buy

a.b.c. Yes, ability to personalize d.

Extras:

Leftover management ribbons with RFID

a.b.c.d.

Interior parts fit into the dishwasher and oven of the same range

a.b.c.d.

Competition?Planning app?

APPENDIX XV: **Semantics and food associations**

The meat/fish box

Since this part of the refrigerator is where the relatively expensive meat and fish should be stored it can be seen as a a more exclusive part. It is therefore suitable with a professional touch and the box should have professional design cues. The box could be in stainless steel with a removable tray that (as common in professional refrigerators) can be placed directly in the oven. Metal emphasises the expression of coldness since it feels cold when touching, an expression important to associated with meat. The box should describe high cleanability, and thus is stainless steel a suitable material. Colours that should be used for meat is red, and a cold bluish lighting could be suitable to communicate the low temperature.

The vegetable/fruit boxes

The expression of the vegetable boxes should be fresh, healthy, crisp and light. The expression could remind of a sunny day in spring with cold fresh high air and vivid colours. Glass was thought of as a suitable material but a glass-like plastic material might be better from a durability point of view and is also cheaper. The vegetables and fruits are often sensitive foodstuff, and commonly wasted why they have to be taken better care of. The box should describe that it protects its contents. In a supermarket fruit is usually presented in an inviting and beautiful way very dissimilar from in the refrigerator at home. A more attractive presentation in the domestic environment that also keeps the freshness of the fruits and vegetables are therefore welcome. Crystal clear plastic express coldness and freshness and suitable colours are foremost green for green for vegetation, but also blue for water and clear sky and white lighting reminding of sunny daylight.

The flexible space

A flexible space is mainly aimed for dairy products, but also leftovers, juice and so on. The colour associated with dairy products is often milk white, which thus is suitable to use. Dairy products are often stored in packages that are square which the interior should be designed to describe. It is important that this area should have flexibility and customization possibilities, described by for example subdivisions movable along both the x- and y-axis. The drawer must be high enough for tall packages, at the same time offer solutions for small things such as yeast or a small piece of cheese. Contrasts could be used to describe which parts that are movable and adjustable, indicating flexibility and describing order. Colours and materials that could be used are milk white glossy plastic, blue and/or green colour for associations to “open landscapes” where the dairy products commonly has its heritage and a contrasting material like a metal communicating coldness.

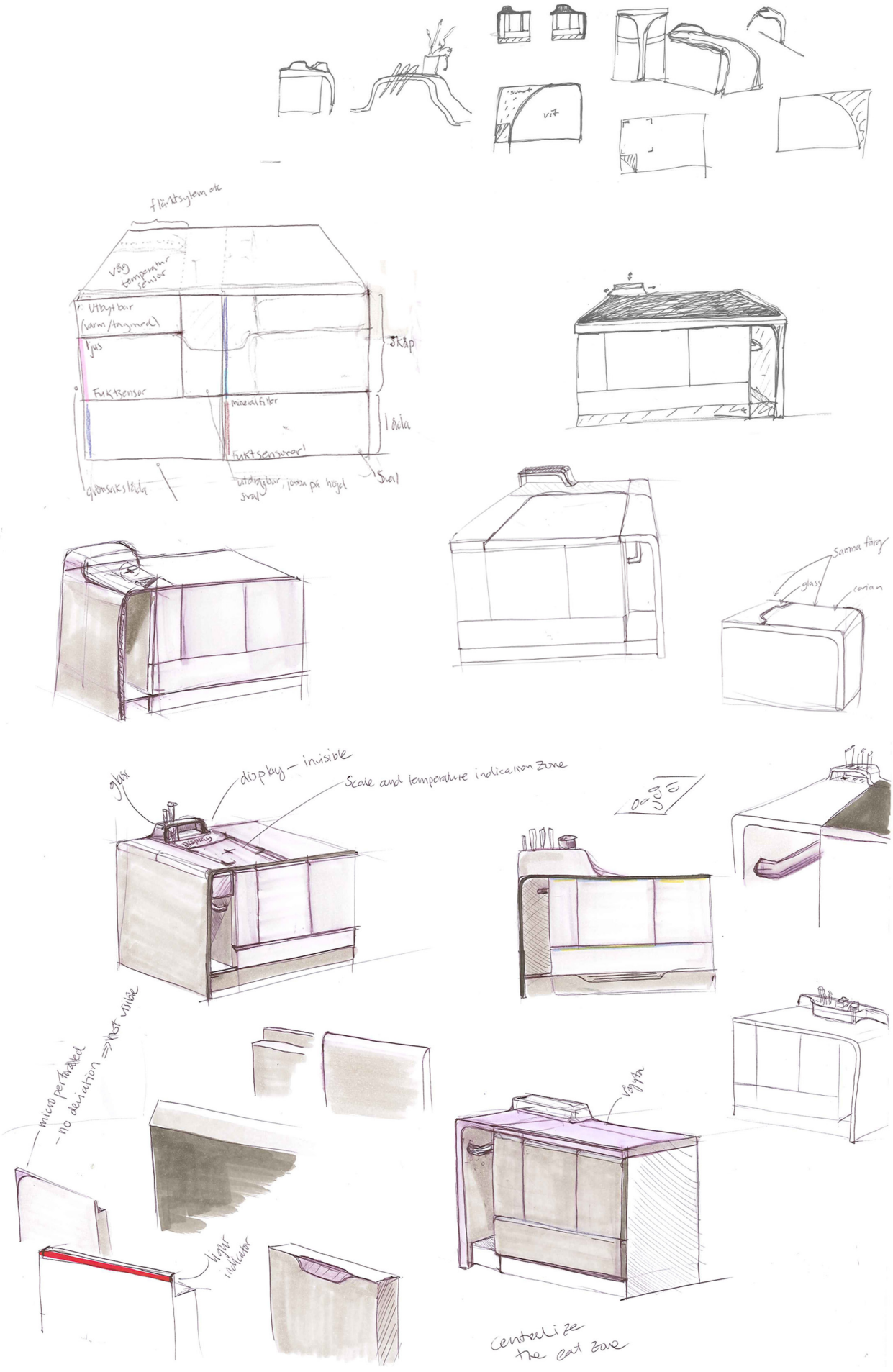
The bottle and jar drawer

This drawer should have the temperature of a chiller and should contain things that has not to be stored as cold or that also could be placed in a pantry. The design could therefore describe that the things here are stored warmer. Its closest equivalence in a conventional refrigerator is the door shelves, or a cold version of the spice-rack. The jars and bottles here are often luxurious and or maybe homemade products with heritage from all over the world. They are often are kept for a long time and used to add extra flavour to or to enhance the taste of a dish. The design of the drawer should display the bottles and jars in a luxurious way and lift forward the vivid coloured contents of for example jars of jam and marmalade. It should describe high cleanability, because the content of jars and bottles sometimes tend to stick to the outside of the packages. This is a compartment that could be frequently open while cooking, why it should express that the contents will not overturn if opening or closing it quickly. Bottles and jars often have a circular bottom surfaces unlike for instance milk packages, which should not be stored in this compartment. By having circular marks on the the shelves it could be communicated that this drawer is not for milk and yogurts. A bit of exclusiveness could be added to this drawer to make it something special, to bring out present the products in a. This could be achieved with the choice of materials and colours, maybe wood or metals. Another aspect to consider is that mostly glass containers will be stored in this drawer, why a metal shelf might give a too hard and not so pleasant feeling when placing glass on it.

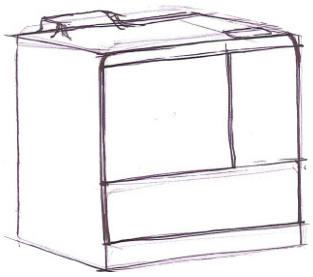
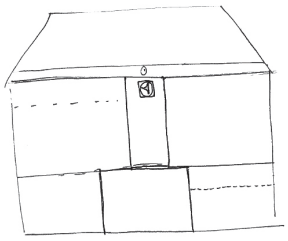
Drawer for drink bottles

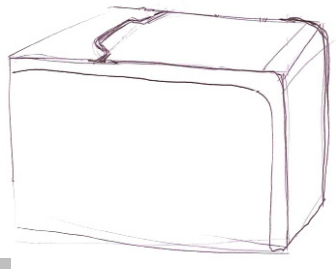
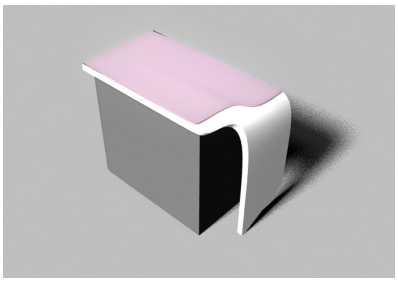
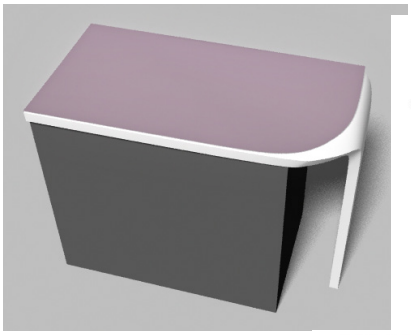
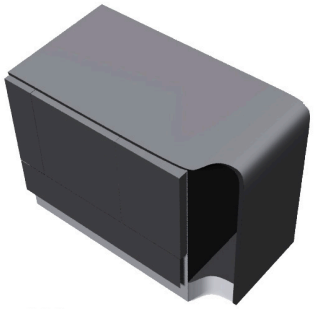
This drawer should share the temperature with the bottle and jar drawer. To describe it is aimed for drinks and bottles a wave-shaped rack could be put there to indicate that bottles should be stored here. It should express stability, safety and comfort for glass bottles but also freshness and tastefulness. In this compartment is often heavy things stored, and it should thus express robustness and high durability.

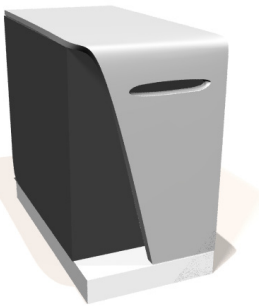
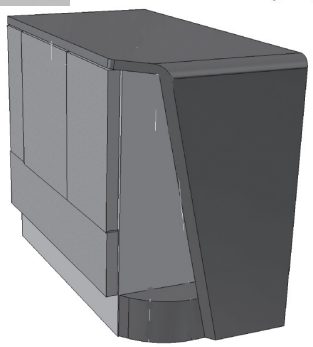
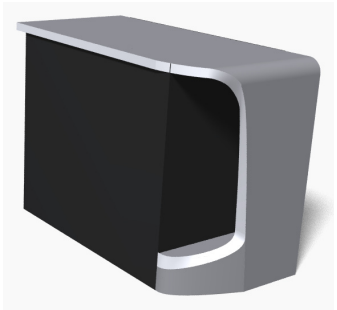
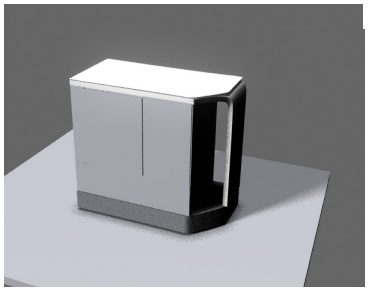
APPENDIX XVI: **Form development –** *sketches*

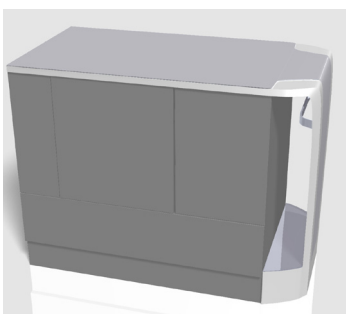
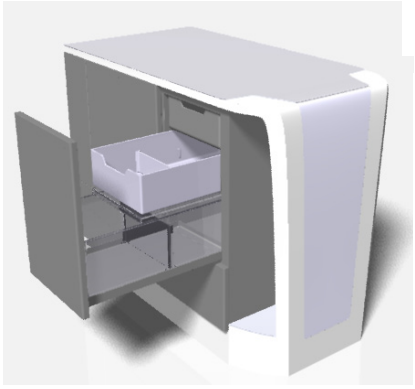
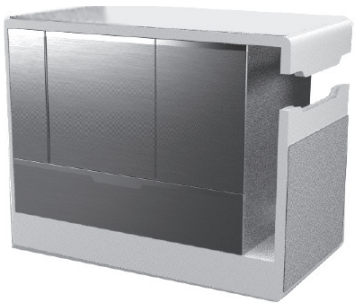


APPENDIX XVI: **Form development** – *from part to final concept*

APPENDIX XVII: **Calculations –** *wall thickness*

Needed wall thickness

- to insulate and preserve temperature differences between the compartments

The largest ΔT between two nearby compartments will be approximately 4 °C.

The Fourier law:

$$q = -kA\frac{\partial T}{\partial x}$$

Where:

q = heat flow rate through the wall
k = thermal conductivity of wall material
A = wall surface area
∂x = wall thickness

k ≈ 0,025 for the insulation material

Hence:

$$\Delta x = \frac{kA(T_2 - T_1)}{q}$$

Inserting the values for the outer wall thickness of standard refrigerator today and normal ΔT between room temperature and the refrigerator gives the value of q:

$\Delta x = 35$ mm
k = 0,025
ΔT = 20 °C
A can be approximated to 1 m^2 and thus be eliminated

$$q = \frac{kA(T_2 - T_1)}{\Delta x}$$

$$q = \frac{0{,}025 \times 20}{35} = 0{,}014285714\ W/m^3$$

Solving for x when $\Delta T = 4$:

$$x_1 = \frac{0{,}025 \times 4}{0{,}014285714} = 7{,}00000\ mm$$

The wall thickness needed to preserve a temperature difference of 4°C is thus 7mm, given that the same wall material as today is used. If using a more efficient insulation material an even thinner wall is enough. However, because of the gaskets a surface of at least 25 mm is needed to keep the doors sealed.

APPENDIX XVII: **Calculations –** *placement of warm food*

If 0.25 kg hot food (in the calculation represented by hot water) with a temperature of 40°C inserted by one person per household it takes about ΔT = 20.5 K to lower it to room temperature (if ambient temperature is of 19.5°C). If this food is directly placed in the refrigerator it will increase the energy consumption with about 1.4kWh/year for a single person household.

Energy needed to chill down the hot food:
Heat load per day/COP*365

Heat load per day:
0.25kg * 4.19kJ/kgK * 20.5 K = 21.47kJ = 0.0059 kWh/day

Energy needed per year:
0.0059 / 1.5 * 365 = 1.4kWh/year

COP = coefficient of refrigerator performance, assumed to be 1.5

(ISIS, 2007)

APPENDIX XVII: **Calculations –** *energy efficiency*

(Statens energimyndighets författningssamling, 2005)

Bilaga 5 **STEMFS 2005:12**

Energieffektivitetsklass:

För att bestämma rätt energieffektivitetsklass skall apparatens energiförbrukning (kWh per 24 h) och nettovolymerna (l) för olika slag av utrymmen bestämmas enligt de standarder som avses i 7 §. Energiförbrukningen för 24 timmar multipliceras med 365 för att få den årliga förbrukningen (kWh/år).

Del 1: Definition av klasserna A- och A+

En apparat skall klassificeras som A+ eller A++ om dess energieffektivitetsindex alfa(I_α) ligger inom de gränser som anges i tabell 1.

Tabell 1

Energieffektivitetsindex α (I_α)	Energieffektivitetsklass
30 > (I_α)	A++
42 > (I_α) ≥ 30	A+
(I_α) ≥ 42	A–G

I tabell 1 gäller följande: $I_\alpha = \frac{AC}{SC_\alpha} \times 100$

där
AC = apparatens årliga energiförbrukning (i enlighet med bilaga 1, not V)
SC_α = apparatens årliga standardenergiförbrukning

SC_α beräknas enligt följande:

$$M_\alpha \times \sum_{\text{Utrymmen}} \left(Vc \times \frac{(25-Tc)}{20} \times FF \times CC \times BI \right) + N_\alpha + CH$$

där
Vc är varje utrymmes nettovolym (i liter) (enligt de standarder som avses i 7 §)

Tc är utrymmets avsedda temperatur (i °C)

Värdena M_α och N_α anges i tabell 2, och värdena för FF, CC, BI och CH anges i tabell 3.

STEMFS 2005:12

Tabell 2

Apparatkategori enligt bilaga 4	Temperatur i det kallaste utrymmet	M_α kWh/l, år	N_α kWh/år
1 Kylskåp utan frysfack	> –6°C	0,233	245
2 Kyl-/svalskåp	> –6°C	0,233	245
3 Kylskåp utan stjärnmärkning	> –6°C	0,233	245
4 Kylskåp *	≤ –6°C	0,643	191
5 Kylskåp **	≤ –12°C	0,450	245
6 Kylskåp ***	≤ –18°C ***/*(***)	0,777	303
7 Kyl-/frysskåp *(***)	≤ –18°C ***/*(***)	0,777	303
8 Frysskåp	≤ –18°C *(***)	0,539	315
9 Frysbox	≤ –18°C *(***)	0,472	286
10 Flerdörrarsapparater eller andra apparater		1	1

[1] För dessa apparater skall temperaturen och stjärnmärkningen för det utrymme som har den lägsta temperaturen avgöra värdena för M och N. Apparater med utrymmen för –18°C *(***) skall anses vara kyl-/frysskåp *(***).

Korrektionsfaktor	Värde	Villkor
FF (frostfritt)	1,2 1	För "frostfria" (ventilerade) frys-utrymmen Övriga
CC (klimatklass)	1,2 1,1 1	För "tropiska" apparater För "subtropiska" apparater Övriga
BI (inbyggt)	1,2 1	För inbyggda apparater[1] med en bredd på högst 58 cm Övriga
CH (nollgraders-fack)	50 kWh/år 0	För apparater med nollgradersfack på minst 15 liter Övriga

[1] En apparat anses vara "inbyggd" endast om den är konstruerad uteslutande för installation i ett köksskåp och har provats som sådan.

Thus: $I_\alpha < 30$, $I_\alpha = AC/SC_\alpha 100$

DATA:

gasket leakage= 2,13 W/m

Pompador

Volume T(10° C): 80,7 litres, i.e. 35 % of total volume
Volume T(4° C): 91,0 litres, i.e 39 % of total volume
Volume T(1° C): 62,1 litres, i.e. 27 % of total volume

Length of gasket seals: 6,74 m

$N_\alpha = 1$, $M_\alpha = 1$, FF =1, CC= 1, BI =1, CH = 50

-> AC=84,48 kWh/year
-> gasket leakage= 2,136,47=14,4 W
-> total heat load =14,4/0,15=96W

Energy savings *(hot and frozen food, temperature settings, data from table 11.1):*

0,87×1,014×0,74=0,6528 -> 65,3 %

Same size as our concept but with one 4 °C compartment

Volume T(4° C): 282,4 litres

Length of gasket seals: 3,22 m

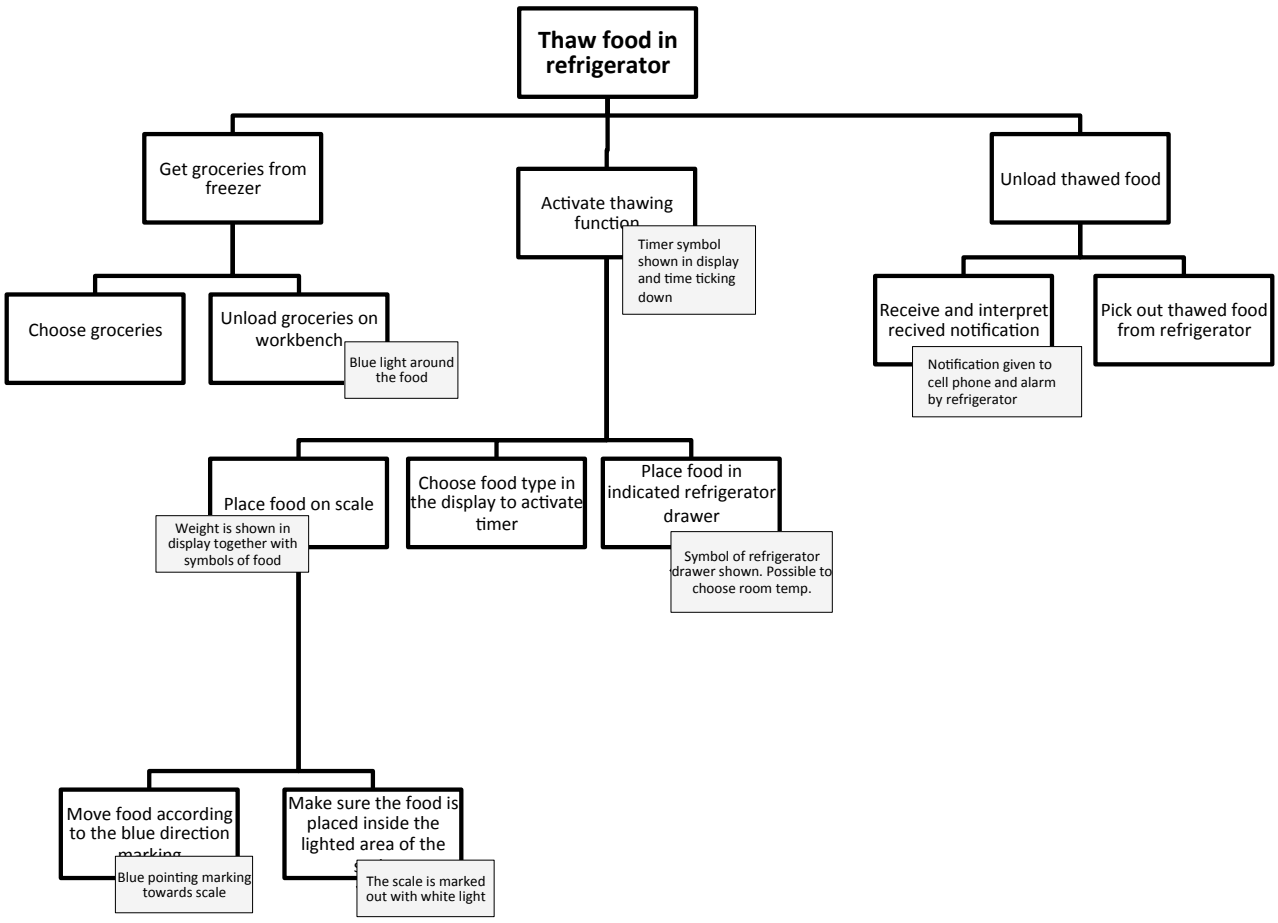
$N_\alpha = 245$, $M_\alpha = 0,233$, FF =1, CC= 1, BI =1, CH = 0

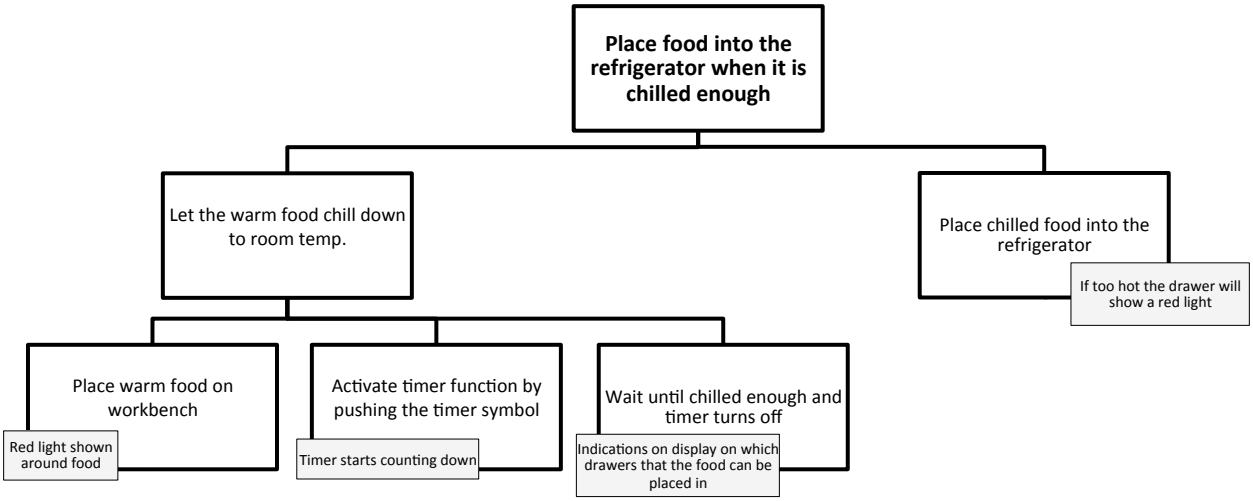
-> AC = 94,5 kWh/year
-> gasket leakage= 2,13×3,22=6,9 W
-> total heat load =6,9/0,15=46W

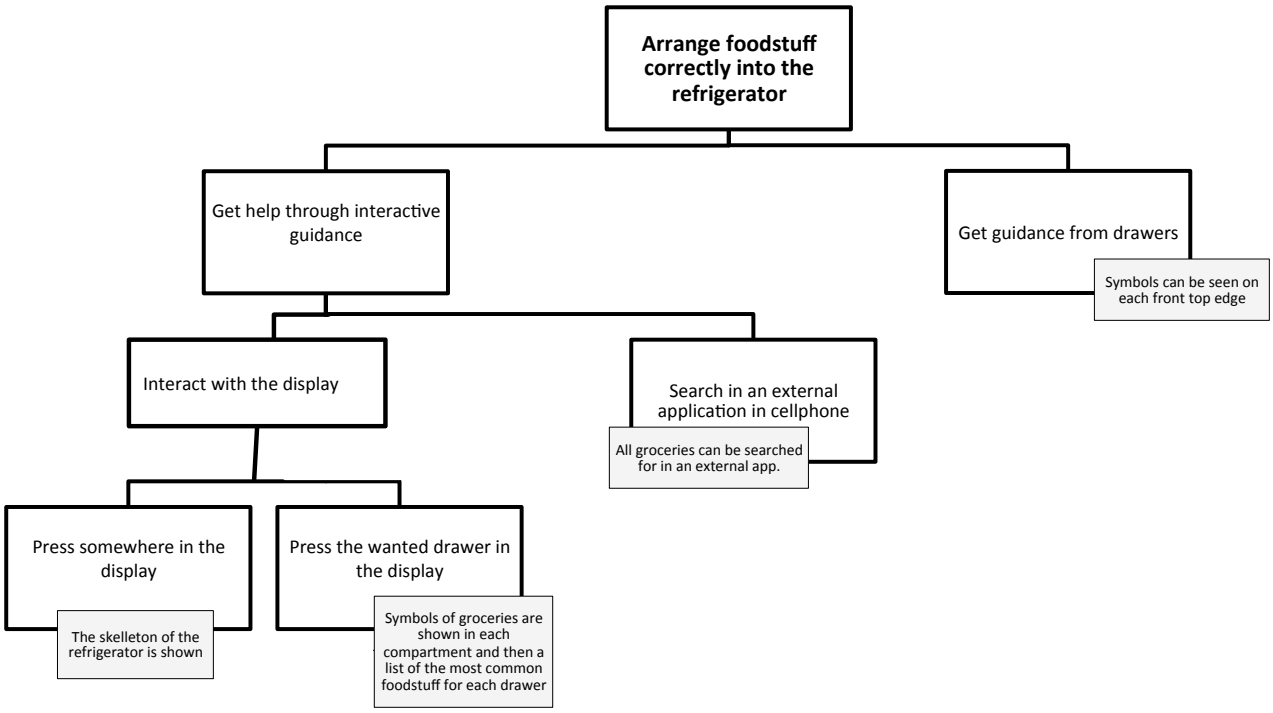
Energy savings *(hot and frozen food, temperature settings, data from table 11.1):*

1,11 -> 11 %

APPENDIX XVIII: **Final concept evaluations** - *HTA*




Place food into the refrigerator when it is chilled enough
Let the warm food chill down to room temp.
Place chilled food into the refrigerator
If too hot the drawer will show a red light
Place warm food on workbench
Red light shown around food
Activate timer function by pushing the timer symbol
Timer starts counting down
Wait until chilled enough and timer turns off
Indications on display on which drawers that the food can be placed in


Arrange foodstuff correctly into the refrigerator
Get help through interactive guidance
Get guidance from drawers
Symbols can be seen on each front top edge
Interact with the display
Search in an external application in cellphone
All groceries can be searched for in an external app.
Press somewhere in the display
The skelleton of the refrigerator is shown
Press the wanted drawer in the display
Symbols of groceries are shown in each compartment and then a list of the most common foodstuff for each drawer

APPENDIX XVIII: **Final concept evaluations** - *CW and PHEA*

CW och PHEA Thawing; unload on workbench to see blue light

	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	J	Placerar varor där naturligt. Vet att funktionen finns.	Skulle kunna placeras på annat ställe.	
2. Kommer användaren att notera att rätt handling finns tillgänglig?	N	Syns ej om ej aktiverad.		
3. Kommer användaren att associera korrekt handling med rätt effekt?	J	Blått ljus runt maten. Blått = kallt.		
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	J	Ja. Feedback med blått ljus som riktas mot våg.		

- Vilken handling kan användaren göra fel vid rätt tillfälle?
- Vilken handling kan användaren göra rätt vid fel tillfälle?
- Vad händer om användaren utför en ej fullständig handling eller utesluter en handling?
- Vad händer om användaren utför handlingarna i fel ordning?

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
Placera varorna på annat ställe.	Vet ej om tiningsfunktionen.	Kan ej få hjälp med timerfunktionen.	–	Ja om placeras på rätt ställe.
Placera kalla varor på ytan vid annat tillfälle.	Använder som avlasntningsyta.	Blått ljus runt varorna/objekten.	Ja.	Flytta på grejorna/ignorera.
–	–	–	–	–
Går in i displayen för att aktivera tining.	Vet ej hur funktionen fungerar.	Går ej. Frustration.	–	–

CW och PHEA Thawing; move food according to the blue direction marking

	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	J	Det blå ljuset har riktning mot upplyst våg		
2. Kommer användaren att notera att rätt handling finns tillgänglig?	J	Ja. Då maten placerats på ytan aktiveras ljusindikationen		
3. Kommer användaren att associera korrekt handling med rätt effekt?	J	–		
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	J	Displayen aktiveras och går in i thawing mode		

- Vilken handling kan användaren göra fel vid rätt tillfälle?
- Vilken handling kan användaren göra rätt vid fel tillfälle?
- Vad händer om användaren utför en ej fullständig handling eller utesluter en handling?
- Vad händer om användaren utför handlingarna i fel ordning?

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
Flyttar inte den kalla maten.	Förstår inte flyttningsmarkeringen.	Tiningsfunktionen aktiveras ej.	oklart	Ja om flyttas.
Flyttar maten direkt in i kylen	Vet bättre. Kan själv.	Timern startar ej	Nej eller sker medvetet	Nej
Flyttar saker som är kalla till vågen som inte ska tinas.				
Flyttar ej maten till vågen		Timern startar ej		
Går in i displayen för att aktivera timern	Dålig koll	Får tipset där att flytta varan	Ja	Ja. Flyttar vara.

CW och PHEA Thawing; Make sure the food is placed unside the lighted area of the scale

	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	J			
2. Kommer användaren att notera att rätt handling finns tillgänglig?	J			
3. Kommer användaren att associera korrekt handling med rätt effekt?	J			
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	J			

- Vilken handling kan användaren göra fel vid rätt tillfälle?
- Vilken handling kan användaren göra rätt vid fel tillfälle?
- Vad händer om användaren utför en ej fullständig handling eller utesluter en handling?
- Vad händer om användaren utför handlingarna i fel ordning?

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
Placera varan utanför vågens	varan är för stor	Ej korrekt vikt visas-> fel tid visas	nej, inte förrrän timern alarmerar	nej
-	-	-	-	-
Varan placeras ej korrekt på vågen, den sticker ut	ignorerar att den är utanför markeringen	Ej korrekt vikt visas-> fel tid visas	nej, inte förrrän timern alarmerar	nej
Går in i display utan att korrigerat placering	ignorerar att den är utanför markeringen	Ej korrekt vikt visas-> fel tid visas	nej, inte förrrän timern alarmerar	nej

CW och PHEA Thawing; Choose food type in the display to activate timer

	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	J	val erbjuds	Inget passande val erbjuds	
2. Kommer användaren att notera att rätt handling finns tillgänglig?	J			
3. Kommer användaren att associera korrekt handling med rätt effekt?	j	Guidas på displayen		
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	J	placering i kyl föreskås och tid visas	förstår ej att varan ska placeras i kyl	

- Vilken handling kan användaren göra fel vid rätt tillfälle?
- Vilken handling kan användaren göra rätt vid fel tillfälle?
- Vad händer om användaren utför en ej fullständig handling eller utesluter en handling?
- Vad händer om användaren utför handlingarna i fel ordning?

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
välja fel slags mat	rätt val erbjuds ej, råkar trycka fel	ev. fel tid	oklart	nej
-	-	-	-	-
timern kan ej aktiveras, det går ej att gå vidare	man är dum	man kommer ej vidare	inget händer	-
-	-	-	-	-

CW och PHEA Thaw, Place food in indicated refrigerator drawer

	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	j	den är upplyst, på display och på lådan	vill tina snabbare och väljer rumstemp.	
2. Kommer användaren att notera att rätt handling finns tillgänglig?	j	dubbel indikstion		
3. Kommer användaren att associera korrekt handling med rätt effekt?	j	timern kör igång, bonusmönstret växer, lådljuset släcks		
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	j	timern räknar ned		

- Vilken handling kan användaren göra fel vid rätt tillfälle?
- Vilken handling kan användaren göra rätt vid fel tillfälle?
- Vad händer om användaren utför en ej fullständig handling eller utesluter en handling?
- Vad händer om användaren utför handlingarna i fel ordning?

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
placerar i annan läda	vill hellre det	timern kan visa felakig tid	-	-
placera maten i lådan innan typ av vara vald	för snabb eller vet redan tiningstiden	timern startar ej	ingen timer	placera varan på vågen igen och gör om
varan lämnas på toppytan	man vill tina varan snabbare	timern slår automatiskt om till rumstemp.	ny, kortare tid visas på timern	-
som punkt 2	-	-	-	-

CW och PHEA Thaw; Understand when food is thawed

	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	J	Hör alarm, ser att timern är på noll, lådan lyser och meddelande mottaget		
2. Kommer användaren att notera att rätt handling finns tillgänglig?	J	–		
3. Kommer användaren att associera korrekt handling med rätt effekt?	J			
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	J	Förstår att kylen vill något...		

- Vilken handling kan användaren göra fel vid rätt tillfälle?
- Vilken handling kan användaren göra rätt vid fel tillfälle?
- Vad händer om användaren utför en ej fullständig handling eller utesluter en handling?
- Vad händer om användaren utför handlingarna i fel ordning?

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
Missar alla upplysningar	Har stängt av meddelandefunktionen, är ej hemma	Maten tinad i kylen	Ja då man tittar in	-
Tror att varan är tinad i förtid	flera varor tinas samtidigt, fel i timersättningen, samma feedback fast för annat event	Maten ej tinad.	Ja	Vänta
Maten glöms i kylen	fattat men glömt	mat kan bli dålig	Ja	Ja/Nej
–	–	–	–	–

CW och PHEA Chill; Place warm food on workbench

	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	N	Lätt att öppna kylen. Ställer annanstans		
2. Kommer användaren att notera att rätt handling finns tillgänglig?	N			
3. Kommer användaren att associera korrekt handling med rätt effekt?	J	Rött = varmt. Reaktion.		
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	J	Temp.feedback på display. Röd färg runt maten.		

- Vilken handling kan användaren göra fel vid rätt tillfälle?
- Vilken handling kan användaren göra rätt vid fel tillfälle?
- Vad händer om användaren utför en ej fullständig handling eller utesluter en handling?
- Vad händer om användaren utför handlingarna i fel ordning?

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
Inte ställa på ytan.	Behöver ej avlastningsytan.	Funktionen blir dåld. Ej timer.	Om ställer in mat i kylen för tidigt. Annars nej.	Om ställer på ytan.
Ställa varm mat på ytan som inte ska svalna	Avlastningsyta.	Displayen aktiveras i onödan. Förvirrande,	–	Ta bort från ytan.
Ställa mat på ytan då värmen är på.	Man vill ha båda funktion-erna samtidigt	Går ej, måste välja,	Fråga på displayen	Val.
–	-	-	-	-
Placerar ej på ytan	Vill aktivera timer utan att först placera på ytan	Går ej	Ja	Ställ på ytan

CW och PHEA Chill; activate timer function by pushing the timer symbol

	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	j	om uppmärksamhet riktad mot displayen är den synlig		
2. Kommer användaren att notera att rätt handling finns tillgänglig?	j	tydlig symbol, få andra störande moment		
3. Kommer användaren att associera korrekt handling med rätt effekt?	j	timern startar när timerns trycks		
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	j	timern startar		

- Vilken handling kan användaren göra fel vid rätt tillfälle?
- Vilken handling kan användaren göra rätt vid fel tillfälle?
- Vad händer om användaren utför en ej fullständig handling eller utesluter en handling?
- Vad händer om användaren utför handlingarna i fel ordning?

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
inte trycka på timer symbolen	noterar eler frstår ej symbo-len, vill ej starta timern	timern startas ej	om funktionen är känd	gör om gör rätt
-	-	-	-	-
trycker ej på timersymbolen	vill ej starta imern eller noterar/förstår den ej	timern startar ej	-	-
letar efter symboln för att ak-tivera innan maten placerats på ytan	missförstått funktionen, vill göra inställning först	timern startar ej	symbolen hittas ej	placera maten på ytan

CW och PHEA Chill; Wait until chilled enough and timer turns off

	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	J	"Nån" ser att man gör fel om ej väntar.	Har inte tid att vänta. Rädd om maten.	
2. Kommer användaren att notera att rätt handling finns tillgänglig?	J	Ja, timern ticker.		
3. Kommer användaren att associera korrekt handling med rätt effekt?	J			
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	J			

- Vilken handling kan användaren göra fel vid rätt tillfälle?
- Vilken handling kan användaren göra rätt vid fel tillfälle?
- Vad händer om användaren utför en ej fullständig handling eller utesluter en handling?
- Vad händer om användaren utför handlingarna i fel ordning?

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
Stoppa in maten i kylen innan den är sval nog	Otålig, stressad, nojig med maten, kollar ej timern	Rött ljus på kyllådan	Ja om rött ljus på lådan	Ta ut lådan igen!!!
Vänta längre än nödvändigt	Man har missat eller glömt alarmet	Maten kan bli dålig	Ja senare	Nej
Väntar för kort eller inte alls	Otålig, stressad, nojig med maten, kollar ej timern	Rött ljus på kyllådan	Ja om rött ljus på lådan	Ta ut lådan igen!!!
-	-	-	-	-

CW och PHEA Place chilled food in the refrigerator

	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	j	display samt ljus på låda indikerar ok		
2. Kommer användaren att notera att rätt handling finns tillgänglig?	j	indikation på display och låda	vitt ljus på låda av annan orsak, tex återuppnådd temp.	
3. Kommer användaren att associera korrekt handling med rätt effekt?	j	om maten placeras in släcks ljuset på lådan & timern borta		
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	j	mission completed		

- Vilken handling kan användaren göra fel vid rätt tillfälle?
- Vilken handling kan användaren göra rätt vid fel tillfälle?
- Vad händer om användaren utför en ej fullständig handling eller utesluter en handling?
- Vad händer om användaren utför handlingarna i fel ordning?

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
låta maten stå kvar trots att den är sval nog	missar alarmet, är ej hemma	maten står för varmt och kan bli dålig	när man ser maten	nej
ställa in maten för tidigt	Otålig, stressad, nojig med maten, kollar ej timern	maten står för varmt och kan bli dålig	Rött ljus på kyllådan, timern låter?	ta ut maten igen!
mat placeras utan att lådan stängs	diströ.	kylskåpet blir varmt, ger feedback på det	Ja	nej, stäng
-	-	-	-	-v

CW och PHEA Placement; interact with display

	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	J/N	Behöver ej, vet ej om funktion, orkar ej kolla upp	Kollar ej på display	Oklart om användaren kommer orka att kolla upp eller bara placera in... Bör utvärderas ytterligare.
2. Kommer användaren att notera att rätt handling finns tillgänglig?	N		Syns ej väl i display och kanske ej ens kollar på display	
3. Kommer användaren att associera korrekt handling med rätt effekt?	J	Får mer information		
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	J	Troligtvis. Fattar kanske att klicka vidare för mer info.		

- Vilken handling kan användaren göra fel vid rätt tillfälle?
- Vilken handling kan användaren göra rätt vid fel tillfälle?
- Vad händer om användaren utför en ej fullständig handling eller utesluter en handling?
- Vad händer om användaren utför handlingarna i fel ordning?

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
Not defined enough				

CW och PHEA Placement; get guidance from drawers

	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	J/N	Om det noteras		Viktigt att symboler syns och är tydliga
2. Kommer användaren att notera att rätt handling finns tillgänglig?	J	Om det noteras		
3. Kommer användaren att associera korrekt handling med rätt effekt?	N	Ingen feedback		
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	N			

- Vilken handling kan användaren göra fel vid rätt tillfälle?
- Vilken handling kan användaren göra rätt vid fel tillfälle?
- Vad händer om användaren utför en ej fullständig handling eller utesluter en handling?
- Vad händer om användaren utför handlingarna i fel ordning?

Fel	Orsak	Konsekvens	Upptäckt	Återhämtning
Man tittar ej på symboler	Uppmärksammas ej	Ev. felplacering	-	.
Man öppnar lådor för att hitta placering istället för kolla i display	Känner ej till display, vill göra så istället	Onödig dörröppning	-	.
Man tittar ej på symboler	Uppmärksammas ej	Ev. felplacering	-	.
Man öppnar lådor för att hitta placering innan man öpppnar för att placera	Vill inte kolla med händer fulla eller saker i vägen	Onödig dörröppning	-	.