CHALMERS

Loop

Development of a washable laundry bag that facilitates the laundry cycle and encourages shared washing

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

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2016

Department of Product- and Production Development
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ABSTRACT

Most of the global climate challenges that the world currently is facing are directly tied to the extensive resources use in developed urban areas. There is a current trend demonstrating that more people are moving into single-living household whilst still maintaining a relatively large living-area, making the energy consumption from these households unsustainably high. The HSB Living Lab is a response to these issues. By creating an adaptable testing environment for new sustainable inventions, new ideas are allowed to surface, and a change can be made towards a more sustainable urban living situation. Washing clothes might not seem as the root of the climate issues, but studies have shown that users in general washes at half capacity, resulting in an unnecessary water, energy and detergent consumption. By developing a new solution for transporting, storing and washing laundry, this unnecessary resource wastage can be eliminated.

The aim of the project was to develop an innovative solution that encourages users to wash laundry simultaneously in the same washing-machine. The purpose was further to develop a solution that facilitates the laundry management throughout the different steps of the laundry cycle, including storing, transporting, washing and drying laundry.

User-studies were conducted with the aim of gaining an understanding of problems with currently used products and with the aim of extracting requirements that the developed solution needs to fulfill. A survey was conducted aimed to retrieve quantitative data and nine interviews complemented the survey with qualitative input. Guidelines from the design for sustainability methodology were used as a basis for the ideation phase where the created concepts were assessed with mockups and sketches. Discussion with supervisors and a concept scoring matrix were used in order to decide on a final concept.

The project resulted in Loop, a multi-functional laundry bag designed to facilitate every step of the laundry cycle. Loop is designed to be stored, filled with pre-sorted laundry, transported to the washing studio, washed, dried and carried back to the apartment before getting back into a new laundry cycle. Loop encourages shared washing by overcoming the obstacles connected to hygiene and privacy. Loop reduces the resource usage, saving both time and money, whilst still maintaining an optimal washing result. Loop further satisfies the individual preferences of various user types by offering multiple dimension, placement and handling options. The materials of Loop are mainly recycled fabrics, easily separable, making Loop fit into a closed loop system.

Keywords: washing, *sustainability, sustainable behavior, HSB Living Lab, laundry cycle, product design, industrial design, shared washing*

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CHAPTER ONE

INTRODUCTION

The introduction contains the background and scope of the project. The **background** explains present sustainability issues tied to urbanization and living conditions with a building and population focused approach. This carries over to an overview of the living lab concept with a deeper introduction to the **HSB Living Lab** project, fully explained with features, aims, detailed building descriptions and present stakeholders. The **scope** of the project contains **goals**, **limitations** and **intended target group** for the main laundry project. Finally **research questions** are posed, which are aimed to be answered and solved during the duration of the thesis project.

1.1 Background

The majority of the global climate challenges faced today are a direct result of the irresponsible resource usage, and the main context in which the resources are being used is within cities. Approximately 70 percent of the global carbon dioxide emissions can be tied to the population-dense urban areas and the buildings are responsible for 30 percent of the global final energy use (Rosado et al., 2014). These are sustainability challenges present all across the globe and Sweden is no exception.

The urban Swedish living capacity is both saturated and ecologically unsustainable. Approximately 86 percent of the Swedish population is living in urban areas and whilst the population is exceedingly growing, the city capacity is not (Utrikespolitiska institutet, 2016). As the population grows the consumption also does, a trend that has made the Swedish population into the seventh highest electricity consumers per capita (Chalmers Tekniska Högskola AB, 2016a). Due to the unsustainable way of which resources tied to buildings are consumed, there is an urgent need of progressive building ideas and living-space plans. By initiating a widespread research program the possibilities of finding the needed sustainable solutions are fast paced and economically responsible. Thus the HSB Living Lab was initiated to find these progressive solutions (Chalmers Tekniska Högskola AB, 2016a).

1.2 HSB Living Lab

A living lab is an experimental environment, physical or virtual, where the residents are located inside the creative social space with the possibilities of shaping and experiencing the environment. The current living labs are used for research and commercialization of innovative systems and new technology (Chalmers Tekniska Högskola AB, 2016a). The residents of a living lab are thus not only a subject of research but also co-creators, responsible for creating solutions for a sustainable future (Rosado et al., 2014).

HSB Living Lab is a project that aims to create a building located on the Chalmers campus in Gothenburg which will contain accommodations for students and guest researchers, see figure 1. The building completed in June 2016. The aim of the project is to enhance the knowledge and understanding of a more sustainable lifestyle of future living and to enhance the quality of future and present homes (HSB, 2015a). The secondary aim is to make use of the residents of HSB Living Lab as active co-creators of new ideas and innovative concepts (Chalmers Tekniska Högskola AB, 2016a).

Figure 1. HSB Living Lab (Chalmers Tekniska Högskola AB, 2016a).

HSB Living Lab is planned to be a dismantlable building containing various internal and external parts of the building that are replaceable. The facade will be interchangeable in order for testing various materials and solutions of interest. HSB Living Lab will contain a residential section that offers homes and an exhibition section for offices and will further house meeting rooms, a shared laundry studio and accommodations for the residents (HSB, 2015a).

Projects will take place inside HSB Living Lab throughout the ten-year life span of the lab with a focus on sustainability in the research, among other topics. HSB Living Lab refers to the third generation of living labs which means that students will live in the research building with various projects ongoing meanwhile (HSB, 2015a).

While the first and second generation of living labs focused on materials, technology and systems with limited interaction with the users, the purpose with the third generation is to optimize the interface to humans in a reality-based context. The third generation of living labs require specific processes and infrastructures for integrated research thinking and system thinking built into an inhabited building. Co-creation and open innovation promotes and creates new co-operation models and practices with the purpose of developing the thinking within the HSB Living Lab environment (Chalmers Tekniska Högskola AB, 2016a).

The goal with HSB Living Lab is to develop resistant and energy-efficient building structures that can meet the effects of regional climate changes. The aim is to adapt to the standard of living through modular homes that meet the requirements that are set when Sweden becomes increasingly urbanized. HSB Living Lab further aims to develop a solution for energy and resource efficiency for sustainable use among the various consumers, which is partially enabled with the help of a digitized accommodation (Chalmers Tekniska Högskola AB, 2016a).

1.3 Stakeholders

The HSB Living Lab research project was initiated by Chalmers University of Technology, HSB and Johanneberg Science Park, which are the main three stakeholders in the project. The project has acquired other partners and sponsors since the launch such as Electrolux, PEAB, Gothenburg Energy, Tengbom architecture, Tieto, Vedum, Climate KIC, Akademiska Hus, Bengt Dahlgren, Swedish-modules and Chalmers student apartments (HSB, 2015b).

1.4 Purpose

The purpose of the project is to develop a solution for facilitating the management of laundry and the laundry cycle in HSB Living Lab environment. The thesis foundation arose during a research study conducted by HSB LL group represented by Chalmers, researchers, students and Electrolux Professional. The solution aims to define how the complete laundry cycle should be handled in a user-centered manner. The aim is to develop a solution that satisfies the full cycle from storage in the accommodation, transportation to the common laundry space, storage in the common laundry space and transportation back to the accommodation, see figure 2. The solution aims to break limits in terms of how laundry is handled, as a shared resource, in order to satisfy the ecological sustainability and the progressive thinking that HSB Living Lab project represents.

Figure 2. Illustration of the laundry cycle.

1.5 Goals

The goal is to develop an innovative solution that represents the sustainability of HSB Living Lab project as well as encourages users to wash laundry together, a principle named shared washing. The goal is further to develop a solution that improves the sustainability connected to laundry ecologically, economically and socially. The aim of the project is to visualize the developed solution in terms of a functional prototype, CAD-renderings and specification images by the time the new generation of HSB Living Lab is initiated, which is by June 2016. The aim is further to bridge across all relevant stakeholders present in the project.

1.6 Limitations

Due to the extent of the research conducted in HSB Living Lab, the context study of the project will be narrowed towards the single-living apartments, the common laundry space and the common spaces in between. The spacial limitations are made in order to process the laundry journey from the users and back to a full extent. The research of stakeholder perspective and implementations will be limited towards Chalmers, HSB, Electrolux and Tengbom since these are the main interessants of conceptualizing and transforming the common laundry space into a social washing studio (Rahe, 2016).

The technology limitations is based on the specified machinery provided by Electrolux Professionals, as in the washing-machine; W575EL (Electrolux Laundry Systems Sweden AB, 2016c), the tumble dryer; T5190LE (Electrolux Laundry Systems Sweden AB, 2016a) and the dry-cabinet; TS5140LE (Electrolux Laundry Systems Sweden AB, 2016b). The solution should thus be able to facilitate factors such as the capacity, size and heat radiation without compromising the trivial functions of the particular equipments. The solution is limited to an external product which results in that design modifications of the washing-machine, dryer and drying-cabinet are not within the limitations of the project. The solution is furthermore limited to external implementation in the building, as the result of architectural requirements specified by HSB and Tengbom. The building could per se be tampered with but the approval and legal time would be too extensive for the scope of the project.

Since a trivial research approach of HSB Living Lab is aimed towards finding the sustainable solutions of tomorrow, the solution should thus be created in line with these aims. This translates to no use of harmful materials or solution implementations that discredits or disrupts the overall ecological sustainability aspects of the main project (Electrolux Laundry Systems Sweden AB, 2015).

Since HSB Living Lab is supposed to be in use in June 2016, the final solution will also be limited towards being implementable in the near future. A limitation that is tied to the dedicated project time of twenty weeks. There are further few specified limitations since the project is supposed to be ground-breaking and edge cutting by developing a completely new solution.

1.7 Intended target group

The majority of the residents of the third generation HSB Living Lab are students with different national backgrounds, aged between 20 to 30 years old. Thus is this the segment that requires the most efforts and thereby the main target group for the project. The other user segments are though not excluded since the trend analysis demonstrates the single-living accommodations increase to span across all ages. By scoping mainly students but account for other user needs, the solution has a higher possibility of being both implementable in HSB Living Lab but also to future proof if and when the research turn into reality.

1.8 Research questions

The main task to be solved was formulated as: developing a new transportation and storage system for the laundry cycle in the third generation of living Labs. The questions below have been formulated with the intention to achieve the main task.

How can a system or artifact that facilitates the laundry cycle be implemented in HSB Living Lab? From the single-living apartments to the washing studio, through the washing process and back.

In what ways can the solution be sustainable and promote sustainability?

How can the solution motivate users to wash laundry together with other residents of HSB Living Lab in order to serve research with regards to water, electricity and water consumption?

CHAPTER TWO

METHOD

The project is divided into seven main phases, **“Pre studies“, “User-studies“, “Requirements and Guidelines“, “Ideation“, “Concept Development“, “Evaluation“ and “Finalization“,** see figure 3. The different phases of the project are going to apply different methods. The phases will be processed through iteration with constant evaluation before entering the next phase. Before a phase is completed, a follow up discussion with the supervisors at Electrolux and Chalmers will take part, ensuring that the phase is thoroughly explored and can be deemed as finished.

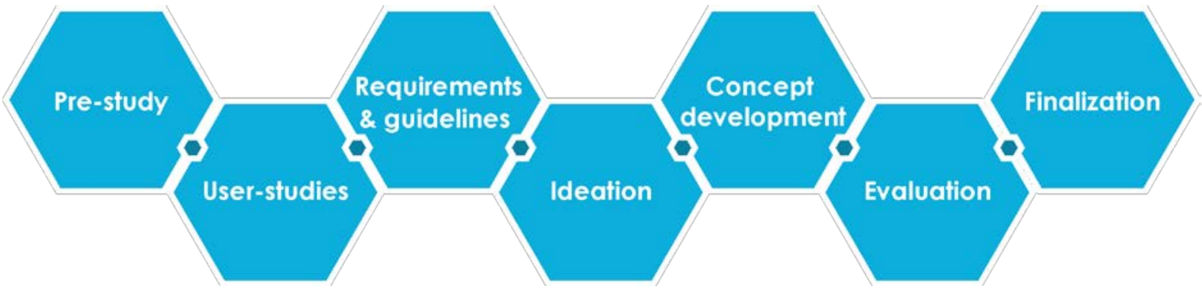

Figure 3. Illustration of the project phases.

The first phase will be "Pre studies". This phase will contain literature studies considering the background of HSB Living Lab, current trends in relation to single-living-housing and sustainability. The phase will further be emphasized with studies regarding the current laundry frameworks in relation to HSB Living Lab. The literature studies are estimated to be carried out throughout the rest of phases in the project.

The second phase, "User-Studies" will focused on methods used to retrieve data from users. A survey will be used for collecting quantitative data and interviews will be conducted to gather qualitative data. The results will then be analyzed with help of the Kawakita Jiro Analysis method, grouping the data into relevant focus areas. A market analysis will also be carried out in order to evaluate the existing solutions and competitors for the developed design. HTA and customer journey mapping are the next methods that will be used to understand and visualize the journey that users experience. The customer journey will further be used for mapping the touch points where users interact with different types of products for storing and transporting laundry. A function tree will then be created in order to visualize the various sub functions that the design has to fulfill. User profiles, scenarios and user types will furthermore be explored in order to resemble a picture of the possible users that will use the developed design solution as well as important aspects to be considered when designing the solution.

The third phase, "Requirements and Guidelines", will consist of a concretization of the retrieved requirements and guidelines from the previous phases. The requirements and guidelines are going to be retrieved from both users and stakeholders. The guidelines of the created list will then be ranked in order to prepare for evaluation of created design concepts in latter phases.

The fourth phase, "Ideation", will be initiated with retrieved knowledge from the previous phases. Mood boards, brain writing, random input are methods that are going to be used to explore a wide range of ideas and concepts. A morphological matrix is going to be used in combination with derived sub-solutions from the function tree in order to create concepts. Design with intent will further be used to gain inspiration in ways of steering users towards a more sustainable user behavior. The 6-3-5 method will be used for increasing the pool of concepts and is going to be evaluated together with the developed concepts in PICK-charts, used for a quick screening of plausible concepts.

The fifth phase, "Concept Development" will consist of concept development and building mockups in order to evaluate concepts and ideas. The concepts are then going to be evaluated with PNI by listing the positive and negative factors of the concepts and by using the important factors retrieved from the user profiles.

The sixth phase, "Evaluation", is going to be conducted with an evaluation of the final concepts. The concepts are going to be evaluated against the customer journey and in a concept scoring matrix. The concept scoring matrix is used in order to ensure that the concept fulfills the guidelines retrieved from the pre study. The customer journey evaluation is used to ensure that the chosen concept is optimal in each step of the journey. A discussion will be held together with the supervisors from Chalmers and supervisors from Electrolux in order to choose one final concept.

The seventh phase, "Finalization", is going to be focused on optimizing the chosen concept with the help of functional prototypes, ensuring that the different functions of the chosen concept are possible to accomplish. The different details of the concept are to be specified with respect to being separable in order to ensure a sustainable design. The process is going to be completed with the final design and discussions regarding the benefits and further development of the design.

CHAPTER THREE

PRE-STUDY

The project was initiated with an information-oriented phase mainly containing **literature studies**. The architecture of **HSB Living Lab** was investigated with a focus on the single-living apartments and washing studio. Various **trends** and behaviors related to the project were studied in order to understand in what direction the society is developing. Sustainability and sustainable behavior were investigated due to the core idea of HSB Living Lab and laundry cycle.

The **Okala eco-design strategy wheel** was used to gain insights into sustainable approaches to product development through the life cycle of a product. Principles from **Design for sustainable behavior** were used gain knowledge about how to alter behavioral patterns. The **technological framework** of the project was set through a study visit to Electrolux Laundry System in Ljungby together with additional literature studies considering products available in HSB Living Lab. The knowledge retrieved from the information-oriented phase created a basis for the user-studies.

3.1 The architecture of HSB Living Lab

The HSB Living Lab extends over four floors with a total of 29 apartments. The first floor is dedicated to common and public areas which offer residents a co-creation studio, a workshop and a next generation washing studio or washing room. The technical surfaces are also located on the first floor of HSB Living Lab (Chalmers Tekniska Högskola AB, 2016a).

The vertical mobility of HSB Living Lab contains a central function for both the systems that are existing in the building and for the transportation possibilities, see figure 4 (Chalmers Tekniska Högskola AB, 2016a). The vertical mobility consists of a staircase and an elevator which connects the four floors together and enables a flow of components through the system.

Figure 4. The architecture of HSB Living Lab (Tengbomgruppen AB, 2015a).

3.2 The single-living apartments

The apartments are located on the three upper floors. Three types of dwellings are explored in HSB Living Lab. The first type are single-living apartments that are built up by six accommodation modules that contain a shared kitchen, a shared living area and two shared bathrooms. The second type are apartments with two bedrooms that contain a shared kitchen, living area and bathroom with the other apartments of different sizes. The third type of apartments are single-bedroom apartments with a private kitchen and a private bathroom (Chalmers Tekniska Högskola AB, 2016a).

The focus of the project has been on the first type of apartments, single-living accommodations that are connected to a shared kitchen, a shared living area and two shared bathrooms. The single-living apartments are dimensioned with a volume of 47 m^3, equipped with a loft, a small pantry area and a toilet. The single-living apartments are located on the second and fourth floor of HSB Living Lab, see figure 5.

Figure 5. Illustration of the single-living apartments (Tengbomgruppen, 2015b).

There is a total of 24 single-living apartments, the first type, in HSB Living Lab together with five apartments that differ in size, the second and third types. One single-living apartment will initially be delegated for the managers of HSB Living Lab. This will result in an approximated maximum capacity of 39 residents at once in HSB Living Lab and minimum of 28. The average amount of residents in HSB Living Lab at once is estimated to vary from 33 to 34 (Sarin, 2015).

3.3 The washing studio

The centerpiece of the shared area on the first floor of HSB Living Lab is the laundry facility, or as referred to, the washing studio. The washing studio is a social area designed for interactions and socializing while the residents manage and wash the respective laundry (Electrolux, 2015a).

The washing studio contains a shared storage space and shared resources for the residents of HSB Living Lab, see figure 6. The social washing studio aims to encourage interaction between the residents of HSB Living Lab (Chalmers Tekniska Högskola AB, 2016a).

Figure 6. Illustration depicting the principle of a washing studio in the heart of the entrance floor (Tengbomgruppen AB, 2015c).

Washing and cleaning in the studio is a central issue for HSB Living Lab. The aim is to develop new ideas that can provide low water and resource consumption and, not least, to develop a good social environment (Electrolux, 2015a, Rahe 2016).

Three washing-machines are supplied to the washing studio by Electrolux, two are bookable and one is used for spontaneous occasions. The washing studio is further supplied with two dryers and one drying cabinet. Two wall-mounted ironing tables are also supplied, enabling surfaces for ironing (Gustavsson, 2016).

3.4 Trends

Different trends that are connected to single-living housing and shared systems have been investigated in order to understand how the trends affect the development of the society, mainly considering the behavior when it comes to accommodation and shared resources.

3.4.1 Urbanization

The world is subjected to a large wave of urban growth compared to the previous centuries. More than 50 percent of the world's population lives in towns and cities at present, see figure 7. The trend of urbanization is expected to grow where the number of populations in cities will be about 5 billion by 2030. There exists a link between urbanization and economic growth where the cities represent 80 percent of the gross national product. Africa and Asia, where the majority of the world's population growth is taking place, will account for the major contribution to the urbanization which will bring huge environmental, economic and social transformations (United Nations Population Fund, 2015).

Figure 7. Illustration of urbanization.

Urbanization has the potential, if the right policies are implemented, of introducing a new era of economic growth, resource efficiency and well-being. Although a problem with urbanization is that cities contain a high concentration of poverty where the rise of inequality is more evident than in suburban areas (United Nations Population Fund, 2015).

The phenomenon of sprawl is connected to urbanization where the urban landscape is expanding much faster that the urban population. The phenomenon of sprawl is driven by increasing urban land consumption by the wealthy and increasing the separation of rich and poor communities within cities. The danger with the phenomenon is that it decreases or even eliminates the opportunities human seek when moving to cities (United Nations Population Fund, 2015).

3.4.2 Single-living housing

As visible in figure 8, there exists a trend of increased single-living households in the world. The trend of single-living is increasing faster than other accommodation types such as couples with children or single-parent families. The global share of single person households in the world has increased from the 1977´s and is estimated to increase even further by 2030 (Euromonitor International, 2014).

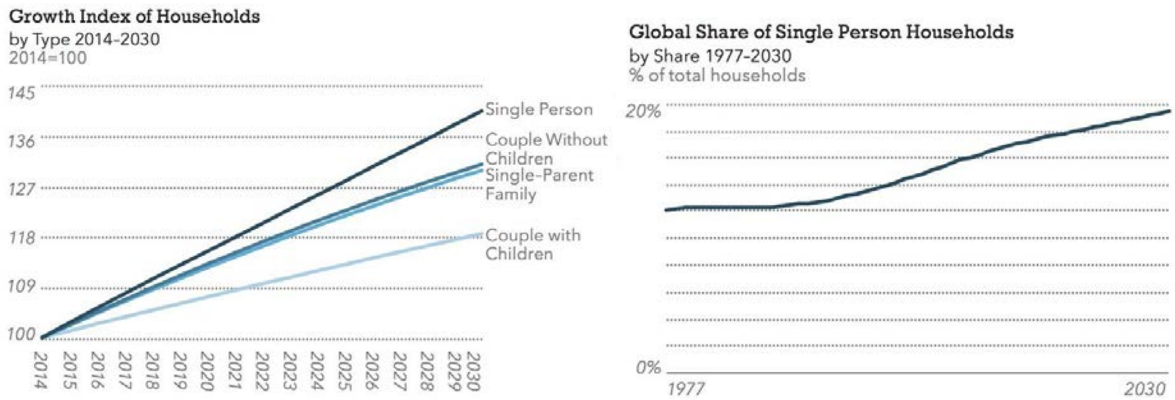

Figure 8. Growth index of households and global share of single person households (Euromonitor International, 2014).

The number of occupants and children per household has decreased since the 1980s which further confirms the trend of increased single-living households in the world (Euromonitor International, 2014), see figure 9. Further statistics are visible in **appendix I**.

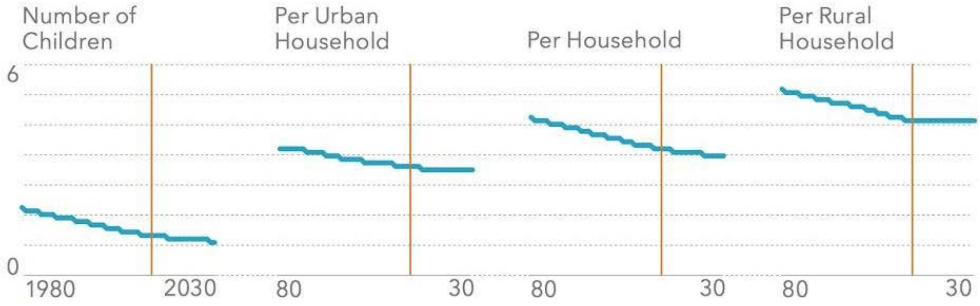

Figure 9. Graph visualizing the trend of decreasing occupants per household in Europe (Euromonitor International, 2014).

An investigation into the Swedish market trend was initiated to further emphasize on the trend of single-living households. There are approximately 1.9 million single-living apartments and 165 000 multi-resident apartments in Sweden today. The buildings are from different time-periods where almost 50 percent are built before the 1960s and have inadequate thermal shells (Chalmers Tekniska Högskola AB, 2016a).

The number of households in Sweden have increased with 58 percent the past 40 years while the average size of a household has decreased with 0,5 persons. The average living space per individual in Sweden is about 32 square meter (Chalmers Tekniska Högskola AB, 2016a), which is considered as an unsustainable situation due to the increasing urbanization and single-living trends.

3.4.3 Textile and Fashion

The need for a sustainable breakthrough has not only moved slowly in the building sector but also the fashion industry is suffering. The most commonly used material sources are two environmentally unsustainable materials. The materials most commonly used world-wide are cotton and polyester, one natural and one man-made material, both with an immense resource wastage factor. It takes approximately 2700 liters of fresh water to produce a single cotton shirt and heavy chemicals are often used during the production (WWF, 2016). Polyester on the other hand is a man-made material based on the decreasing supply of oil and gas, which also strains the environment extensively. Unfortunately the production materials and resources are not the only issue. Studies shows that 75 percent of all consumed clothing articles in the European Union ends up as landfill (Briga-sá et al., 2013).

Although the clothing industry has been moving slowly, there are a lot of new initiatives inbound, aimed to add the fashion industry on the list of sustainable businesses. The use of organic cotton or recyclable polyester is a way of achieving the same basic functionality and user experience familiar to the user but with less production, material and end-of-life impact. Another way of increasing sustainability into fashion is to target the use-phase itself, an approach closely tied to the scope of the project. By shifting the view of clothing as a privately owned artifact and thus view it as a shared resource, the clothing industry can allow the clothes to be used for a greater time period as well as being serviced consequently to extend the lifespan even further. Examples of this can be found in clothing libraries and fashion rental services online. This enlightens an interesting case where users have accepted clothing to be viewed as a shared resource.

3.5 Sustainability

The purpose of HSB living lab is to build an environment in which sustainable solutions to the trends of increasing single-living households and future accommodation solutions are investigated. The initial idea formulated for this thesis is to facilitate the laundry cycle in HSB Living Lab, to encourage a sustainable behavior of the residents in terms of facilitating shared washing, thus decreasing the environmental impact (Rahe, 2016).

3.5.1 Design for sustainable behavior

Design for sustainable behavior, DfSB, is aimed to alter the design of an artifact in order to evoke a more sustainable interaction pattern or behavior in relation to that artifact. The principles are furthermore used to reduce the excessive resource wastage. The principles can be used as design guidelines when creating a sustainable artifact or be implemented as values in order to change the user behavior into a more ecologically sustainable manner. In order to design for sustainable behavior there are three main principles to follow. Either directing, by letting the designer be in control or by motivating, letting the user be in control. The third principle is called match and lies in between of the designer or user being in control, see figure 10 (Renström et al., 2013).

The motivating approach targets the user behaviors in two ways, spur and enlighten. Spur is a way of encouraging or challenging the user into changing or adopting a desired behavior. By making the user feel that the required efforts are worth the time spent. A prime example of this is recycling stations for bottles or cans whereas the users get an economical reason to follow a more sustainable behavior. The money is already paid by the user when the bottle is purchased, which enhances the desire to get it back. The enlighten principle is aimed towards knowledge and user awareness. By implementing design cues that depict unintended behavior or use, the user receives an instant feedback of how to not use an artifact or how to reduce the impact of said artifact. An example of this principle is a glowing charging cord that indicates that it should be removed when not used through the luminance (Renström et al., 2013).

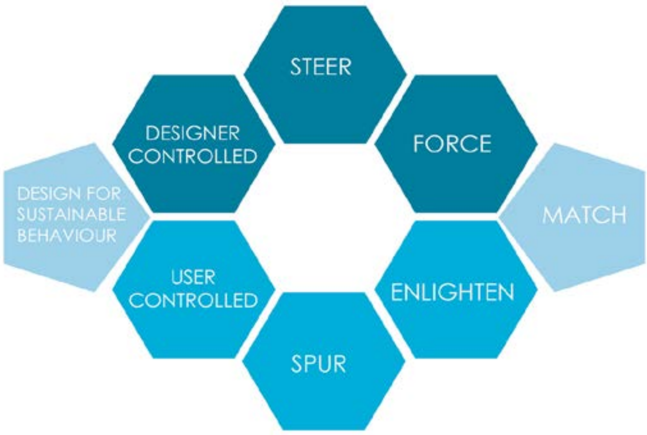

Figure 10. Illustration of the process used to design for sustainable behavior, according to (Renström et al., 2013).

The directing approach lets the designers implement intended user behaviors based on two principles, steer and force. The first principle, steer, is a more direct guidance feedforward compared to the user controlled enlightening principle. By guiding the user into an intended behavior the design is less likely to be used or disposed of in an unintended manner. One way of achieving this is to directly give instructions how the product should be used or how to dispose of it properly, as in a shape-steered recycling basket. The second directing approach is force, a principle that limits the functions of a product or adding barriers in order to force the user into an intended behavior or a way of use. The force-principle can be implemented as road-bumps, a form of physical barrier that makes the user follow the speed limit to avoid the vehicle from taking damage (Renström et al., 2013).

The match-principle aims to create a design that corresponds to or mimics the current user behavior. By replicating functions of current artifacts but making the new artifact less resource heavy, the users will get the same experience without the excessive resource waste. An example of the match-principle could be an electrical car. It fulfills the same function, transportation, but with considerably lower environmental impact (Renström et al., 2013).

The principles from the design for sustainable behavior were used to reach a deeper user behavior insight, through discussion considering how to steer and spur users towards shared washing. By realizing when the user needs direct or indirect input, the solution has a greater chance of actually be used in the intended manner in order to reach a higher level of sustainability. The principles are to be considered as design guidelines during the concept specification and detailed design phases. Assuring a user-centered approach to sustainable behavior targeted design, allowing more layers to be added to the final design.

One of the design guidelines derived from the method was the one of steering the amount of laundry the user can load into one batch of laundry. There are possibilities to steer users to load a laundry bag with a specific amount of laundry by dimensioning the laundry bag properly. This could be achieved by setting feedback through the limitations when the bag is full, which would prevent the users from overloading the machine and encourage the users to fill the laundry bags properly.

3.5.2 The eco-design strategy wheel

The design disciplines have realized that ecological design is used as an imperative over the past decades. The awareness parallels to a broader transformation of the society that is focused on sustainable development. It is therefore important finding paths to meet the future needs of humanity through the use of the limited resources that are available on the planet. Product designers, among other disciplines, are influential stakeholders in the occurring transformation (White et al., 2013).

The eco-design strategy wheel of Okala contains strategies to aid designers and system developers to find new approaches in the product development process. The design approaches of the strategy wheel are intended to decrease the ecological impact of a system, a service or a product that is developed. The eco-design strategy wheel contains different approaches adapted to the different stages of a product's life-cycle, from raw material extraction to end-of-life management, see figure 11. The life-cycle of a product or system can be broken down into different phases where each phase consumes resources and releases emission to various extents. The aim of the strategy wheel is to aid designers as an ideation tool aimed to explore new ideas and areas with a focus on decreasing the ecological impact (White et al., 2013).

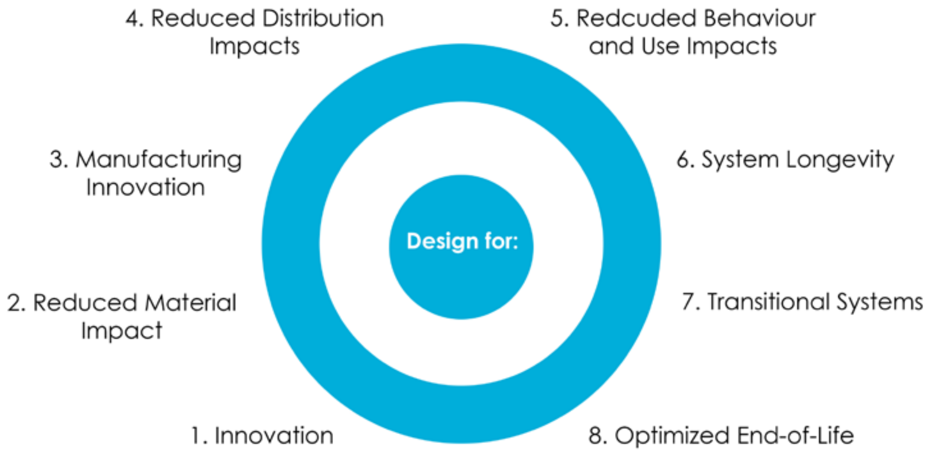

Figure 11. Illustration of the eco-design strategy wheel of Okala, according to (White et al., 2013).

The aim of the first approach is to design for innovation. This approach is adapted to the first phase of the product life-cycle, investigating ideas with a focus on emphasizing the benefits of the solution. The second and third approaches are used for reducing material impacts and improving manufacturing techniques. The fourth and fifth approaches aim to reduce the impacts when considering distribution, behavior and use. The sixth, seventh and eighth approaches consider the longevity of the product, transitional systems and optimizing the end-of-life of the product (White et al., 2013).

The eco-design strategy wheel was used in the ideation phases. The guidelines for designing for innovation and the guidelines for user behavior and impacts were used initially to discover innovative solutions that decrease the ecological impact of the product. Examples of ideas spawned from the eco-design wheel were the initial thought of expandability, compressibility and using burdocks for stacking and locking laundry baskets. The guidelines from the later approaches were used further on in the project when developing the concepts and considering material choice, manufacturing techniques, distribution and end-of-life.

3.6 Laundry framework

A study visit was conducted to Electrolux Laundry Systems in Ljungby, Sweden. The aim of the visit was to gain knowledge about the laundry framework of the project, including the machinery installed in the washing studio. The study visit resulted in insights considering the technology behind the washing-machine and insights considering gentle washing, resulting in valuable inputs to the project.

3.6.1 Washing-machine

A washing-machine consists of a fixed outer drum and a rotating inner drum. The inner drum has a smaller diameter than the outer drum and is fitted with small holes, made for the water to flow through. The inner drum is commonly supported by springs to help the machine absorb the created vibrations when the laundry is rotating and centrifuged. The process of the washing-machine is initiated by hot and cold water entering the backside of the machine through a detergent tray, mixing the water with the detergent on the way to the inner drum, see figure 12 (Johansson, 2016a).

There are defined programs that regulate the water temperature, rotation and mix of detergent which are controlled by a pre-programmed control system. There are machines that contain more than 500 defined programs in order for the user to choose a suitable range of laundry functions depending on the user preferences and context (Johansson, 2016a).

Figure 12. Illustration depicting the inside of a washing-machine (How it works daily, 2012).

The washing-machine is commonly driven by an electric motor that rotates the inner drum using a rubber belt. The inner drum initially rotates in one direction for a period of time followed by an identical rotation in the opposite direction, continuing with this pattern, depending on the active program. A heating radiator is used in the machine to heat the water to the desired temperature together with a water-level sensor that determines the amount of water that should be applied to the inner drum (Johansson, 2016a).

The paddles placed on the inside of the inner drum aid the washing-machine in rotating and mixing the clothes with the detergent and water. It is beneficial for the clothes to rotate the full cycle in order to be mixed properly. The inner drum commonly contains a cone that further helps the laundry to mix in the orthogonal direction to the rotation of the drum. This makes the laundry to not only rotate in one direction but actually two, see figure 13. A pump is used to withdraw the water from the washing-machine, when the chosen program is finished, through a tube connected to the drain (Johansson, 2016a).

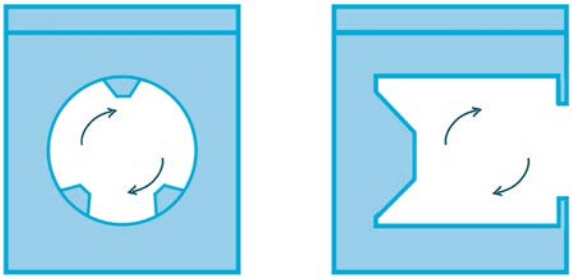

Figure 13. Illustration of the rotation of laundry in two dimensions.

3.6.2 Gentle washing

Extending the lifespan of laundry by washing gently, was an aspect discussed together with experts at Electrolux. There are programs available for gentle washing of laundry with the aim of carefully washing delicate clothing items, as wool or cashmere, materials that otherwise are sensitive to the normal programs. When using a program for gentle washing, the inner drum of the washing-machine does not fully rotate the laundry. The washing-machine is instead gently swinging the laundry back and forth. This avoids the fibers of a single laundry item getting stuck to the fibers of the other items and thus tearing the laundry. The tearing of the laundry is not directly connected to the drums of the washing-machine but instead the laundry itself. The tearing is in fact something that is commonly wanted in order for the laundry to be optimally cleaned in the washing-machine (Gustavsson, 2016).

3.6.3 Products

The washing-machines of HSB Living Lab are of model W575HLE. The machines have a capacity between one to eight kilograms of laundry, with an inner drum volume of 75 liters and an inner diameter of 520 millimeters. The door opening has a smaller diameter of 310 millimeters. The washing-machine has a g-factor of 450G when centrifuging the laundry. The washing-machine supports temperature programs of 30, 40, 60 and 95 degrees Celsius (Electrolux Laundry Systems Sweden AB, 2016c), see figure 14.

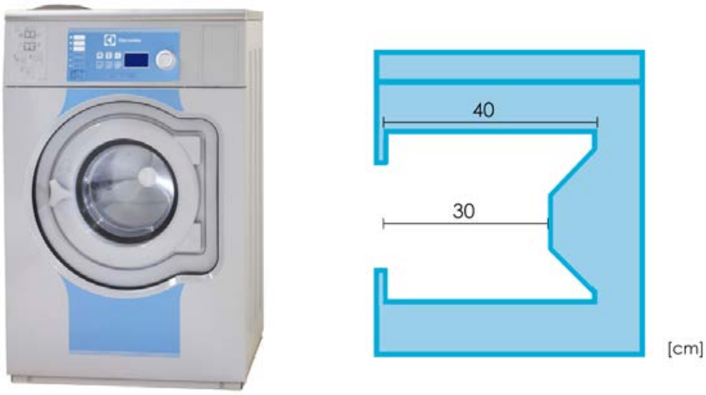

Figure 14. Left image: Washing-machine (Electrolux Laundry Systems Sweden AB, 2016c). Right image: Illustration depicting the inside dimensions of the washing-machine.

Statistics retrieved from Electrolux confirmed that users commonly submit laundry beneath the maximum capacity. The statistics also indicated that users in general load the washing-machines with approximately three kilograms, see **appendix II**, which is less than a half-full machine. Users that live in single-living accommodations are likely to load the machine with even less laundry (Gustavsson, 2016). A quick test demonstrated that the capacity of a washing-machine is greater than users expect, which is something that should be more prominent and thus considered in the design of the developed solution.

The drying cabinet is of model TS4140LE. The cabinet have a maximum loading capacity of ten kilograms. The cabinet further contains 20 hangers in stainless steel and a total of 20 meters of suspension length, see figure 15 (Electrolux Laundry Systems Sweden AB, 2016b).

Figure 15. Drying cabinet (Electrolux Laundry Systems Sweden AB, 2016b).

The dryers of HSB Living Lab are of model T5190LE, see figure 16. The dryers have a capacity of 8,6 kilograms and contain an inner drum volume of 190 liters and diameter of 680 millimeters. The door opening has a smaller diameter of 400 millimeters (Electrolux Laundry Systems Sweden AB, 2016a). The dryer is also supported by paddles used to rotate the laundry inside the dryer. The paddles are similar to the paddles in the washing-machine but has a thinner and longer dimension (Gustavsson, 2016).

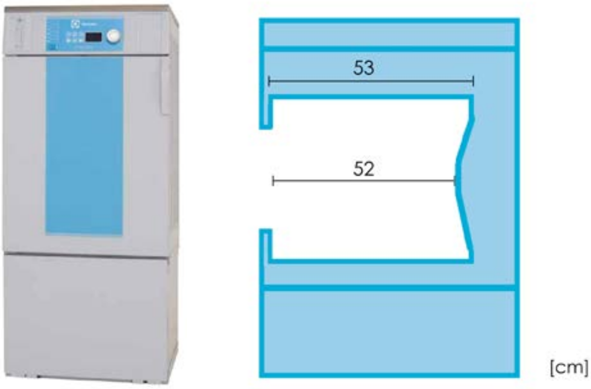

Figure 16. Left image: Dryer (Electrolux Laundry Systems Sweden AB, 2016a). Right image: Illustration depicting the inside dimensions of the dryer.

Electrolux are currently providing two laundry carts for washing rooms represented by TRP4S and TRP2 which both have a capacity of 80 liters, see figure 17. The model of TRP4S has a price of 694 SEK and the TRP2 has a price of 894 SEK. The carts are purchased from a supplier and provided to various stakeholders through Electrolux. The carts are used in various washing rooms with purpose of transporting laundry from the available machines in the washing room (Gustavsson, 2016).

Figure 17. Left image: TRP2. Right image: TRP4s (Electrolux Laundry Systems Sweden AB, 2016e).

3.6.4 Booking board

A booking board will be available in the washing studio of the HSB Living Lab, named Vision, see figure 18. The booking system Vision will be configurable where the anonymous identity of the residents is modifiable. By decreasing the anonymous identity, it is possible to allow the residents of HSB Living Lab to retrieve information regarding which accommodation that has booked a specific washing-time through the booking board. This would simplify the collaborative possibilities of the residents when for instance booking washing-times (Gustavsson, 2016).

Figure 18. Booking board - vision (Electrolux Laundry Systems Sweden AB, 2016d).

The booking board will allow residents the possibility to book and cancel washing-times. The booking board will display information regarding available time slots for washing with a personal site and a stairwell register. The booking board will further allow the possibility of booking washing-times through the web or with an application for cellphones (Electrolux Laundry Systems Sweden AB, 2016d). The vision system is also capable of locking digital locks with RFID tags that are commonly used for locking public storages and organizing microeconomic systems (Jonasson, 2016).

3.6.5 Shared detergent system

The washing studio of HSB Living Lab will be installed with an automatic and shared detergent system. The washing-machines will therefore not be supplied with slots for detergent and softeners. The residents will therefore not have to consider bringing detergent or load the machines. The aim is to simplify the living for the residents of HSB Living Lab but also to lower the costs related to the washing-machine since as much as 50% of current costs connected to washing-machines are represented by detergent costs (Gustavsson, 2016).

3.6.6 Conclusions derived from the study visit

The dimensions of the different machines provided by Electrolux and importance of paddles were made visible when conducting the study visit. The importance of indicating to the user how many percent of a fully loaded washing-machine that the laundry represents was also an interesting aspect that arose.

The extensive functions of the vision system creates a lot of potential when it comes to the design of the studio storage and how shared washing can be organized and maintained in the leanest way possible. By realizing this potential there are a lot of solutions that might reap the benefits of the additional booking system functions. The lock-mechanism can be controlled with the vision system, shared washing can be organized and even a micro-economical system can be introduced that takes care of the organization of the shared washes (Jonasson, 2016).

CHAPTER FOUR

USER-STUDIES

The project continued with user-studies based on the retrieved information from the pre study. A **survey** was used for collecting quantitative data and analyzed with the help of a **KJ-analysis**. The quantitative result from the survey was combined with **interviews**, focusing on gathering more detailed and specific qualitative data. A **market analysis** was conducted to complement the retrieved information from the survey and interview.

A **hierarchical task analysis** was created for the laundry cycle and illustrated with the help of a **customer journey**. The customer journey was used to visualize the cycle and facilitate the evaluation of concepts. A **function tree** was created to divide the main task into subtasks and a **user-profile** to elicit important factors that need to be considered when developing a new solution. **Scenarios** were investigated considering the laundry capacity and two main **user types** were stated. The user-studies, together with the pre study, formed a base for the list of requirements and for the ideation phase.

4.1 Survey

A survey is foremost used to collect data from a large number of users. Surveys are used for retrieving a view of who the customers are by listing demographic profiles, perceptions of different products, prioritizations of different problems and requirements (Chalmers Tekniska Högskolan AB, 2016b).

A survey was used as an initial data collection method. The advantages with a survey are the simplicity and efficiency considering the processing, analysis and general insights. The drawbacks with using a survey is that the method is relatively inflexible and in that sense cannot use the advantage of probing. The method further lacks direct personal contact with the user which decreases the commitment of the user and decreases the possibility to further develop arisen thoughts from the survey (Karlsson, 2007).

An internet-based survey was conducted as an introduction to the user-analysis. Questions were asked with the aim of investigating current laundry solutions used for transportation, and storage, the reason behind why the specific transport and storage solutions were used and the general opinion about viewing laundry as a shared resources. The survey was also used in order to gain a general insight into laundry habits and current products that are used as transportation solutions at present.

The complete survey with results can be found in **appendix III**. The survey resulted in 66 responses mainly represented by Swedish users aged 20 to 29, accommodated in apartments or student apartments, who wash laundry from two to four times per month. Some quantitative data regarding how users transport and store laundry before and after usage of the washing-machine are available in figure 19.

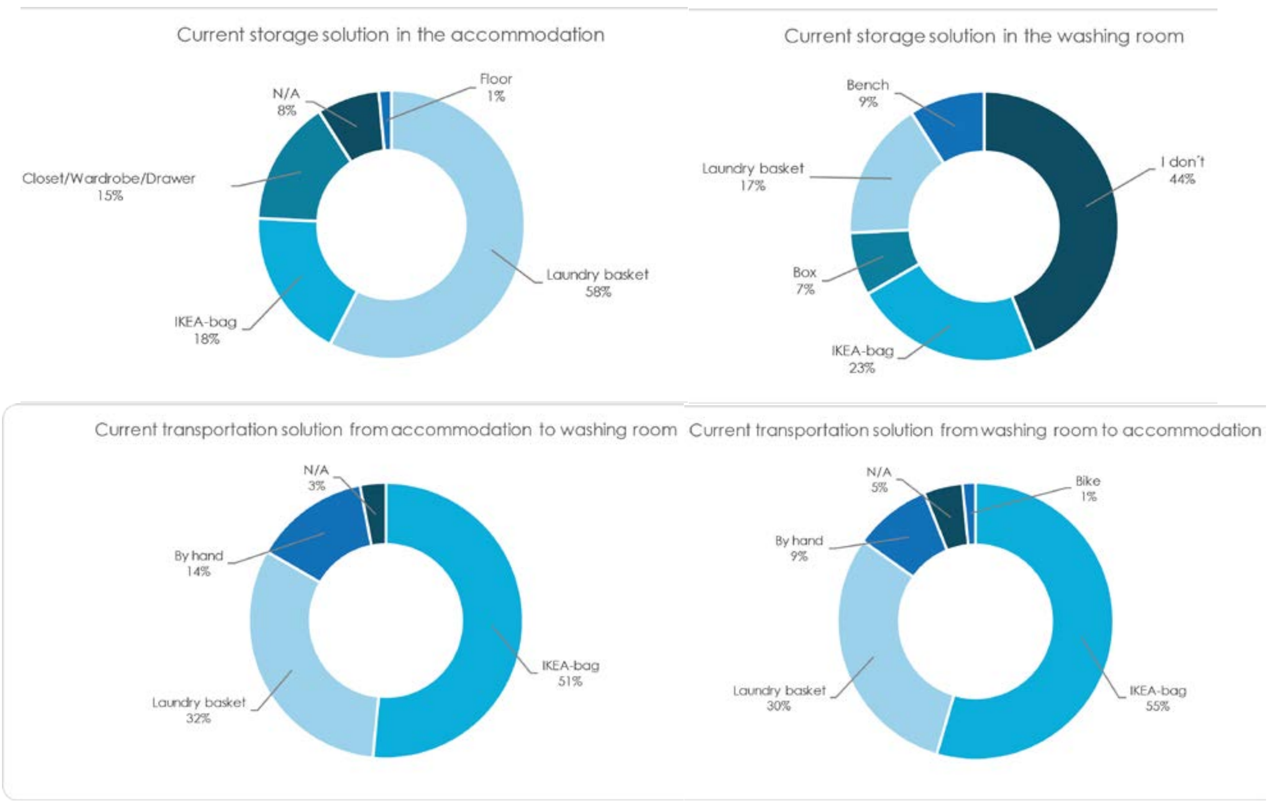

Figure 19. Illustration of the quantitative result from the survey.

The result of the survey demonstrated that the majority of the respondents stored the laundry in the living space with the help of laundry baskets. The majority did not store the laundry in the washing room at all since the laundry was placed in the washing-machine instantly. The respondents generally brought the amount of laundry that is appropriate for the available amount of machines into the washing room. The same transportation device was commonly used to transport the laundry from the accommodation to the washing room and vice versa. The result from the survey further demonstrated that the transportation device most commonly used was a fairly even split between different types of laundry baskets and IKEA-bags.

An interesting finding from the survey demonstrated that it was common for users to have two different products for storage and transportation of laundry. This was due to the fact that different products have different attributes. The attributes of one product were preferred over the other depending on if the product was used for transportation or storage. The laundry baskets were mainly used due to the concealing attributes, connected to the personal integrity, and for ensuring that laundry does not get dropped during transportation.

The IKEA-bags were used because of storage capacity and flexibility. The bags were scalable and easy to store when not being used. The bags were furthermore used because of the low price and variety in straps, that allowed different grips dependent of the situation and personal preference. Two illustrations with positive quotations regarding the common IKEA-bag and laundry basket are available in figure 20.

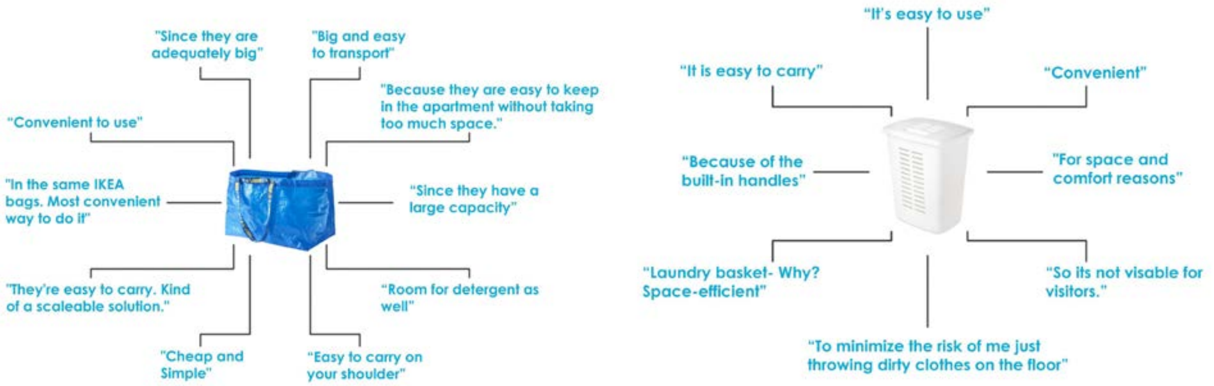

Figure 20. User-quote infographic demonstrating the positive aspects of an IKEA-bag and a laundry basket.

4.2 Kawakita Jiro analysis

Created by the Japanese anthropologist Jiro Kawakita, the KJ-analysis is a structured way of organizing large quantities of epistolary data. The method also known as the "affinity-diagram" is an excellent way of compiling the subjective replies by categorizing the replies in clusters (Chalmers tekniska högskola AB, 2016b).

The KJ-analysis was conducted in order to organize the qualitative responses mainly focused on attitudes of the respondents towards viewing laundry as a shared resource. The replies were printed, sorted and organized in respective groups in order to obtain an overview of the areas that the responses cover. The result from the KJ-analysis was compiled and illustrated in form of a user-quote overview visible in figure 21.

Figure 21. User-quote overview clustering the survey respondents view on sharing laundry.

The result from the KJ-analysis demonstrated that the aspects considering laundry as a common resource could be divided into neighbor-related aspects, time-related aspects, access-related aspects, hygienic-related aspects, sustainability-related aspects, economical-related aspects, privacy-related aspects and some individual aspects.

4.2.1 Neighbors

The neighbor-related aspects were further divided into positive and negative attitudes towards sharing laundry with the neighbor. The negative attitudes were connected to the unfamiliarity between the neighbors and the uncertainties regarding the cleanliness of the neighbors laundry. Whilst the positive attitudes towards sharing laundry with a neighbor were connected to the familiarity and close relations with the neighbors which resulted in a positive attitude towards sharing laundry.

4.2.2 Hygiene

The hygiene-related aspect was closely connected to the neighbor-related aspect where the attitude was connected to uncertainties to the neighbor and the laundry of the neighbor. The risk of mixing laundry with the neighbor was clearly connected to an uncertain attitude towards sharing laundry with a neighbor together with the unwillingness of having to visually perceive and manually interact with the laundry of the neighbor.

4.2.3 Time, sustainability and economy

The time-, sustainability- and economical-related aspects were connected to the potential benefits that sharing laundry would lead to, both on an ecological and an economical level, in terms of time and money saved. Some respondents stated that sharing several household products would be beneficial from an economical perspective but also from a spatial perspective where, for instance, owning a washing-machine was impossible due to limits in accommodation space. The negative attitudes were connected to time issues and that users want to wash the laundry on individual terms, not having to adapt to other neighbors.

4.2.4 Privacy and access

The privacy- and access-related aspects were based on the integrity of the user and the need of a reliable and accessible booking system. The risk of mixing clothes with the neighbor was clearly stated in this aspect as well, together with the inconvenience of having to visually and manually interact with laundry of the neighbor. The aspect of security was also mentioned whereas it existed a lack of trust towards unknown neighbors and an insecurity when leaving personal items unlocked.

Several of the negative attitudes that derived from sharing laundry with a neighbor could be solved through emphasizing the user relations of the residents in HSB Living Lab. This could be achieved by developing a solution which emphasizes on frequent interaction between neighbors leading to improved relations between the residents. A lot of the derived aspects connected to hygiene and unfamiliarity could be solved through a product. Another solution could be to emphasize the economic and ecological benefits that sharing laundry would conduce to. The question derived from the analysis consider the potential of solving a lot of the retrieved negative aspects with a suitable product that enables the concept of shared washing.

4.3 Interviews

Interviews are one of the most basic techniques used for collecting customer and user-related information. The interviews result in, for instance, a picture of what a user thinks about a particular product, the perception the user has of a specific question or the users perception of a certain situation. Interviewing in product development is primarily a way to gain deep understanding of problems and lists of requirements (Chalmers Tekniska Högskolan AB, 2016b).

It is important to determine what purpose the interview has before initiating an interview and to specify the purpose before it is carried out. The introduction should describe the interview, including, as mentioned, the purpose, how long it will take, how it is documented, how the results will be used etc. Conducting test interviews is good to facilitate the real interviews and to discover potential problems. Using interviewees that belong to the same category as those who will participate in the real is suggested for the best result (Lantz, 2007).

Interviews were used for further investigation of user requirements and guidelines considering the laundry cycle. The interviews focused on qualitative data collection and retrieving detailed input from the potential users of the developed solution.

The primary target group was determined as students since the third generation of the living labs mainly is aimed towards the mentioned target group. The nine interviews were semi-structured combined by both closed and opened questions made to spawn a deeper discussion. The interviews were conducted in a natural environment adapted to the needs of the different interviewees.

A template was used containing introduction questions considering the interviewees washing habits and general information. The template continued with questions digging deeper into requirements considering how the interviewees store and transport the laundry. The template ended with questions considering the probability of viewing laundry as a shared resource and motivations for spending time in the washing room when not specifically utilizing the equipment of the washing room. The template and answers are available in **appendix IV**.

The result from the interviews was used for stating specific guidelines and requirements that were put into a list of requirements. The interviews further resulted in positive, neutral and negative aspects regarding shared washing and factors that would motivate users to utilize the washing room as a social place. The positive, neutral and negative aspects together with the factors were put together in word clouds available in **appendix V**.

The positive aspects of shared washing were connected to the economic benefits in terms of time and money and the ecological benefit of sharing detergent costs and water. Another positive aspect was sharing washing times and having the possibility of washing the laundry more frequently, which was connected to the possibility of getting washing times easier if two users co-operate.

The neutral aspects were connected to the aspects of relations to the neighbors, hygiene and booking access, similar to the result from the survey. The neutral aspects were factors that need to be solved and simplified through a product or system in order to transform the doubtful aspects into positive. The negative aspects were further connected to the privacy, hygiene and unfamiliarity connected to neighbors, similar to the results mentioned from the KJ-analysis.

Aspects that would motivate users to utilize the washing room as a social space were mixed. Possibilities of free WIFI, coffee and availability of furnitures were strongly represented in order to achieve a positive experience. Decreasing the noise, mainly from the machines, was important for users to be able to relax. Having a functional and shared detergent system was also important for users in order to avoid unnecessary discussions and distribution of responsibilities.

4.4 Market analysis

Investigating current competitors on the market is one of the most important methods when new or improved developments of products are conducted. The method is mainly carried out by examining competing products and similar products that solve sub functions, which could be used for inspiration (Pahl et al., 2007).

The results from the market research demonstrated that there were different types of products currently used to transport and store laundry depending individual preferences of various users, see figure 22.

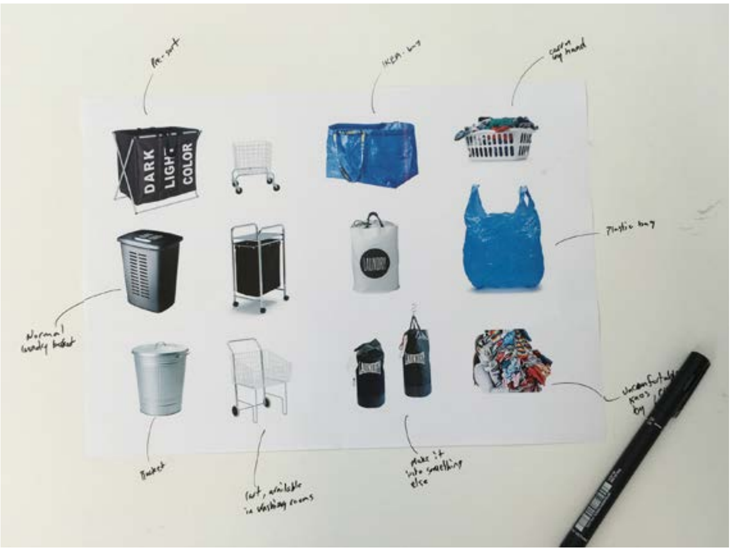

Figure 22. Image of the infographic chart depicting the different competitors.

The results from both survey and interviews demonstrated that there were a range of products used for storing and transporting laundry in the various accommodation types. The most commonly used products for storing laundry were different types of laundry baskets, boxes and bags. The most commonly used products for transporting the laundry were different kind of bags, most frequently the IKEA-bag, laundry baskets or manually by hand. The interesting aspect was the frequency of users having two separated products for storing and transporting laundry.

4.5 Hierarchical task analysis

Hierarchical task analysis is a method that can be used to examine the ways that users conduct specific tasks. The process of the task analysis is to understand the requirements of a user who conducts a task. The next step is to assess whether the task, situation or environment in which the task is conducted is designed in a way that fulfills the requirements (Sandom & Harvey, 2004).

A Hierarchical Task Analysis, HTA, was conducted considering the tasks generally performed by users during a laundry cycle visible in figure 23. The HTA-method was modified by keeping the steps on a general level, not specifying the subtasks. The HTA-method was used to gain a deeper insight into how the cycle of laundry is built up from the step of the dirty laundry being collected to the user having a clean set of laundry.

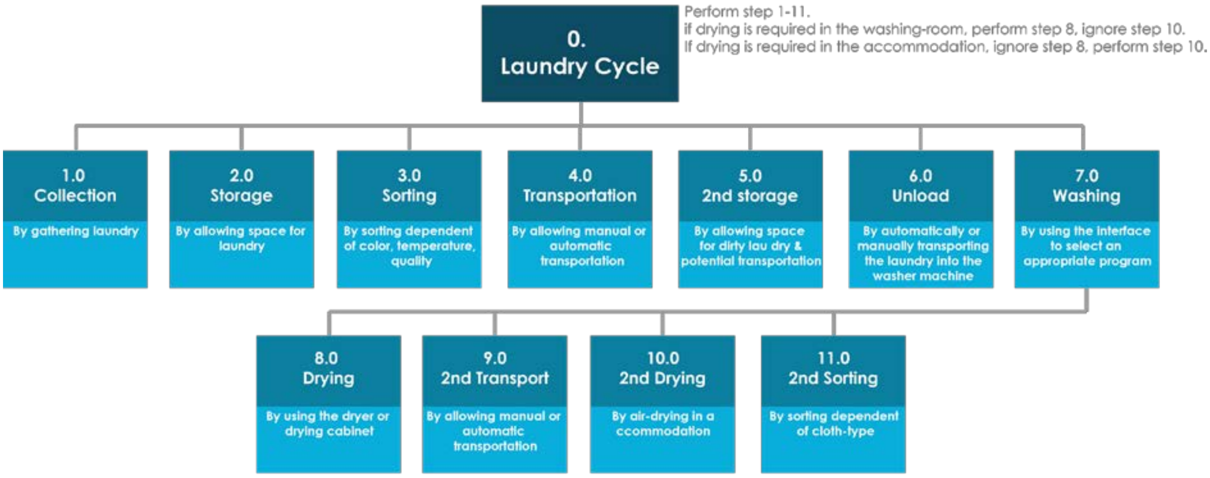

Figure 23. The HTA for the laundry cycle.

The result of the HTA demonstrated that the laundry cycle consisted of eight main steps; collection, storage, dirty sorting, transportation, secondary storage, unload, washing, drying, secondary transportation, secondary drying and finally clean sorting. The course of which the steps were taken was dependent on individual users and the individual preferences. A larger focus was set on the steps of sorting, transportation and storage. The steps of collection, unloading, washing, drying and clean sorting were although also investigated.

4.6 Customer Journey Mapping

Customer journey mapping is a user-oriented method, created to define and analyze the steps the user goes through during the interaction with a service, system or product. By characterizing each step and defining the touchpoints, HMI or product interaction, a graph is created to visualize the customer journey. The data, which the customer journey is based on, is collected from user interviews and or observations. Observations are used by letting the user walk through a pre-defined situation where the observant documents the process (Tassi, 2009).

A customer journey mapping was conducted and illustrated with using the basis from the HTA. The customer journey was further distributed in steps, resulting in a total of 18 steps divided into three phases. The different steps of the customer journey were adapted to the different environments of HSB Living Lab, such as the single-living apartments, staircase, elevator and washing studio, available in figure 24 and **appendix VI**. The customer journey was used for evaluating concepts and ideas throughout the project by evaluating the concept through the different steps of the journey.

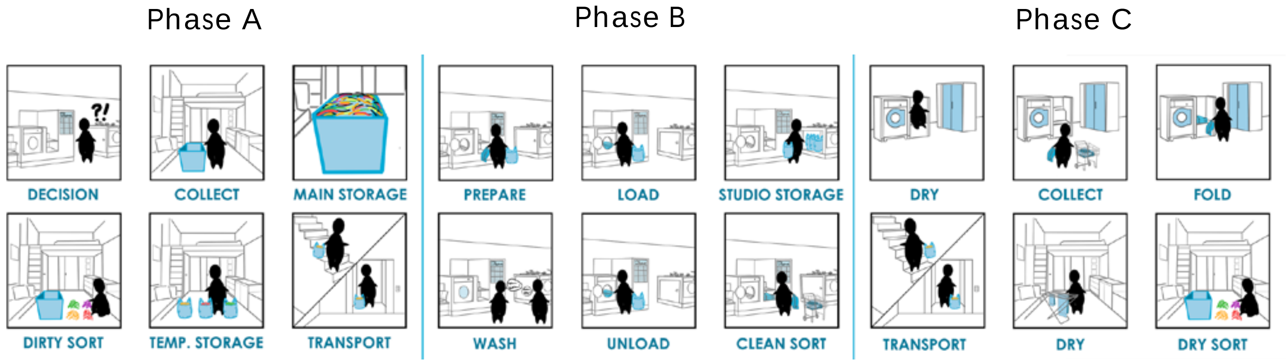

Figure 24. The customer journey for the laundry cycle.

The customer journey is initiated through a decision that the user makes, making the judgement that the laundry has to be washed. The decision step incorporates the practical booking of available washing-times in the laundry room and planning. The user commonly book a washing-time by walking to the washing room and selecting a time, although modern estates provide booking systems through the internet, which increases the user control. The next steps contain collection and main storage of the laundry in the main container, commonly a laundry basket. These steps could occur before, simultaneously or after the first step of decision. The laundry is then sorted and temporary stored in additional containers depending on individual preferences of different users, commonly different types of laundry bags. The laundry is then transported to the washing room manually by the user with the help of the temporary containers. The laundry is prepared and loaded into the washing-machine depending on the requested preferences of the user. The laundry that does not fit in the machine is temporarily stored in the washing room, if more laundry than the washing-machine holds is brought by the user.

The laundry is then washed and manually unloaded before sorted once again depending on whether it should be dried in the dryer or drying cabinet. After this step, the laundry is dried and collected from the different drying components. The clothes that require folding are folded before being transported back to the accommodation. The next step is occurring if the user prefers to dry the clothes with air instead of using the drying components in the washing room. The final step is the step of sorting the clothes. The washed laundry is sorted depending on the individual preferences of the user.

The customer journey was used to demonstrate and highlight the troublesome steps of the process. The most troublesome and unnecessary steps are the dirty sorting, temporary storage and preparation of laundry before the washing-machine. The mentioned steps require an additional product and effort from the user, mainly in terms of time. The steps of collection, loading, unloading and clean sorting are additional steps that require unnecessary effort, mainly in terms of time. The steps of transportation in both directions are fairly inconvenient and troublesome because of the design of currently used transportation solution, such as laundry baskets and bags.

The results from the customer journey were used in order to eliminate unnecessary steps and to improve the steps that require additional effort from the users, both in terms of time and inconvenience.

4.7 Function tree

A function tree is used to elicit and clarify the objectives of a product or service. The method works like a simplified mission statement where the main objective is broken down into sub-goals and the relationships between the sub-goals are visualized with a graphical tree. The aim is to understand what the purpose of the product or service is and to investigate the actual demands made on the product and the purport of these (Cross, 2008).

A function tree was made in order to analyze how the main task of the solution could facilitate the laundry cycle built up by subtasks. The subtasks had to be achieved in order to fulfill the main goal of the solution, which was transporting laundry from the single-living apartment to the washing studio and back. The result from the function tree analysis is shown in figure 25.

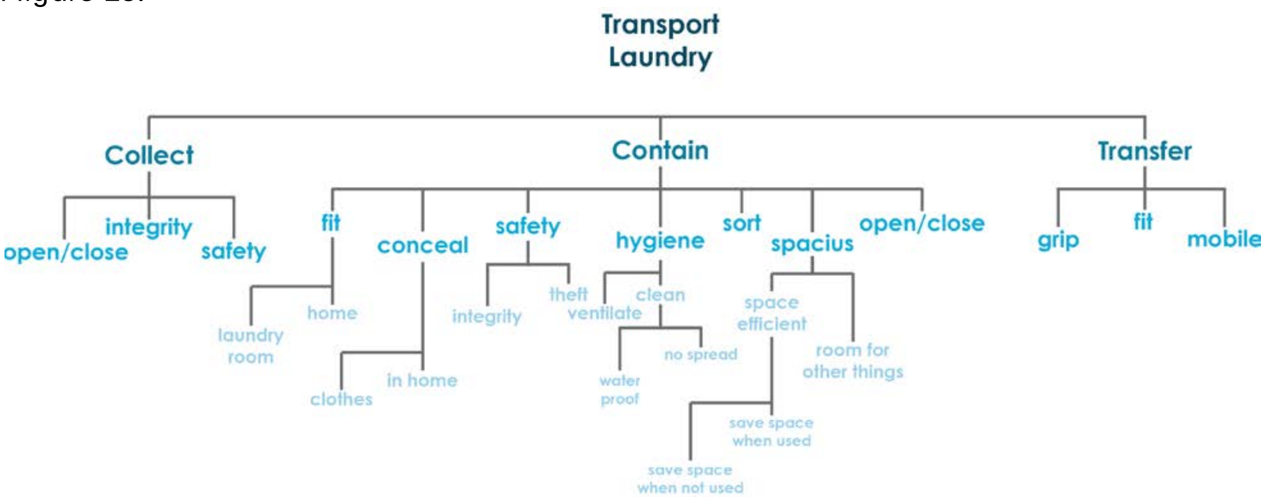

Figure 25. Illustration of the function tree for storing and transporting laundry.

The result from the function tree demonstrated that the three main subtasks of collecting, containing and transferring have to be fulfilled in order for a solution to fulfil the main task. The subtask of transferring is quite similar to the main task but divided further into graspability, safety etc. The subtask of containing was investigated further and divided into insights in the integrity, hygiene, possibilities to sort and open or close etc. The result from the method gave insight into aspects that have to be considered when investigating requirements and guidelines related to a transportation solution for laundry. The results from the function tree were used further on in the project in the ideation phase for finding solutions to the different subtasks and combinations of the solutions in a morphological chart, see chapter 6.5.

4.8 User profile

User profile is a complementary or substitute method to a persona. In contrast with the sibling method, user profiles are based on real scenarios instead of a made-up target user. By analyzing three user categories based on skill and experience, important design aspects are withdrawn from Janhager´s model. The method can further be used as an underlay for securing that all major user-centered areas are being addressed (Janhager, 2005).

Two user profile models were created. One representing an experienced user of a current transportation system and the other was created for a user of the future solution. Both user profiles were created with the help of Janhager´s model, see **appendix VII**. Important factors were derived from the method by considering the experience of the user, the influence of responsibility, the degree of interaction and the emotional relationship connected to both the current products and a future solution.

The result from the user profiles demonstrated that there were several aspects to be considered when developing a new solution for the laundry cycle. These aspects were compiled into important factors to consider during the development, illustrated in figure 26. The cognitive ergonomics, stress factor, reliability, confidence, aesthetics, characteristics, ease of understanding and physical ergonomics were derived factors that needed to be considered independent of what product that is used, either current or future solution.

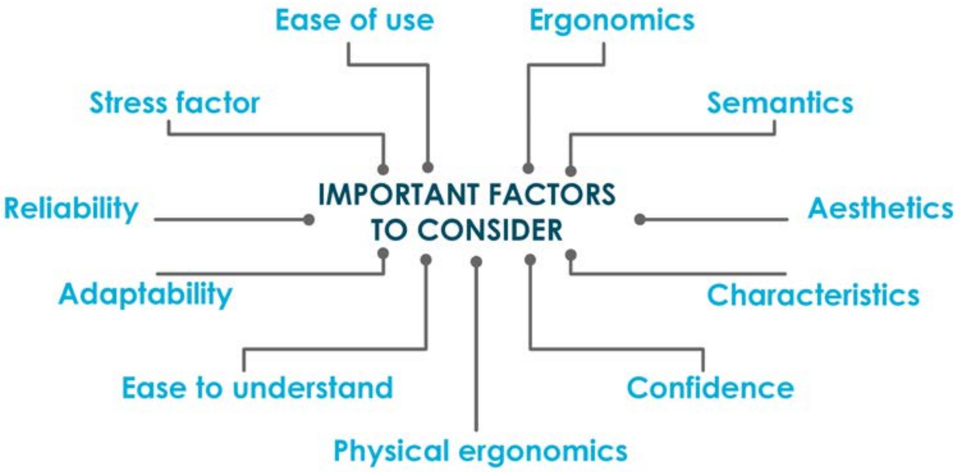

Figure 26. Illustration of important factors that have to be considered according to the created user profiles.

The aspects of adaptability, ease of use and semantics were derived factors that needed to be primarily targeted if the user profile was focused on a novice user when developing a future solution. The result from the user relation was used as inspiration for the ideation phases and for pinpointing the factors that are of greatest importance when developing a new solution for the laundry cycle.

4.9 Scenarios

Scenarios, a method sprung from usability sciences, describes why a user is drawn to a product or can be used as a way of categorizing different use-cases and use-conditions. Scenarios are used to withdraw specific use-conditions and the individual use-cases that describe a certain condition in which the product is used. The scenarios are completed by analyzing all the possible use-conditions (U.S. Department of Health and Human Services, 2016).

Discovered during the user and literature studies, a number of different scenarios could arise whilst handling the laundry. The first group of scenarios were laundry related ones, describing the amount of laundry and laundry sensitivity, mainly categorized based on the percentage of the basket volume that the laundry occupies, see figure 27. The first scenario was max, the basket filled completely. The second scenario was big, the laundry takes up more than 50% of the total basket volume. The third was half and occurred as described when the laundry takes 50% of the basket volume. The fourth laundry scenario was mini and described the basket filled with less than 50%. The fifth was single**,** the basket contained one or a few individual items. The sixth and final was special**,** implying that the laundry was mixed with special items such as sportswear, brassieres and delicate clothing that require special treatment.

Figure 27. Illustration of the scenarios considering the amount of laundry.

The second group of scenarios treated the containment of the laundry, which described the type of laundry articles present in a single basket. These items were sportswear, delicate clothing, regular clothing, bed sheets and towels. The third scenario type was tied to transportation possibilities, limited to either taking the stairs or the elevator. The fourth and final scenario type was based on the laundry being dried and could be done by dryer, dry cabinet or open ventilation.

The laundry scenarios were used during the dimensioning of the concepts. Filling the bag to the maximum capacity is the desired scenario since it ensures a minimum resource wastage during usage in the washing-machine. It is also the most demanding scenario since it requires the largest bag volume and storage space, which might also affect the long term washing result. The other scenarios were used as design guidelines by providing a view of how laundry products are currently used.

4.10 User types

User types is a method used to describe the users and the connection between user and product. The method is an important addition in order to understand the previously defined scenarios. The users are categorized mainly based on the degree of product or service interaction. The primary user will interact with the product and have it in a relatively close proximity whilst the secondary user will be able to see and feel the product but not necessarily interact with it. By categorizing users and specify needs present within each category, new demands are allowed to surface which might be forgotten if only the users in direct interaction are targeted (U.S. Department of Health and Human Services, 2016).

The solution should accommodate for two different user types that will be present in the HSB Living Lab. These users types were identified during the pre-study and grouped in two main user groups, see figure 28. The first user group contained the primary users, including residents of the house mainly represented by students, researchers and real estate managers. The real estate managers will mainly be in contact with the solution during the mounting and possible service instances. The needs of the primary users that will be in direct contact with the solution were deemed as utterly important to ensure. The secondary user type consisted of third party visitors to the Lab as in friends, families and bypassers. The secondary users will most likely not be in direct contact with the laundry system but will be able to visually and olfactory examine it. The needs of the secondary users were thus also important. Overlooking the secondary users could result in creating discomfort, both for the primary and for the secondary users.

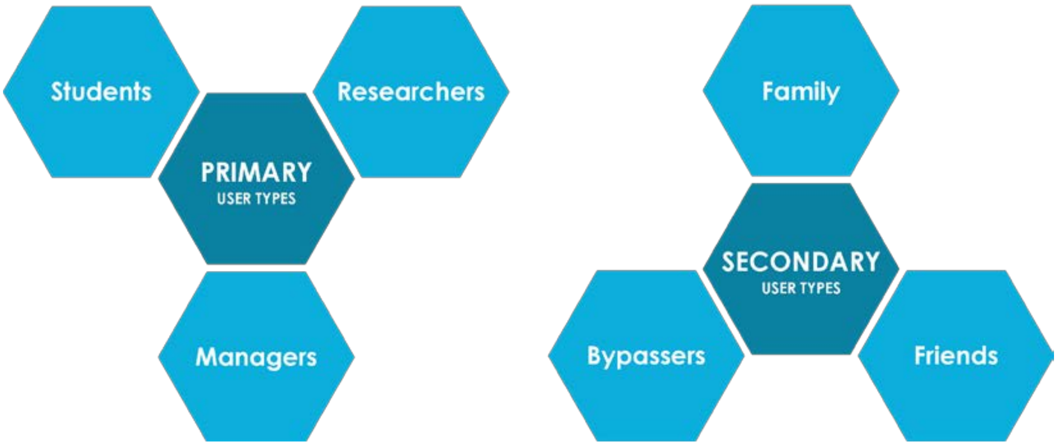

Figure 28. Illustration of the primary and secondary user types.

The user type analysis resulted in the realization of how important the privacy aspect was during the storage, transport and washing sequences. Since the secondary users always will be able to visually examine the product, it was deemed as highly important to be able to keep a privacy aspect for the primary user, by concealing the dirty laundry. This aspect was kept in the design phases when both visuals and material was to be decided and set. The solution should thus maintain the laundry concealed when stored and transported, whilst still giving sufficient air and water accessibility during usage in the washing-machine and dryers.

CHAPTER FIVE

REQUIREMENTS AND GUIDELINES

A list of requirements was created based on the results of the pre study, user-studies and stakeholder interviews. The list of requirements contained all demands and guidelines that the solution has to achieve. Furthermore, a weighting of the guidelines was conducted, placing the highest ranked guidelines in an individual list.

5.1 List of requirements

A requirement specification lists the different types of needs that a product is facing. A list of requirements can be divided into two different groups, demands and guidelines. The demands must be met for a solution to be acceptable and should ideally be measurable. Guidelines are requirements that have to be taken into account but must not necessarily be met or implemented into the solution. The guidelines should ideally be measurable as well. It might be an advantage to have the demands and guidelines assigned in different areas in the specifications such as geometry, safety, kinematics, environment, economy etc. for an increased graspability (Pahl, et al., 2007).

The list of requirements was structured according to Pahl et al, dividing the requirements into demands that have to be fulfilled and guidelines that not necessarily have to be fulfilled, available in **appendix VIII**. The demands and guidelines were further divided into the different categories of sustainability, properties, space, handling, hygiene, visibility/privacy, society, behavior, aesthetics and safety/comfort for an easier overlook. The requirements were mainly formed from a combination of user-requirements withdrawn from the user-studies and stakeholder requirements given by Electrolux, HSB, Tengbom and Chalmers. The last requirements were drawn from common societal norms and regulations.

5.2 Weighting of Guidelines

Concept choice matrixes list the weighted requirements in order to evaluate different concepts against each other. The requirements are therefore weighted by distributing 100 percent between the requirements where the most important requirements are assigned with the highest amount of percent (Ulrich & Eppinger, 2012).

A weighting of the guidelines from the list of requirements was conducted in order to extract the most important guidelines. The weighting process also functioned as an initiation of the concept choice matrixes further into the evaluation stages of the process. The weighting was performed by ranking all of the guidelines in the list of requirements, the pure demands were already deemed as essential to be solved and thus overlooked in this method. The scoring was accumulated by deriving important aspects from the pre-study and user-studies where the most important guidelines were assigned a score of five. The scale continued further down to guidelines assigned with one depending on the calculated importance of each guideline. The most important guidelines, rated with fives and fours, were withdrawn to be used as a ranking guideline for concept evaluations and can be seen in **appendix IX**.

5.3 Analysis of the requirements and guidelines

The most important requirements and highest ranked guidelines with a focus on the user, were divided into the two main areas of handling and privacy. The requirements connected to the handling area were for instance the demands requiring pre-sorting possibilities and easy access to all stored laundry items. Developing a solution that is time-efficient and connected to an easy loading/unloading from the different machines in the washing studio was also ranked high. The requirements connected to the privacy were built up by a major demand of allowing several users to interact with the same laundry bag without physically interacting with the stored laundry. Other important design guidelines were for instance considering the visibility of the laundry, concealing the laundry from unwanted eyes, but still allowing users to assess the amount of the laundry and potential errors that could occur during the sorting of the laundry.

CHAPTER SIX

IDEATION

The design methodology used during the ideation phase acted as a support in creative thinking and innovation and was carefully picked based on the individual traits of each method. Two **mood boards** were created with the aim of enhancing the creativity. **Brain writing** was used as a result of the capacity of creating a large quantitative idea pool quickly, due to the method being fairly unstructured and open. **Random input** was selected due to being immensely open and was used as a more targeted method for important function areas identified through the user-studies, producing interesting results.

Design with intent, based on the user oriented cases, was a method used as an inspiration to target user behaviors in a more complete manner. A **morphological matrix** was used due to the ability to cover all possible directions of which the solution could be made, generating both unrealistic but mainly inspirational concepts for the complete laundry cycle. The **6-3-5-method** was used as a way of breaking patterns and retrieving external input to the ideas. **Pick charts** were finally used as a way of clustering, sorting and evaluating the concepts and ideas created throughout the ideation.

6.1 Mood boards

Two different mood boards were created with the purpose of enhancing the creativity and providing inspiration in the ideation phase. The mood boards were created by finding inspirational pictures on the internet represented by the keywords of sustainability, fashion trends and laundry. The first mood-board was created with the help of current laundry trends and existing laundry solutions of today. The second mood-board was built up by inspirational pictures representing the emotions related to the developed solutions. Both boards are available in figure 29.

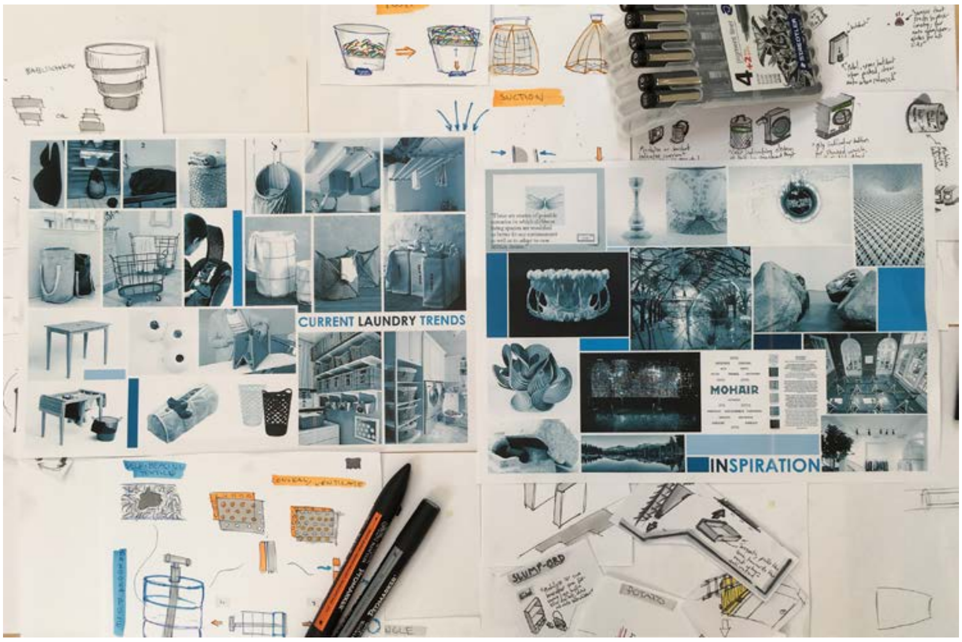

Figure 29. Image depicting the two mood-boards used in the project.

The mood boards were used as a starting point for the ideation phase, by providing both inspiration for new ideas but also current ways of handling laundry. The ideas that surfaced were allowed to be both new and progressive at the same time as being rooted to something proven, that was currently being used. This was a desired mix since the final design goal was to create a new and progressive product based on proven technology and functions.

6.2 Brain writing

Brain writing is a modified variant of brainstorming aimed to enhance creativity and developing ideas. The idea behind brain writing is that the team members document the ideas independently to avoid that all the ideas that arise channelize through constant discussions and influences. The participants are allowed to find inspiration in each other's ideas when five to fifteen minutes have passed since the method has started. A second alternative is to forward the ideas to the next participant so that the idea can be further developed (Österlin, 2010).

Brain writing was used as an initial ideation method. The method was used as a substitutional method instead of conventional brainstorming. The topic of a complete laundry cycle was discussed and possible ideas of how to solve sub-functions or the complete cycle were generated and sketched, see figure 30. Ideas that arose from the brain writing session were for instance a laundry bag expanding with a spiral joint, similar to a shell, or a hexagonal laundry bag that utilized the wall for storage.

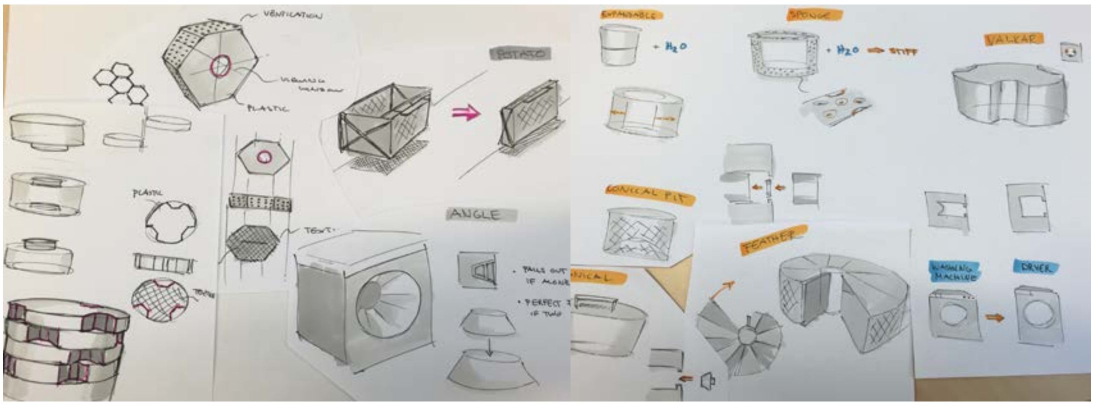

Figure 30. Ideas retrieved from the brain writing session.

The ideas in figure 30 were the first sketched ideas, processed, and used as inspiration for the concept development or as a basis for the pre-concepts. The ideas were later compiled with the results from the random input, for presentational and structural reasons before finally being placed into the pick chart diagram.

6.3 Random input

Random input is a method aimed to enhance creativity in order to aid in the creation of new ideas unbound by ordinary limits. By using an assortment of random events and divergent thinking, free-flowing ideas are allowed to surface, according to de Bono (1984). The method is conducted by processing a list consisting of random words, metaphors and/or events, which preferably should be nouns. The words are then arbitrarily selected and processed one by one, were associations and discussions become the basis of new ideas and insights. The result might at first seem slightly inapplicable but when processed in group with rational thinking and area adaption, the ideas might become solutions usable in a later stage of the ideation (de Bono, 1984).

Random input was used as a way of freely generating ideas unbound by normal restrictions and the method was prepared by gathering an extensive number of words, printing the words, cutting the words into individual strips and then placing the words in a bowl. The words were randomly selected from an existing pool of words and contained words such as; potato, bicycle, hat, window, bible etc. The method itself was conducted by retrieving one of the words at a time from the bowl, discussing the basic features and associations of each word and then see if that word sparked an idea regarding the laundry transportation topic, see figure 31.

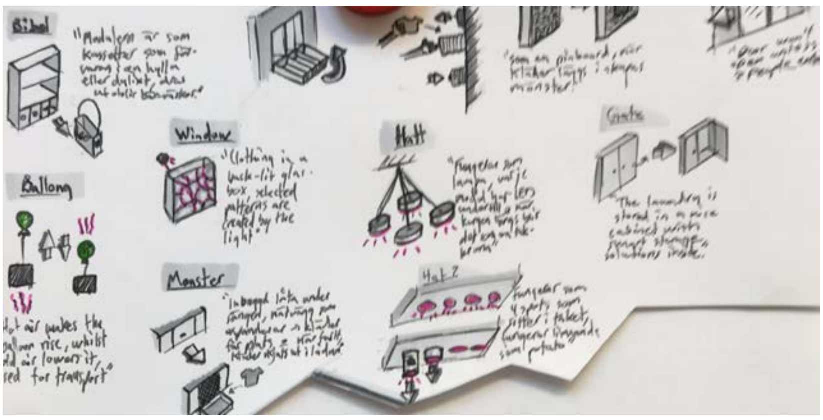

Figure 31. Ideas related to the random input method.

If a word contributed to an idea, a sketch was made named after the random word, if it took too long, the word was deemed useless and was thereafter scrapped. Example of ideas created from the random input session was a retractable, ceiling-mounted laundry basket and a laundry basket incorporated with a luminaire. The created sketches from the random input sessions were then gathered and collected on an A4 sheet before being separately placed on the pick chart diagram.

6.4 Design with intent

The starting point of the design with intent method is the existence of a service, environment, system or product where the behavior of a user is important for the operation or where it would be desirable to modify the behavior. The goal with the method is to influence the behavior of the user through a redesign or modification of the product, service, environment or system. The general structure of the method is divided into two modes, inspiration and prescription. The inspiration mode is initiated through a set of design patterns, divided into six groups of lenses, which are applicable to a wide range of target behaviors. The six group of lenses consist of architectural, error-proofing, persuasive, visual, cognitive and security lenses where each lens contains a set of design patterns, see figure 32. The prescription mode is initiated through a formulated brief, specified for one range of target behaviors, describing the interactions (Lockton et al., 2010).

The design with intent method was applied by using the inspiration toolkit containing a set of design patterns. The design patterns were images depicting current solutions to steer users towards a desired behavior. An example from the persuasive lens, was the name-marking of Starbucks coffee cups, making users less likely to litter the coffee cups, which is connected to the unwillingness of littering something that is tied to the identity of the user.

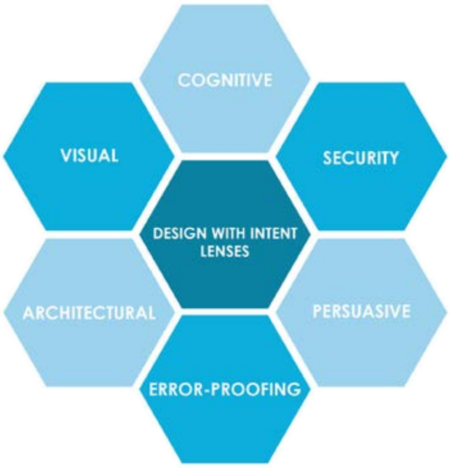

Figure 32. Illustration of the six groups of lenses from the design with intent method, according to (Lockton et al., 2010).

The design patterns were used as inspiration for evoking ideas to promote the principle of shared washing. The patterns created ideas such as conveying feedback through the form of the laundry bags, telling the user when the laundry bag is full or making it troublesome to start the washing-machine without loading two bags inside the machine. Each of the design exemplification cards were studied and discussed, trying to create a way of implementing the thoughts into the laundry cycle topic. By discussing how a certain behavior is encouraged or steered today, a couple of design principles applicable to the laundry collection, transfer and storage were created. The principles were used in order to sketch part solutions of how to make the laundry cycle easier for the user and more ecologically sustainable.

6.5 Morphological matrix

A morphological matrix is used by dividing the main function of the solution into sub-functions, where sub-solutions are ideated for each sub-function. The list of sub-functions and sub-solutions must not be too long since it will lead to a number of combinative solutions that become unmanageable large. About four to eight sub-functions are enough. The sub-solutions of each listed sub-functions are then combined together to form a complete solution to the main function. Some of the combinations will form a possible solution, some combinations will be imaginable and a large number will be impossible to realize. The less likely solutions can be avoided by only combining the most likely and most interesting sub-solutions (Cross, 2008).

A Morphological matrix was created based on the eight most important functions withdrawn from the function tree. The method started with the three basic functions; collect, contain and transfer. Each individual function was researched and prepared separately by generating ideas on how to satisfy each function. The suggestions were then compared and matched, creating concepts with one of each main function present, in order to ensure the solution to fulfill each property. The model was thereafter extended as a supervision request to include five more key aspects, open/close, sort, ventilate, conceal and grip, see figure 33. This addition was done to make sure all important properties to be included and not only the three basic features.

Figure 33. Illustration of the eight main sub-functions used for generating sub-solutions.

Each solution to the specified area was sketched and placed orderly on a paper sheet. This created a morphological matrix board which was used to structurally process one solution at a time, a solution containing one piece of each from each of the categories. The full morphological matrix is available in **appendix X**.

6.6 The 6-3-5 method

The 6-3-5 method is conducted through six participants that are informed in advance about the problem that is supposed to be investigated, allowing incubation of ideas. The participants visualize three ideas on a paper that solve the problem with sketches before the paper is sent to the next participant who can draw inspiration from the ideas of the previous paper (Pahl et al., 2007). Each set of three ideas are limited to a time span of five minutes before the paper is sent further, which is where the name of the method originates from, six participants, three sketches and five minutes (Österlin, 2010).

An ideation session was conducted with six participants according to the 6-3-5 method. The method was used in two main sessions with the aim of discovering solutions to the transportation of laundry and storage of laundry in the apartment. The participants were briefly informed about HSB Living Lab as a whole and displayed the conceptual images of the single-living apartments and washing studio. Each of the six participants were given one colored pencil in order to facilitate the tracking of previous ideas. The ideation session encouraged wide thinking in order to discover as broad areas as possible for storing the laundry in the apartment and transporting it to the washing studio. The result from one of the sessions is visible in figure 34.

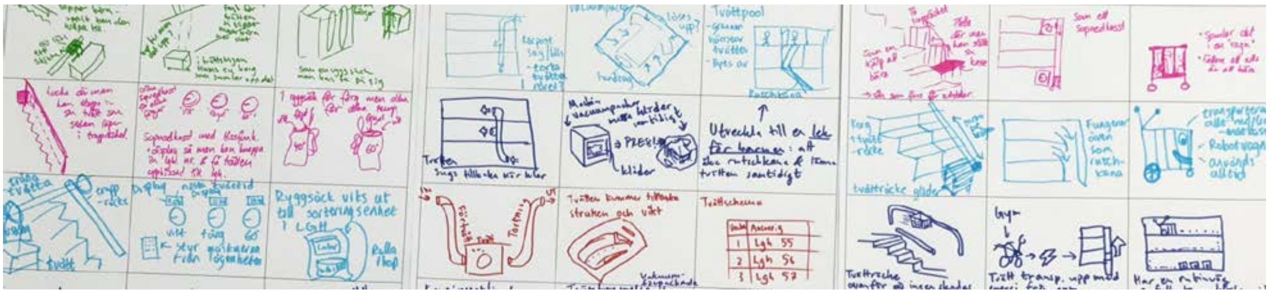

Figure 34. Image depicting the result from the ideation-session conducted with the 6-3-5-method.

The first ideation-session resulted in approximately 90 ideas that facilitated the transportation of laundry back and forth from the single-living apartment and the washing studio. The second session resulted in approximately 90 ideas for enabling storage in the single-living apartments. Many of the ideas retrieved from the ideation sessions were similar and sorted further on in the process with the help of PICK charts.

6.7 PICK chart

PICK chart is a method used to aid a team to prioritize and organize ideas by assigning the ideas between the four categories of possible, implement, complicated and kill. The ideas are placed in the different categories with respect to the payoff and implementation possibilities of each idea (George, 2003).

PICK charts were created as a structural base for quickly comparing and sorting amongst the extensive number of created ideas, see figure 35. The early concepts withdrawn from the brain writing, random input, design with intent, morphological matrix and 6-3-5 methods were evaluated in order to be accurately placed in one of the four quadrants representing a key-word for the future of the idea. Three PICK charts were created, one for the evaluating the ideas that considered the transportation, one for ideas considering the storage and one for ideas that considered both the transportation and storage. The ideas were evaluated with respect to the individual level of difficulty in terms of implementation possibilities and effect in terms of ease of usage. The commonly used IKEA-bag and laundry baskets were placed in the PICK charts and used as references, visible in **appendix XI**.

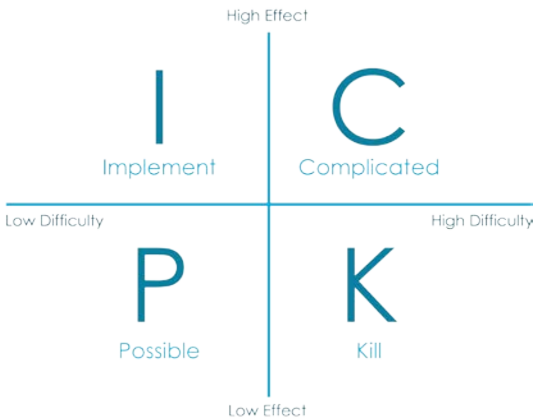

Figure 35. Illustration of a pick-chart, according to (George, 2003).

The most interesting or viable ideas took place in the implement quadrant whereas these were ideas worthy of direct concept specification or further development. The ideas that ended up in the possible and complicated quadrants were deemed to be evaluated again to investigate if useful thoughts could be withdrawn from these. The kill quadrant were deemed as too complicated as to be viable and therefore scrapped. The PICK charts are available in **appendix XI**.

6.8 Idea-area-categorization

Since a lot of the ideas accumulated were targeted towards a specific area, it was decided to compile the different ideas depending on the area of which the idea mainly was targeted. The three main areas that the solution should improve were categorized as; apartment storage, transportation and washing studio storage. The three areas were divided with an individual sign and concept pictures whereas the idea sketches were placed according to the related area. This resulted in three main ideation areas with five to fifteen concepts in each category. The apartment storage and transportation section were the two main foci points of ideation and therefore contained the most elaborated solutions whilst the studio storage was a late addition and almost out of scope for the main project. The studio storage was decided to be included anyway due to the importance of storage in the studio, an aspect retrieved from the studies.

The categorized idea sketches became the preferred way of presenting the result of the ideation since the more targeted ideas could be further built upon and improved after evaluation and discussion forum. A concept covering all aspect would be deemed as more complete and bound by the pre-sets, making it more difficult to change or replace individual parts. The categorization was also made in order to cover all possible solution aspects, presenting the broadest idea pool possible.

6.9 Creation of concepts

The concept creation process became an evolution of the categorization since the part-concepts already been produced during the ideation phase. This meant that the concept generation was initiated by combining interesting sub-solutions from each category. The concepts were combined by posting a number on the present sketches, forming a complete concept. When a few interesting combinations were made, new concept sketches were produced based on the complete function of the concept with all relevant aspects covered. These aspects were storage, transportation, ventilation, opening/closing mechanisms, behavior in the machine, general form design and details.

The concepts were procedurally discussed and evaluated in order to withdraw if some aspects were overlooked or if some concepts were far too similar to another idea. If a specific idea was left out or not explored, more effort was taken to assure the presence of all ideas deemed interesting. Even though most ideas were pre-defined from the previous work, new concepts arose as the ideas were processed and were given a new name after the sketch was completed. The final result of the concept creation phase are 21 concepts that are briefly explained in the following section.

6.9.1 Laundry bags

The first batch of concepts, concept 1 through 6, were based on a laundry bag, made as half or quarter sized, washable bags. All of the bags were fitted with carry straps and clothing inlets, but varied in terms of shape, fabric, size and storage. The bag concepts were made to be stored in the apartments and transported to the washing room manually with the help of different straps. Various numbers of bags were intended to be carried by the user depending on whether the bag adjusted to half or a quarter of the machine size. The bag concepts were intended to be loaded directly into the washing-machine with minimum effort by not requiring the individual clothing items to be loaded separately.

Concept 1, see figure 36, was a laundry bag solution that consisted of four quarter-sized bags, meaning that when four bags were filled it equaled to the laundry capacity of a fully loaded washing-machine. The bags were made in a perforated fabric, with a strap for hand or shoulder carriage and could be stored wherever the user desired, due to the flexible quarter size. The perforated fabric enabled ventilation and decreased the accessibility of the laundry, in terms of visibility and integrity.

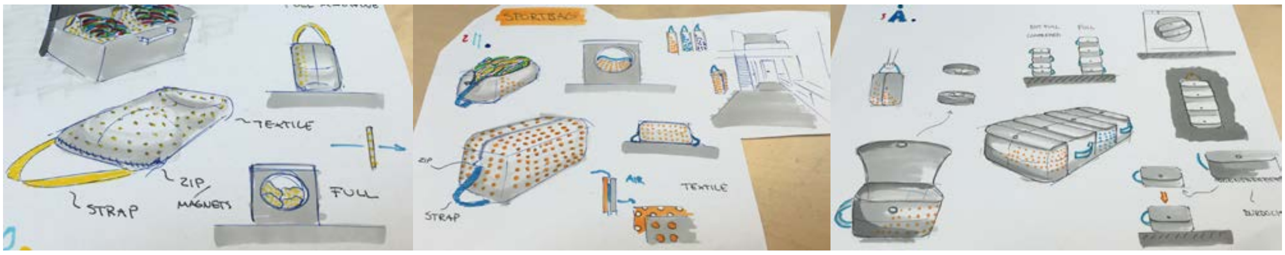

Figure 36. Illustration of concepts 1, 2 and 3, starting from the left.

Concept 2, see figure 36, was the original sports bag-like concept. The bag functioned as a sports bag made to store, transport and wash laundry with. It contained one pocket for clothing, which was tied to a zip lock-based inlet and a large shoulder strap that also functioned as a wall-mount. The bag itself had two fabrics placed with an offset from each other in order to regulate ventilation, color and clothing perception.

Concept 3, see figure 36, was a bag-solution with four individual laundry bags that could be stacked together as one unit. Each of the bags contained half a machine worth of clothing, was fully washable in the washing-machine and could be carried with a side-strap. Finally, the clothing inlet was achieved with the help of a magnetic button, which enabled a quick opening of the top.

Concept 4, see figure 37, was a similar solution to concept 3 but made as one bag with four storage brackets with an individual laundry mesh in each of the brackets. The laundry meshes could be removed and carried separately with the side strap or be transported as a unit.

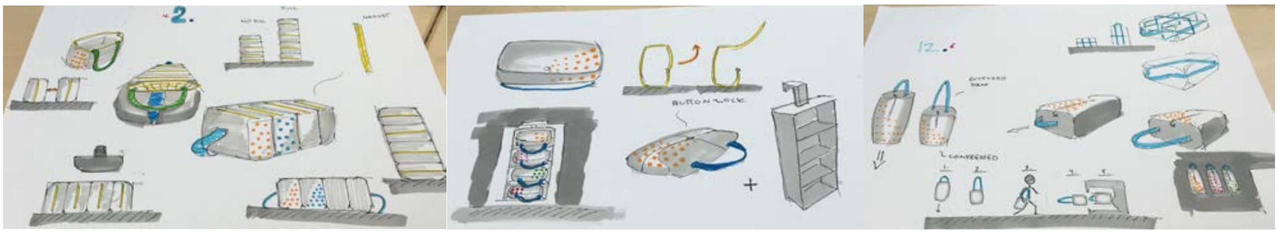

Figure 37. Illustration of concepts 4, 5 and 6, starting from the left.

Concept 5, see figure 37, was a laundry bag solution with a complementary storage system. The bags were fully washable, had a stretch-strap which enabled several carry alternatives and had a front-facing clothing inlet regulated by a button. The storage system enabled up to four half-machine sized bags to be stored on the wall, on a door or beneath the bathroom basin.

Concept 6, see figure 37, was a compressible laundry bag solution based on the bag being framed in elastic straps tied to the carry strap. While the bag was mounted to the wall it could be compressed by pressing down on the top of the bag. The bag was then locked in the compressed state, got carried to the washing studio and finally decompressed when placed in the washing-machine. The strap could be used as a handle or a shoulder strap and the clothing inlet was achieved by a zipper on the front side where the bag gets ventilated through the perforated sides.

6.9.2 Custom stored bags

The second concept batch, concept 7 through 10, were based on laundry bags with customized storage solutions, made for HSB Living Lab as the main area of usage. The main laundry bag was based on the same principle as the previous concepts but varied in terms of storage, size and extra functionalities. The custom stored bags were designed to facilitate the transportation of the laundry by utilizing existing concepts such as straps used in backpacks. The bags were transported to the washing room by the user utilizing different handles or straps, to carry the bags as backpacks or satchels. The laundry bags were washable and adjusted to half or a quarter of the machine size. The bags were further loaded directly into the washing-machine, thus requiring minimum effort from the user.

Concept 7, see figure 38, was a laundry bag solution stored beneath the loft stairs in four retractable boxes, each one containing one laundry bag. The bag itself contained half a machine worth of clothing and was opened and closed with a magnetic strip on the top. Furthermore the bag was carried with two straps, similar as an IKEA-bag and could thus be carried by hand or on the shoulder.

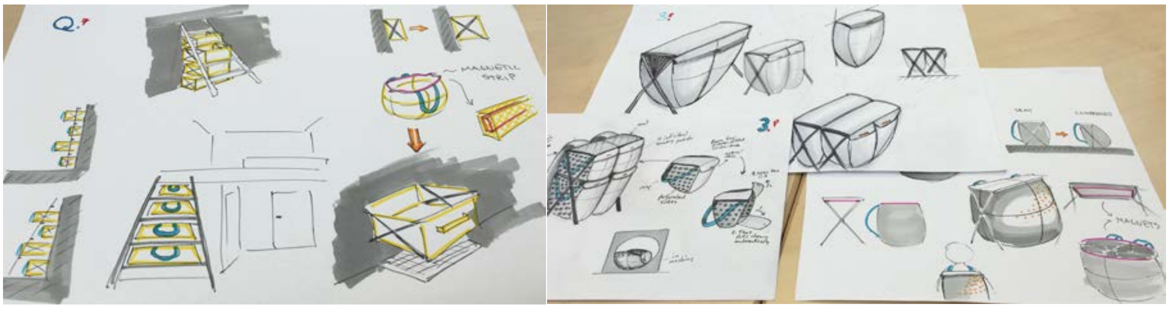

Figure 38. Illustration of concepts 7 and 8, starting from the left.

Concept 8, see figure 38, was a multi-functional backpack/seating/laundry bag solution. The laundry bag storage was a combination of a backpack and a stool, making it easy to carry, which gave the user further value with the product as it could be used to sit on, both in the apartment and the washing studio. Two half machine-sized bags were attached beneath the seat with a square magnet strip that easily detached before washing the laundry bags. Furthermore the frame could be connected to other frames, creating a bench or a work-station if multiple bags were stored in the same place.

Concept 9, see figure 39, was an aluminum frame with four detachable, quarter sized laundry bags similar to concept 1. The frame was intended to hang on a door but could also be mounted to a wall. The bags were attached to the frame with magnets, making it possible to fit four bags per frame. The bags were opened with a magnetic lid on the top-side which enabled a big and easily accessible clothing inlet. The bag was furthermore equipped with magnets on the bottom, intended to attach to the cone in the washing-machine, which would enable the bag to be easily placed whilst being optimally stored in the machine.

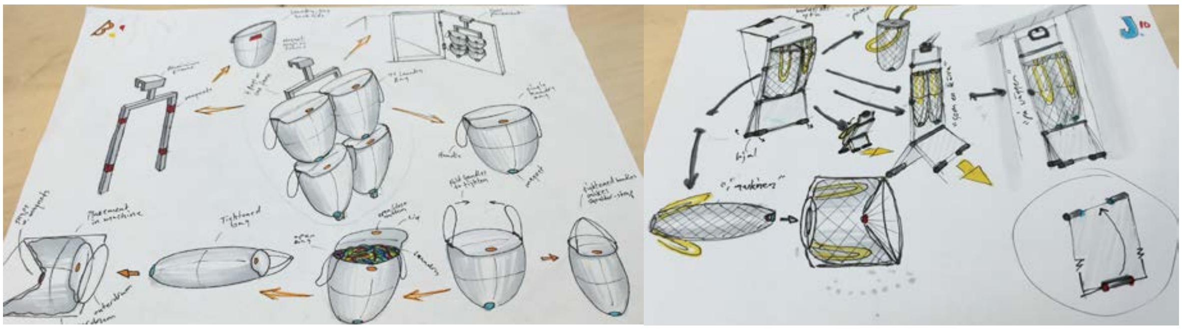

Figure 39. Illustration of concepts 9 and 10, starting from the left.

Concept 10, see figure 39, was a transforming frame solution with two attachable and detachable laundry bags. The transforming frame could be used for different purposes by having movable and rotatable flat sections with joints that could be made into wheels. The first purpose of the solution was a wall mount for the laundry bags, by being hanged straight on the wall or on a bathroom door. When removed, the frame could be transformed into a laundry trolley, a stool, an end table for temporary laundry storage or as a work surface. The laundry bag itself was based on the same magnet-principle as concept 9, which snapped to the cone in the washing-machine, which helped when achieving optimal machine storage during wash.

6.9.3 Custom baskets

The third batch containing concept 11 through 21, were made to achieve a perfect machine fitting by being expandable and compressible in one, two or three directions. The common denominator of the custom baskets were the compressibility but variations existed in terms of mechanism, structure and storage. The custom baskets were designed as washable bags, filling half or a quarter of the machine size. The baskets were meant to be wall mounted or stored on top of each other, minimizing the already strained floor space. The user was then intended to use various compression mechanisms in order to facilitate an easy transportation and an effortless loading of the baskets into the washing-machine. The intention was to optimize the machine fitting by decompressing the baskets after being loaded into the machine.

Concept 11, see figure 40, was a floor-stacked special solution, focused on optimal washing conditions. The concept was based on a circular, two-way expandable, fully washable laundry basket. The two-way expandability was constructed due to the outer- and inner-drum of the washing-machine and dryer having different radiuses. This meant that the basket needed to go from thinner and longer into shorter and broader in order to achieve an optimal washing results. The mechanism was regulated with a plastic frame, containing movable parts that in conjunction with a flexible fabric enabled the two-way expandability. The baskets could further be stacked together with help of tracks in the frames that could snap together. The clothing inlets were side-mounted and the baskets were carried with a side-mounted strap.

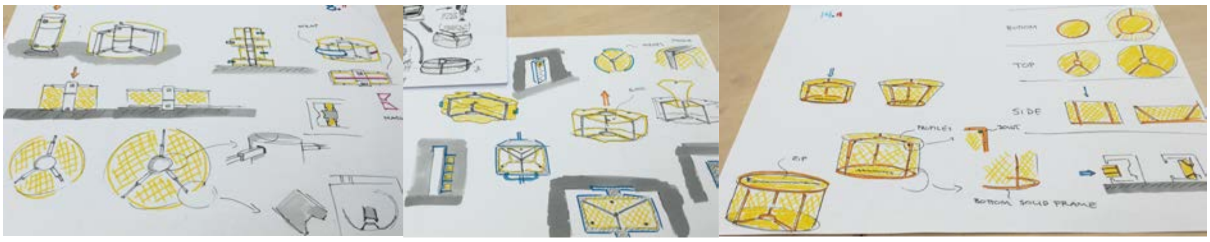

Figure 40. Illustration of concepts 11, 12 and 13, starting from the left.

Concept 12, see figure 40, was a two-way expandable laundry basket based on the same principles as concept 11. The main difference was the storage intention and clothing inlet. The storage was enabled with a separate mount, with storage space for four half-machine sized clothing baskets. And the clothing inlet was a top-mounted lid with a button for regulating opening and closing of the basket.

Concept 13, see figure 40, was a two-way expandable laundry basket based on the main frame of concept 11 but with a different transformation mechanism. The frame had three ball-joint making the transformation more conical compared to the straight transformation in the previous two-way expandable solutions. The concept contained a circular profile on the bottom without plastic profiles in the center, facilitating the fitting adapted to the inner cone of the washing-machine. The solution was otherwise intended to have the same carry solution, clothing inlet and storage as concept 11.

Concept 14, see figure 41, was an extension of the two-way expandable laundry baskets shaped as a sports bag. The frame was a bit longer compared to the other expandable baskets in order to achieve a greater transformation to reach a perfect machine fitting. The bag was stored by hanging four baskets on a wall-mounted frame. The bags were attached to the frame with magnets or mechanical fittings where the frame could be placed on a wall or door. The clothing inlet was a zip-lock and the retractable strap could be carried by hand or as a sports bag on the shoulder.

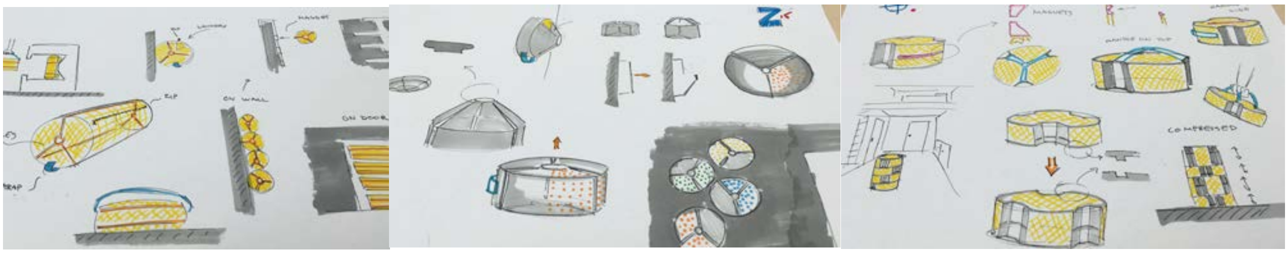

Figure 41. Illustration of concepts 14, 15 and 16, starting from the left.

Concept 15, see figure 41, was a directly wall-mounted three-way expandable laundry basket based on concept 11 and the expandability of concept 12. The big difference was an added third-expandability mechanism, which made the basket cone shaped in the front and back, resulting a perfect machine-fitting and a bigger clothing inlet. The wall-mounting was done by placing round-mounting brackets on the wall and then mounting the baskets to the brackets, forming aesthetic patterns and structures on the wall.

Concept 16, see figure 41, was another special laundry-basket solution with a two-way expandability. It differed from the previous expandability by having a three-lane pad-shaped frame connected to a thinner top and bottom covering frame. The main expandability was regulated with the pad-frame being compressible and a flexible fabric that bulges out on the sides where the top and bottom adapted to the cone on the inside of the machine. The clothing inlet was made with a magnetic strip and the handles consisted of three straps on the top or on one side of the basket.

Concept 17, see figure 42, was another type of two-way-transforming special-solution laundry basket based on a frame-compression mechanism in order to compress and decompress the basket. The frame consisted of three main sections, shaped after the machine pads, that could be retracted in order for the basket to be compressed and worked in conjunction with the top and bottom parts that are made of a flexible fabric. The basket was intended to be stored on a separate frame that could be placed on a wall or door, in order to free-up floor space in the smaller apartments. The clothing inlet was regulated by a magnetic-locked lid and the strap was a retractable shoulder strap made for hand or shoulder carriage.

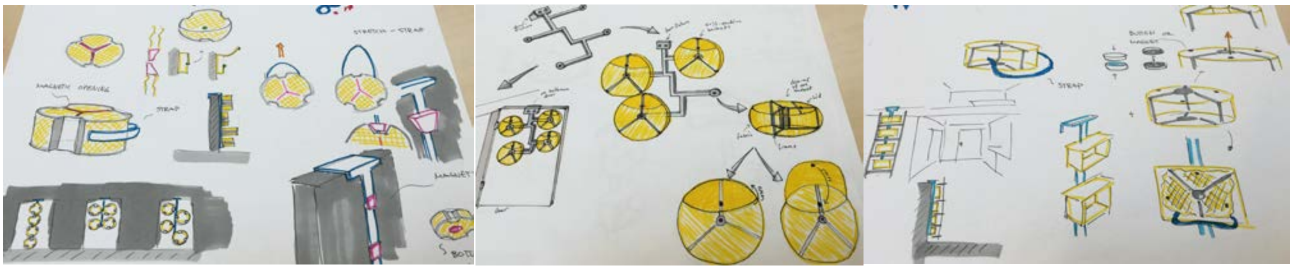

Figure 42. Illustration of concepts 17, 18 and 19, starting from the left.

Concept 18, see figure 42, was a round, two-way expandable laundry basket with the same features and mechanisms as concept 11. The difference lied within the wall-mount, a magnetic frame that could be placed on a wall or a door, with space for up to four baskets.

Concept 19, see figure 42, was another expandable basket based on the foundation of concept 11 which drew close resemblance to concept 18. The baskets were stored on a separate wall-mount with four pockets, the clothing inlet was regulated by a magnetic lid and the basket was supposed to be carried with the retractable shoulder strap.

Concept 20, see figure 43, was a further development of the expandable laundry baskets made to simplify the compression mechanism. The round basket made of flexible fabric was covered with three straps tied to the top. The compression was accomplished by dragging the front-knot while the basket was securely mounted to the wall, the straps then pushed the basket together and flexed out a bit in the top and bottom, which made the basket smaller thus easier to carry. The compression was then released when placed in the washing-machine in order to achieve an optimal machine fitting. The clothing inlet was regulated by opening to pads on the top and carriage was performed with a side-placed strap.

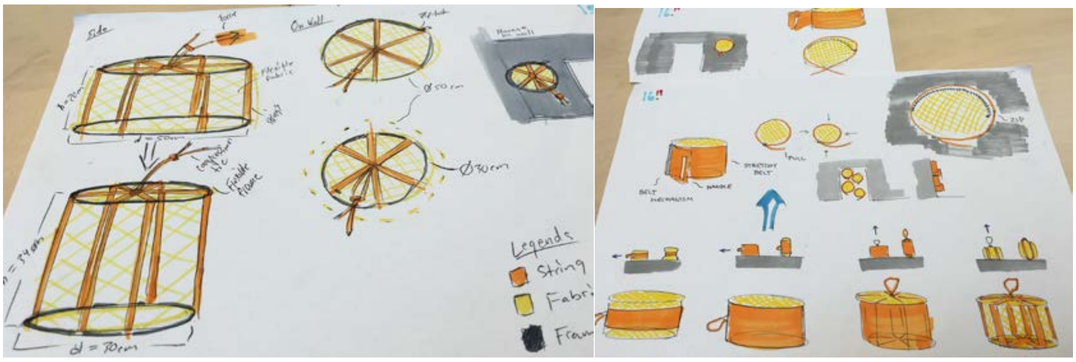

Figure 43. Illustration of concepts 20 and 21, starting from the left.

Concept 21, see figure 43, was based on the same compression mechanism as concept 20 but had one big strap covering the entire side of the basket. Otherwise the solution was supposed to have all the previously mentioned features of concept 20.

CHAPTER SEVEN

CONCEPT DEVELOPMENT

The concept development picked up where the ideation phase ended, with 21 concepts being discussed, tested, evaluated and narrowed. **Mockups** and **scale models** were created in order to conduct tests and evaluate the technical principles of the concepts. After the 21 initial concepts were evaluated, **two main concept families** were chosen for further development and evaluated against the retrieved factors from the user profile. The concept families were further evaluated and combined with the aim to take the strength from each and thus eliminating the weaknesses. With two main tracks to follow, five new concepts were detailed and finally presented to Electrolux. This process resulted in one concept being set as the final design.

7.1 Mockups

Prototypes are used as a way of visualizing and understanding how various concepts function. The prototypes can be divided into different states depending on the functionality. A mockup is a test prototype with limited technical functionality but is usually scaled to reality. A function-model contains the intended functionalities of the solution but might lack the desired finish and aesthetics (Ulrich & Eppinger, 2012).

7.1.1 Washing-machine

A 1:1 scale mockup model of the existing washing-machine was created with the help of cardboard, see figure 44. The purpose of the scale model was to gain understanding of volumes and distances in order to evaluate the generated concepts.


Figure 44. Two images depicting the 1:1 scale mock-up model of the washing-machine volume.

The scale model demonstrated the challenges related to the difference in diameters between opening and inner drum diameter. There were two main states that the developed solution had to adapt to. A first state where the solution had to fit the smaller diameter of the outer drum and a second state where the solution had to utilize the larger diameter of the inner drum and paddles.

7.1.2 Laundry weight

The retrieved statistics from Electrolux considering the laundry weight confirmed that the washing-machines in general were loaded to less than half of the intended machine capacity. There was thus a potential of utilizing the maximum capacity of the washing-machine if the developed solution would be capable of maintaining three to four kilograms of laundry for each user. Two users sharing washing-machine simultaneously and loading the machine with two batches with three to four kilograms would therefore increase the ecological benefit twofold.

Three and four kilograms of laundry were weighed and loaded in the scale model of the washing-machine, see figure 45.

Figure 45. The 1:1 scale model loaded with three kg to the left and four kg to the right.

The test demonstrated that four kilograms worth of laundry for a half machine-load leads to a strained condition where loading the machine with another load of four kilograms would be possible, but highly troublesome for the user. Three kilograms worth of laundry gave the user a greater possibility to manage the laundry and loading the machine with another batch of three kilograms, and was deemed as more beneficial from a user-perspective.

7.1.3 Scale models of volumes

Scale models were created with the help of cardboard, representing the two main states in volumes that the developed solution had to facilitate for, see figure 46. The first volume was represented as a cylinder adjusted to the outer drum diameter and the inner depth of the inner drum. The second volume was represented as a cylinder with a larger diameter adjusted to the inner drum diameter and the half length of the inner drum depth in order to potentiate two products inside the washing-machine.

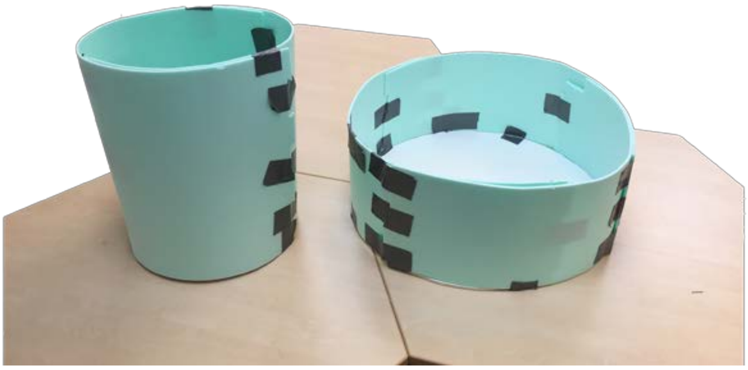

Figure 46. The scale models of the two volumes. The first state to the left and the second state to the right.

The scale models demonstrated the difficulties with the high demand of radial compression that the custom basket concepts had to withstand. The radial compression was thus deemed as ineffective due to the required compression force. This revelation steered the machine loading ideation towards new mechanisms and principles.

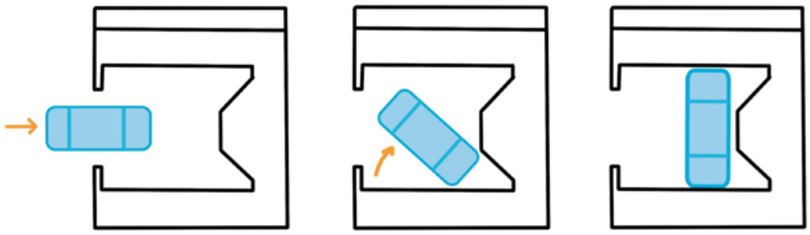

Figure 47. Illustration of the twisting mechanism.

A frontal 180 degree twist principle was made out to be extra interesting due to the simple nature and effectiveness of the concept. An illustration of the twisting mechanism can be found in figure 47. In the light shed by testing, the twisting principle was also proven to work as effective as believed which led to the creation of additional concepts based on the twisting mechanism.

7.2 Concept evaluation

All concepts were evaluated on different levels, both individually and with supervisor evaluations. The individual concept evaluation worked as a discussion forum and was mainly evaluated with the help of the customer journey and the requirements and guidelines retrieved from the user-studies. The evaluation of the developed concepts was discussed with the supervisors, whereas the discussion lead to a focus on two main concept families.

7.2.1 Concept family laundry bags

The first concept family was based on the principle of laundry bags, made to fill half or a quarter of the washing-machine, see figure 48. The concepts were simple and based on proven mechanisms but lacked the desired degree of innovation. The concept family was further not optimized to fill the inner drum completely.

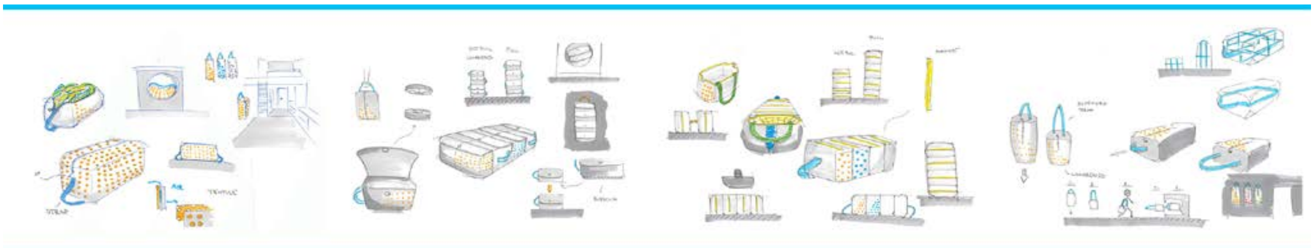

Figure 48. Concept family of laundry bags.

7.2.2 Concept family custom baskets

The second concept family was based on optimizing the machine fitting by expanding and compressing the laundry bag in order to satisfy the needs of the two states, see figure 49. The concepts were deemed as intuitive and space optimized but the great need of radial compression was questioned in conjunction with the transportation capabilities.

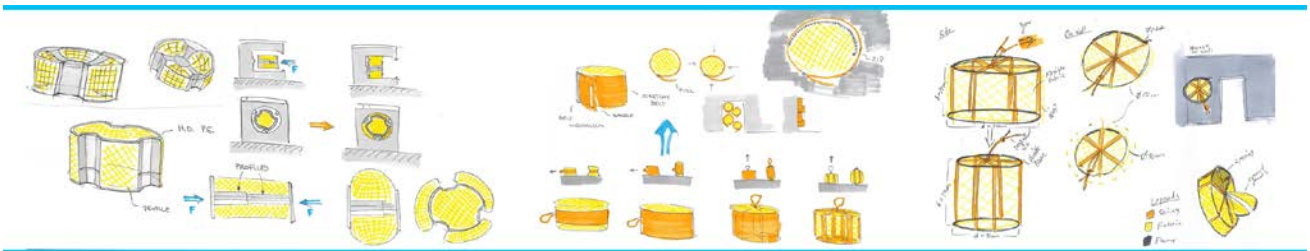

Figure 49. Concept family of custom baskets.

7.2.3 PNI-evaluation

PNI stands for positive, negative and interesting. The method is used to list advantages, disadvantages and interesting parts of various ideas in order to evaluate ideas. The PNI-method can be used to combine the advantages and interesting parts, forming new ideas (Österlin, 2010).

The positive and negative aspects of each concept family were listed in order to evaluate the ideas individually, visible in figure 50. The positive and negative aspects were retrieved from the requirements and guidelines that the solution has to fulfill.

Laundry Bag	Custom Basket
+ Implementable	+ Innovative
+ Simple	+ Space efficient
+ Multifunctional	+ Simple loading into machine
+ Simple storage	
- Not space efficient	- High demand of compression
- Not innovative	- Ergonomics during transport
- Troublesome loading	- Requires additional storage

Figure 50. Positive and negative aspects of each concept family.

The result indicated that the positive aspects of the laundry bag family proved to be more or less the negative aspects of the custom basket family. The optimal concept could thus be developed through combining the concept families by adding the strengths of one family to the other and eliminating the weaknesses.

7.2.4 User profile evaluation

The concept families were further evaluated with the help of the important factors retrieved from the user profile. The important factors were assigned to the concept families with respect to the family more likely to fulfill each factors optimal potential. The fulfilled aspects are represented with a highlighted blue color in the figures, see figure 51.

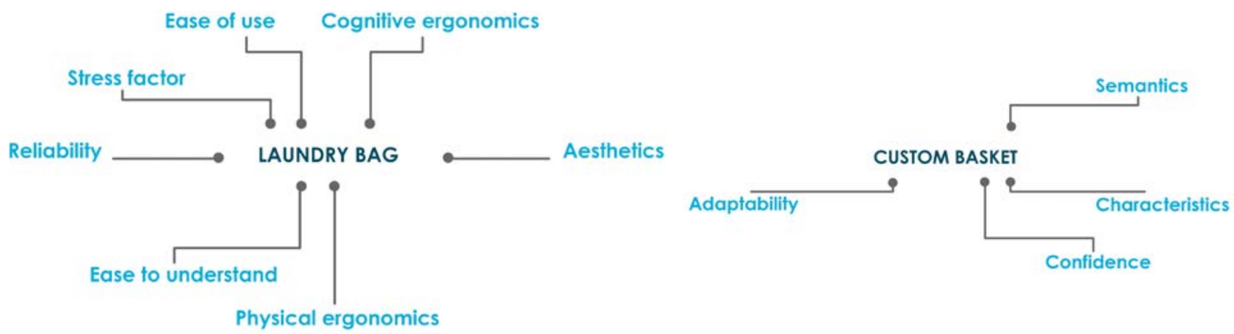

Figure 51. The important factors divided between the two concept families.

The results from the evaluation of the concept families indicated that the laundry bag concept were assigned more important factors and had more strengths than the custom basket, mainly because of the simplicity of the concept. The custom basket on the other hand had the strength of innovation and space efficiency in terms of optimal effectiveness inside the machine and mounting into the machine. The optimal combination would thus be to develop the laundry bag concept in order to make it more space efficient and innovative, thus transferring the strengths of the custom baskets to the laundry bags.

7.3 Concept A-E

Five main concepts named A, B, C, D and E were created. A and B originated from the custom basket family and represented two variants utilizing the circular inner drum of the washing-machine. Concept C and E originated from the laundry bag family and represented two different levels of complexity. Concept D was created from a combination of the custom basket family and laundry bag family, with the aim of combining the positive aspects of each family into one concept.

7.3.1 Concept A

Concept A, see figure 52, was based on the custom basket family. It was shaped as a round 50 cm cartridge intended to keep a maximum of three kilograms of clothing. The compression mechanism was rooted from a twist thread, located in the top center of the cartridge and utilized the side compression found during the scale-model testing, and thus relied on the same loading procedure, see figure 47. The strings crossing the basket tied as the plastic thread was rotated resulting in a side-wise compression, whilst automatically locking when the basket was compressed enough to fit the outer diameter of the washing-machine drum. The circular structure was kept by circular tube-piping located on both top and bottom of the cartridge. The intended storage was aimed towards a wall or the bathroom door and the transportation was handled by a side-mounted, expandable strap. The clothing inlet was located on the perforated side-parts and was regulated by a zip-lock. Material wise the basket was intended to be made of perforated nylon on the back and side whilst the covered top was made of reinforced nylon. The twist thread was set to be made in high-density polyethylene.

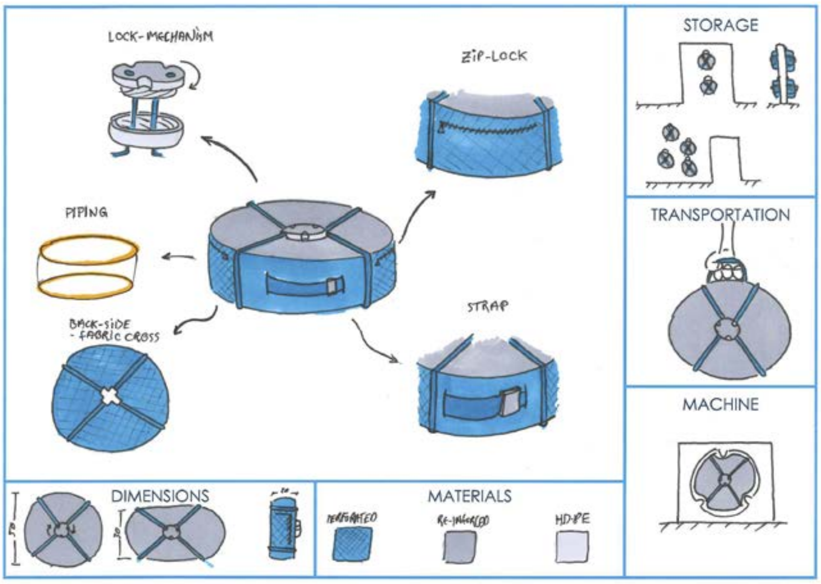

Figure 52. Illustration of Concept A.

7.3.2 Concept B

Concept B, see figure 53, was the second concept derived from the custom basket family, standing quite similar compared to A as a circular cartridge, structured by piping and utilizing the side-compression principle. Each cartridge was intended to be 50 cm in diameter in order to store three kilograms of laundry. The compression was based on the same principle as concept A but had a dragging mechanic instead of rotation. The compression stopped when the two plastic plugs attached to the conical lock and released by pressing the plugs, thus deforming the plugs thanks to the flexibility of the plastic. The cylindrical shape was also updated with a paddle-fitted pattern in order to achieve a perfect machine fit. The clothing inlet was located on the reinforced side-parts and regulated with a zip-lock. The intended materials of concept B was set as reinforced and perforated nylon, with the conical lock made of high density polyethylene. The concept also had three intended storage possibilities; on a wall, the bathroom door or in a custom storage rack. The transportation mechanic was achieved through straps unfolding as the basket got compressed.

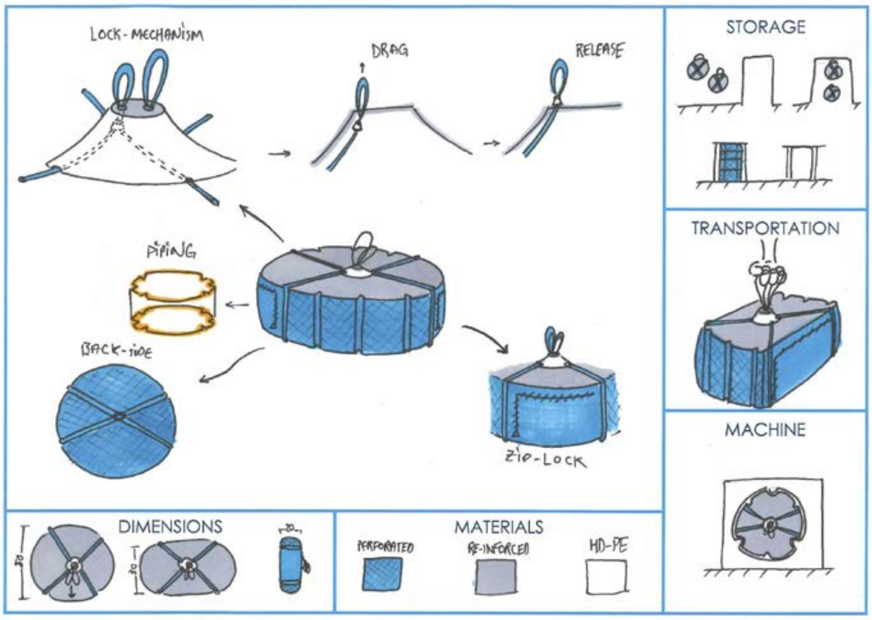

Figure 53. Illustration of Concept B.

7.3.3 Concept C

Concept C, see figure 54, belonged to the laundry bag family and was shaped as a rectangular bag with piping on top and bottom to ensure the rectangular structure. Each bag was dimensioned to be 50 x 40 x 20 cm in order to store a maximum of three kilograms of laundry. The bag was made compressible in order to lower the transport volume and make the machine loading easier. After the loading, the user was intended to release the compression, making the bag bigger which would allow more water to pass through. The compression principle was an even compression based on the same mechanism as concept B, with a conical lock, and a string equipped with two plastic stops. The string also worked as the wall-mount as the intended storage was on a wall or the bathroom door. The transportation was enabled through two side-mounted straps that also helped during the compression as the straps could be used as force-leverage. The intended materials were reinforced nylon on the sides, perforated nylon on top and bottom with the conical lock made out of high density polyethylene.

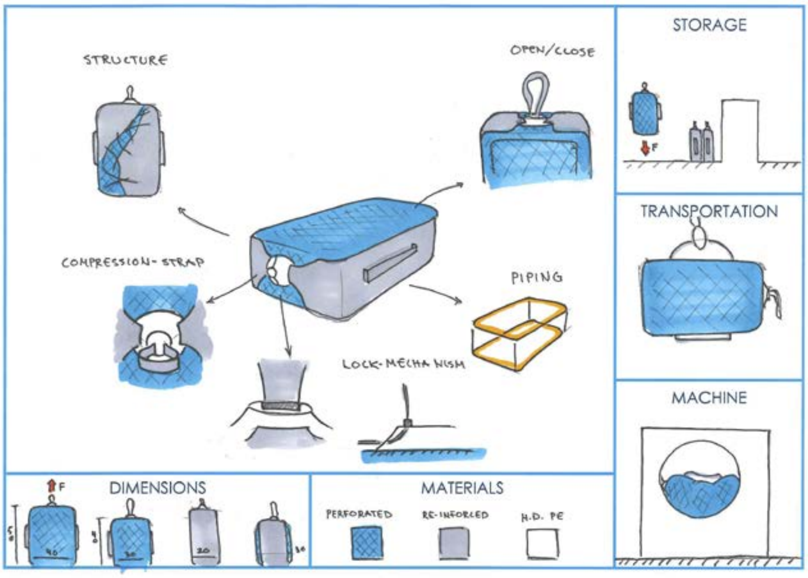

Figure 54. Illustration of Concept C.

7.3.4 Concept D

Concept D, see figure 55, was the result of an attempt to join the two concept families together. It was shaped as a triangular laundry bag with a radius on the front and back, structured by piping. Each bag was dimensioned to be 50-30* x 50 x 20 cm in order to store a maximum of three kilograms of laundry. The concept also had paddle-fitted sides, in order to improve the machine fitting closer to the design-intentions of the circular cartridges. The bag was equipped with a compression mechanism based on the same principle as concept B, a conical lock with plastic stops but was only needed on the back since the triangular shape allowed the side with the smaller radius to pass through the outer drum without the need of compression. The bag was equipped with a groove made to fit the palm of a hand, intended to be pushed when concept D was placed in the machine in order to make the twisting mechanism, see figure 47, easier when loading the bag. The clothing inlet, regulated by a zip-lock, was placed on the front-side along with the carry-strap for transportation. The bags were further intended to be stored on a wall or the bathroom door. The materials of the bag was set to perforated nylon on sides and back, reinforced nylon on top and at the paddle-fit and the conical lock as high-density polyethylene.

**front dimension: 50 cm, bottom dimension: 30 cm*

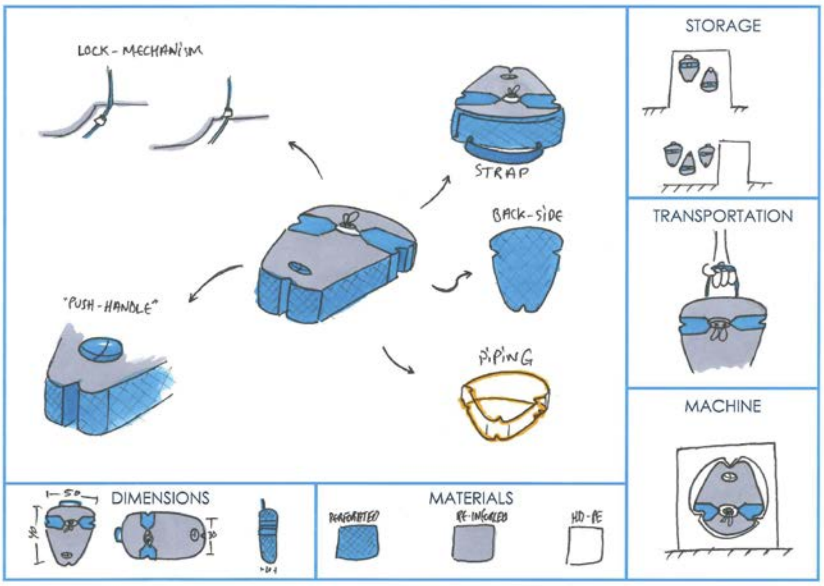

Figure 55. Illustration of Concept D.

7.3.5 Concept E

Concept E, see figure 56, was the second concept derived from the laundry bag family. The bag was shaped as a 40 x 30 x 30 cm rectangular bag made to contain a maximum of three kilograms in laundry capacity. The bag was structured by piping and had an extendable shoulder strap with a ball-joint, making it possible to be carried on each side. The concept was further intended to be stored on a wall or on the bathroom door. The intended materials were perforated recycled nylon for the bag and reinforced recycled nylon for the strap. The concept was made as the simplest form of storage device not requiring any compression. The focus was instead set on materials and patterns, experimenting in ways of hiding or showing the laundry.

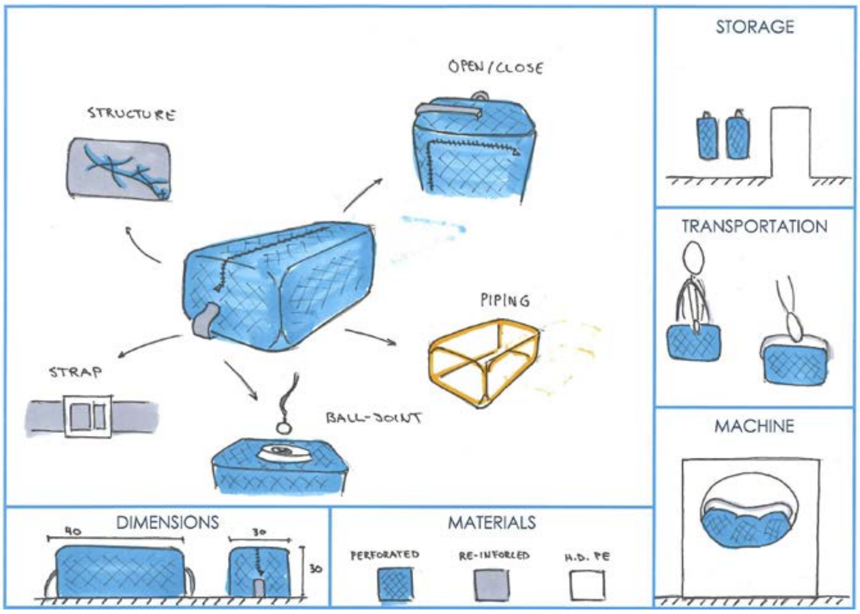

Figure 56. Illustration of Concept E.

CHAPTER EIGHT

EVALUATION

The evaluation of the five concepts was conducted with the help of **the customer journey** and **the list of requirements** converted into a **concept scoring matrix**. The concepts and the results from the evaluation were then discussed with the **supervisors** at Electrolux in order to determine one concept as the final design proposal.

8.1 Customer journey evaluation

The final five concepts were evaluated against the various steps of the customer journey. The evaluation was carried out by approaching each step of the customer journey, one at a time, and assigning the concept or concepts that fulfilled the requirements of each step optimally, see figure 57. The steps where the concepts were deemed as equal and the no longer necessary steps were ignored. Examples of two steps that were removed from the customer journey by all concepts were the steps of dirty sorting and temporary storage which were implemented into other steps instead.

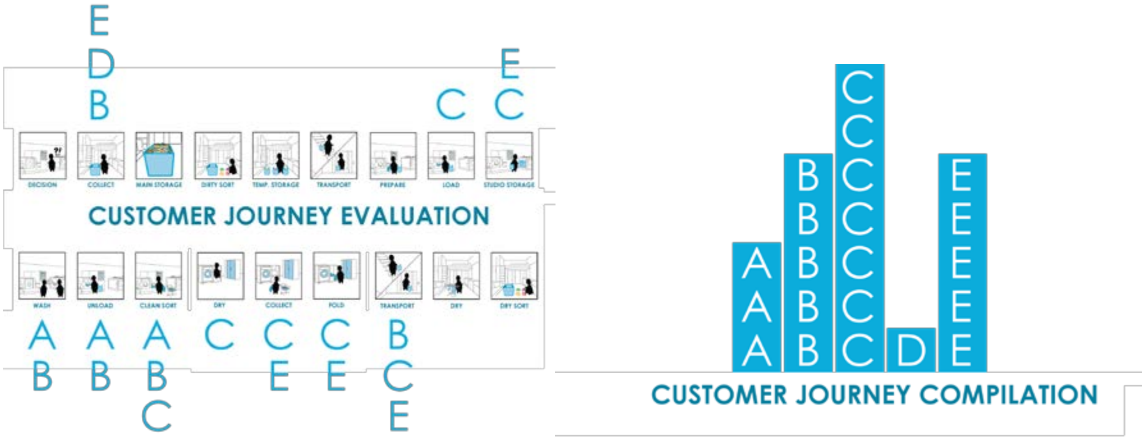

Figure 57. Illustration of the customer journey evaluation.

The evaluation resulted with a winning concept C that fulfilled the requirements of the majority of the steps. Concept B and E were represented on an equal amount of steps in the customer journey and therefore placed on a shared second place in the ranking. Concept A was ranked as number three and concept D as number four. The result from the evaluation was used to analyze the steps where concept C was missing and by combining the beneficial aspects of the represented concepts at the steps in order to develop C further.

8.2 Pugh concept scoring matrix evaluation

Concept scoring is a method used for evaluating concepts with respect to customer needs and other criterias. The purpose of the concept scoring method is to narrow down the number of concepts and to improve the concepts. The method is used by comparing the relative strengths and weaknesses of the concepts in order to select one or more for further development. A scale from one to five is recommended since a wider scale will require more time and effort, see figure 58 (Ulrich & Eppinger, 2012).

Relative Performance	Rating
Much worse than reference	1
Worse than reference	2
Same as reference	3
Better than reference	4
Much better than reference	5

Figure 58. Illustration of the concept scoring scale, according to (Ulrich & Eppinger, 2012).

The guidelines from the list of requirements and guidelines, see **appendix VIII,** were weighted from one to five. The highest weighted guidelines, rated with fives, were deemed to be similar to the demands of the list, fulfilled by all five concepts and thus not taken into account into the scoring matrix. The scoring matrix was represented by the 14 second highest weighted guidelines, rated with fours. The concept scoring matrix was used by evaluating each concept against one guideline at a time. The concepts were ranked from one to five for each guideline and the total rank was calculated by summarizing the score for each guideline, see **appendix XII** and figure 59.

Figure 59. Illustration of the weighted concept scoring matrix.

The result from the concept scoring matrix demonstrated a winning concept C, which obtained the highest ranking score of the concepts. The second best concepts from the scoring matrix were B and E, followed by D and finishing with A in last place. The result demonstrated similar results to the customer journey evaluation, with concept C as the winner. The result of the evaluation was used for further development of concept C by analyzing the guidelines in the concept scoring matrix where C was given a low score, in order to improve and optimize concept C.

8.3 Supervisor feedback

The five concepts were presented and discussed together with the supervisors at Electrolux and Chalmers in order to determine a final concept. The supervisors were further presented with the results of the concept evaluations. The discussion resulted in a consensus of concept C as the optimal concept for further development. The simplicity and user-friendliness of concept C were key-factors in determining C as the winner.

The discussion with a technician at Electrolux confirmed that the laundry bag principle of concept C and E would obtain similar results in terms of washing quality compared to concept A, B and D (Johansson, 2016b). Concepts A, B and D utilized the space inside the washing-machine better, and were therefore assessed as better than concept C and E before receiving the mentioned insight. This insight resulted in a breakthrough, further confirming concept C as the winning concept.

A laundry firm was further contacted in order to question the feasibility of several laundry bags washing simultaneously inside a washing-machine and potential problems that could occur. The problem that the laundry firm experienced currently was described as the washing bags opening up during the washing, resulting in an additional sorting procedure. The laundry firm had never experienced problems with several laundry bags getting caught to each other, an aspect previously seen as a potential problem with the bag solutions. The laundry firm also stated that the most important aspect to consider was not filling the bag to 100% of the bags capacity, but rather 80-90% in order for the laundry inside the laundry bag to get properly cleaned (Kalliokoski, 2016).

CHAPTER NINE

FINALIZATION

The following chapter describes the finalization phase aimed to optimize the chosen concept C, the winning concept from the concept evaluation stage found in the previous chapter, into a final design. A **prototype** was ordered through Electrolux in order to evaluate the functions and details of concept C, see chapter 7.3.3. A **final design** was based on the results from the evaluation that led to several improvements.

9.1 Prototype

A prototype was ordered through Electrolux, based on the design specified in concept C, see chapter 7.3.3. The prototype was made mainly to evaluate the compression of the design concept. The bag was dimensioned according to the dimensions of the dryer, which created the need to compress the design in two phases. The first phase compressed the design from the dryer adapted mode to a washing-machine adapted mode, since the dryer required a larger volume to completely dry the clothes. The second phase compressed the design from the washing-machine adapted mode to a compressed transportation mode. The prototype contained one clothing inlet on the front and two cords running through an inner piping placed in the edges of the design. The bag was ordered with a stiffer fabric on the sides with the intent of maintaining the rectangular shape and a perforated fabric in the middle with the intent of allowing flexibility, ventilation and water flow. A hook was attached to top of the prototype, placed in the center, in order to enable the wall-mounting of the design. The prototype was further equipped with two handles for transportation. The prototype was created with the available materials at the manufacturer, resulting in a thicker and non-perforated textile in the center, visible in figure 60.

Figure 60. Left image: Drawings of prototype 1. Right image: The ordered prototype.

Tests with the prototype demonstrated problems with the compression mechanism. The tests confirmed that the main compression of the bag was occurring in the length and barely in the width, leading to the bag becoming shorter but still remaining wide. The prototype further demonstrated problems with the functionality of the cords running through the piping. The piping complicated the withdrawal of the cords and therefore the compression, making it troublesome to compress the design. The test demonstrated that the piping created wrinkles when compressing the prototype which in return prevented the cord from moving freely inside the piping. The prototype further demonstrated issues with the structural integrity of the design concept, especially when mounted on a wall. The stiff fabric was not structural enough to maintain the rectangular shape and the single hook placed in the center emphasized the irregular shape of the concept even further when mounted on a wall. A final design was therefore set, aimed to solve the problems discovered with the first functional prototype.

9.2 Final design

The final design was dimensioned to fit within the dimensions of the washing-machine but still enabling compression in the length for simplified loading, making the design taller and thinner compared to the prototype, see figure 61. To maintain the intended compression and expansion mechanics, a central zipper was added which allowed the bag to expand ten centimeters in depth when released. A bottom zipper was added and the top zipper was extended and moved to the edges due to the design being thinner and thus in need of more inlet space in other directions.

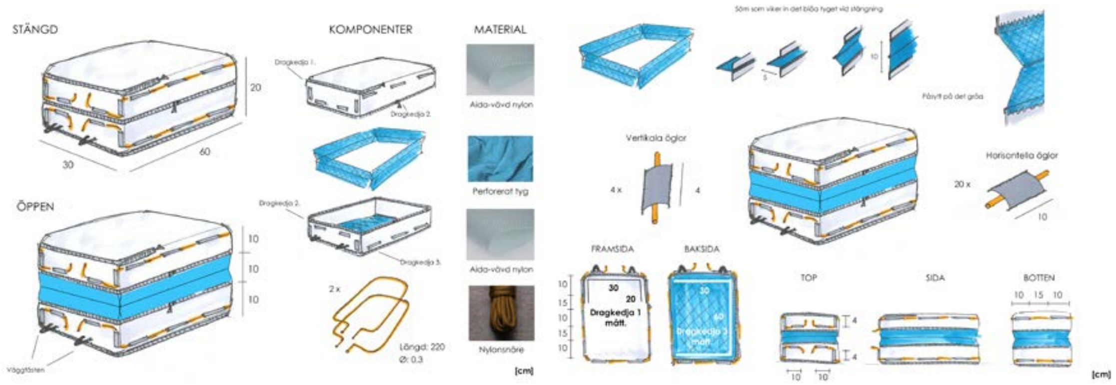

Figure 61. Drawings of the final design.

The compression cords, previously placed within the piping, were moved slightly towards the middle in order to make room for the zippers placed on the edges. The piping itself was also deconstructed into 24 cord paths running along the top, bottom and sides. This was done to house the compression cords and allow for a more effortless compression mechanism, eliminating the risk of wrinkles. Furthermore, the top was decided to be closed by a non-perforated fabric to achieve maximum integrity security during storage and transport, whilst still allowing a flow of water, air and detergent to pass through. The number of wall-mounts were increased from one to two in order ensure a more balanced design and to keep the intended shape when stored.

9.2.1 Choice of materials

Various textiles were analyzed with the help of the computer program CES Edupack and cross referenced against the restricted material list provided by Electrolux (Electrolux Laundry Systems Sweden AB, 2015b). The material selection had previously been set on different types of fabrics that enabled different degrees of integrity and ventilation. Textiles was the natural choice due to the demand of washability and flexibility. The CES Edupack was used by specifying the demands that the material had to withstand when used in the washing-machine, dryer and drying cabinet. The program was set to list materials able to withstand a temperature up to 105 degrees Celsius, which endured water, weak and strong alkalis and that were recyclable. The program listed four main materials that were deemed as interesting, polyethylene, PE, polyamide, PA or nylon, polyester, PET, and polypropylene, PP (CES Edupack, 2016). Discussions were further held with a material expert within plastics, which suggested high density polyethylene, H.D PE, as a suitable material for more rigid components that would endure the demands listed in CES Edupack (Boldizar, 2016).

9.2.2 Storage

A study visit was conducted at HSB Living Lab in order to evaluate the available storage possibilities in the single-living apartments. Utilizing the walls was something prominent due to the limited storage capacity in the apartments. The already limited floor area was regarded as strained enough and thus solutions for mounting the final design on the walls were investigated. Utilizing the available space in the bathroom was deemed as a natural storage location, unlikely to be utilized efficiently by the residents due to the small space. The study visit confirmed the existence of available space on the wall behind the toilet and on the bathroom door, see figure 62. The study visit further confirmed storage possibilities on the small wall behind the staircase which was deemed as interesting. Scale models of the final design were created, represented by two differently dimensioned variants. One variant was dimensioned with a length of 60 centimeters and the other with a length of 40 centimeters.

The two variants were created as a result of four 60 centimeter variants being perceived as to spaciously demanding when tested in the small bathroom. The scale models were placed at the various storage possibilities in the apartment and evaluated based on the aesthetics and practicality.

Figure 62. Image depicting the evaluated storage possibilities in the single-living apartments.

The quick tests confirmed that all of the evaluated storage locations were applicable depending on the combination of the two variants. The test demonstrated that containing four larger designs, which was suggested, solely in the bathroom could be troublesome due to the small space. The test further demonstrated that combinations of the two sizes and storage locations would be the optimal choice, depending on the individual preferences of the user.

9.2.3 Laundry collection

The clothing inlets were experimented with in terms of locking mechanism, number of inlets and placement. Magnets, buttons and zippers were discussed as the main locking mechanisms but it was decided rather early that zippers was the best option, since zippers provided a secure lock during the high demanding steps of washing and drying the bags. It was also discovered that zippers made of nylon could be used, a material evaluated as a possible material choice for other components, making the decision towards zippers a natural choice. The number of clothing inlets were determined considering two factors, to prevent leakage during use and easy accessibility. The leakage aspect drew the attention towards a top-mounted zipper, making it easy to load when stored without the risk of laundry falling out during the load. The problem with the top-mounted zipper was the accessibility in case the user wanted one or a few specific items to be removed from the bag. Due to this aspect a second inlet was developed, placed on the back of the bag, enabling a large inlet for easy access and loading possibilities, see figure 63.

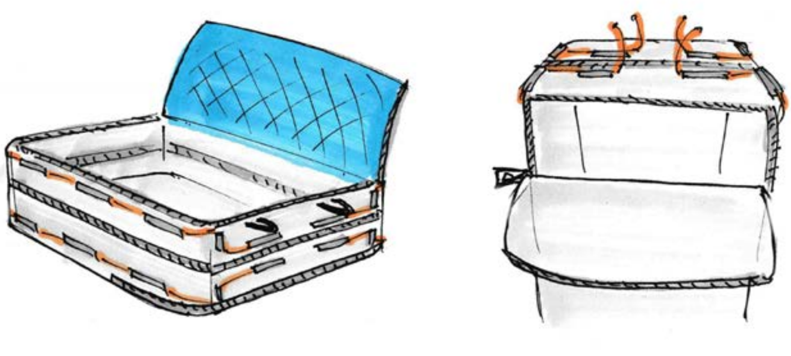

Figure 63. The clothing inlets of the design, the larger to the left and the top-mounted to the right.

9.2.4 Structural integrity

Creating a solid structural integrity was an important aspect in order to enable an aesthetically appealing expression when stored in the apartment, thus making the users more keen on actually storing the design on the wall and keeping it visible in the accommodation. Both internal material properties and external structural stabilizers were explored in order to enable the structure. The intention of making the material solid enough to create its own structural integrity was deemed as troublesome, due to the nature of fabrics not being rigid enough. The design was thus drawn towards external structural stabilizers, in the shape of piping, a solution that would let the design maintain the benefits of a softer fabric whilst maintaining the intended design expression when stored. The structural stabilizers were decided to be placed in the corners of the design, a total of eight components, see figure 64. The stabilizers enabled the structural integrity when the bag was wall-mounted without compromising the compression mechanism, since the stabilizers were able to move in relation to each other. The eight identical pieces of piping were designed to support the rectangular shape through the different steps during usage, with a focus on the storage in the accommodation.

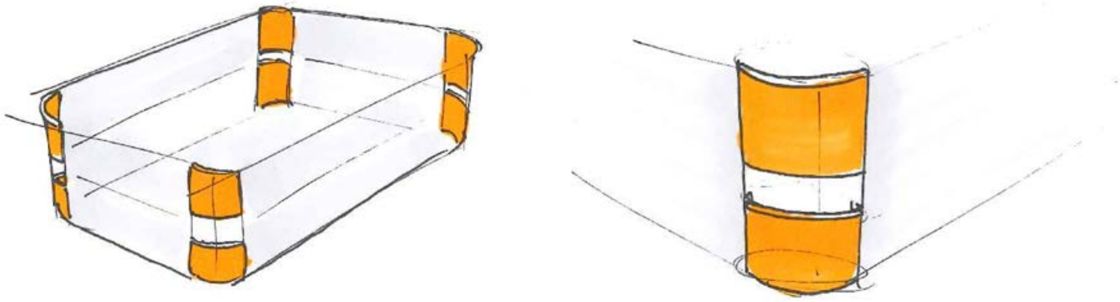

Figure 64. The concept of piping in the design.

9.2.5 Compression and expansion

Different ways of compressing and expanding the final design were investigated in order to facilitate the loading into the washing-machine, transportation from the apartment to the washing studio and ventilation of the laundry in the dryer or drying cabinet. The final design was adapted to the main compression in the length and adjusted to the dimensions of the washing-machine. The compression mechanism was decided to be achieved through two cords running within 24 cord paths along the outside of the final design. The cords are withdrawn by the user, thus compressing the final design, making it easier to transport and load the bag in the washing-machine. Various dimensions were explored and tested with the help of scale models until deciding on the expansion through one main zipper, dividing the final design in half. The main zipper thus enabled an expansion in the depth, making the compression in the length less demanding for the user, see figure 65.

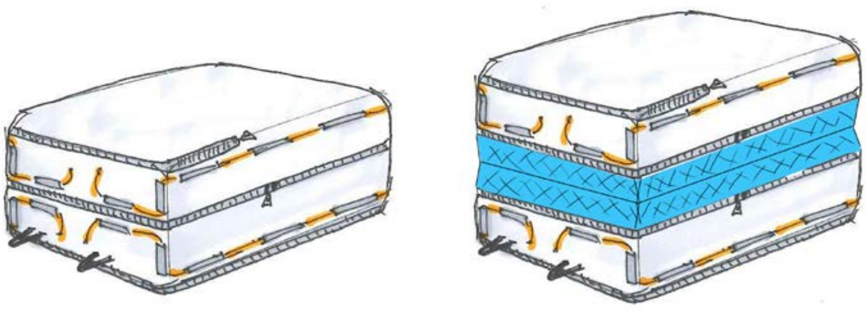

Figure 65. Illustration of the compression and expansion mechanism through the main zipper.

9.2.6 Locking mechanism

A locking mechanism was needed in order to keep the final design in the compressed state. The mechanism was initially composed of a support- and a drag-handle, due to the initial design requiring quite a hefty force to be fully compressed. The shape of the support handle was experimented with and tested extensively by producing scale mock-up models of a number of conical and cylindrical shapes, see figure 66. By letting randomly selected students test and evaluate the different designs with respect to graspability and comfort, a conical shape was decided. Even if the shape was set, the locking mechanism itself was still in need of specification. Current cord and rope locking mechanisms were investigated in order to find a suitable option. Cord-locks were deemed as both plausible and probable, because of the self-locking mechanism, rigidity and feasibility towards the demands connected to the washing-machine, dryer and drying cabinet. The conical shape was thus designed to house two cord-locks, ensuring a tight and secure lock of the two cords.

Figure 66. Scale mock-up models of conical and cylindrical shapes.

When the final design was set, it was discovered through tests with the prototype that the required compression force was almost non-existent, thus eliminating the demand of a support handle. This aspect removed the need of a conical shape and it was decided to only keep the cord-locks as locking mechanism. The final design was attached with one larger cord-lock consisting of two holes, enabling all four cord endings to run through the two holes, see figure 67. The drag handle was designed as a fabric-support, to evenly tie the four endings of the two cords together and relive the user from interacting directly with the nylon strings.

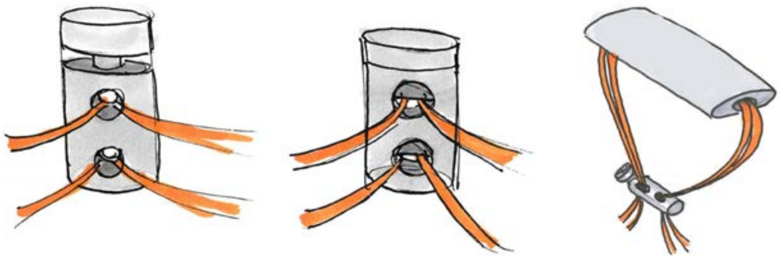

Figure 67. The cord-lock.

9.2.7 Transportation

In order to ensure a pleasant laundry transportation for as many users as possible, different strap lengths and placements were tested with the help of silk ribbons. The results from the user-studies had showcased the benefits of having two strap lengths, one to enable hand-carriage and one to be placed on the shoulder, thus relieving one hand for opening doors or similar tasks during transportation. When two separate straps were tried in the prototype, the design became unbalanced. It was thus decided to have one strap which steered the design towards a retractable solution, enabling all users to choose the desired strap length, see figure 68.

Figure 68. The retractable strap.

To further expand the strap placement flexibility, the number of anchor points was researched. The initial intention was to have two anchor points, mounting the strap solely to the side of the bag, but when dry, folded laundry is to be transported in the bags, users might want the possibility of carrying the bag with the top upwards because of the larger clothing inlet. This discovery resulted in the development of a third anchor point which would allow the user to move one of the strap attachments and thus making the bag top-up transported, see figure 69.

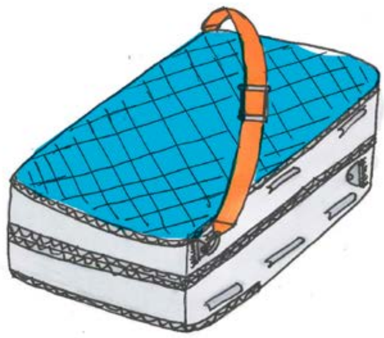

Figure 69. Illustration of the final design during top-up transportation.

9.2.8 Ventilation and integrity

Various patterns for openings were investigated in order for the final design to enable ventilation of laundry when stored, and to allow for a continuous flow of water and air when used in the washing-machine, dryer and drying cabinet. The main zipper which expanded the depth of the final design helped with this, but not enough. The challenge was therefore to find a pattern that allowed the continuous flow of water and air but still maintained the integrity aspects, not allowing other users to directly distinguish the concealed laundry. The goal was to find a pattern that communicated sustainability and that was deemed as aesthetically appealing when stored in the single-living apartments. Different patterns were investigated and sketched with inspiration derived from the shape of the Electrolux logo, sustainability aspects, the continuity of water and functionality, see figure 70.

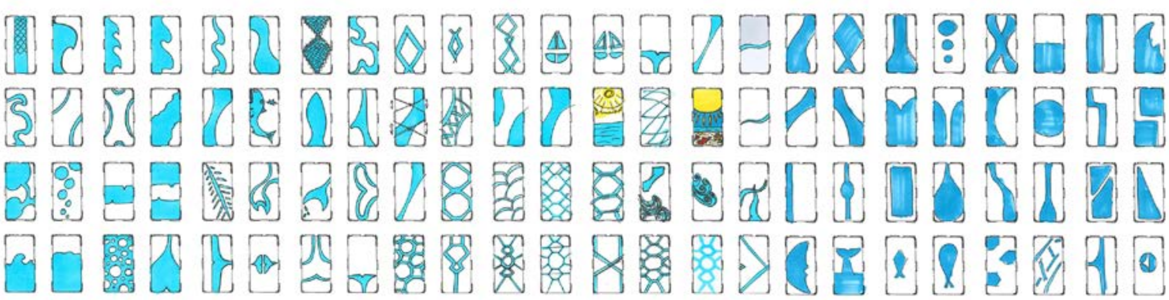

Figure 70. Different patterns investigated for the openings on the front.

The patterns were evaluated through a peer-to-peer discussion carried out with eight fellow industrial design students. When asked which of the patterns that were favored, the majority was drawn towards a wave-inspired pattern, visible in figure 71. The wave pattern was perceived as sustainable and aesthetically appealing. Another interesting aspect that was appreciated, was the functionality of allowing the users to assess the amount of laundry through the vertical opening. The material of the wave pattern was decided to a perforated textile weaved with small holes. The holes are big enough to allow ventilation but still concealing the laundry, not allowing users to distinguish specifically stored laundry items. The size of the pattern was decided based on achieving an optimal washing result whilst maintaining the integrity aspects.

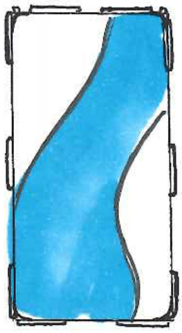

Figure 71. The chosen wave pattern.

9.2.9 Color coding

The color selection for each part of the final design were investigated and experimented with. The color choice was decided with respect to the three main aspects of pre-sorting indication, specific user discernment and intended product expression. Since a pre-sort capability was set as a requirement, it was desired to develop a color code to allow for an instinctive distinction between white and colored clothing items. Furthermore a second color code was investigated in order to allow the users to distinguish the individual bags during shared washing. Since two color codes were needed it was decided to make the main color of the bag into a rather subtle color and to use the coding as highlights. These aspects resulted in the base color set to a subtle gray in order for the design to blend into the single-living apartments. The openings were decided to be distinguished by two colors. One bright color representing white laundry and one darker color for colored laundry, making it possible to distinguish between the pre-sorted laundry, see figure 72.

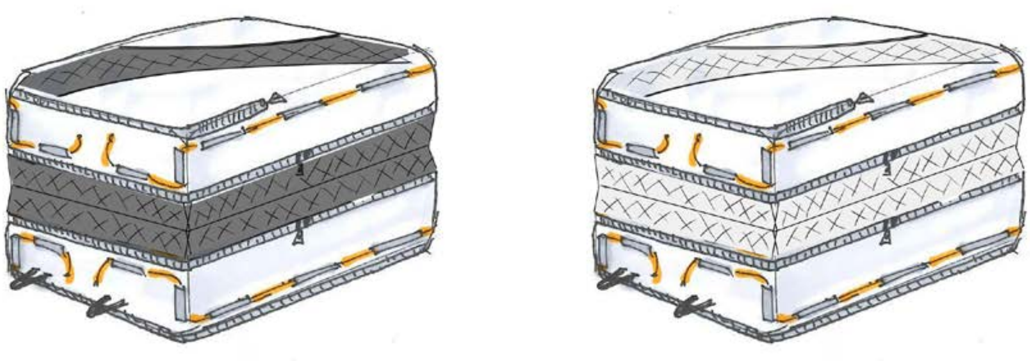

Figure 72. The two types of final designs, one for colored laundry and one for white.

9.2.10 Identification

The single-living apartments of HSB Living Lab are color-coded with an individual color, which was confirmed through study visits. Each set of six apartments are assigned with individual colors resulting in that the six individual colors are shared by four residents in HSB Living Lab, housing 24 single-living apartments. The color-coding was thus used to separate the bags belonging to the different residents by coloring the cords with the individual apartment colors. This allowed users to easily distinguish between the bags in the machines, eliminating the risk of mixing the bags. The final design was further divided with the help of an identification marking placed on the drag handle. The marking was designed to identify the floor level and cardinal direction, divided in south and north, making it possible to distinguish between the different sets of apartments, see figure 73.

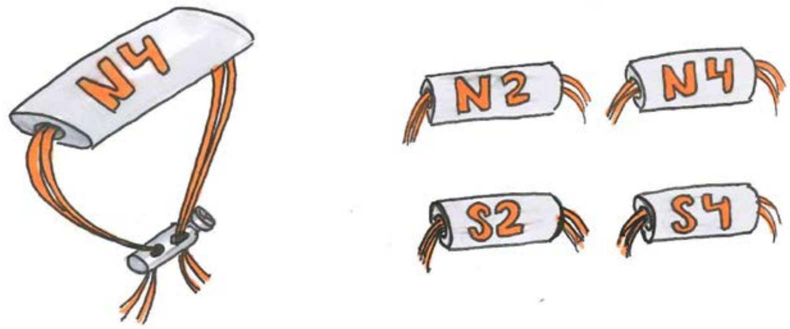

Figure 73. The identification marking on the drag handle.

9.2.11 Safety

The aspects of safety and theft were explored for the final design. There are possibilities to enable a tag lock mechanism connected to the washing-machine which was connected to individual RFID tags owned by all residents of the HSB Living Lab. By locking the washing-machine, users could secure that only the user or users who have locked the washing-machine with specific RFID tags could access and open the washing-machine. Using a notification system through the app could be a solution in order to prevent theft connected to drying in the dryer or drying cabinet, since these lack the locking possibilities of the washing machine. The app could allow possibilities to track the progress of the initiated program as well as notify the user if the program was finished, paused or disrupted.

The location of the washing studio itself will minimize the risk of theft because of the constant movement of people. Residents of HSB Living Lab will frequently pass through since the studio is positioned at the entrance, enabling an inevitable interaction. The risk of theft is therefore minimal in HSB Living Lab system.

The RFID tag could also be used for available storage space that is available in the washing studio. The personal belongings of the residents could be securely stored in available storage space by utilizing the same locking mechanism as the one connected to the washing-machines.

CHAPTER TEN

RESULT

The finalization ended with **Loop** as the final product that is to be showcased. The following chapter contains the introduction and complete explanation of the final design with **renderings**, **materials showcase**, **storage**, **placement**, **components** and **general dimensions**. Loop is furthermore presented from the user's perspective in the **new customer journey**, explaining how it is used during complete laundry cycle and highlighting important interaction aspects. The user experience is followed with a showcase of the **benefits** with Loop, both from a user perspective and from a sustainability point-of-view. The chapter ends with an **evaluation** of Loop, validating if the product lives up to the set demands and guidelines.

10.1 Loop

The final product is called "Loop", a name derived from the idea of the product looping in the laundry cycle and the idea of the materials traveling in a closed loop system. Loop is a multifunctional laundry bag intended to be used throughout the complete laundry cycle. The number of owned Loops are up to the individual preferences of the user, an aspect mainly based on sorting requisites, laundry quantity and available space. Based on the user-studies, the average user sorts laundry based on color and temperature. The color is divided into white and colored laundry items and the temperature is divided between high and low, which would result in a total of four owned Loops. Loop is designed to be stored, filled with laundry, transported to the washing studio, washed, dried and carried back to the apartment before getting back into a new laundry cycle. By using Loop both time and resources are cut by providing an alternative to conventional sorting and laundry handling using laundry baskets, IKEA bags, plastic bags and laundry carts. The resources are cut due to less products being used during laundry storage, handling and transport, and a design that promotes sustainability through sharing washing times and optimizing space efficiency. A product overview can be found in figure 74, depicting a rendered ISO-view of Loop.

Figure 74. ISO-view render of Loop.

Loop comes in two dimensions, one 60x30x20 centimeters made to store a maximum of three kilograms of laundry, and a smaller version dimensioned 40x30x20 centimeters, made to contain 2 kilograms, see figure 75. This allows two users to share two larger Loops or three users to share three smaller Loops in a washing-machine, which promotes both sustainability and interaction. The shared washing is optional but nevertheless highly recommended in order to minimize resource wastage and expenditure of time.

Figure 75. The larger dimensioned Loop to the left and the smaller to the right.

Loop comes in two different color schemes. The base color is set to a light gray, homogeneously on all of the closed rPET fabric parts, whilst the perforated rPET fabric comes in either black or white. The hue of the perforated fabric is set as a sorting indication, making the user instinctively realizing if Loop contains colored or white laundry items, see figure 76. The color coding thus works as a safety regulation, minimizing the chance of miss-sorted items and discoloration.

Figure 76. Renderings of the color schematics.

Loop is suggested to be stored at the sides of the staircase and in the available space in the bathroom, depending on the amount of Loops placed and the combination of sizes, see figure 77. The ideal case would be to store two larger and two smaller Loops at the staircase, the products will then be visible and accessible for the resident but partly concealed to visitors. The case of a user requiring a total of four larger Loops would require the user to store two in the bathroom and two beside the staircase. The other numerous combinations are decided upon individual user demands and preferences.

Figure 77. Rendering of Loop during apartment storage.

Loop has the unique feature of allowing the bag to be both slim when stored and transported whilst freeing more space in the washing-machine and dryer in order to achieve an optimal washing and drying performance, a feature that is made possible with the compression/expansion mechanism, see figure 78. Loop is designed to be easily handled during transport, a feature partly enabled by the possibility to compress Loop before transportation. The compression mechanism is realized by two cords running alongside the sides of Loop. When Loop is to be compressed the user releases the main zipper and grabs the handle, pushes the cord lock button and with a dragging motion, tightens the cords which in return compresses the bag. The product then becomes approximately two thirds of its original size, making it both easier to transport as well as place in the washing-machine.

Figure 78. The three states of Loop, from the left: standard, expanded, compressed.

10.2 Components of Loop

Loop consists of ten main components, which are made in as many identical materials as possible in order to enable a sustainable product design. The majority of the components are made in rPET fabric combined with details made of nylon and H.D PE.

10.2.1 Fabrics

Loop is mainly made of recycled polyester, rPET, a material possible for all fabric details. The material choice is based on the important aspects of the rPET fabric being sustainable, flexible and having properties that allows water, air and detergent flow. Loop consists of two main fabrics, one closed and one perforated. The closed fabric is colored with a light gray and the perforated fabric is hued with the color indicator, white or black. The closed fabric is made of weaved rPET and the perforated fabric is made of warp weaved rPET, which creates the perforation.

10.2.2 Hooks

Loop is wall mounted with the help of two textile-hooks made from rPET, identical to hooks available on shirts or jackets, see figure 79. The two hooks are sewn onto the top corners of Loop, enabling an even weight distribution and ensuring that Loop is hung straight when wall mounted. The hooks are colored with the identical light gray as the closed fabric is colored with. The hooks are further attached to Loop with the help of seams.

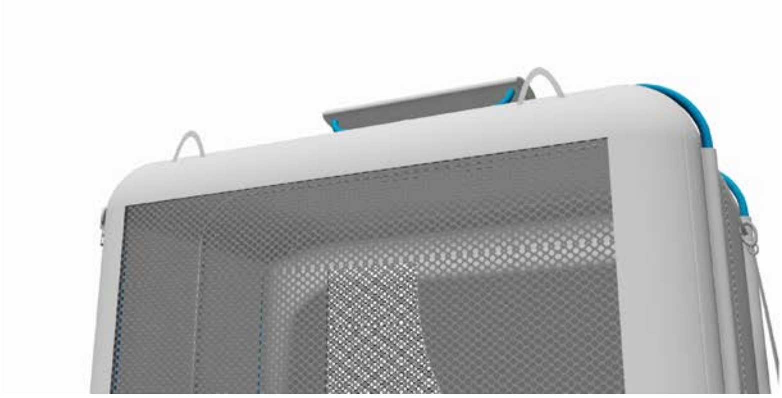

Figure 79. Renderings of the two hooks enabling the wall mounting.

10.2.3 Piping

Loop maintains the rectangular shape through eight pieces of high-density polyethylene, H.D PE, see figure 80. The eight pieces function as piping, securing the rectangular shape and thus enabling the structural integrity of Loop. The pipings are dimensioned to 10x10x10 centimeters and sewn into pre-defined pockets in each corner of the closed fabric.

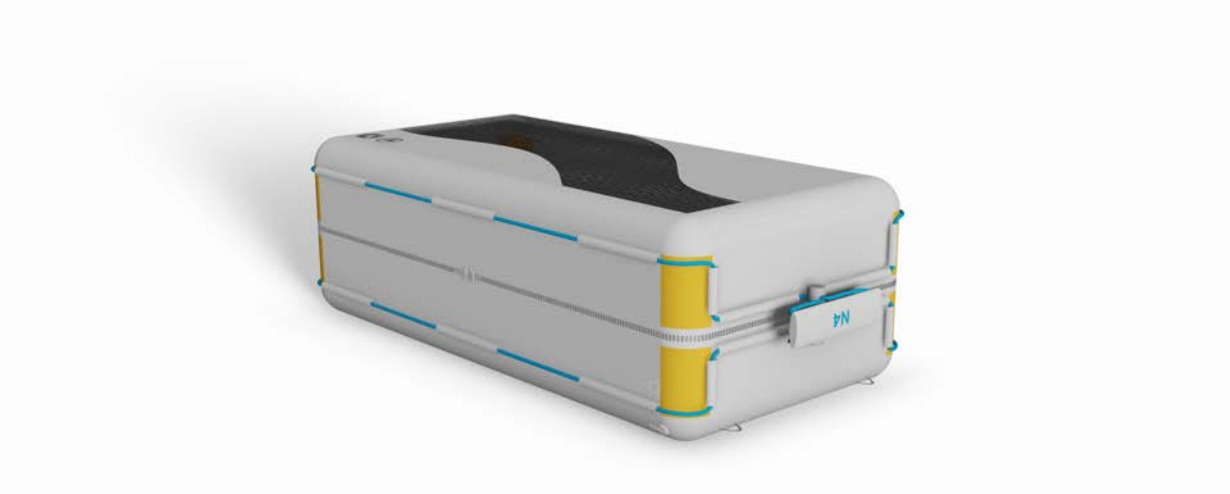

Figure 80. Renderings of eight pieces of piping, highlighted in orange.

10.2.4 Wave pattern

Loop contains a perforated fabric pattern on the front, made from rPET. The pattern is colored with the same sorting indication as the perforated fabric hidden by the main zipper, either black or white. The perforated fabric is created by warp weaving the rPET which creates holes that allow ventilation and semi-visibility. The holes are large enough to ventilate the laundry and release dirt, such as dust and gravel, but small enough to hinder the eye of visitors to distinguish specific laundry items. The pattern itself is designed to symbolize a wave, emphasizing on the continuous flow of water and air running through Loop, see figure 81. The pattern runs along the length of Loop, allowing the user to assess the amount of laundry items stored within Loop if investigated from a closer distance. The perforated fabric pattern is sewn onto a cut-out made in the closed fabric top, which creates the wave pattern.

Figure 81. Renderings of the perforated fabric pattern.

10.2.5 Clothing inlets

Loop is designed with two clothing inlets, one positioned on the front, the top mounted zipper, and one on the back, see figure 82. The clothing inlets are designed with respect to the user scenarios retrieved from the user-studies, enabling loading of a variety of laundry items and quantities. The clothing inlets are enabled through two zippers made of nylon, which ensures the laundry being securely locked during the different steps of the usage. The zippers are hidden, making sure that Loop maintains a clean expression when stored on the wall in the accommodation. The top mounted zipper is sewn onto edges of the closed fabric of Loop, running along the edge of the top and 20 centimeters down on each side. The zipper is thus dimensioned to be big enough for intake of larger laundry items, but small enough to prevent leakage during usage. The clothing inlet on the back is also sewn onto the edges, running along the edge from the top, down one side and along the bottom edge. The zipper on the back thus covers three quarters of the total circumference, enabling a large opening if requested from the user. The bottom part of Loop is further made of the perforated rPET fabric in order to assure the desired ventilation when stored and water flow whilst giving the user visibility when accessing the larger clothing inlet.

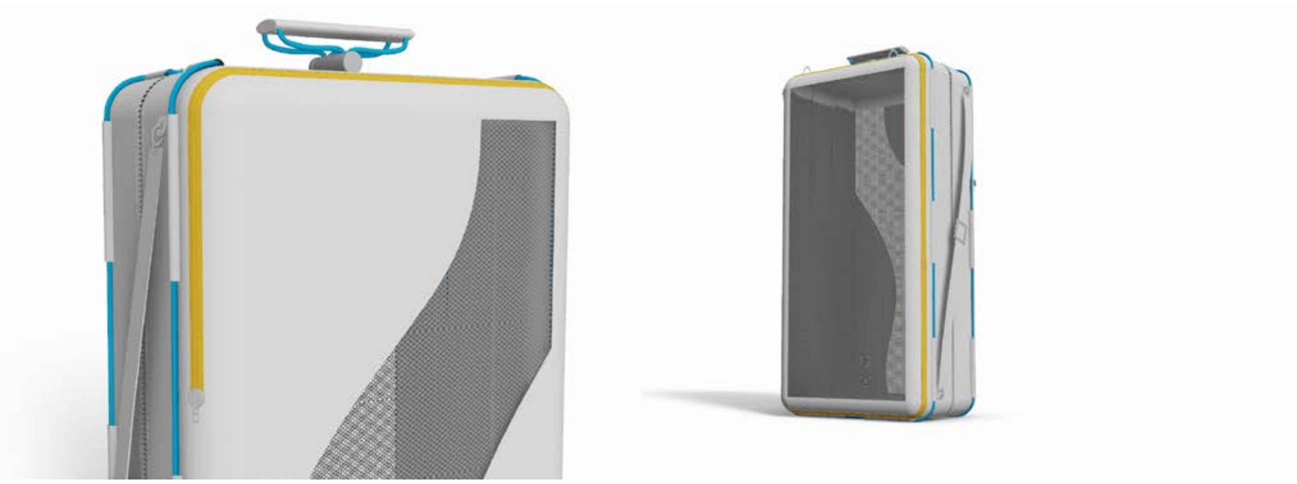

Figure 82. Renderings of the clothing inlets, highlighted in orange. Left image: the top mounted zipper. Right image: the back zipper.

10.2.6 Main zipper

Loop is designed with a main zipper made in nylon, the same material as the two clothing inlet zippers. The main zipper is sewn along the center and runs along the whole circumference, see figure 83. The main zipper is visible to the user in contrast to the clothing inlets, intended to express the functionality to the user, and is colored with a darker gray to further emphasize the presence to the user.

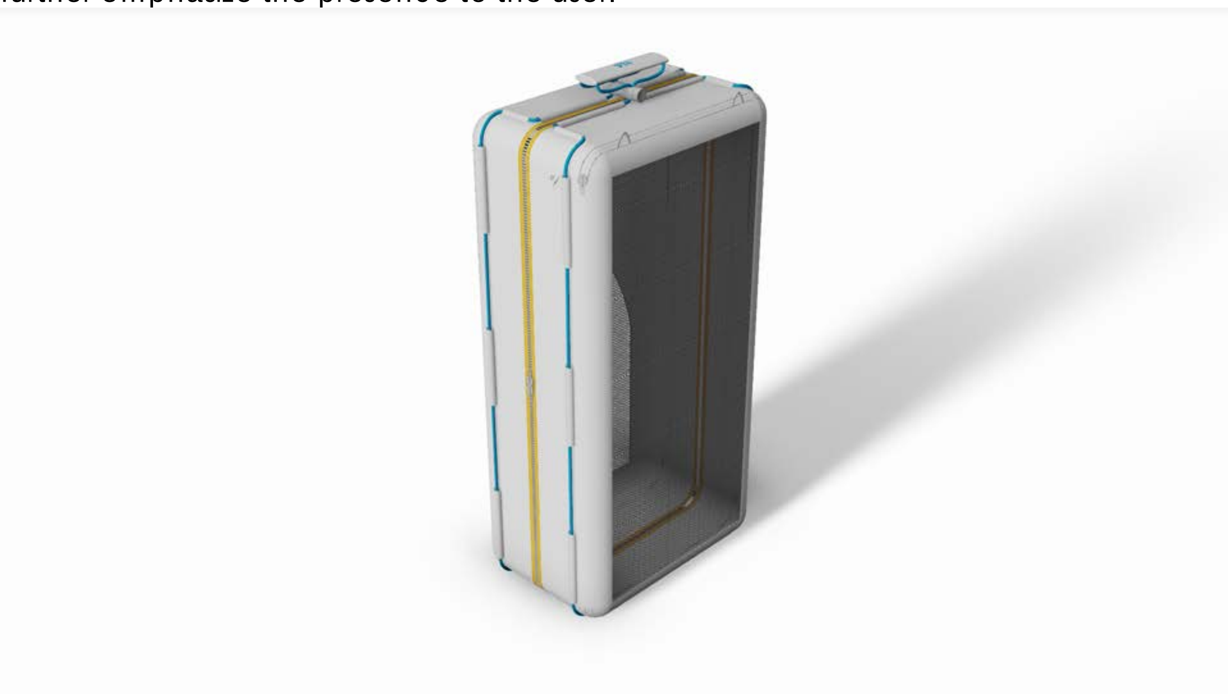

Figure 83. Rendering highlighting the main zipper of Loop, colored in orange.

The main zipper serves as the initiating feature of both the compression and the expansion. The visible main zipper makes use of existing mental models that users have of suitcases that are expandable with zippers, improving the intuitiveness of the design. When the zipper is opened, a patch of perforated rPET fabric is revealed. The patch unfolds with the help of a seam running across the middle, making the perforated fabric completely hidden inside of Loop when closed, see figure 84. The perforated fabric stretches across the entire circumference of Loop and allows for ventilation as water and air can flow through.

Figure 84. Rendering the folded perforated fabric inside Loop.

To benefit from the extra space created by the perforated sides, the zipper is released before compressing Loop in order to decrease the required force from the user by increasing the available space in depth. The zipper thus provides both expansion and a possibility of an effortless compression. Loop is designed to always contain 33% unfilled space when the main zipper is released, which secures an optimal washing and drying result by allowing a sufficient amount of water or air to flow through.

10.2.7 Cord paths

Loop is equipped with 24 cord paths, sewn onto the closed fabric, made to house the two cords, see figure 85. The cord paths are made in two different dimensions, colored with the identical gray as the closed fabric. The four vertical paths on the top are 4x1 centimeters and the remaining 20 horizontal paths are 10x1 centimeters. The dimensions are set for the cord paths to fit within the design and to securely contain the cords in the intended place.

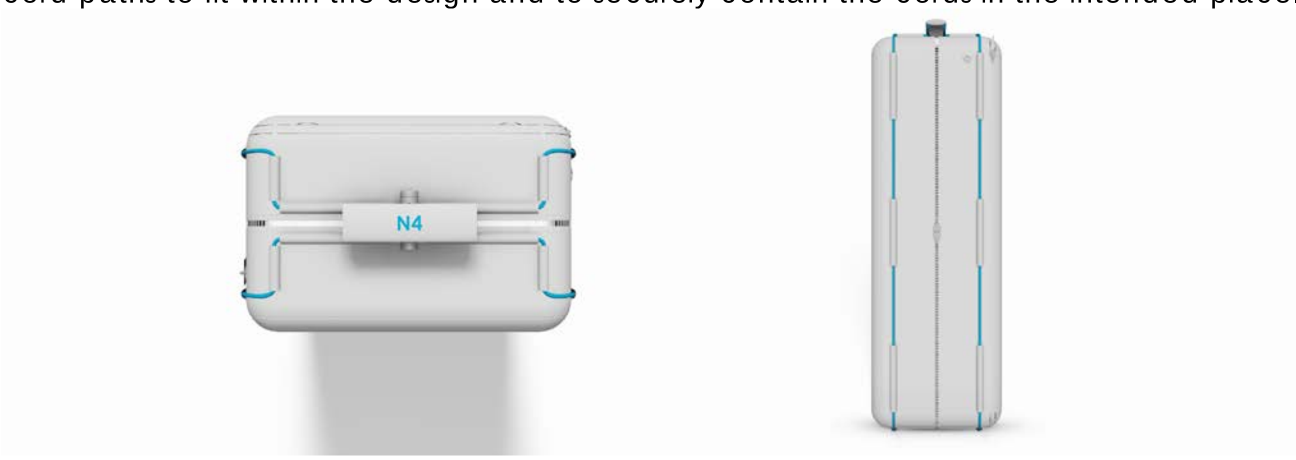

Figure 85. To the left: rendering the cord paths of Loop. To the right: the vertical paths dimensioned shorter.

10.2.8 Drag-handle

Loop is designed with a supporting drag-handle aimed to relieve the user from interacting directly with the cords. The four cords are tied together and stitched to the handle, securing a durable placement, see figure 86. The drag-handle is made from rPET with the same color as the closed fabric. The drag-handle is designed according to anthropometric measurements covering the span from the 5th percentile Swedish female to 95th percentile male. The drag handle is thus designed with a length of 11,5 centimeters, covering the hand width span from 7,8 centimeters to 8,4 centimeters with margin (Högskolan i Skövde, 2011). The drag-handle is designed with a width of 3,3 centimeters and five centimeters of space between the handle and the top, creating an optimal grip width and space (Eklund et al., 2013). The drag-handle further aids in the product identification by having a color coded identification marking individual to each user in HSB Living Lab. The identification marking represents the color, floor level two or four, and cardinal direction north or south, related to the specific user.

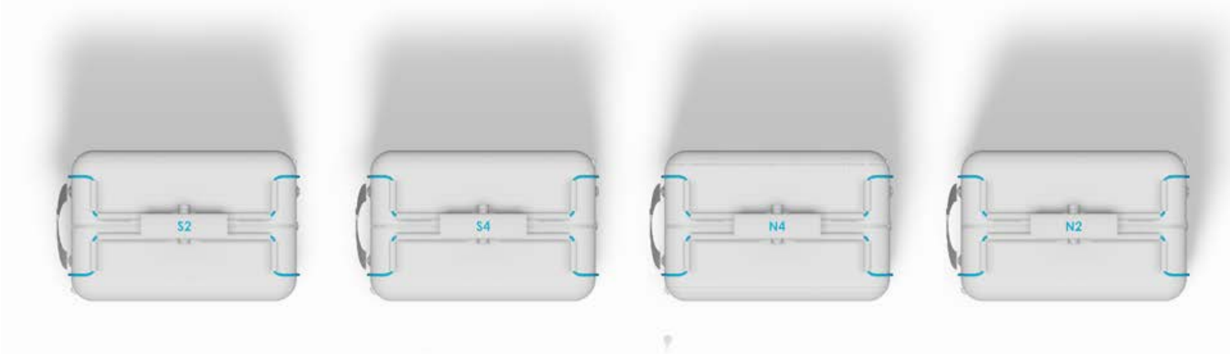

Figure 86. Rendering of the drag-handle and the identification marking.

10.2.9 Cords

Loop is equipped with two nylon cords running within the 24 cord paths, see figure 87. The cords are dimensioned with a four millimeter diameter and a length of 220 centimeters, ensuring that the drag-handle always has five centimeters of space between the handle and the top, independent of whether Loop is compressed or expanded**.** The cord diameter comes from being able to place two cords in each hole of the cord lock and the length is set to provide for the intended compression and expansion. The cords are further equipped with a knot, strategically placed to prevent the user from over-compressing Loop. The knot also works as an indicator of when the Loop is compressed enough for an easy machine fitting and a convenient handling during transportation. The color of the cord is individual to each user and set as the same color coding used in the single-apartments of HSB Living Lab. The main colors are blue, red, green, orange, dark blue and yellow and are further complemented with the color coded identification marking on the drag-handle, specifying the cardinal direction and floor related to the owner. The color coding thus makes it easy for users to distinguish the individually owned Loops. If Loop should be used in a different context, outside of HSB Living Lab, the cords can be replaced with colors individually chosen by the users.

Figure 87. Rendering of the different colored cords running through the cord paths of Loop.

10.2.10 Cord lock

Loop is being kept in its compressed state with the help of a cord lock (UMX, 2016), automatically keeping the cords closely tied together, see figure 88. The user simply pushes the button of the lock to release the compression. This releases the tension which drives Loop to its expandable state again. The cylindrical cord lock is made in H.D PE, dimensioned with two eight millimeter holes in order to house the four cords running through the two holes of the cord lock. The cord lock is further dimensioned with 16 millimeter in diameter and 46 millimeter in length, ensuring a larger grip compared to conventional cord locks.

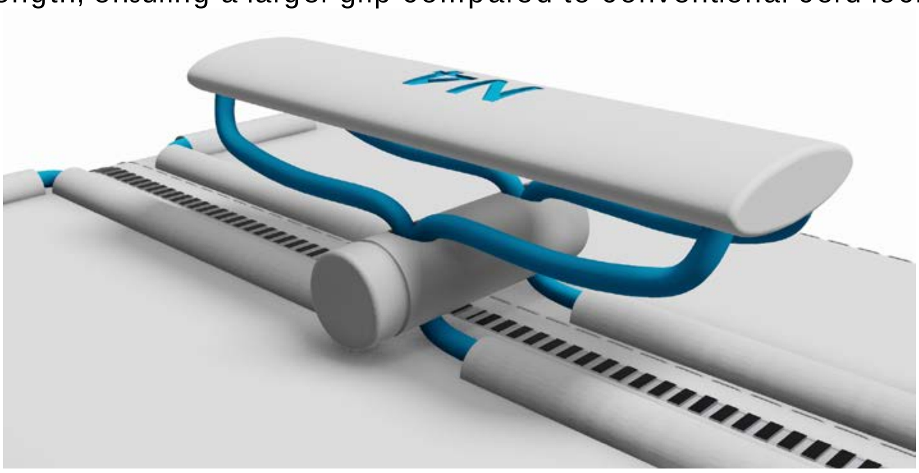

Figure 88. Rendering of the locking mechanism.

10.2.11 Retractable strap

Loop is designed with a retractable strap made from rPET with the same color as the closed fabric, see figure 89. The strap is attached to two of three available anchor points, made in H.D PE, sewn onto Loop. The strap has a hook made of H.D PE sewn onto each end which is attached to the anchor points. The strap is dimensioned to be adjustable from 75 to 120 centimeters in length. It was decided to keep the shortest length as close to the length of Loop as possible, in order to maintain a clean expression when stored. The strap is further designed to be adjustable according to the preferences of the user, making sure that each individual can decide the whether the strap should be used as a handle or a shoulder strap.

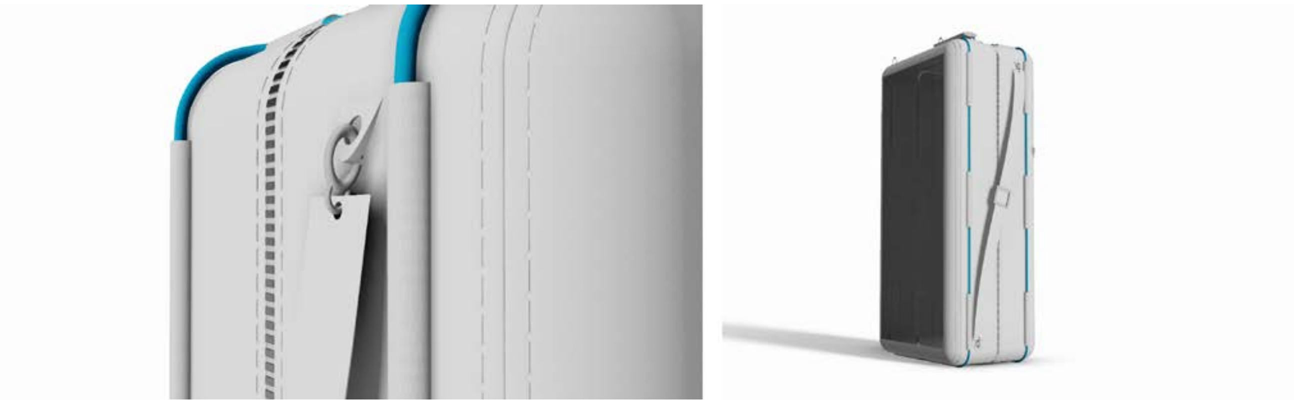

Figure 89. Rendering of the retractable strap.

10.2.12 Logos

Loop is designed with two logos sewn onto the front and closed fabric, beside the perforated pattern, see figure 90. The first logo is the Electrolux logo, representing the company behind the product. The second logo is a recycling logo of rPET, expressing the conscious material choice and recyclability of the rPET used for the majority of the components.

Figure 90. Rendering of the two logos sewn onto Loop.

10.2.13 Booking system

Loops is designed to work with the booking system in HSB Living Lab. The interface of the booking board is improved by implementing possibilities to communicate with other residents through the Vision system. The board also adds information regarding washing details displaying the booked time, laundry type and amount of laundry with a notification regarding preferred division of labor.

10.3 Customer journey of Loop

The customer journey explains the use procedure of Loop, tied to the complete laundry cycle, and is divided into the six main steps of planning, collecting, compressing, transporting, washing and drying.

10.3.1 Planning

The first step of the customer journey is the planning step. This step is mainly considering the booking system which is physically accessible in the washing studio, and digitally through the internet or an application for cellphones. The first step is initiated when the user decides that the Loop or Loops**,** depending on the individual need and preferences, are full and that the clothes need to be cleaned.

The user access the booking system to scan for available washing time. The user interacts with the booking system to reserve a time and to have the possibility of communicating with the other residents. The booking system further displays the laundry type that is going to be washed and the preferred division of the labor. The different users that are going to wash together can decide whether to take turns washing or whether to meet up in the washing studio and co-operate. The first step of planning is visualized in figure 91.

Figure 91. Illustration of the first step.

10.3.2 Collecting

The next step of the customer journey is the collecting step, visualized in figure 92. One or several Loops are used depending on the individual preferences tied to sorting and the quantity of stored laundry items. The Loops are strategically placed either by the staircase, in the bathroom or on both locations, enabling an easy access when the users is changing clothes. Loop is hung on the wall with the help of the two hooks and enables an easy loading of laundry through the top-mounted zipper. The color coding of Loop together with the perforated opening window allows the user to decide when it is time to perform the first step of planning through the vision system.

Figure 92. Illustration of the second step.

10.3.3 Compressing

Compressing is the next step of the customer journey where the user removes the wall mounted Loop to prepare it for compression, see figure 93. The main zipper is first released, either when Loop is wall mounted or when placed on the floor. The drag handle is then used at the same time as the cord lock is used, releasing the automatic locking mechanism. The user activates the automatic locking mechanism of the cord lock when the cords and drag handle have been withdrawn until the point that the knots on the cords have reached the cord-lock, making it impossible to compress Loop further. The Loop is now compressed mainly in the length, making it easier to transport and load into the washing-machine. The larger dimensioned Loop compresses down to one third of the length whereas the smaller dimensioned bag compresses down one quarter of the total length.

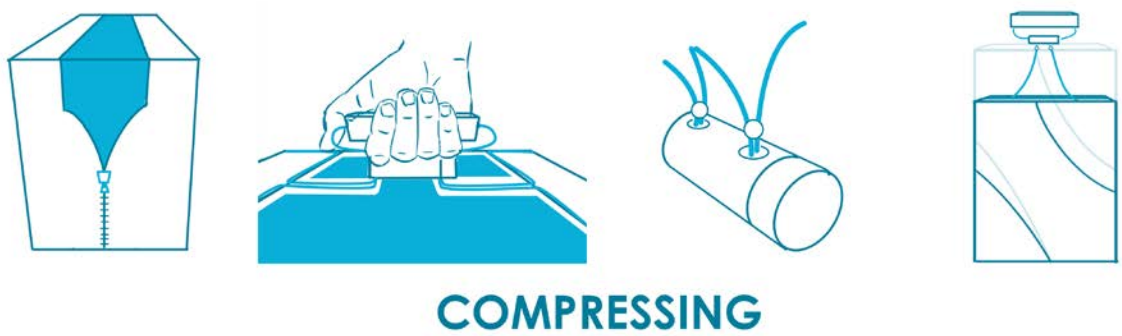

Figure 93. Illustration of the third step.

10.3.4 Transporting

The Loops are now compressed and prepared for transportation to the washing studio, see figure 94. The adjustable strap, attached to the side of Loop, makes it possible for individual users to decide whether to use the strap as a handle or a shoulder strap. Depending on the amount of laundry to be washed, one or several Loops are carried with the help of the straps. Three larger Loops could be carried simultaneously by the user, carrying one on the shoulder and one in each hand. The results from the user-studies confirmed that users in general bring the specific amount of laundry that is going to be washed to the washing studio, which demonstrates that one or two Loops will be carried to the washing studio in general. Carrying four Loops is possible, but could be troublesome.

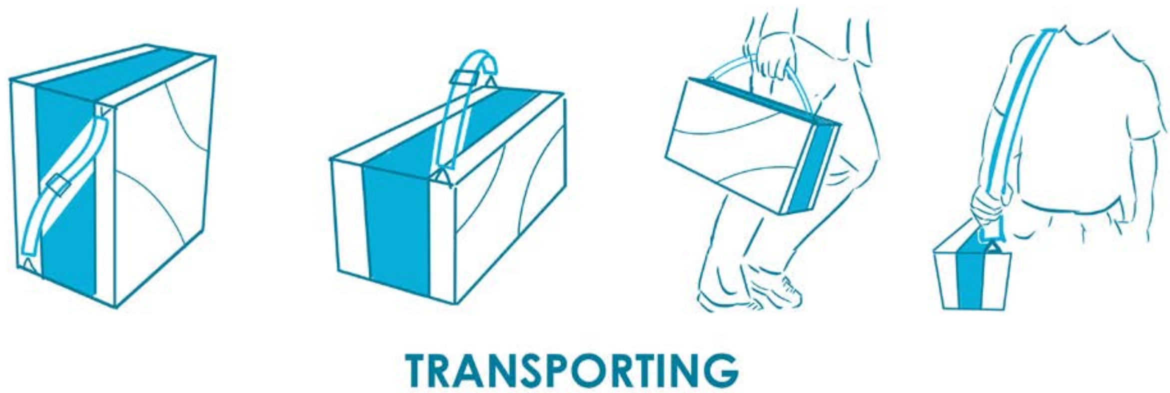

Figure 94. Illustration of the fourth step.

10.3.5 Washing

The compressed Loops are now transported to the washing studio and prepared to be loaded into the washing-machine, see figure 95. Two larger Loops of two residents sharing laundry or, three smaller Loops of three residents, are easily loaded into the washing-machine due to Loop being in the compressed state. The compressed states of the two or three Loops are released simultaneously when placed into the washing-machine. The compressed state is released with the help of the automatic locking mechanism of the cord lock. The Loops are now placed in the washing-machine and the automatic detergent system is activated when the washing-machine is started. The available storage spaces in the washing studio are utilized, with the help of the RFID tags, if the users have brought additional Loops aimed to be washed afterwards the current washing is done. The next step is to remove the Loops from the washing-machine when the washing is complete. The identification marking on the drag-handles and color coding aid the different users in identifying the individual Loop.

Figure 95. Illustration of the fifth step.

10.3.6 Drying

The Loops are at this step prepared for drying after being washed and unloaded from the washing-machine, see figure 96. Depending on the individual preferences, the Loops are either loaded into the dryer, drying cabinet or carried back to the accommodation for air drying. No compression is required whether the dryer or drying cabinet is aimed to be used. In the scenario of the dryer being used, the Loops are easily loaded into the dryer and allowed to dry due to the perforated fabric on the front, back and sides.

In the scenario of the drying cabinet being used, the larger clothing inlet on the back is opened up and the individual laundry items within the Loop are hung in the drying cabinet. The larger clothing inlet allows for an easy retrieval of laundry items but also a large opening when dried laundry is carried back to the accommodation with the help of Loop. The strap is then switched from side-attached to bottom-attached, allowing the Loop to be carried with the bottom up, which will allow the users to transport the cleaned laundry items on a larger surface during the transportation.

The customer journey ends when the Loops are transported back to the accommodation of the user. The cleaned laundry items are sorted and stored in the apartment and the main zipper is closed before, or when, Loop is placed on the wall, ready for a new laundry cycle to be carried out.

Figure 96. Illustration of the sixth step.

10.4 Benefits

The Loop design comes with several benefits when it comes to washing laundry. The benefits are divided into two main categories of sustainable benefits and user benefits.

10.4.1 Sustainability

The sustainable benefits of Loop are numerous. The most prominent one is the optimization when utilizing the washing-machine capacity. By containing two or three kilograms of laundry, Loop secures a machine load of six kilograms which is twice as much as the average load, see **appendix II**. The resource usage is thus reduced with 50% by having users sharing washing-machine and loading the washing-machine with two larger or three smaller Loops.

The materials of Loop are chosen with respect to recyclability and environmental impact. The majority of Loop is made of rPET, a material that possesses a high sustainability profile by being recyclable and easily accessible due to the quantity of PET being produced, thus raising the recycled material supply. The other materials used for zippers, cords, piping etc. are also recyclable made in nylon and H.D PE. Loop is consciously designed with as many similar materials as possible, enabling easy recycling possibilities. The zippers, anchor points and cord paths are sewn onto Loop and the piping is detachable thanks to pre-defined pockets. The handle, cords and cord lock are separate parts that are easily removed. The strap is removable with help of the hooks, which further can be released from the strap after being detached. These aspects allow Loop to be separated into the respective materials quickly at the end of use. To reduce the environmental impact further, all of the fabrics are colored by using C02 instead of water, eliminating the extensive water and chemical usage during the coloring process whilst still securing a persistent color (DyeCoo, 2015).

10.4.2 User

The Loop design comes with numerous advantages when considering the users and the handling throughout the laundry cycle. The design of Loop eliminates the most troublesome and unnecessary steps of the customer journey such as the dirty sorting, temporary storage and preparation of laundry before loading washing-machine. Loop allows the user to eliminate these steps by integrating the dirty sorting with the collection, eliminating the temporary storage by using one product instead of two and preparation of laundry by integrating the pre-sorting in the first step of collection.

The most time-consuming steps in the customer journey were represented by the collection of laundry, loading into the washing-machine, unloading from the washing-machine and clean sorting. The time-consuming steps are simplified and optimized with the help of Loop**.** Using Loop allows the user to quickly collect laundry, quickly load and unload from the washing-machine with ease and the clean sorting is done automatically. The transportation is also simplified with Loop**,** allowing users to compress the laundry when transporting as well as securing the laundry items inside with the help of the closable clothing inlets. The laundry within Loop is further concealed, not allowing other residents to distinguish specific laundry items, an aspect that solves the integrity obstacles discovered during the user-studies.

Loop further allows several users to share washing times in the washing studio, which enables the possibility to wash more often and an increased access to washing times. The consequence could thus be that the residents of HSB Living Lab and users of Loop could decrease the number of owned laundry items, such as bed sheets and towels, which would be economically, ecologically and spaciously beneficial.

Another benefit with using Loop is connected to saving time and money. As mentioned previously, if the users decide to take turns and wash each other's laundry with the help of Loop, time could be spent on other activities. A rewarding system could perhaps be introduced to the resident who takes on the responsibility of washing the laundry of other residents, by for instance receiving a smaller payment from the other residents that are more resistant to household chores.

10.5 Evaluation against the requirements and guidelines

In order to validate the final design of Loop, an evaluation against the list of requirements and guidelines was made. A figure depicting the full evaluation can be found in **appendix XIII**. The requirements used in the evaluation were the ones being ranked as a demand. The guidelines used were those ranked with a four or a five, since these were the most important requirements in need of being fulfilled in order for Loop to live up to the aims, goals and design intentions. The evaluation was carried out by specifying whether the demand or guideline was deemed as solved, marked with "yes", if it was solved but still in need more testing to be validated, marked with "test". If the demand or requirement was not met by the final design, it was marked with "no".

The evaluation demonstrated that all of the strict demands were fulfilled with the design of Loop. The evaluation furthermore showed that all but one of the highest ranked guidelines were solved as well. That was the guideline specified as; the solution should not affect the laundry negatively (e.g. discoloration), and was deemed as not being fully validated before more testing could be conducted. The results of the evaluation of the second highest ranked guidelines showed a mix of fully validated guidelines and guidelines in need of further testing. The guidelines that required further testing considering the integrity aspects were closely connected to the material and warp weaving of the perforated fabric, which required a functional prototype for validation. The requirements considering the product life span, handling, intuitiveness and mechanical properties also required a functional prototype for further testing and validation. The evaluation finally demonstrated that none of the demands or requirements were left unsolved or not met.

CHAPTER ELEVEN

CONCLUSION

Chapter 11 contains the reflections and conclusion withdrawn from the results from the project. The result from the project, Loop, is discussed based on the **aim** of project and the **research questions** posed in the introduction.

How can a system or artifact that facilitates the laundry cycle be implemented in HSB Living Lab?

The goal of the project was to develop an innovative solution that represents the sustainability of HSB Living Lab project and encourages users to wash laundry together. The purpose was further to develop a solution that facilitates the management of laundry and the laundry cycle, everything from the storage in the accommodation, transportation to the washing studio, storage in the washing studio and transportation back to the accommodation.

Loop is a laundry bag that facilitates the laundry cycle for the user, specifically developed for the single-living apartments of HSB Living Lab but consciously designed to allow implementation in other accommodation types with minor modifications. Loop is designed to fit in each step of the customer journey through the entire laundry cycle. Loop is dimensioned to be stored in the single-living apartments of HSB Living Lab, dimensioned to fit within the different machines and storage spaces of the washing studio. The storage in the washing studio was although left out of the scope during the project due to it being projected by another student group and due to the limited time of the project. A larger scope was instead set on allowing the solution to be washable and dryable. Loop is further equipped with gripping possibilities that allow for a comfortable transportation back and forth from the washing studio.

In what ways can the solution be sustainable and promote sustainability?

There are two variants of Loop, the larger containing three kilograms of laundry and the smaller containing two kilograms. Due to the fact of users in general washes three kilograms laundry per washing-machine, Loop allows users to save resources from both an economical and an ecological point of view. The purpose of Loop is to encourage several users to wash laundry together and by containing three kilograms, two or three users sharing the washing-machine, will reduce the required resources with 50%. If the user has more than three kilograms of the same type of laundry, the user can still use Loop as effectively, by placing two or three individually owned Loops in the washing-machine or dryer.

Loop itself replaces the usage of three products, allowing users to store and transport laundry with the same product, both in the accommodation and the washing studio. The conscious material choice when making Loop, promotes sustainability through the majority of the components and fabrics being made of rPET, a material with a recognized sustainability profile. The attached rPET logo further expresses the recyclability and consciousness of Loop to the different user types that may come in contact with Loop.

How can the solution motivate users to wash laundry together with other residents of HSB Living Lab?

Loop encourages users to wash laundry together by offering benefits that are easily retrieved with the help of Loop itself and the bookings system. Loop is designed to overcome the hygienic obstacles retrieved from the user-studies, such as the physical interaction with other residents laundry, the integrity issues connected to visibility and doubts created by sorting issues. Loop is closely connected to the booking system and the functions available in the system. The booking system will be accessible from multiple sources, making it easier to access, plan and book washing times.

The booking system together with Loop allows the users to save time by taking turns washing. Loop allows the users to save money through the shared detergent system and by being relieved of owning several laundry containers. Loop further allows the users an increased availability of washing sessions and the possibility to retrieve clean clothes more often by allowing two or three users to share a booked session in the washing studio.

CHAPTER TWELVE

DISCUSSION

In chapter 12, the **limitations** of the project are discussed together with thoughts considering the used **methodology**. The **result** of the project is further discussed with respect to material choices and validation. Finally, the **recommendations for the further development** of Loop are presented.

The project was limited to the development of an external product that facilitates the laundry cycle and did not involve a redesign of the existing laundry machines used in the washing studio, such as the washing-machine, dryer or drying cabinet. Re-designing the washing-machine was discovered as way of overcoming some privacy obstacles retrieved from the user-studies. Adding a separation of the laundry within the machine would be a way to avoid using bags, and was deemed as the second optimal way of efficiently separating different users laundry within the machine. Using a separation wall in the washing-machine would although still require an additional product for storing and most likely an additional for transporting the laundry within the HSB Living Lab context. The separation wall would further be required inside the dryer as well, making the option less likely since it would require two large modifications of the existing machinery. The separation is still enabled with Loop, which also allows storage and transportation of laundry with the help of the same product, overcoming all obstacles with one product.

The limitation of using only the existing equipment further resulted in a few complications during the development phases of the cylindrical cartridge solutions. The idea of maximally utilizing the space in the washing-machine and dryers resulted in the bag having to transform from 30 centimeter diameter, to fit the outer drum of the washing-machine, to having a 72 centimeter diameter to fill the entire inner drum of the dryer. This was a task simply impossible to solve without compromising several important demands and it was thus deemed as a hopeless cause. But a breakthrough appeared nevertheless, majorly influenced by two aspects. The breakthrough was achieved by utilizing both expansion, compression and by the technical confirmation that the bag could be rectangular but still achieving a desired washing and drying performance. Loop could thus be designed to fit both the dryer and washing-machine, for optimal washing and drying performance without compromising any other demands.

The development early spawned ideas regarding having an automatic laundry transportation system integrated in HSB Living Lab. This was although deemed as out of scope for this master thesis. It was realized quite early that the current way of transporting laundry, by hand, was the best system with regards to cost, time and technical aspects. Making an automatic system would be far too expensive, it would require a lot of planning, modifications and deconstruction of the HSB Living Lab environment as well as taking too much time to develop. The aim was thus set towards making the manual washing transportation as convenient and seamless as possible, which resulted in the retractable strap for both hand and shoulder carriage.

The methodology used in the project has worked well where the literature studies and results from the user-studies have functioned as a reliable basis for the ideation and development phase. Although a deeper research considering the washing quality connected to washing laundry bags and importance of utilizing the entire space of the inner drum of the washing-machine could have been investigated earlier in project. This would eventually have resulted in an earlier reception of the breakthrough and more time could have been spent on developing the laundry bag concept itself.

Using user profiles instead of the conventional personas was a conscious choice, retrieving the specific aspects that were considered through the development and used to evaluate the final five concepts from the concept development phase. The user profiles were supplemented with a customer journey, user types and scenarios in order for the developed solution to cover the wide aspects of different usages. The supplementation to user profiles was added without creating fictive and misleading personas, solely developed to fit the specific project. The user profiles are considered to be a more objective method for retrieving important aspects rather than the subjective personas.

User-observations could have been used when conducting the user-studies to receive a deeper insight into problems occurring today, which might be troublesome to retrieve from surveys and interviews. It was decided not use planned observations because of the extensive width received from the survey and interviews. Observations were assessed as potentially privacy intrusive, an aspect that could affect the result retrieved from the observations. Self-observations were instead made when washing laundry individually and together with partners, to confirm the results from the survey and interviews.

The ideation phase was large and iterative, searching for the optimal solution for facilitating the complete laundry cycle. The ideation methods used were applicable for the specific project even though the morphological chart was troublesome to use when considering the large amount of sub-functions. It was difficult to find a balance between covering all functions whilst still creating plausible ideas, which might have resulted in the morphological matrix not being used to the full potential of the method.

The project could have utilized more evaluation tools throughout the process with the help of for instance focus groups consisting of the intended target group, receiving a more continuous feedback from the users. It was difficult to evaluate the different concepts with the help of sketches without having a physical prototype backing up the visual material. It was also difficult to evaluate the concepts without a prototype since the function of the product is dependent on physical interaction to such a large extent. It was thus decided to leave the evaluation of Loop to further development, including functional prototype testing.

The result is meant to be further validated with the help of a second prototype, bearing a closer resemblance to the final design of Loop. The validation of a second prototype was not possible due to time restrictions, limited knowledge, limited skills in textile manufacturing and troubles with finding a producer capable of making the prototype. This resulted in the first prototype being slightly altered in order to test the trivial compression features. The tests showed that a compressive mechanism utilizing cord paths and cords would work, but the tests would have been more reliable using a proper prototype. The lack of a final prototype also meant that the intended user validation evaluation have to be postponed to a later stage since the first prototype did not include all of the intended features of Loop. An evaluation of a differently working prototype would result in insufficient and incorrect data. Loop was instead evaluated according to the list of requirements which demonstrated several requirements that require testing to ensure confirmation.

Recommendations for further development

In order to develop Loop further**,** several functional prototypes should be made. The purpose of the prototypes would be to evaluate the functionality and usability of the design in order to optimize the design further and to confirm the compression and expansion mechanisms. The prototypes should further be used to evaluate the intuitiveness of Loop and the different mechanisms connected to the compression of the bag. The functional prototypes should be made in the specified materials in order to evaluate Loop throughout the steps of the customer journey and the requirements mentioned as directly connected to the material. The prototypes should also be used as a tool of evaluating the washing result, mainly aimed to determine the balance between the non-perforated and the perforated fabrics. These tests should be made in order to investigate the intended water, air, dirt and detergent flow.

The dimensions of the clothing inlets would have to be tested as well as the aesthetic expression when stored in the single-living apartments of HSB Living Lab. Furthermore, a user test should be conducted to find ways of creating acceptance towards a wall-mounted laundry storage. The piping requires functional testing in order to make sure that Loop maintains the rectangular shape throughout the usage, mainly during the apartment storage and washing sequences. The structural integrity embedded in the fabric itself should be investigated further, in order to obtain an optimal structural integrity of Loop.

A further material research is also recommended in order to determine a more specific weaving technique, in order to facilitate for all of the intended fabric features. Even though warp weaving is a possible manufacturing technique, the fabric quality, weave pattern and mesh size is in need of further specification. Furthermore, all of the dye colors need to be specified with color codes in order to achieve the desired dying result. An estimation of the costs should also be made, although Loop replaces three products and could thus have a relatively high manufacturing and purchase cost. Finally, proper drawings should be made in order to making Loop producible.

The interface of the booking system and the functions connected to it should be developed in order to ensure an optimal system that encourages and promotes the advantages of shared washing to the users.

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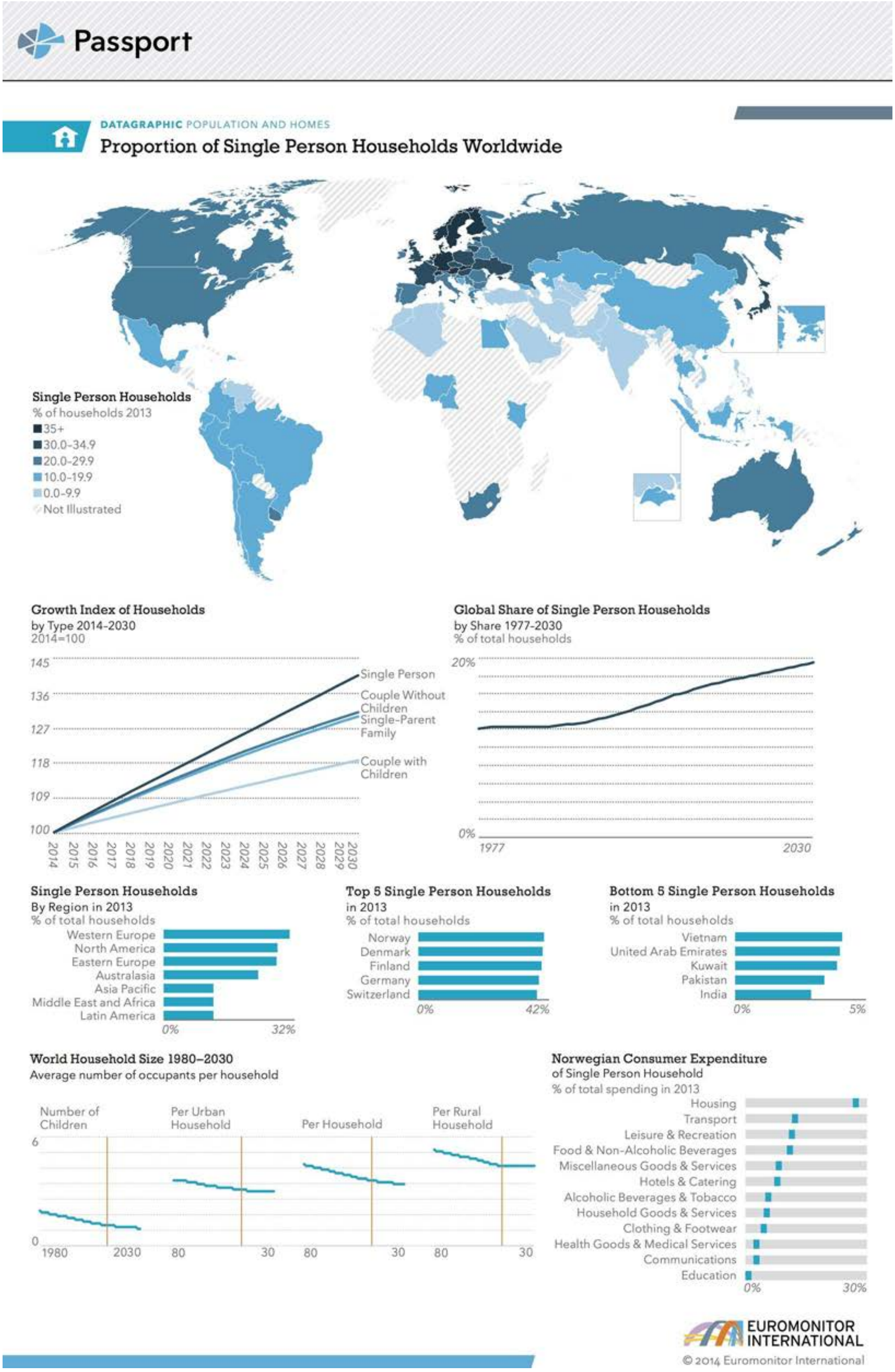
APPENDICES

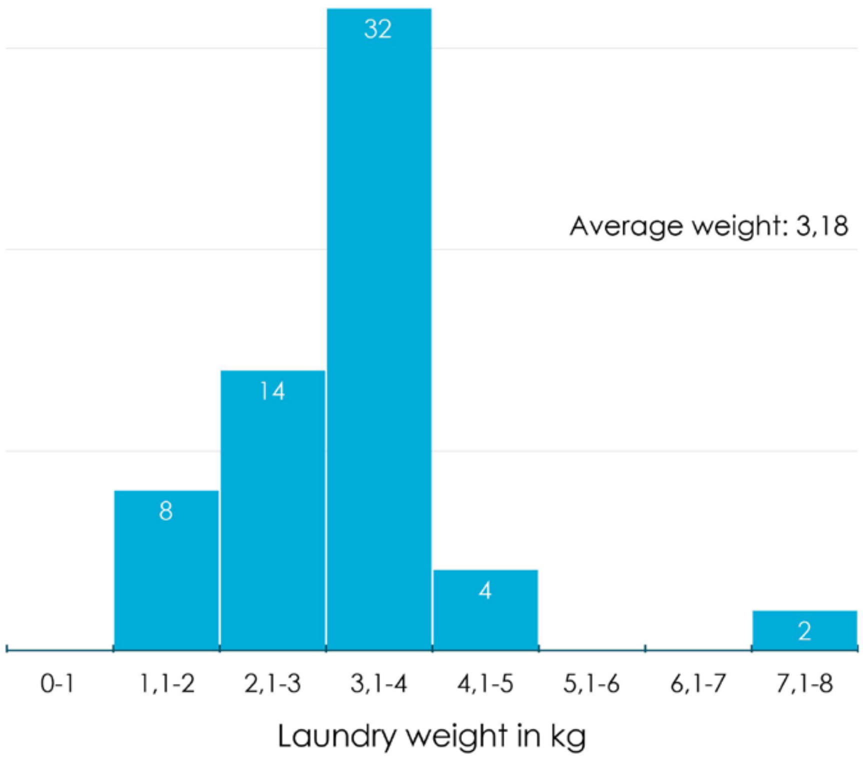
APPENDIX I

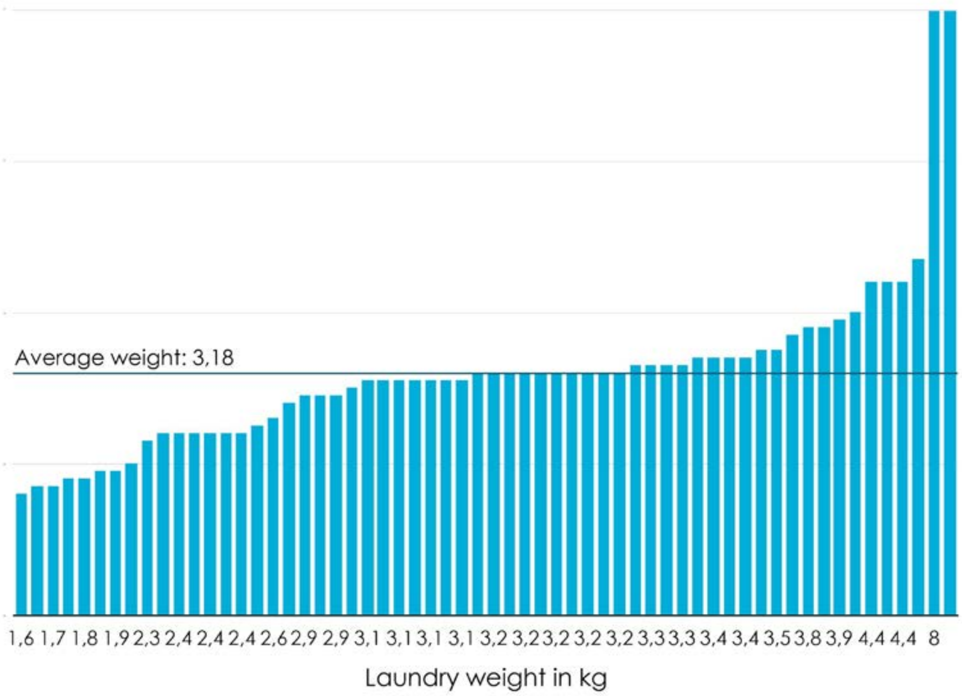
Statistics considering proportion of single person households worldwide from Euromonitor International (Euromonitor International, 2014).



APPENDIX II

Statistics for average weight of laundry, retrieved from Electrolux.





APPENDIX III

Survey template

Laundry cycle

Thank you for helping us developing future transportation systems of laundry!

How old are you?
0-19
20-24
25-29
30-39
40-50
> 50

Define your living-space
House
Apartment
Student apartment
Other accommodation

How many people are currently living in your living-space?
1
2
3
4
5
> 5

Your laundry habits

How often do you wash your clothes per month? Choose from the alternatives
1
2
3
4
5
> 5

How do you store your laundry in your living-space? Why?
How do you transport your laundry to the washing room?
How do you store your laundry in the washing room?
How do you transport your clean laundry back to your living-space?

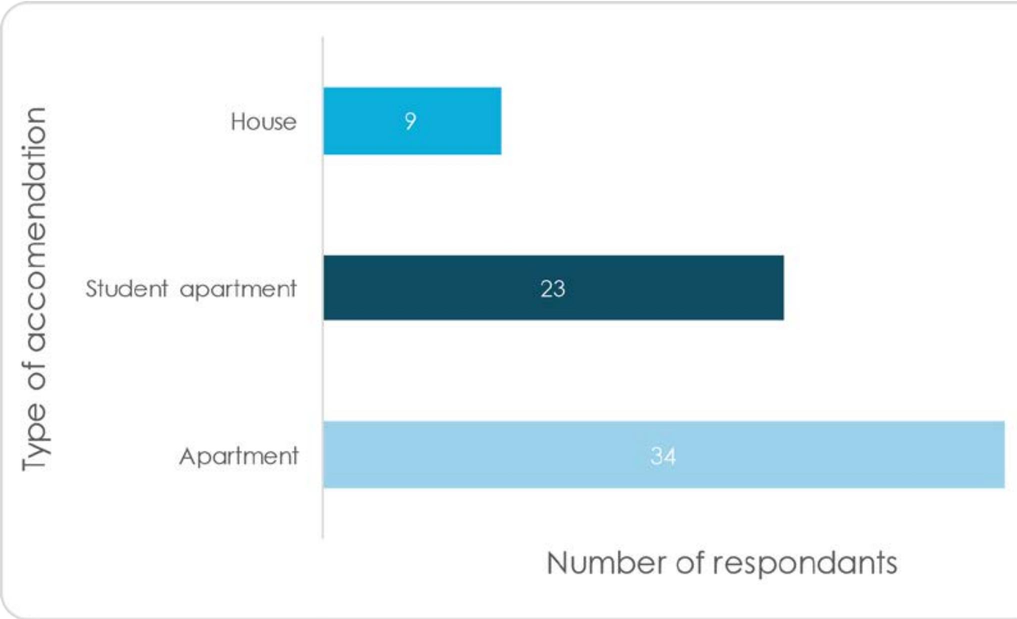
In the near future...

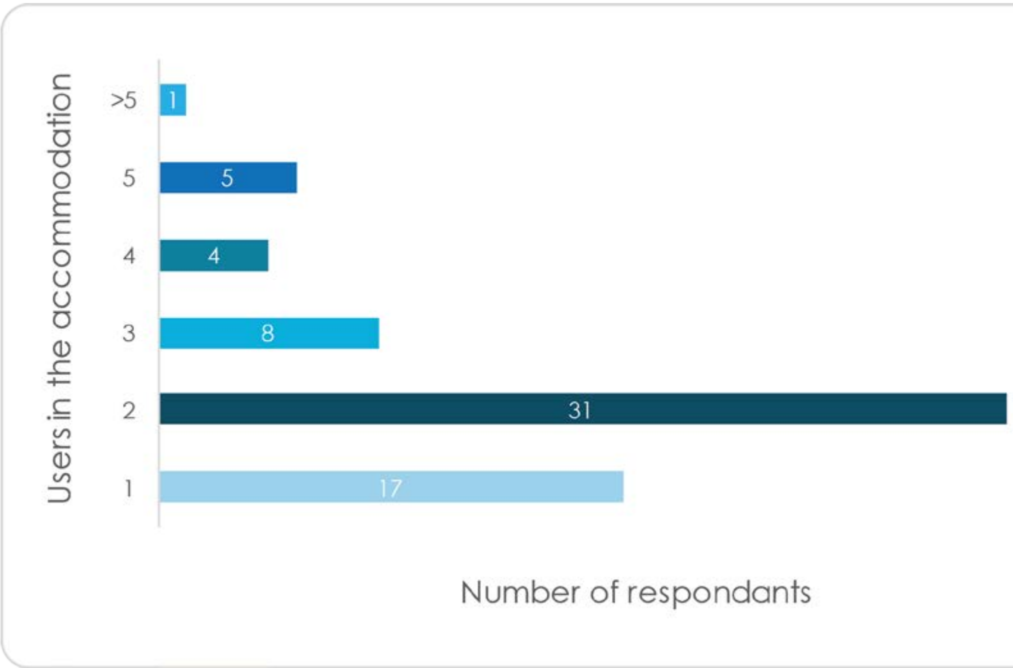
a quick question about future laundry habits

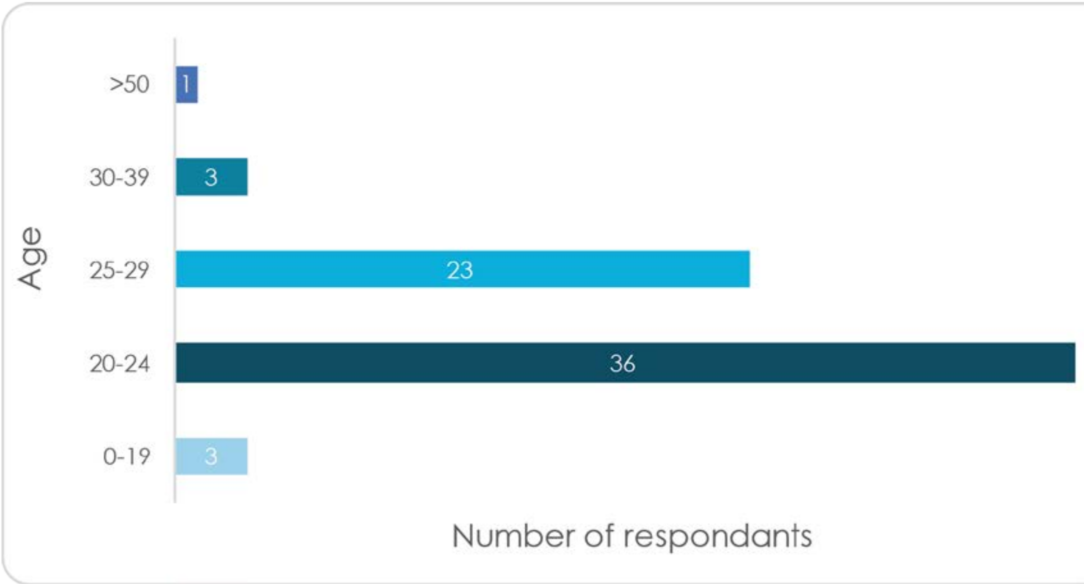
Would you be prepared to share a washing-machine with your neighbor?
Yes
No

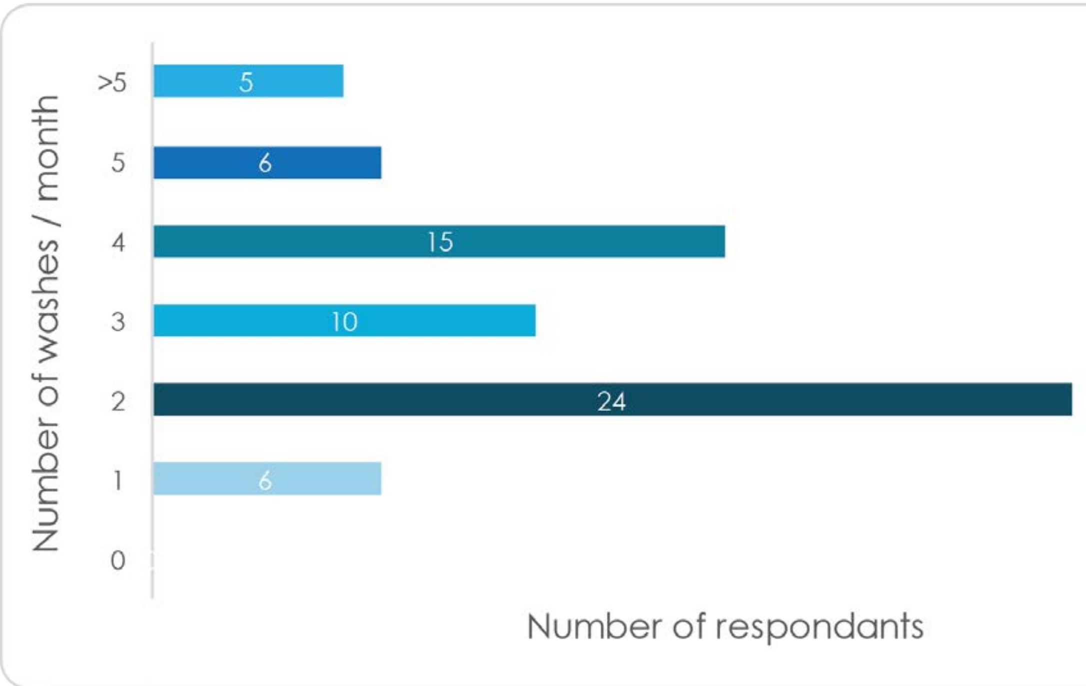
Why?

Quantitative results from the survey

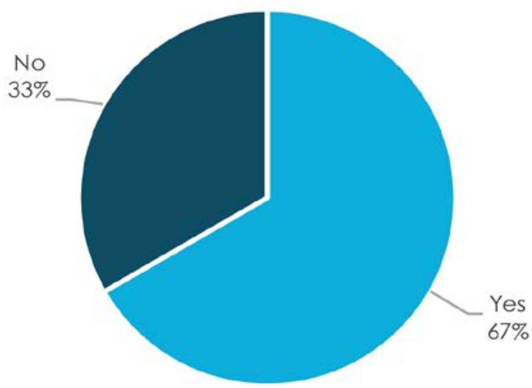








Would you be prepared to share a washing-machine with your neighbour?



APPENDIX IV

Interview template

Interview template

The purpose of the interview is to gain qualitative insight in what requirements and guidelines users might have on a transportation device designed for transportation and storage of laundry. The interview will take approximately five to ten minutes and will be documented simultaneously as the interview is ongoing.

Introduction questions

Age:____
Type of accommodation:____
Number of people in your household:____
How often do you wash your clothes:____

Questions

How do you store your dirty laundry today?

*In your house/apartment:*____

In your Laundry room: ____

- *Why?*

____

____

What aspects do you consider when choosing your laundry storage? I.e what demands do you have on your laundry storage?

____

____

How do you transport your dirty/clean laundry today? Forth and back from the laundry room to your house/apartment.

____

____

- *Why?*

____

____

What aspects do you consider when choosing your transportation device? I.e what demands do you have on your transportation device?

____

____

Would you be prepared to use a single washing-machine at the same time as your neighbor?

Yes / No

- *If yes, why?*

____

____

- *If not, what would motivate you to share a washing-machine with your neighbor?*

____

____

What would motivate you to use a washing room as a social place?

____

____

Interview results

Interviewee 1
The purpose of the interview is to gain qualitative insight in what requirements and guidelines users might have on a transportation device designed for transportation and storage of laundry. The interview will take approximately five to ten minutes and will be documented simultaneously as the interview is ongoing.

Introduction questions
Age: **20**
Type of accommodation: **Apartment**
Number of people in your household: **2**
How often do you wash your clothes: **4-5 times per month**

Questions

How do you store your dirty laundry today?

In your house/apartment: ***Laundry basket, in a storage room***

In your Laundry room: ***Laundry carts in the washing room for transportation of the wet laundry, since the laundry is wet and the basket is made of fabric. Would have used a plastic bag if the carts were unavailable.***

- *Why?*

Convenient since it is made of fabric, is lightweight and is equipped with handles. It is roomy so it can contain a lot of laundry. It is foldable which makes it easy to store when not used. Works for all types of laundry and is eliminates the need of another product.

What aspects do you consider when choosing your laundry storage? I.e what demands do you have on your laundry storage?
It should fit in the house. Should not be difficult to carry, i.e. it should have handles. It should be easy to store, be foldable and easy to stowed when not used. It should also be fast and convenient to use.

How do you transport your dirty/clean laundry today? Forth and back from the laundry room to your house/apartment.

The same laundry basket I use for storage.

- *Why?*

What aspects do you consider when choosing your transportation device? I.e what demands do you have on your transportation device?
The same aspect described earlier.

Would you be prepared to use a single washing-machine at the same time as your neighbor?
Yes

- *If yes, why?*

Smarter since it is difficult to get a washing time and some people doesn't do that much laundry. It is also ecologically sustainable.

Problem: People are working at different times, neighbors does not greet each other (no social interaction), although this would solve that issue. The laundry has a possibility of being mixed.

- *If not, what would motivate you to share a washing-machine with your neighbor?*

What would motivate you to use a washing room as a social place?
Like a coffee shop, coffee is enough, it is easy to make and everyone drinks coffee. Somwhere to sit, make it look social and pleasing. A place where you can sit down casually, where you are able to blend in.

Interviewee 2
The purpose of the interview is to gain qualitative insight in what requirements and guidelines users might have on a transportation device designed for transportation and storage of laundry. The interview will take approximately five to ten minutes and will be documented simultaneously as the interview is ongoing.

Introduction questions

Age: **22**

Type of accommodation: **Student apartment**
Number of people in your household: **2**
How often do you wash your clothes: **3-4 times per month**

Questions

How do you store your dirty laundry today?

Laundry basket

In your house/apartment:

In your Laundry room: ------------

- *Why?*

Because it is big enough to contain all my laundry.

What aspects do you consider when choosing your laundry storage? I.e what demands do you have on your laundry storage?
Big enough to contain all of the laundry. Durable. Should not take up too much space. Should preferably have a lid, to visually conceal the laundry in my small apartment.

How do you transport your dirty/clean laundry today? Forth and back from the laundry room to your house/apartment.

Fabric bags, I first sort the laundry into individual fabric bags and then carry it to washing room.

- *Why?*

In order to sort and to be able to carry it in different batches.

What aspects do you consider when choosing your transportation device? I.e what demands do you have on your transportation device?
Big enough to contain all laundry, should not affect the clothes in any way (discoloration).

Would you be prepared to use a single washing-machine at the same time as your neighbor?
No

- *If yes, why?*

- *If not, what would motivate you to share a washing-machine with your neighbor?*

why not: Hygiene, you don't know where the neighbors clothes have been and how dirty they are. Socks and shirts might disappear.

Motivate: If there was a possibility of splitting the machine in two.

Om möjligheten fanns att dela med någon annan (halva maskinen var, dela upp var)

What would motivate you to use a washing room as a social place?
WIFI and more washing-machines so more people could wash at the same time

Interviewee 3
The purpose of the interview is to gain qualitative insight in what requirements and guidelines users might have on a transportation device designed for transportation and storage of laundry. The interview will take approximately five to ten minutes and will be documented simultaneously as the interview is ongoing.

Introduction questions

Age: **60**
Type of accommodation: **Apartment**
Number of people in your household: **1**
How often do you wash your clothes: **1 time per week, approx: 4-5 times a month**

Questions
How do you store your dirty laundry today?

In your house/apartment: ***Plastic laundry basket***

In your Laundry room: ***IKEA bag***

- *Why?*

Laundry basket: DOn't want to store the dirty laundry directly in the closet. All of the laundry doesn't fit in the transportation bag. The basket is rigid and easy to place without taking up too much space. A bag is more speciously demanding on the floor. It can hold a lot of laundry.

IKEA bag: It is convenient since I carry the laundry in that bag. It is also convenient to keep it gathered in one place instead of throwing it all on a bench.

What aspects do you consider when choosing your laundry storage? I.e what demands do you have on your laundry storage?

Ventilation, not too tight or completely closed, in order for air to flow into the bag. Should be visually pleasing since it becomes part of the interior. It should conceal the laundry.

How do you transport your dirty/clean laundry today? Forth and back from the laundry room to your house/apartment.

IKEA bag.

- *Why?*

Easy to carry, easier than carrying a laundry basket due to the handle and size. Can be carried on the shoulder and only requires one hand during transportation.

What aspects do you consider when choosing your transportation device? I.e what demands do you have on your transportation device?

Roomy in order to fit at least two machines worth of laundry. Lightweight, preferably with handles in order to be carried on the shoulder. It could be good with two handles, on for hand-grip and one for shoulder carriage. It should only require one hand to be carried so you can have another bag in the other hand.

Would you be prepared to use a single washing-machine at the same time as your neighbor?

No

- *If yes, why?*

- *If not, what would motivate you to share a washing-machine with your neighbor?*

Why not: Does not feel good, dirty laundry is very private. The neighbors are strangers.

Motivate: If I could choose a nice neighbor that I trust. If underwear and socks was excluded. Would work for towels and bed sheets though, since these items are more neutral. If the items are guaranteed to not be mixed, it would be more okey. If there was a good way of organizing it.

Problem: A lot of theft in the laundry rooms and it would be more difficult to lock organize security. If someone sorts wrongly since this would discolor your laundry as well. I would probably not want to wash delicate clothing with a neighbor no matter what.

What would motivate you to use a washing room as a social place?

Would be nice since you don't have to run back and forth. You often talk to your neighbors anyway in the laundry room. A room where you could sit down and have a cup of coffee, that looks nice and maybe has some magazines or books to be borrowed. It would be good, if not necessary, with an automatic detergent dispensing system, although this might cause problems for people with allergies. It would also be convenient if this system (detergent dispenser) would be paid monthly with the rent instead of organizing buying detergent with your neighbors.

Interviewee 4
The purpose of the interview is to gain qualitative insight in what requirements and guidelines users might have on a transportation device designed for transportation and storage of laundry. The interview will take approximately five to ten minutes and will be documented simultaneously as the interview is ongoing.

Introduction questions

Age: **23**
Type of accommodation: **House**
Number of people in your household: **3**
How often do you wash your clothes: **3 times per month**

Questions
How do you store your dirty laundry today?

In your house/apartment: **Laundry basket**

In your Laundry room: **Laundry basket**

- *Why?*

Convenient with a single container

What aspects do you consider when choosing your laundry storage? I.e what demands do you have on your laundry storage?
Sort after need (40, 60, color etc.) To be able to see how filled it is and what items are stored in it.

How do you transport your dirty/clean laundry today? Forth and back from the laundry room to your house/apartment.

The same laundry basket.

- *Why?*

Relieved of lifting all of the laundry as single items and do not drop any items on the way.

What aspects do you consider when choosing your transportation device? I.e what demands do you have on your transportation device?
You should be able to carry it with one hand if necessary.

Would you be prepared to use a single washing-machine at the same time as your neighbor?
No

- *If yes, why?*

- *If not, what would motivate you to share a washing-machine with your neighbor?*

Why not: It is to intimate

Motivate: If I do not see the other person's laundry. A product that conceals the laundry but still displays the color of the laundry.

What would motivate you to use a washing room as a social place?
If it is silent. Integration with furniture that serves another purpose. If the laundry room would be filled with other stuff. If it is quiet and you have a chair to sit in.

Interviewee 5
The purpose of the interview is to gain qualitative insight in what requirements and guidelines users might have on a transportation device designed for transportation and storage of laundry. The interview will take approximately five to ten minutes and will be documented simultaneously as the interview is ongoing.

Introduction questions

Age: **25**
Type of accommodation: **student apartment**
Number of people in your household: **1**
How often do you wash your clothes: **Every 10th day**

Questions
How do you store your dirty laundry today?

In your house/apartment: ***A big laundry basket in shower***

In your Laundry room: ***IKEA bags***

- *Why?*

It is the only possible place to store the basket (in the shower). It is quite big, square, relatively high and foldable.

What aspects do you consider when choosing your laundry storage? I.e what demands do you have on your laundry storage?
I only buy stuff that is aesthetically pleasing, and i rather not buy unnecessary stuff.

It should be lightweight, an aluminum frame with a fabric bag beneath.

How do you transport your dirty/clean laundry today? Forth and back from the laundry room to your house/apartment.

I sort the laundry first and then I carry it down in a blue IKEA bag or in the laundry basket.

- *Why?*

Laundry basket: Just happens without a specific intention

IKEA bag: Convenient with the handles, makes it possible to carry on the shoulder. The bag is also roomy and has place for a lot of laundry.

What aspects do you consider when choosing your transportation device? I.e what demands do you have on your transportation device?
Should not be made out of paper due to hygiene reasons, it should also be water resistant.

Would you be prepared to use a single washing-machine at the same time as your neighbor?
No

- *If yes, why?*

- *If not, what would motivate you to share a washing-machine with your neighbor?*

Why not: Unfresh, sounds a bit ridiculous but still, might be a semiotic aspect.

Motivate: It is more sustainable. If it is easier to get a washing time and if it would require less effort to wash. If it reduces the water wastage.

What would motivate you to use a washing room as a social place?
Can't think of anything right now. Not even when I lived in a student dormitory I spent much time in the washing room.

Interviewee 6

The purpose of the interview is to gain qualitative insight in what requirements and guidelines users might have on a transportation device designed for transportation and storage of laundry. The interview will take approximately five to ten minutes and will be documented simultaneously as the interview is ongoing.

Introduction questions

Age: **33**
Type of accommodation: **House**
Number of people in your household: **5**
How often do you wash your clothes: **1-2 washes per day**

Questions

How do you store your dirty laundry today?

In your house/apartment: ***Laundry baskets made of steel threads, one in the bedroom and two in the washing room***

In your Laundry room: ***Laundry baskets made of steel threads, one in the bedroom and two in the washing room***

- *Why?*

Since I havn't found anything else with the possibility of pre-sorting and that is roomy enough. It is a temporary solution.

What aspects do you consider when choosing your laundry storage? I.e what demands do you have on your laundry storage?
Roomy, be able to contain bedsheets and towels. Fit beneath the washing-machine drum. Should be able to use for clean laundry as well. Should have a good grip, that doesn't hurt my hand. Easy to collect laundry without having to lift a lid, it should also be easy to remove the laundry.

How do you transport your dirty/clean laundry today? Forth and back from the laundry room to your house/apartment.

Carry in one of the thread baskets or throw it down and grab it by hand.

- *Why?*

No specific reason, since it is quick I guess.

What aspects do you consider when choosing your transportation device? I.e what demands do you have on your transportation device?
A hole in the floor that leads directly to the washing room. A better basket with nice handles, more like a wash tub.

Would you be prepared to use a single washing-machine at the same time as your neighbor?
Yes

- *If yes, why?*

As long as they can sort properly and I don't have to do the work for them. It is not that critical when you have kids. Depends on the neighbor, if you get to choose which neighbor to share with it would work.

- *If not, what would motivate you to share a washing-machine with your neighbor?*

What would motivate you to use a washing room as a social place?
If it is a nice environment unlike the ordinary washing room. Remove echoes and lower the noise, If it is warmer (not cold)

Interviewee 7
The purpose of the interview is to gain qualitative insight in what requirements and guidelines users might have on a transportation device designed for transportation and storage of laundry. The interview will take approximately five to ten minutes and will be documented simultaneously as the interview is ongoing.

Introduction questions

Age: **23**
Type of accommodation: **Apartment**
Number of people in your household: **1**
How often do you wash your clothes: **2 times a month**

Questions
How do you store your dirty laundry today?

In your house/apartment: **IKEA-bag**

In your Laundry room: ***IKEA-bag (only during laundry)***

- *Why?*

You need something to store it in. It has a good size and can be stowed away. I keep it in the cleaning cabinet.

What aspects do you consider when choosing your laundry storage? I.e what demands do you have on your laundry storage?
Room for all of the laundry and some extra space for large items as curtains and table cloths. Should be convenient and should fit in the cleaning cabinet. No aesthetics requirements since i stow it in the cleaning cabinet, but it is not so nice having a IKEA bag lying around.

How do you transport your dirty/clean laundry today? Forth and back from the laundry room to your house/apartment.

IKEA bag, one or two depending on how ambitious I am (sometimes a sort in my apartment and sometimes in the washing room).

- *Why?*

I had one so I used it.

What aspects do you consider when choosing your transportation device? I.e what demands do you have on your transportation device?
Reasonably portable. Different lengths on the straps. Convenient, since it is quite troublesome carrying laundry from the third floor to the basement. Closable, since laundry runs the risk of falling out of the IKEA bag.

Would you be prepared to use a single washing-machine at the same time as your neighbor?
Yes

- *If yes, why?*

Doesn't matter that much as long as I get my laundry back. Requires you to know your neighbors. You would get your laundry washed more often and you could devide the workload.

- *If not, what would motivate you to share a washing-machine with your neighbor?*

What would motivate you to use a washing room as a social place?
A table and chairs would be sufficient. WIFI. You should have a reason to sit there. Larger space. It needs to be quiet.

Interviewee 8

The purpose of the interview is to gain qualitative insight in what requirements and guidelines users might have on a transportation device designed for transportation and storage of laundry. The interview will take approximately five to ten minutes and will be documented simultaneously as the interview is ongoing.

Introduction questions

Age: **24**
Type of accommodation: **Student apartment**
Number of people in your household: **1**
How often do you wash your clothes: **1 time per week**

Questions

How do you store your dirty laundry today?

In your house/apartment: ***In a small laundry basket and in IKEA bags***

In your Laundry room: ***I don't since I don't trust my neighbors.***

- *Why?*

Unclear, the IKEA bags requires the least amount of space, doesn't take up more space than the laundry itself. My apartment is not designed to store big items.

What aspects do you consider when choosing your laundry storage? I.e what demands do you have on your laundry storage?
It works relatively well to use some kind of bag, it should fit in the apartment and you should be able to stowe it without having to serch enerywhere in order to find the laundry. Maybe you could wash in the sink or wash the laundry in the container so everything is clean.

How do you transport your dirty/clean laundry today? Forth and back from the laundry room to your house/apartment.

IKEA bag.

- *Why?*

The most simple solution since it is roomy and relatively ergonomic.

What aspects do you consider when choosing your transportation device? I.e what demands do you have on your transportation device?
A solution on wheels, although I don't fully believe in that. It would be cool with an automatic system that does the laundry for you.

Would you be prepared to use a single washing-machine at the same time as your neighbor?
Yes

- *If yes, why?*

It depends on who you share it with. As long as you don't have to touch other people's clothes. If the clothes doesn't get mixed up.

- *If not, what would motivate you to share a washing-machine with your neighbor?*

What would motivate you to use a washing room as a social place?
Remove the washing room from the basement. More lighting and something new and fresh. A smart booking system. Some activities, not only washing as the main reason to be there.

Interviewee 9

The purpose of the interview is to gain qualitative insight in what requirements and guidelines users might have on a transportation device designed for transportation and storage of laundry. The interview will take approximately five to ten minutes and will be documented simultaneously as the interview is ongoing.

Introduction questions

Age: **24**
Type of accommodation: **Apartment**
Number of people in your household: **1**
How often do you wash your clothes: **1-2 times per month**

Questions

How do you store your dirty laundry today?

In your house/apartment: ***Laundry bag in the closet***

In your Laundry room: ***IKEA bags***

- *Why?*

To conceal the laundry and keep everything in one place.

What aspects do you consider when choosing your laundry storage? I.e what demands do you have on your laundry storage?
No, but it would be nice to have the possibility to pre-sort.

How do you transport your dirty/clean laundry today? Forth and back from the laundry room to your house/apartment.

IKEA bags

- *Why?*

Convenient to carry a lot of laundry in.

What aspects do you consider when choosing your transportation device? I.e what demands do you have on your transportation device?
The laundry should not fall out. It should not be difficult to carry.

Would you be prepared to use a single washing-machine at the same time as your neighbor?
Yes

- *If yes, why?*

Easier to get a washing time, the laundry room becomes more of a social area. Nice for single households.

- *If not, what would motivate you to share a washing-machine with your neighbor?*

What would motivate you to use a washing room as a social place?
Get rid of the running back and forth to the laundry room. A place to sit and work or have a cup of coffee with the neighbors, like a café. Similar to a lounge area with couches and stuff. The social area doesn't have to be placed in the washing studio, it could be in the same room as the apartment lounge.

APPENDIX V

Wordclouds derived from the interviews, representing positive and negative aspects with the principle of shared washing and factors that would motivate users to use the laundry room as a social place.

Positive aspects

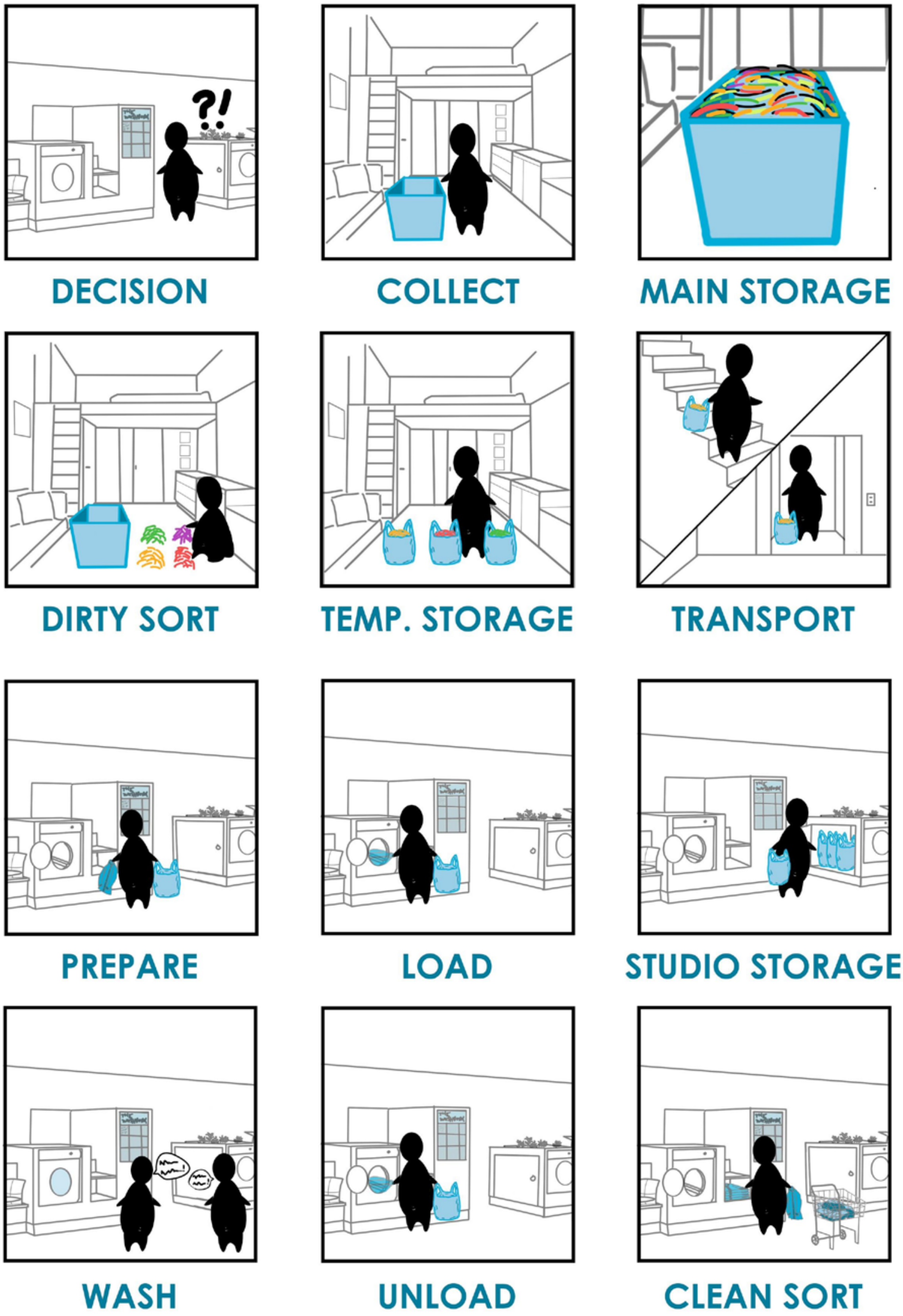
Neutral aspects

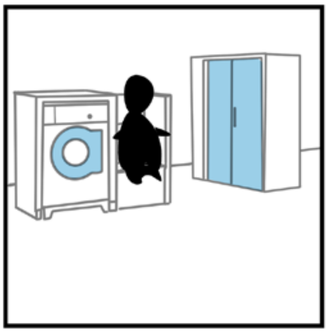
Negative aspects

Laundry room as a social place

APPENDIX VI

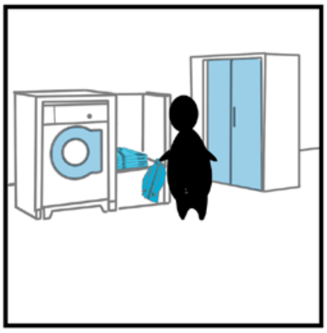
Customer journey of the current laundry cycle.



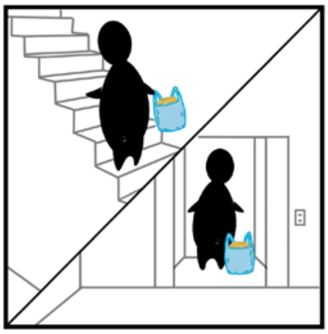


DRY

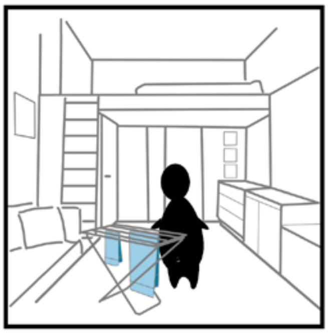
COLLECT



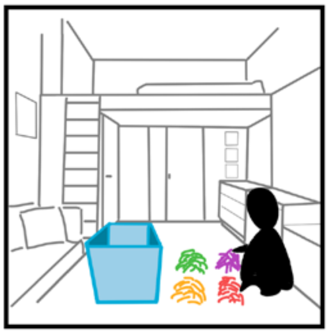
FOLD



TRANSPORT



DRY



DRY SORT

APPENDIX VII

Template used for the user profiles.

High extent

Low extent

	Categories	Degree of performance	Extent of importance of the product
Use experience	Length of use and education	Newcomer Experienced Specialist	Easy to understand and use
	Frequency of use	Rare Occasional Frequent	Ergonomics Stress factors
Influence on and responsibility of use	Influence on the choice of product	No influence Some influence Great influence	Adaptability
	Influence on the use situation	No influence Some influence Great influence	Physical ergonomics Confidence
	Responsibility in use	No responsibility Some responsibility Great responsibility	Reliability Confidence
Emotional relationship to the product	Ownership	Use of general product Use of rented product Use of owned product	Easy to use Characteristic Adaptability
	Social aspects	Of little importance Of some importance Of great importance	Aesthetics/sense Characteristic
	Mental influence of product	User with no mental influence User with some mental influence User with great mental influence	Semantics Aesthetics/sense
Degree of interaction with the product	Cognitive interaction	No cognitive interaction Some cognitive interaction Great cognitive interaction	Semantics
	Physical interaction	No physical interaction Some physical interaction Great physical interaction	Physical ergonomics

Results from the user profile.

Experienced User	Categories	Degree of performance	Important factor to consider
Use experience	Length of use and education	Experienced	
	Frequency of use	Frequent	Ergonomics and Stress factor
Influence on and responsibility of use	Influence on the choice of product	Great influence	
	Influence on the use situation	Great influence	
	Responsibility in use	Great responsibility	Reliability and Confidence
Emotional Relationship to the Product	Ownership	Use of owned product	Characteristics
	Social aspects	Of some importance	Aesthetics and Characteristics
Degree of Interaction with the product	Cognitive interaction	No cognitive interaction	
	Physical interaction	Great physical interaction	Physical ergonomics

Novice User	Categories	Degree of performance	Important factor to consider
Use experience	Length of use and education	Newcomer	
	Frequency of use	Occasional	Ergonomics and Stress factor
Influence on and responsibility of use	Influence on the choice of product	No influence	Adaptability
	Influence on the use situation	Great influence	
	Responsibility in use	Great responsibility	Reliability and Confidence
Emotional Relationship to the Product	Ownership	Use of rented product	Easy to use and Adaptability
	Social aspects	Of great importance	Aesthetics and Characteristics
Degree of Interaction with the product	Cognitive interaction	No to great cognitive interaction	If Great: Semantics
	Physical interaction	Great physical interaction	Physical ergonomics

APPENDIX VIII

The list of requirements, divided into demands and guidelines

Laundry cycle		Requirements & Guidelines		2016-03-08
Weight	D/G	Requirement area	Description	Other info
		Sustainability		
	D	Materials	No usage of materials according to the Electrolux Restricted Materials List v.15	
3	G	Recycling	Allow possibilities to disassemble the components with respect to materials	
3	G	Water	The solutions should strive to minimize resource usage by promoting sharing of washing machine	
		Properties		
	D	Life-span	Minimum life-span of 10 years	
	D	Weight	Maxiumum weight of 20 kg with laundry included	
	D	Strain	Allow sufficient forces to be applied without breackage	
	D	Material	The solution should be water-proof	
4	G	Part replacement	Possibilities to replace parts	
4	G	Time 1	A reasonably quick time-to-empty equal or better compared to existing	
4	G	Time 2	A reasonably quick time-to-fill equal or better compared to existing solutions	
4	G	Time 3	A reasonably quick time-to-sort equal or better compared to existing solutions	
2	G	Stability	The solution should offer structural integrity when used	
		Space		
4	G	Spacius 1	The solution should be space efficient when not used	
4	G	Spacius 2	The solution should be as slim as possible during storage	
4	G	Spacius 3	The solution should be as slim as possible during transportation	
5	G	Spacius 4	Min 3 kg of clothing capacity	
2	G	Spacius 5	Allow more than laundry to be carried (I.e. detergent, fabric-softener etc.)	
3	G	Spacius 6	Allow separate storage for sensitive clothes	
5	G	Spacius 7	The solution should be able to carry at least two machine-worth of clothing	
4	G	Spacius 8	The solution should utilize the maximal space of the washing-machine and dryer	
		Handling		
	D	Transport 1	The same solution should be applicable in both transport directions	
	D	Transport 2	The solution should be adapted to the space requirements driven by the building properties (e.g. stair, doorway and elevator measurements)	
	D	Transport 3	Wheelchair operateable	
5	G	Portability	Allow possibilities to be carried	
5	G	Sorting	Allow possibilities to pre-sort the laundry	
4	G	Handling 1	Easy access to ALL laundry stored	
5	G	Handling 2	The solution should be able to be operated with ONE hand	
5	G	Usage 1	Allow possibilities to be used in the different steps of the laundry cycle	
4	G	Usage 2	The solution should be as intuitive as possible	
4	G	Loading	The solution should be easy to load inside the washing-machine and dryer	
4	G	Unloading	The solution should be easy to unload from the washing-machine and dryer	
		Hygiene		
4	G	Hygiene 1	Allow possibilities to clean the transportation device	
5	G	Hygiene 2	Allow air-feed to the laundry	
5	G	Hygiene 3	The solution should not affect the laundry negatively (e.g. discoloration)	
		Visability/Privacy		
4	G	Visability 1	Allow possibilities to conceal laundry during storage	
4	G	Visability 2	Allow possibilities to conceal laundry during transportation	
3	G	Visability 3	Allow wrongly sorted items to be spotted	
3	G	Visability 4	Allow some visability to percieve the amount and type of laundry	
5	G	Privacy	The solution should allow other users to intearct with the solution without physically interacting with the laundry	
5	G	Seal	The solution should prevent laundry leakage during transportation and use	
		Society		
	D	General 1	The solution should not interfere with current laws and norms	
		Behaviour		
	D	Shared resource 1	Allow two or more users using the washing-machine at the same time	
2	G	Shared resource 2	Encurage users to percive laundry as a shared resource	
2	G	Social 1	The solution should attract users to spend time in the washing-studio	
1	G	Social 2	The solution should attract users to interact with neighbours	
		Aesthetics		
2	G	Expression 1	Allow a product expression that conforms to expression of the the living space	
3	G	Expression 2	Allow a product expression that conforms to the expression of Electrolux products	
3	G	Expression 3	Allow a product expression that conveys sustainability	
5	G	Expression 4	Allow users to distinguish their individual solution	
		Safety/Comfort		
	D	Ergonomics 1	The solution should not cause harm when handled	
3	G	Ergonomics 2	The solution should not evoke unnecessary effort during interaction	
5	G	Ergonomics 3	The solution should offer different ways of being handeled depending on user preferences	
3	G	Security	The solution should evoke a sense of security to the users	

APPENDIX IX

Weighting of the guidelines.

Weighting			
5	G	Spacius 3	Min 3 kg of clothing capacity
5	G	Spacius 6	The solution should be able to carry at least two machine-worth of clothing
5	G	Sorting	Allow possibilities to pre-sort the laundry
5	G	Usage	Allow possibilities to be used in the different steps of the laundry cycle
5	G	Hygiene 2	Allow air-feed to the laundry
5	G	Hygiene 3	The solution should not affect the laundry negatively (e.g. discoloration)
5	G	Privacy	The solution should allow other users to intearct with the solution without physically interacting with the laundry
5	G	Ergonomics 3	The solution should offer different ways of being handeled depending on user preferences
4	G	Time	A reasonably quick time-to-empty, time-to-fill and time-to-sort
4	G	Spacius 1	The solution should be space efficient when not used
4	G	Spacius 2	The solution should be as slim as possible during use
4	G	Portability	Allow possibilities to carry by grabbing
4	G	Handling 1	Easy access to ALL laundry stored
4	G	Hygiene 1	Allow possibilities to clean the transportation device
4	G	Visability 1	Allow possibilities to conceal laundry
4	G	Seal	The solution should prevent laundry leakage during transportation and use
4	G	Part replacement	Possibilities to replace parts
4	G	Handling 2	The solution should be able to be operated with ONE hand

APPENDIX X

Morphological chart divided into the subfunctions of collect, contain, transfer, open/close, sort, ventilation, conceal and grip.

APPENDIX XI

The three PICK charts with the IKEA-bag, illustrated as a blue box, and laundry basket, illustrated as an orange box, inserted as references.

Ideas for transportation

Ideas for storage

Ideas consisting of both transportation and storage

APPENDIX XII

The PUGH concept scoring matrix used to evaluate concept A-E.

Weighting				A	B	C	D	E
4	G	Time 1	A reasonably quick time-to-empty	2	1	5	3	4
4	G	Time 2	A reasonably quick time-to-fill	1	3	4	5	2
4	G	Spacius 1	The solution should be space efficient when not used	1	2	4	3	5
4	G	Spacius 2	The solution should be as slim as possible during storage	2	1	5	3	4
4	G	Spacius 3	The solution should be as slim as possible during transportation	4	2	5	1	3
4	G	Handling 1	Easy access to ALL laundry stored	3	1	4	2	5
4	G	Hygiene 1	Allow possibilities to clean the transportation device	4	5	2	3	1
4	G	Visability 1	Allow possibilities to conceal laundry during storage	4	5	2	3	1
4	G	Visability 2	Allow possibilities to conceal laundry during transportation	3	5	2	4	1
4	G	Part replacement	Possibilities to replace parts	1	2	4	3	5
4	G	Usage 2	The solution should be as intuitive as possible	1	3	5	2	4
4	G	Spacius 8	The solution should utilize the maximal space of the washing-machine and dryer	4	5	2	3	1
4	G	Loading	The solution should be easy to load inside the washing-machine and dryer	3	2	5	1	4
4	G	Unloading	The solution should be easy to unload inside from washing-machine and dryer	3	5	1	4	2
			SUM	36	42	50	40	42
			RANKING	4	2	1	3	2

APPENDIX XIII

The evaluation of Loop against the list of demands and guidelines.

Laundry cycle		Requirements & Guidelines		2016-05-20
Weight	D/G	Requirement area	Description	Other info
		Sustainability		
	D	Materials	No usage of materials according to the Electrolux Restricted Materials List v.15	Yes
		Properties		
	D	Life-span	Minimum life-span of 10 years	Test
	D	Weight	Maxiumum weight of 20 kg with laundry included	Yes
	D	Strain	Allow sufficient forces to be applied without breackage	Test
	D	Material	The solution should be water-proof	Yes
4	G	Part replacement	Possibilities to replace parts	Yes
4	G	Time 1	A reasonably quick time-to-empty equal or better compared to existing	Test
4	G	Time 2	A reasonably quick time-to-fill equal or better compared to existing solutions	Test
4	G	Time 3	A reasonably quick time-to-sort equal or better compared to existing solutions	Test
		Space		
4	G	Spacius 1	The solution should be space efficient when not used	Yes
4	G	Spacius 2	The solution should be as slim as possible during storage	Yes
4	G	Spacius 3	The solution should be as slim as possible during transportation	Yes
5	G	Spacius 4	Min 3 kg of clothing capacity	Yes
5	G	Spacius 7	The solution should be able to carry at least two machine-worth of clothing	Yes
4	G	Spacius 8	The solution should utilize the maximal space of the washing-machine and dryer	Yes
		Handling		
	D	Transport 1	The same solution should be applicable in both transport directions	Yes
	D	Transport 2	The solution should be adapted to the space requirements driven by the building properties (e.g. stair, doorway and elevator measurements)	Yes
	D	Transport 3	Wheelchair operateable	Yes
5	G	Portability	Allow possibilities to be carried	Yes
5	G	Sorting	Allow possibilities to pre-sort the laundry	Yes
4	G	Handling 1	Easy access to ALL laundry stored	Yes
5	G	Handling 2	The solution should be able to be operated with ONE hand	Yes
5	G	Usage 1	Allow possibilities to be used in the different steps of the laundry cycle	Yes
4	G	Usage 2	The solution should be as intuitive as possible	Test
4	G	Loading	The solution should be easy to load inside the washing-machine and dryer	Yes
4	G	Unloading	The solution should be easy to unload from the washing-machine and dryer	Yes
		Hygiene		
4	G	Hygiene 1	Allow possibilities to clean the transportation device	Yes
5	G	Hygiene 2	Allow air-feed to the laundry	Yes
5	G	Hygiene 3	The solution should not affect the laundry negatively (e.g. discoloration)	Test
		Visability/Privacy		
4	G	Visability 1	Allow possibilities to conceal laundry during storage	Test
4	G	Visability 2	Allow possibilities to conceal laundry during transportation	Test
5	G	Privacy	The solution should allow other users to interact with the solution without physically interacting with the laundry	Yes
5	G	Seal	The solution should prevent laundry leakage during transportation and use	Yes
		Society		
	D	General 1	The solution should not interfere with current laws and norms	Yes
		Behaviour		
	D	Shared resource 1	Allow two or more users using the washing-machine at the same time	Yes
		Aesthetics		
5	G	Expression 4	Allow users to distinguish their individual solution	Yes
		Safety/Comfort		
	D	Ergonomics 1	The solution should not cause harm when handled	Yes
5	G	Ergonomics 3	The solution should offer different ways of being handeled depending on user preferences	Yes

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