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Improving environmental sustainability in use phase of product lifecycle
Case: Reima Oy

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Abstract

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Reima Oy is a Finnish clothing brand that produces functional casualwear and outerwear for 0-12 years-old active children. The aim of this thesis is to provide suggestions for Reima Oy on how to improve the sustainability of the garment use phase and how to engage customers more to sustainability.

Based on 93 responses, the profile of Reima customers' laundry behaviour was formed and it was used as a base for further calculations. Data was collected with a constructed, quantitative consumer survey from Reima Club members from Europe. Additional information was collected as a desktop study. The results were used for Material Input per Service (MIPS) calculations to measure the environmental sustainability of the washing and drying stages of the use phase in the garment lifecycle. MIPS measures the material flow, and in this research the material flow of machine washing per load and per one season. Four different scenarios were formed with the assumed improvements in laundry habits. The results of the scenarios were compared to survey based calculations to find out how the changes in set affected.

Data for the research was collected from Reima Club members about the laundering of children's outerwear in the autumn-winter season (October-February). In addition to laundry behaviour, respondents were asked how they feel about second hand and repairing services if Reima were to offer them.

The outcomes of this thesis are a theoretical base that includes the garment lifecycle, user and laundry behaviour, tools to measure environmental sustainability and sustainability communication. In addition, the visualized survey results and material Input calculations are among the outcomes. As a result, the laundry profile of typical European Reima customer was identified and was used as a base for suggestions. According to calculations, the biggest change could be achieved by decreasing the amounts of loads per season.

Key words

Garment life cycle, life cycle assessment, laundry behaviour, use phase, MIPS

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1 Introduction

The apparel industry is one of the most polluting industries in the world. It represents alone 6.7 % of greenhouse gas emissions (GHG) globally (Quantis 2018). To stop global warming in 2 Celsius degrees and reaching zero GHG emissions, the industry needs big changes from fashion producers, but also from the consumers. Because producing raw materials impacts the environment the most during product life cycle, garments should stay as long as possible in use (Mikkonen 2019). The consumer has a remarkable role; in decision making where to buy, what to buy and how to dispose the garments, but also their role as a user and a caretaker of the clothes. Clothing is essential part of everyday life and most of the people wash their laundry weekly, if not daily. Use phase of the garment caused around a third of its carbon emissions during its lifecycle in UK in 2016 according to The Waste and Resources Action Programme (WRAP) (2017, 13). Fashion and clothing companies have slowly started to publish the data about their processes and operations. In the media the focus has mainly been on companies' responsibilities, but in practise it is shared with the company and the garment user. Consumer's part, what happens after the purchase, has mostly stayed in the shadows so far. The laundry is not one of the hot topics at the moment, even though it has an essential impact on households' environmental sustainability.

Reima Oy, a Finnish children's functional wear brand, wants to engage the customers more to sustainability (Mahmood 30 March 2020). This research will form the base for developing the sustainability of the Reima's garments use phase. Data about consumers' laundry habits with children's outerwear during autumn-winter season was collected from European Reima Club members with a survey, and the results formed a base for Material Input per Service (MIPS) calculations to measure the environmental sustainability. MIPS was also used for comparing the different scenarios of assumed better practises. In addition to laundry behaviour, the Reima Club members were asked about the feelings towards second hand and repairing services provided by Reima.

The first chapter includes the background information and the research problem. Report continues with the demarcation, international aspect, benefits for shareholder groups, key concepts and Reima company presentation including their sustainability priorities. Chapter two includes the theory basis for garment life cycle, measuring the environmental impact and briefly about sustainability communication related to engaging the customers. In the third chapter the focus is on selected methods and the data analysis. The survey process with the results are reported, as well as the calculations with comparative scenarios. The fourth chapter includes the final conclusions and the suggestions for Reima Oy.

1.1 Background

The fashion and clothing industry has faced extremely difficult times because of COVID-19 pandemic during 2020, and it has impacted on consumers' attitudes towards clothing purchases (Berg, Haug, Hedrich & Magnus 2020, 3). The pandemic has forced many companies to re-think its business models and products to stay alive, but on the other hand, the sustainable business practices can reveal new business ideas and revenue streams but also reduce the risks in the long run (Danziger 2020). According to recent study, 16 percent of consumers in Europe said they will buy more socially and ecologically sustainable clothing in the future (Berg, Haug, Hedrich & Magnus 2020, 12). Another study showed, that 65 percent of the consumers are planning to purchase more durable fashion items, and 71 percent are planning to keep the items they already have for longer (Granskog, Lee, Sawers & Magnus 2020). The consuming habits have showed signs of change and the consumer awareness is slowly increasing, but by focusing the garment maintenance, lengthening the product life cycle can be started right away.

Topic of the thesis was selected due to both parties' interest. Reima has been focusing on product life cycle, but so far other areas than the use phase (Mahmood 30 March 2020). This research supplements their work. This area interests me, because my background is in textile and clothing industry, and there I have gained the knowledge about the garment lifecycle and textile materials. I prefer durable and high quality materials personally in clothing, and I want to take good care of my clothes to maximize their life time in my wardrobe. I would like to share the awareness about the importance of garment maintenance for others and increase the respect for natural resources. Sustainability communication interests me, because it is the tool for more sustainable world: with its help the knowledge of more sustainable practises and the environmental impacts can be spread. The topic interests me also because it is practical; small daily acts to make a change for everybody, but also an interesting area for companies to take care the end of product life cycle and develop their business.

1.2 Research question

This thesis aims to create a base for developing the sustainability of the Reima outerwear use phase. It was examined and analysed, how the consumers wash and dry children's outerwear during autumn-winter season, and how they could improve it from environmental sustainability point of view. In addition to assess critically the data sources and the measuring tool, as well as give Reima suggestions how they could develop the environmental sustainability in the end of product life cycle in the use phase.

Research question (RQ) is how Reima Oy could have an impact on the end of product life cycle and improve their products' environmental sustainability. To find a problem for this problem, three investigative questions (IQ) needed to be solved first:

RQ: How Reima Oy could have an impact on the end of product life cycle and improve their products' environmental sustainability?
IQ1: What aspects are included in environmental sustainability of use phase and how to measure it?
IQ2: How consumers wash Reima outerwear and how they feel about services Reima could offer to extend the product life cycle?
IQ3: How Reima's customers could change their laundry habits and decrease environmental impact, and how Reima could help them?

The outcomes of the first investigative question are the understanding of the role of use phase and its impact on garment life cycle and to introduction to the MIPS calculation method (table 1). After the second phase, investigative question number two, the survey results and MIPS calculations are the end result. After answering the third questions about how the customers could change their laundry habits, the conclusions of the research results, the comparative scenarios with MIPS calculations and the suggestions for Reima Oy are the outcomes.

This increases awareness of use phase impacts internally in Reima, but also gives an additional tool for sustainability development in the future. Results of the survey with the analysis and MIPS comparison calculations, expand the knowledge how customers around Europe do children's outerwear laundry, and helps to invent more specific solutions for different customer groups and new business models. Given suggestions based on this research will help Reima in the development of more sustainable practises in the future and to engage the customers in the use phase.

1.3 Research methods

This research is combining quantitative and desktop research methods. External desktop study was made to build up the theoretical framework about garment life cycle and the assessment methods of environmental sustainability. By selecting multiple international sources, the diversity and the reliability of the data were provided. To collect the background data about commissioning company and company's needs, the information was collected as an internal desktop research. Research & Development and Sustainability Director and Sustainability Specialist from Reima were interviewed to collect the background information. (Table 1)

For assessing Reima's customers' laundry behaviour with children's outerwear, the data for calculations was collected with a quantitative structured survey and from the desktop research. Saunders, Lewis and Thornhill (2016, 166) describe the quantitative research method as followed: "Quantitative research examines relationships between the variables, which are measured numerically and analysed using a range of statistical and graphical techniques." Quantitative research was a suitable method, because the large sample gives more reliable result, but also because with this method the topic is more separate from the researcher than with qualitative research. Also the results can be considered to be more reliable. (Hirsjärvi & Hurme 2015, 23.) Additional reasons are that quantitative method is based on numerical information that was needed in calculations (Hirsjärvi & Hurme 2015, 24), and the survey was quick way to gather information internationally. Survey was structured because certain specific data was needed for further calculations. Desktop study method was combined with the survey information because of reliability; for example, the washing machine energy consumption data is more reliable from the governmental source. MIPS calculations summarized quantitative survey responses.

Table 1. Overlay matrix of investigative questions

RQ: How Reima Oy could have an impact on the end of product life cycle and improve the products' environmental sustainability?				
	Theoretical framework	**Methods**	**Outcomes**	**Chapter**
IQ1: What is garment life cycle and what is the role of use phase in its sustainability? How to measure it?	Garment lifecycle, garment lifetime, material impact, user and laundry behaviour, lifecycle assessment, MIPS and other assessment methods	Desktop research about industry specific information and MIPS calculation	Understanding of the role of use phase and its impact on garment life cycle, introduction to MIPS method	2.1, 2.2, 2.3
IQ2: How consumers wash Reima outerwear and how they feel about services Reima could offer to extend the product life cycle?		Quantitative survey for consumers, analysis of the results in Excel	Survey results, statistically analysed data about customers' laundry behaviour and attitudes towards new business models, customer laundry behaviour presented with MIPS calculations	3.2.4
IQ3: How Reima's customers could change their laundry habits and decrease environmental impact, and how Reima could help them?	User and laundry behaviour, sustainability communication	MIPS calculations based on quantitative data and comparative scenario calculations in Excel	Conclusions of research results, comparative scenarios with MIPS calculations, suggestions for Reima Oy	3.3.7, 4.1, 4.2

1.4 Demarcation

The focus of this thesis is the use phase of the garment life cycle and household laundry particularly. This research focuses on the washing and drying stages of use phase especially, because for these phases the consumer has the significant control and they are clearly measurable.

The product group is Reima children's outerwear for autumn-winter season which in this study is considered to be from October to February. Reima has a long history especially in outerwear and they are famous for durable, high-quality products worldwide. In this study autumn-winter season is considered as from October to February. Taken into consideration the different weather conditions in different parts of Europe and the most likely months for children to wear overalls and other full coverage outerwear with technical features. Autumn and winter season were reviewed as combined because the outerwear during that time is relatively similar and the length of the winter is different in different countries but also the length of winter is unstable. In the Northern Hemisphere autumn is considered to begin from equinoxes, days that have equal amounts of daylight and darkness, and winter begins on winter solstice in December, when is the day of the year with the shortest period of daylight (National Geographic 2020).

Ironing is part of use phase but is excluded in this research due to the lack of need with outerwear. Repairing is excluded from the calculations due to its diversity and challenges to measure. Although the repairing services are included in the second part of the survey, because the repairing is related to product lifecycle and lengthening it, and this study offered a good opportunity to explore its possibilities one step further in smaller scale. Transportations in use phase (e.g. to customer from the store and from customer to end-destination) as well as after use actions like disposal, recycling as fabric or as fibres, are excluded.

When the consumers' behaviour and the attitudes were in focus, the survey was the most suitable method to collect information. Data research and the calculations to measure the environmental impacts supports the survey, and give the new perspectives for the study.

Consumer survey was targeted to the Reima Club members, because they already have a relationship to Reima and engagement, and it was assumed that most likely they have some experience of Reima outerwear. With this targeting the research may produce accurate results of their customers' laundry behaviour for Reima. The aim of this thesis is to research the laundry behaviour of the customers in Europe, and by targeting the survey to Reima Club members the location of the respondents can be limited carefully and precisely.

Circular economy as a concept is excluded, but it is related to material selection and durability as well as in garment use time. Circular model in fashion and clothing industry is defined more detailed in chapter 2.1 Garment life cycle.

1.5 International aspect

Reima Oy is an international company because of its global production and export. Reima produces most of their products in China and also in Vietnam, India, Sri Lanka, Taiwan, Italy and Finland (Reima 2020m). More than 80 percent of Reima's revenue comes from export to over 70 countries. Biggest export country is Russia, and after that Scandinavia and China. (Reima 2020c.)

In the thesis international sources have been used to form a comprehensive basis for the research. Customer survey of this research was published in Reima Club with members worldwide and respondents from 13 countries were represented.

1.6 Benefits

Topic and the type of this research was selected to create a benefit for wider group of stakeholders (table 2). It will benefit Reima by offering insights about their products' effects in use phase and in the end of the product life cycle as well as increasing the awareness internally about laundering phase of the products. Research will help them to develop further their sustainability goals and it engages the customers more to sustainability.

With this research the awareness of ways to effect on use phase will be spread among Reima customers, but also among Haaga-Helia University of Applied Sciences students and staff. Research will gain knowledge about the clothing industry's environmental challenges in general and increase the knowledge about measuring the environmental sustainability. Additionally, this study will popularise Haaga-Helia's sustainability studies.

For the author this research will expand the knowledge base about environmental calculations and effects of apparel use phase. Gaining experience about evaluating available data from the field, is important for the future career in sustainability field. This research will give more experience in survey creation and analysis of the data and will move forward in general in the path of becoming sustainability professional.

Table 2. Benefits for stakeholder groups

<table>
<tr><th colspan="2">BENEFITS</th></tr>
<tr><td>Reima Oy</td><td>Industry and my field of specialization Supply Chain Management</td></tr>
<tr><td>Insights about their products' effects in use phase and in the end of the product life cycle
Increase awareness internally about laundering stage of the products
Developing further their sustainability goals
Suggestions to develop their business and engage customers to sustainability</td><td>Spreading the knowledge in general about fashion industry's use phase and its environmental impacts
Increase knowledge about assessment tools for clothing industry
Insight how to develop the end of product life cycle together with the customers</td></tr>
<tr><td>Haaga-Helia UAS</td><td>Author</td></tr>
<tr><td>Increase the awareness of consumers' responsibility with clothing
Gain knowledge about clothing industry's environmental challenges
Increase the knowledge about assessing environmental sustainability
Popularise Haaga-Helia's sustainability studies</td><td>Deepen the knowledge about environmental footprint calculations and effects of apparel use phase
Evaluating available data in the field
Gaining more experience in survey creation and analysing the data
Move forward in general in the path of becoming sustainability professional</td></tr>
</table>

1.7 Key concepts

In this chapter the key concepts of this thesis are defined.

Sustainable development occurs when the needs of present is combined with the ability of future generations without compromises (United Nations 2020). The main goal of sustainable development is the long-term stability of the economy and environment, and it can be achieved by the integration and acknowledging the economic, environmental, and social concerns (Emas 2015, 2).

Ecological Footprint measures the demand on and supply of nature in other words, it measures how fast certain group of people consume and generate waste. (Global Footprint Network 2020a.) It is the total surface area of biologically productive land and amount of water needed to produce all the goods and energy, and needed to decompose or compensate the produced waste (Sustainable Footprint 2020). With current lifestyles, we are overusing the Earth's bio capacity by at least 56 per cent (WWF 2020). **Footprints**, in environmental context, describe in general the marks we leave behind; mostly they vanish immediately, but some will stay for a short or long period of time (Sustainable Footprint 2020).

Product lifecycle, considered in this research as **a garment life cycle***,* is a journey of a product, consisting raw material extraction, manufacturing and processing, transportation (this can be included in all the stages), use phase and retail and waste disposal. (Liebsch 2020.) Garment's phases typically are fibre production, fabric production, garment manufacturing, transportation and distribution, use phase and recycling/waste. Product life cycle is also referred to *cradle-to-grave*, see below.

Life Cycle Assessment (LCA) provides a framework for measuring, for example product's, impact to the world around it. Its goal is to collect and create data, but more importantly to facilitate the decisions, for example to develop a product more sustainable. LCA is a very specific analysis and it builds a base for any sustainability strategy. (Liebsch 2020.) LCA has been standardized with ISO 14040 and ISO 14044 (Guinée & al. 2011). LCA is explained in more detailed in chapter 2.3.1.

The use phase is the part of garment lifecycle that starts when the consumer takes the garment to her home and ends when she disposes the item or takes it to recycling. Use phase involves washing, drying, ironing, repairing and using the garment.

Cradle-to-grave is a concept, where the *cradle* means the beginning, the raw materials to produce a product, and *the grave* means the disposal of the product (Liebsch 2020). Cradle-to-grave is a model to describe a life cycle of a product. It is often referred as a linear model.

Cradle-to-cradle is a variation of *cradle-to-grave*, but in this concept 'recycling' replaces the 'disposal' and the materials become another product. This concept is also referred to *closed loop process* and *circular economy*. (Liebsch 2020.)

Circular economy is an economic model where the focus is on using services, like sharing, renting and recycling, instead of producing constantly more goods and owning. Materials are circulating as long as possible in new products after the life of previous form has come to an end. (Sitra 2020a.) Circular economy business models can be used for example to shorten production chains, extend the life cycle of products, reduce the amount of waste and create sustainable economic growth and jobs (Lehtinen, Leppänen & Hughes 2020).

Closed loop model is a process, where the material of used item is collected and turned into new item without waste. This model saves resources, energy and water, but using closed loop it needs to be taken involved in early design stage. This model takes into account the materials, processing into recycled fibre, new manufacturing techniques and suitable system-based collection for material. Model is about multiplying the reuse through the 'loop' and minimizing the waste as near zero as possible. Opposite is 'open loop' where new virgin material is needed to make a new item. (Ellen Macarthur Foundation 2011.)

Material Input per Service (MIPS) value expresses how much natural resources have been used for certain product or service compared to benefit. MIPS calculations can be used as a tool for companies to measure the environmental aspects during the whole life cycle of a product or service. Main goal of MIPS is to decrease the material flows. (Ritthoff, Rohn, Liedtke & Merten 2004, 9.)

Greenhouse effect means the warming of the planet's surface, when concentrations of *greenhouse gases (GHG)*, like carbon dioxide, methane and nitrous oxide concentrate and trap radiation from the sun. More warming occurs because of greenhouse gases than would happen naturally. Most of the gases is carbon dioxide (76 %), that is caused by fossil fuels, industrial processes, forestry and other land use. (U.S. Energy Information Administration 2020, United States Environmental Protection Agency EPA 2020.) Process is also known as *global warming*.

Carbon neutrality is an economic system that produces emissions as near zero as possible, and compensates the rest to achieve neutrality. This system has been adapted to the earth's carrying capacity and the planetary boundaries. (Sitra 2020b.)

1.8 Reima Oy

In this chapter the commissioning company Reima Oy will be presented. After a general information, the chapter continues to Reima's sustainability goals in materials and the development of 100 % recyclable products, lengthening the product life cycle and Reima Kit service.

1.8.1 General information about Reima Oy

Reima Oy is founded in 1944 in Finland and the headquarters is in Vantaa. Reima produces functional casualwear and outerwear for 0-12 years-old active children. Company has a long history and since 1950s they have developed durable outdoor materials for children. During the years they have produced also clothing for youth and adults but in 2000s have concentrated on children's wear. (Reima 2020a.) Their most famous winter overall is Stavanger (picture 1) that has won unbiased 'Bäst-in-Test' in Norway and Denmark in 2020 where the jury rated it as a best snow overall (Reima 2020b).

Reima's revenue in 2018 was around 124 million euros and since 2012 the growth has been two-numbered. More than 80 percent of net revenue is exports and it includes over 70 countries. Biggest export areas in order are Russia, Scandinavia and China. (Reima 2020c.) Elina Björklund has been working as CEO since 2012 (Miltton 2012). The majority of the shares are

Picture 1. Reima's winter overall Stavanger ©Reima 2020

owned by an international investment company Riverside Company. There are around 132 employees in Finland and additionally around 150 employees worldwide. (Reima 2020d.)

1.8.2 Sustainability of Reima from use phase perspective

At Reima there are many projects in progress towards more sustainable practises. By 2023, Reima's goal is to be carbon neutral in all their operations worldwide (Reima 2020e, 7), which means that all carbon emissions of their operations cause will be balanced by funding an equivalent amount of carbon savings elsewhere in the world (Carbon Footprint 2020).

Reima has been developing durable materials for decades (Reima 2020a). At the moment one area the company focuses is the garment lifecycle; measuring the footprints of manufacturing and transportation (Mahmood 30 March 2020). Reima wants to be responsible with active and transparent communication, and they want to offer consumers information that helps them to sustainably use and care for their products (Reima 2020f). They have been questioning if the gear need to be new every season and what happens when the garment has come to an end. Their goal is to keep the clothes in use as long as possible and they have been developed lately the recyclability in addition to durable materials. (Reima 2020e, 23.)

Developing recyclability

Reima's (2020g) aim is that the durable synthetic fibres would be recycled as many times as possible into new products before finally the fibres are destroyed. Reima's sustainability goals for 2023 is to have 20 % of clothing recyclable and to have recycled polyester at least 50 % of the polyester they use (Reima 2020e, 6). At the moment they have at least 70 % of the wadding recycled (Reima 2020o). Reima is working to improve the recyclability through design (Reima 2020h), but also through participation in the EU's Trash-2-Cash research project to identify new recycling opportunities. So far they have got several recyclable product ideas, like rain wear, fleece made of cellulosic fibres, stretch jeans without elastane fibre. (Reima 2020g.) Two first products have seen the daylight this year: Voyager spring jacket and Kulkija winter jacket, made of just one material (100% polyester) (Reima 2020i, 2020j). Garments can be recycled as a new fibre easily after use without time-consuming material separation. With the registration the path of the jacket can be followed from one owner to another and in the end of its use time Reima will take the jacket back and turn it into new material for future products (Reima 2020j).

Lengthening the life cycle with less washing and repairing

One of Reima's key objectives in product development is to reduce the need for washing. They are trying to tackle this by improving dirt and water resistance. All their outdoor clothing has been treated to be dirt-resistant entirely without fluorocarbons. Reima is looking for more environmental friendly materials and finishing constantly. (Reima 2020g.) To lengthen the life cycle of outerwear they have in their selection a repair kit including the most common spare parts, as well as a popup service for in-store repairs (Reima 2020k).

Reima Kit service

They have a collaboration with the second hand online store Emmy regarding Reima Kit service in Finland. Reima Kit is a service, where the customer can order a complete curated set for a child for next season. With all the deliveries they send a bag where the clothes can be shipped to Emmy for re-sale after the use, and give an account for the customer. (Reima 2020l.)

2 Sustainability from designer's pen to customer communication

All the phases of the garment life cycle have negative environmental impacts, and the manufacturer is responsible for them from the raw material farming or creation until the minute the piece of clothing has been delivered to the customer. After that the customer takes care of laundry, repairing and the disposal or recycling. Additionally, the time the garment is in use is significant, because the longer it is in use, more efficiently the used natural resources have been used.

In this chapter the life cycle of garment will be clarified step-by-step with their main environmental impacts, but the main focus in this research is in the use phase. Also the length of garment use time and previous studies about sustainability measuring in fashion and clothing industry are discussed. Tool of this study, the Material Input per Service calculation, is looked closer but also LCA in general is presented, as well as carbon footprint and Product environmental footprint (PEF) as other tools.

It is important nowadays for companies and organizations to communicate internally as well as externally about their sustainability and how they measure it. In the last subchapter the sustainability communication will be defined.

2.1 Garment life cycle

Garment life cycle includes all the stages in garment's life from raw material production until the disposal or recycling the garment (figure 1). Linear model (also known as *cradle-to-grave*), where the product is made of new material and is disposed after the use, is commonly used in fashion and clothing industry.

Linear model is problematic, because it demands a lot of resources and has harmful impacts for environment and people. Material production needs raw material itself, but developing it into textile consumes resources significantly. For example, non-renewable oil is used to produce synthetic materials, fertilizers for cotton growth and enormous amounts of toxic chemicals for producing, dyeing and finishing the fabrics (Ellen MacArthur Foundation 2020, 38). Textile production, including cotton farming, uses around 93 cubic metres of water annually from scratch to ready garment, which is equivalent to 4 % of global fresh water withdrawal (Ellen MacArthur Foundation 2020, 38). All the stages of garment life cycle build up greenhouse gases. The major greenhouses gases are carbon dioxide (76 % when fossil fuels, industrial processes, forestry and other land use combined), methane

(16 %) and nitrous oxide (6 %) (United States Environmental Protection Agency EPA 2020).

Option for linear model is circular (closed-loop) model that's aim is to extend the use-time of garments and maintain the material and garment value as long as possible (Niinimäki 2018, 17). The difference to linear model is that with that model, the manufacturing raw material and manufacturing the textile phases are excluded due to already existing material. In circular model the garment doesn't go to disposal because the materials are collected and re-used or recycled as a fibre after the garment has come to its end with the user.

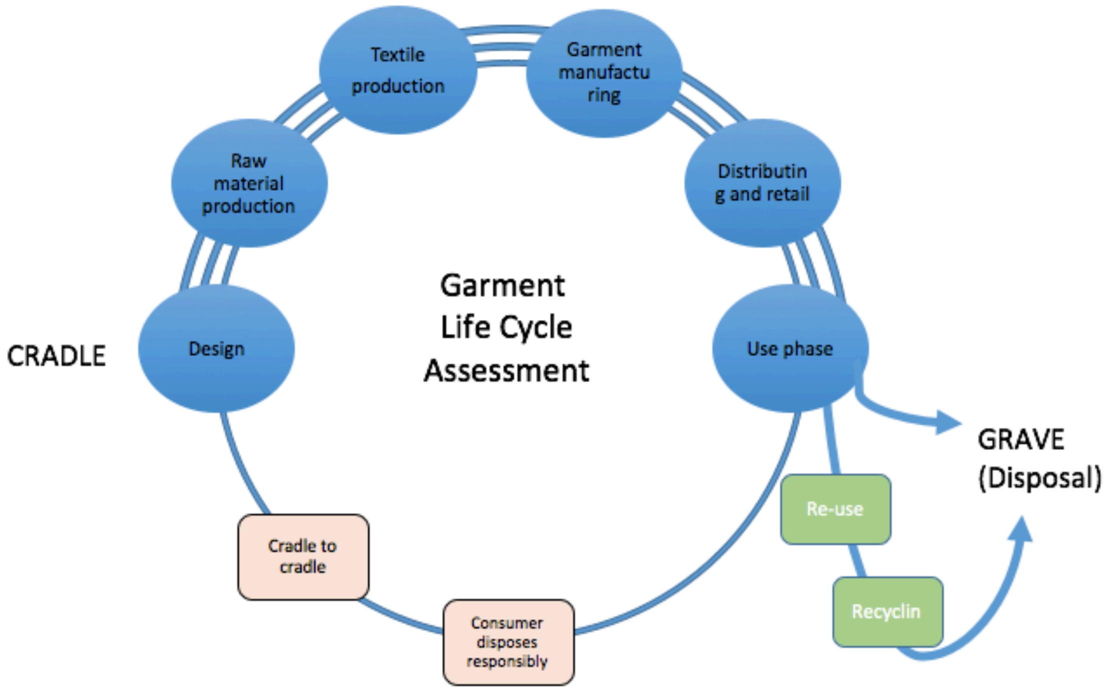

Figure 1. Garment life cycle assessment with cradle-to-grave and cradle-to-cradle models (adapted from Payne 2011, 3)

Design

In the design phase the decisions about the garment style, material and additional accessories, and maintenance are made. WRAP's guide 'Design for Longevity Guidance on increasing the active life of clothing' (Cooper, Hill, Kininmonth, Townsend & Hughes 2013) states following: "The best opportunity within the clothing lifecycle to increase longevity is at the product design stage, where changes to design practices can have a significant impact on how long individual items remain wearable. The fundamental reason for consumers to discard clothing is that it no longer looks good – which is an issue the designers can directly influence."

There are several demands for the designers that need to take into consideration while developing design ideas, called as design brief: meet consumer's needs, meet market trends, represent the brand's vision, work in relation to body, considers target market, occasion, season or function, work in relation to fabric selection, stay in budget and required resources are accessible (Qwilt & Rissanen 2012, 63). Design may support the long life time by timeless style and colours.

Material determines the environmental impact of material production, and textile made of high quality fibres, that can carry several recycling rounds later on. Kirsi Niinimäki states in her book 'Sustainable Fashion in a Circular Economy' (2018, 17) about the design phase in circular business model: "-- Products are designed to be included in a system where all aspects support circularity. The original design needs to take account of several lifecycles. Materials need to flow within the system and waste needs to be collected and appreciated as a valuable material for recycling and material recovering". The recyclability is determined in this early stage, as well as the possibilities to maintain and care the garment in a sustainable way from environmental point of view. Material determines how much the maintenance needs resources like energy, water and chemicals. Material determines the need for example for washing, ironing and drying. Durable materials with the quality craftsmanship make the garment to last long in the use.

Design should meet the environmental sustainability issues, and according to Qwilt and Rissanen (2012, 18-20) there are three ways how to reach it: by providing the designer an understanding of sustainable design strategies, the designer links the strategies within their own design practice and production process and by applying the lifecycle thinking in design brief.

Raw material production

Synthetic fibres are the most common materials in outerwear due to the weather profess. Creation of synthetic fibre needs a lot of water, energy and other resources for the production. To mention few fibres, 1 kg of polyester fibres needs 97.4 mega joule (MJ) of energy and 17.2 kg of water. It causes 2.3 kg of CO_2, 18.2 g of carbon monoxide, 39.5 g of methane emissions to air and 3.2 g of water emissions. To produce same amount of polyamide 66 takes 138.62 MJ of energy and 663 kg of water. (Muthu 2015, 125.) For comparison cotton farming to produce 1 kg of cotton takes 10 000 litres of water that equals to 10 000 kg (The World Counts 2020).

Textile production

After having the raw material ready, depending on the material, spinning, fabric manufacturing, dyeing and finishing are the following phases before sewing ready garments. These stages need sources like water, energy, dyes and chemicals (Muthu 2015, 125), for example dyeing can demand up to 150 litres of water per kilogram of fabric (Šajn, N. 2019, 4). In the fashion industry over 1 900 chemicals are used in the production of clothing and 165 of them are classified as hazardous to health or the environment. Most of the textile production takes place in developing countries, and a big problem is that there the environmental legislation is not as strict as in the EU so the wastewater is often poured into waterways as unfiltered and it causing serious problems for nature, humans and animals. (Šajn, N. 2019, 4.)

Ways to improve above environmental issues are for example replacing chemicals with enzymes, using the dye controllers and the dyeing machinery, that require less water and the new dyeing processes, such as replace water as the dyeing medium with CO2 (Šajn, N. 2019, 4).

Garment manufacturing

Garment manufacturing consumes large amount of energy for sewing but also for especially in outerwear for gluing, welding and seam taping equipment. 20 % of the fashion industry's fabric waste comes from the leftover material in cutting stage. These issues have been started to tackle with different cuts, computer controlled tools for pattern making to use more of the fabric with less cut-off waste, garments with fewer seams, bonding or gluing instead of sewing. (Šajn, N. 2019, 4.)

Distribution and retail

Distribution means the transportation from the manufacturer to the warehouse in brand’s home country, often from developing counties to EU, and later distribution shipping to the customer after purchasing the product. The goods can be transported by road, rail, water, air or combination of these, and the amount of emissions depend on the chosen transportation mode. This phase accounts for only 2 % of the climate-change impacts of the fashion industry, as the big fashion brands have optimised the flow of goods. However, this phase causes a lot of waste through packaging, tags, hangers and plastic bags. (Šajn, N. 2019, 4.)

In the retail the garment is warehoused and sold from there to the customer in online store or in brick-and-mortal. Garments waiting to be sold in the warehouse or store consume energy. Also products that never reach consumers as the unsold are leftovers and eventually are disposed (Šajn, N. 2019, 4).

Use phase

Use phase of the product lifecycle includes transportation of the garment to the customer, use time, laundry (including washing, drying, ironing), repairing, and transportation to recycling or to disposal (figure 2). Depending on the transportation mode and the distance it causes emission in the beginning of use phase as well in the end. Use time or wearing tells the time when the garment is owned by consumer and longer the use time, better used manufacturing resources. Laundering needs energy, water and chemicals and drying and ironing energy. Repairing causes emissions via spare parts and energy if done with the machines, but it lengthens the life time as whole. In reselling the environmental impacts are cased via transportation. Recycling and disposal cause emission depending on the needed processes and they often need transportation as well.

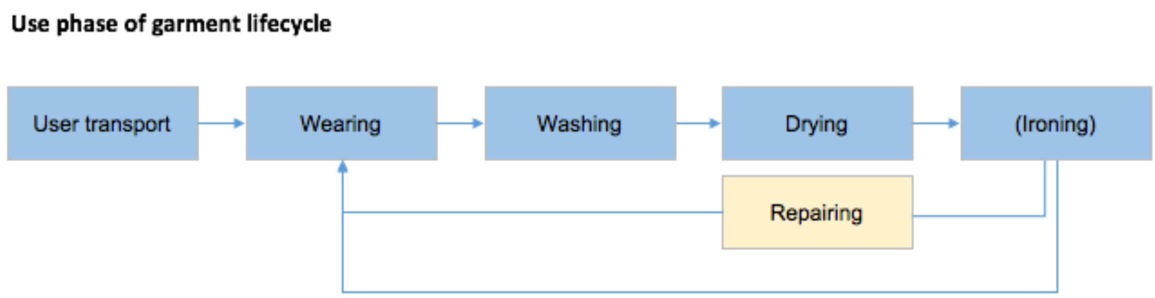

Figure 2. Use phase process flowchart (adapted from Sandin & Roos & Spak & Zamani & Peters 2019, 31)

Disposal, re-use and recycling

In linear model and cradle-to-grave, the garment goes to disposal after use (figure 1). Second option is to lengthen the life cycle by recycling the garment into the fibre or re-using the garment as textile material as it exists, for example remodel or use textile for other purpose. Pure Waste is a Finnish company, that turns the post-consumer waste and cut-off waste from fashion industry in their own factory into fibres and produces new fabric and products. Pure Waste says, the consumer waste varies a lot in quality, and usually the quality is so poor that it can be recycled barely once. They find important to increase the quality so that the fibres could be used 2-3 times easily. (Hakola 2019.) According to Pure Waste, fashion industry in general is not interested at all to improve this (Nurmi 2017).

Used fibre and fabric type of a garment has a big impact for sustainability during its life cycle in manufacturing phase. The most commonly used textile fibres in clothing purchased new in European Union in 2015 were cotton (43 %) and polyester (16 %) (Statista 2020). Biggest problems in synthetic fibres are unrenewable oil, that is needed for synthetic fibre production, and in use phase that the micro plastic is released to the nature (chapter 2.1.2 Micro plastics). However, the synthetic fibres are more durable than natural fibres and offer better protect from the wind, the rain and the snow.

2.1.1 Garment lifespan

According to research by Kaitala and Klepp (2015) in Norway, the total average lifespan of the garment is 5.4 years. However, WRAP (2020) in United Kingdom has estimated it is around 2.2 years. In Finland the use time of adult's outerwear is 7.5 years and t-shirt 4.5 years (Suomen Ympäristökeskus 2015). Children's under 12 years, the average lifespan of clothing is around 4,2 years (Laitala & Klepp 2015). Consumers value the quality but often they do not know how to measure it; according to WRAP (2012, 24) only a third 'usually' examines the seams and stitching before making a purchasing decision.

Clothing is discarded for several reasons. In Finland clearly most significant reasons to get rid of clothes are wrong size and broken (Aalto 2014). Common reason is that the body has changed and the garment does not fit anymore. Second option often is that the fabric appears worn, has been torn, stained, faded or damaged other way. Additional components, like zippers, buttons or elastic bands, may have broken or buttons been lost. User's style might have been changed or the garment does not look appealing anymore in the middle of today's trendy pieces. In children clothing the most common reason for disposing is that the child has outgrown the garment; children are expected to grow 6-7cm per year, which affects sizing and fit. Clothing often gets dirty in kids' play and their clothes require a frequent laundering. Repeated washing and drying may decrease the longevity. (Cooper & al. 2013.)

Garment lifespan is affected by a group of decisions that are made in the design phase: choice of fibre and yarn, fabric production with finishing and trimmings. Garment construction is a key factor in garment longevity; different stitch types and the quality of sewing threads, machine types and settings effect on the durability. Today's technology and materials would able the production of clothes that stay in good shape for longer, but it would increase the costs and the retail price. (Cooper & al. 2013.) Consumers are used to poorer quality with a good price, so an attitude change would take time and be a big shift to value the quality in clothing.

To have this change in quality in fashion industry in general, the design and manufacturing departments would need a clear guidance from the head of organizations. Companies should also reconsider their strategy, because lengthening the garment lifespan would need a bigger change in business models and retargeting. (Cooper & al. 2013.)

2.1.2 Micro plastics

Synthetic fibres are problematic from environmental point of view, when looking at the sustainability of the use phase. It means small, less than 5 millimetres, solid plastics particles that are released to the nature from synthetic textiles during machine washing in households. Other sources for releasing micro plastics are for example car tires and beauty products. (Euroopan Parlamentti 2018.) Micro plastics are harmful for animals and humans; they have been found from marine animals that have ingested the small pieces and humans as a part of food chain. According to European Parliament (2018), the effect on human health is as yet unknown, but plastics often include additives and other possibly toxic chemical substances.

Ellen MacArthur Foundation (2020) has estimated, that washing synthetic clothes releases half a million tonnes of plastic micro fibres into the ocean in a year globally. It is equivalent to more than 50 billion plastic bottles. In Germany have been estimated the amount of micro plastic released annually by laundering is between 80–400 tonnes and Europe to be between 500-2500 tonnes (Essel, Engel & Carus 2014, 27). In Denmark laundering of textiles causes micro plastics is in the range of 200-1000 tonnes per year (Lassen & al. 2015, 126). SYKE Finnish Environment Institute (2020) has estimated in their recent study that in Finland annually the municipal wastewater includes 7-290 tonnes micro plastics from laundering the synthetic fibres.

In European Union area the capture of micro plastics is estimated to be between 53 and 84 per cent by wastewater treatment but systems vary in different countries (Hann, Dr Sherrington, Jamieson, Hickman & Bapasola 2018, iv). In Finland more than 99 per cent of the particles are caught from the water in wastewater treatment plants, but part of the small plastic pieces ends up to sludge, that is collected for agricultural purposes and spread to the fields (Nyrhinen-Blazquez 2018). To minimize the impact in laundry, the consumers can minimize the synthetic material in clothing by the washing clothing only when it is necessary and using the washing bags for synthetic materials in washing machine (Nurmi 10 September 2020). Manufacturers could decrease the impact by developing materials and increasing the use of natural fibres. Haan & al. (2018, iv) suggest in their study, that the European Union could regulate the filters to wastewater treatment plants in EU countries or for set a specification for washing machine filters for households.

2.2 User and laundry behaviour

According to Swedish Mistra Future Programme Fashion (2019) 3 % of garment's carbon footprint during its life cycle is from user laundry, but according to WRAP (2012, 5) the laundry accounts for around 25 % of the carbon footprint of clothing.

On average about 90% of the Europeans have washing machine in their household. Almost a third of the respondents said the price was the most important criterion when buying a washing machine. After that machine's extra equipment and energy consumption were next important factors. (Sammer and Wüstenhagen 2006.) The average capacity of the washing machines (in kilogrammes of cotton) was 7.04 kg in 2013 in European households in the research made by Boyano, Espinosa and Villanueva (2019). Another study from them found out the average capacity of washing machines was 6.5 kg in 2017 (Boyano & al. 2017, 24). The level of filling was 82 % according to 'Pan-European Consumer Habits Survey 2020' made by A.I.S.E (2020). However, in another study the average washing load is 59 per cent of a full load (Faberi & al. 2007, in Sandin & al. 2019, 56).

The number of washes per two weeks has decreased 10 per cent from 2017 study to 6.7 loads according to (A.I.S.E. 2020). The average washing temperature per wash cycle for European countries was 42.4 °C. (A.I.S.E. 2020.) Differences between the countries even in Europe are significant: the lowest average washing temperature was in Spain with 37.9 °C, while it was the highest in Finland with 45.1 °C. (Boyano & al. 2017b, 228.) The lower average washing temperature in Spain is because of the low temperature programmes that are there common, for example cotton is washed in cold 20 °C, whereas in Finland and Sweden is common to use programmes with 60 °C for cotton laundry. (Boyano & al. 2017b, 228.) 28 % of wash loads were washed at 30 °C or colder in Europe in 2020 (A.I.S.E. 2020.) and according the survey in 2017 these loads usually included delicate garments (58%) (A.I.S.E. 2018).

The average energy consumption per cycle is 0.830 kWh in 2013 in European households and the average washing temperature is 46 °C (Boyano, Espinosa & Villanueva 2019). A++ washing machine consumes energy the same amount with 60°C program and A++ machine with 40°C programme consumes 0.5 kWh per cycle (MTP 2009; in Thomas & al. 2012, 23.). The most popular washing machine type in Europe is A+++ based on Michel, Josephy, Bush, Attali and Zuloaga study (2020); its energy consumption annually is 175 kWh meaning it is 0.79 kWh per cycle (175/220 cycles a year=0.79 kWh per cycle) (Boyano, Espinosa & Villanueva 2017a, 37). In EU Energy labelling washing machines are considered to have 220 cycles per year (EUR-Lex 2010). Consumers are not always aware which programmes are the most energy efficient. Around 40% of respondents of a study made by Boyano, Espinosa and Villanueva (2017, 24) did not know, that longer washing programmes save more energy and that shorter programmes with the same temperature, use more energy. Short programme duration was one of the most important aspects for consumers when looking for a new washing machine or selecting a washing programme. (Boyano & al. 2017a, 24.)

Average water consumption per cycle is 45.1 litres (Boyano & al. 2017a, 19). A+++ class machine consumes 10 544 litres annually so per cycle the amount is 47.9 litres (Coolblue 2020). EU Energy label shows the water consumption, but it may vary considerably among machines with the same energy label, because some washing machines have special techniques for saving water (Coolblue 2020).

The price of the laundry detergent is the most important factor for consumers and the sustainability profile of the product was ranked lower (A.I.S.E. 2018). Drying the laundry was explored in the study made by Boyano & al. (2017b, 238), where during the winter 19 % of the respondents use tumble dryer for drying their laundry. Two per cent of the participants dries in a cabinet dryer, 19 % outdoors, 41 indoor heated room, 18 indoor unheated room.

EU Energy Label

EU Energy Label is a label for household appliances that indicates the energy consumption level and has been created to standardize the labelling. Label may contain additional data about noise emission and water consumption. It has been created to make it easier for consumers to save money on their energy bills, but also to reducing greenhouse gas emissions in the European Union. (European Commission 2020a.) Latest directive 2010/30/EU has been set in September 2010. There are different energy efficiency classes that are based on Energy Efficiency Index (EEI): A-D and A class includes A+, A++ and A+++. In the label the energy consumption is announced as kWh per year and it is based on 220 standard washing cycles for 40 °C and 60 °C cotton programmes at full and partial load, and additionally the consumption of the low-power modes. The final energy consumption depends on the way the appliance is used. (EUR-Lex 2010.) According to recent study (Michel, Josephy, Bush, Attali & Zuloaga 2020) showed that current Ecodesign and Energy Label policies for washing machines could have been set at a higher level because already 43% of the sales in EU were in the current top class A+++ (Michel & al. 2020). EU Energy label categories will be rescaled in year 2021 from A to G in five product groups and washing machines is one of them (European Commission 2020a).

Previous large studies about laundry behaviour

There are previous studies in Europe about user phase carbon emission calculations in clothing industry. In United Kingdom 2012 Thomas, Fishwick, Joyce & van Santen published for WRAP a study called 'A Carbon Footprint for UK Clothing and Opportunities for Savings'. It focused on measuring the carbon footprint of clothing in United Kingdom and researchers modelled the total potential for reduction. In 2019 Mistra Future Fashion, in a cross-disciplinary research program in Sweden, published a paper 'The impact of Swedish clothing consumption'. Authors Sandin's, Roos's, Spak's, Zamani's and Peters' (2019) aim was to find out and understand the environmental impact of Swedish clothing consumption. Researchers calculated six garments' carbon footprint, energy use, water scarcity, land use impact in soil quality, freshwater eco-toxicity and human toxicity. Larger worldwide study about apparel and footwear industries' impacts is made by Quantis (2018). It is a metrics based guide for companies for making applicable changes to reduce their environmental impacts.

2.3 Measuring the sustainability

To get an understanding about the current state and considering development in sustainability, measuring is the key. With the data received the targets can be set and future actions determined. Before selecting the tool, the company need to have a sustainability strategy or guidelines and know clearly what are they measuring. After that, selecting a suitable tool for the issue is important to get the full benefit, and to be able to take the next steps in the development the company wants to achieve.

Measuring and observing the whole product lifecycle may seem enormous, time consuming project, but the effects of having a closer look; actions, new insights, new innovations and process developments it creates, strengthens the company's finance and produces a lot more benefits than lost resources (Ritthoff & al. 2004, 10).

Lifecycle Assessment (LCA) as a tool is introduced in this chapter as well as the Material Input per Service (MIPS) method, that was used in this research. Also carbon footprint and Product Environmental Footprint (PEF) are presented briefly to achieve the wider picture about the possible tools for assessing the environmental sustainability in fashion industry.

2.3.1 Lifecycle assessment calculation

Lifecycle assessment (LCA) is widely used analysing tool. It can be used for analysing the environmental impacts of products, processes and services. In terms of products, LCA can be used for cradle-to-grave type of products. Different environmental indicators can be measured with LCA, for example carbon footprint, ecological footprint, water footprint and human toxicity. The International Organization for Standardization (ISO) has series of standards for LCA, but as a method it is constantly expanding and developing to meet the changing needs. LCA is a process with four steps: goal and scope definition, life cycle inventory, life cycle impact assessment and life cycle interpretation. (Muthu 2015.)

Life cycle assessment's history has started late 1960s to early 1970s, when the first studies were published about energy efficiency, raw material consumption and, to some extent, waste disposal. Coca-Cola Company funded a study about resource consumption and environmental releases related to beverage containers of in 1969 in United States. Meanwhile a similar inventory approach was released in Europe that has later been known as 'Eco balance' and few years later in United Kingdom Boustead made calculations regarding various types of beverage containers where he focused on energy consumption of the production. Later he consolidated that methodology to be applicable for variety of materials and published the Handbook of Industrial Energy Analysis. (European Environment Agency 1997, 13.)

1980s and 1990s it had been recognized that for many of products a big part of the environmental impacts comes from manufacturing, transportation and disposal instead of the use phase. Life cycle assessment (LCA) was born from this insight and nowadays it is a core element in environmental policy worldwide. LCA has been standardized with ISO 14040 (2006E) 'Principles and framework' and with ISO 14044 (2006E) 'Requirements and guidelines'. (Guinée & al. 2011.)

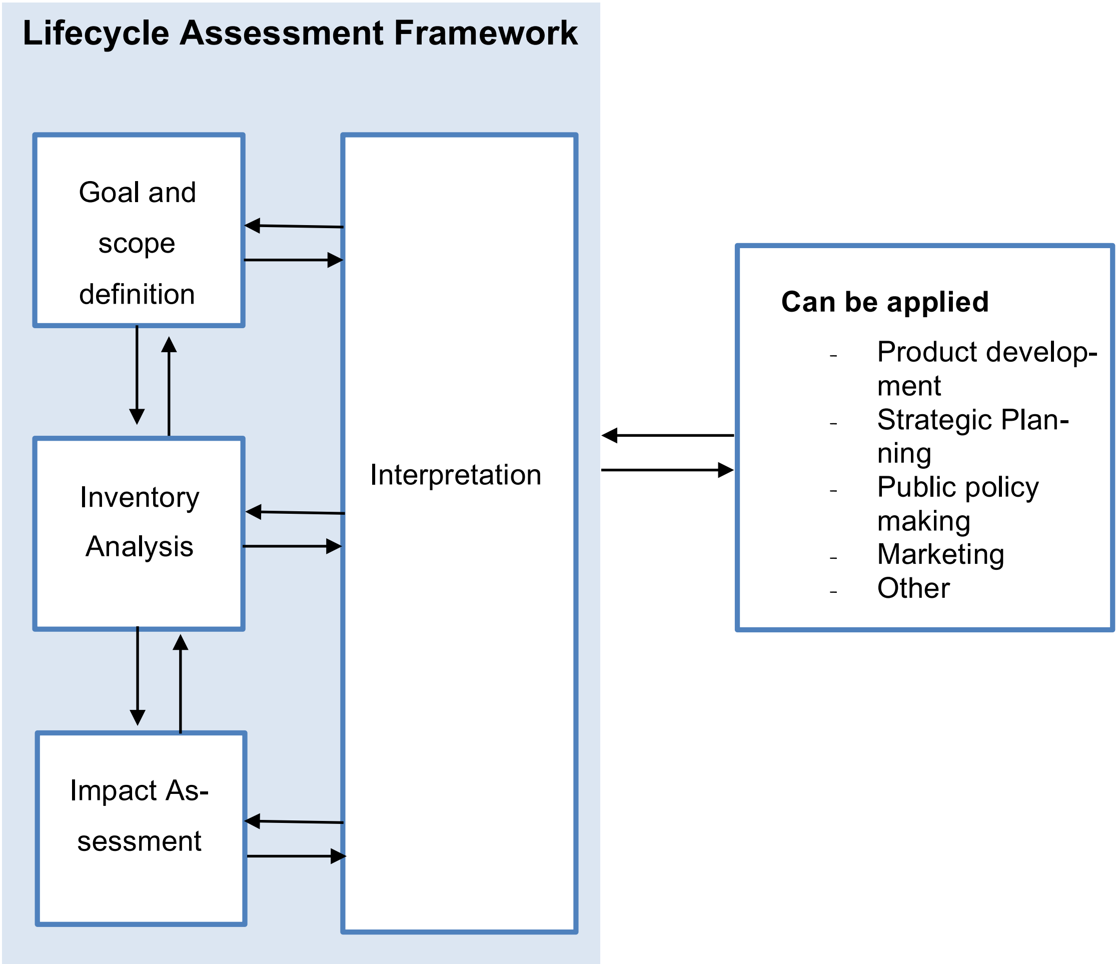

Figure 3. The general methodological framework of LCA (adapted from Guinée & al. 2011)

Four steps of Lifecycle Assessment:

1. Goal and scope definition: Process starts by setting clear and exact intent, audience and boundaries for the study (Muthu 2015, 3-4). It will be set how deep the analysis will be (Liebsch 2020).

2. Inventory analysis: The aim is to determine the environmental inputs and outputs, in other words to measure everything that flows in and out of the system that was defined in previous phase (Liebsch 2020). In fashion industry inventory includes material, manufacturing, transport, use and disposal (Muthu 2015, 4).

3. Impact assessment: In this step the classification of inventory is done how significant the impacts are. Common impact categories are global warming potential, human toxicity, eco toxicity, acidification and eutrophication. Also all the equivalents are calculated. (Liebsch 2020.)

4. Interpretation: According to ISO 14044:2006, interpretation of Life Cycle Assessment should include: Identifying significant issues based on our LCI and LCIA phase, evaluating the study itself (sensitively, consistently, accuracy, correct analysis). (Liebsch 2020.)

In the last decades the LCA has taken new forms and has broadened to cover people, planet, and prosperity. When including all these three aspects in addition it is called as Lifecycle Sustainability Assessment (LCSA). It also expands the scope from product level to sector level and to economy-wide levels. (Guinée & al. 2011, Guinée 2016.)

2.3.2 Material Input per Service Unit (MIPS)

Material Input per Service Unit (MIPS) value tells how much natural resources have been used for certain product or service compared to benefit. With MIPS companies can examine the environmental aspects in whole life cycle. Main goal is to decrease the material flows. Instead of considering only the end products, MIPS takes into consideration the inputs as well as the outputs, because the input become output eventually. This way MIPS works as preventive tool. (Ritthoff & al. 2004, 9.) MIPS method covers the whole lifecycle and it brings up the nature impacts worldwide. MIPS thinking is based on idea that product's or service's possible environmental impacts can be estimated by its material inputs: less the raw materials are used, the smaller is the risk to cause disadvantages for the environment. (Ritthoff & al. 2004, 10.) Improving the natural resource productivity can be achieved by minimizing the material input or maximise the benefit of the product (Autio & Lettenmeier 2002, 24). Difference between MIPS and emission calculators is that MIPS guides towards future product and service innovations where emission calculations concentrate on emissions at the moment (Ritthoff & al. 2004, 9).

Material input categories:

- Abiotic materials; minerals, fossil fuels, over material, moved land material
- Biotic materials; cultivated bio mass, bio mass from natural area (plants, animals etc.)
- Moved land (mechanical land work and/or erosion); mechanical land moving, erosion
- Water; surface water, ground water, well water
- Air; air in burning processes, chemically and physically transformed
  (Ritthoff & al. 2004, 12.)

The total use of natural resources during the production, use, disposal or recycling are included when the whole lifecycle is wanted to be covered. All the numbers equal to tonnes moved in the nature. (Ritthoff & al. 2004, 12.) First the use of demanded resources, *material input*, is calculated with material input (MI) factors. Material input equals amount of input (e.g. kg or kWh) multiplied by MI-factor and the material unit is expressed in kilograms (Ritthoff & al. 2004, 28). MI factors describe the material intensity that has been determined for raw material and other production inputs by different operators with complicated analytical systems. MI factor expresses how many kilograms of natural resources are used for one kilogram of certain raw material. MI factors have been calculated also for abstract sources like electricity and transportation. Updated MI factor list is available on Wuppertal Institute's website. (Ritthoff & al. 2004, 13.)

In some cases, only the used material input (MI) is enough to be calculated. Service performance term is based on a thought, that consumer usually does not need a machine itself but the service it provides (Autio & Lettenmeier 2002, 23). During its lifecycle the amount of used resources (MI) is divided by service performance units (S) during the lifecycle and this will result as natural resource consumption per one service performance unit (=MIPS). When product or its service is measured primarily by its benefit and added value, looking it via MIPS method may lead into new, service-based eco-efficient innovations and moving the business perspective from products to services. Material intensity calculation (MIT) means the use of natural resources per one raw material, energy source, electricity or transportation unit.
(Ritthoff & al. 2004, 14.)

Seven phases of MIPS calculation:

1. Determination of the goal, product/service and service performance
2. Describing the process chain with separate stages, and how they are related
3. Data collection
4. Calculation of material input from "cradle to product" – collected amounts multiplied by MI factors
5. Calculation of material input from "cradle to grave" – combining the material inputs
6. Calculation of material input per service (=MIPS)
7. Interpretation of the results
   (Ritthoff & al. 2004, 17.)

2.3.3 Other measuring tools

Product Environmental Footprint

Product Environmental Footprint (PEF) is a method based on life cycle assessment and it is created by the European Commission. PEF is used to measure the environmental performance of products over their life cycles. It was developed for harmonizing already existing international standards and life cycle assessment models like ISO 14040-44, ISO 14025, Ecological Footprint and PAS 2050 as one. (European Commission 2019.) PEF is more detailed then previous models due to specific guidance for the required data in each product category. Because of more detailed guidance PEF results are more comparable than previous life cycle assessment models. (Suikkanen & Nissinen 2020; 3, 10.)

Considered categories of Product Environmental Footprint (European Commission 2013):

- Climate change (check the term *greenhouse effect* in chapter 1.7 Key concepts)
- Ozone Depletion (ozone layer gets thinner causing ultra violet radiation increasing)
- Eco toxicity for aquatic fresh water
- Human Toxicity - Cancer effects
- Human Toxicity – Non-cancer effects
- Particulate matter/Re-spiratory inorganics (Emissions of Particulate Matter and its precursors, that cause health issues for humans (European Commission 2020b).)
- Ionising Radiation – Human health effects (Radiation with enough energy to remove tightly bound electrons from the orbit of an atom, causing that atom to become charged or ionized. Occurs as waves or particles. (World Health Organization 2020.))
- Photochemical Ozone Formation ("Formation of ozone at the ground level of the troposphere caused by photochemical oxidation of Volatile Organic Compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NOx) and sunlight (European Commission 2020c).")
- Acidification (the process of turning into acid or being converted into an acid)
- Eutrophication – Land and aquatic (the land tor waters turn into enriched with nutrients and it increases the amount of plants and algae growth)
- Decrease of water resources
- Decrease of mineral, fossil
- Land Transformation

Carbon Footprint

Carbon Footprint measures the total greenhouse gas emissions of a product, an activity, an organisation or an individual. It takes into account carbon dioxide emissions but also other greenhouse gases like methane and nitrous oxide. (Sitra 2020b.) It expresses the amount of carbon usually in tonnes. "In fact, the climate problem emerges because the planet does not have enough bio capacity to neutralize all the carbon dioxide from fossil fuel and provide for all other demands (Global Footprint Network 2020b)."

Carbon Footprint is a simplified version of product environmental footprint (PEF) calculation (chapter 2.1.5.). Both calculations are ultimately based on ISO14040, the global standard for life cycle assessment (LCA). In carbon footprint only climate change is considered as an impact category whereas in PEF or LCA calculations other factors are considered in environmental and human health categories, e.g. energy consumption, impacts on habitat and the emission of carcinogens. (Muthu 2015, 3.)

2.4 Sustainability communication

Sustainability communication provides information about sustainability matters for internal and external stakeholder groups; strategy, objectives, projects and daily practises. Investors and customers are the main target group and despite a top line plan, this approach has a positive influence on the growth of the company (Bhatia 17 February 2020). According to Bhatia (17 February 2020), "sustainability communication is an approach to engage your customers and investors in order to showcase your progress on sustainability commitments."

Sustainability communication and corporate responsibility go hand in hand: Communication about it needs concrete actions and goals, and community responsibility cannot exist without communication and dialog with stakeholders. Without communication about the implemented sustainable practises the benefits will be lost (Liappis, Pentikäinen & Vanhala 2019, 222.) but also today it is often considered as those practises does not exist. Genuine business attached to sustainability opens, ensures and improves company's business possibilities. Good sustainability communication does not tell only positive aspect or hide made problems but tells the challenges. (Liappis & al. 2019, 224.) Most important thing in sustainability communication is to know thorough the target audience, employees, customers and investors, to find the correct style of communications and the right channels to reach them (Bhatia 17 February 2020).

One of the advantages of sustainability communication is that it helps improve the company's Environmental, Social and Governance (ESG) Rating, that measures the sustainability and the ethical impacts of a company. It is a score, but often an important tangible indicator of a sustainability performance, and it may inform about risks in company's operational or non-operational activities as it relates to ESG factors. (Bhatia 17 February 2020.)

For the consumers the company can inform about environmental sustainability in strategic level, but also about their daily practises. Communication is a tool for consumer to make more sustainable choices and develop her own practises towards more sustainable life, for example via maintenance of the garments. Care label in the garment's seam is one example of communication and in terms of product lifecycle, it provides very concrete and important instructions to user how to get the full value of the garment.

Certificates are a fast way to express the information about company's sustainability. They help the consumer to select a product that stands for her values and is a tangible prove about company's values. Consumers demand for simple, guaranteed and fast facts about sustainability of the products (Liappis & al. 2019, 228).

Quite recent examples of sustainable communication are environment labels and measures in the goods. In food industry Swedish oat product company Oatly added carbon footprint information to their products in spring 2019 (Briggs 2019). Emissions from field to store are included and on their website they open how the calculations have been made (Oatly 2020). Example of the fashion industry is British Continental Clothing Co. who launched the world's first 'Carbon Reduction Label' in March 2009. In the product card there is label certified by Carbon Trust that tells about carbon neutrality of the product, but from their website there is a chart available including carbon footprints of all their products. (Continental Clothing Co. 2020.) Another example is company Allbirds, that is a footwear company from New Zealand. It labels all their products with a number representing emitted CO_2. Products have different amounts of emitted CO_2 so that the company's all products average is –7.6 kg CO_2e. This tool is developed together with third-party carbon company. (London 2020.) Allbirds emission calculations include raw materials, manufacturing, product use and end of life. Allbirds' aim is to become a carbon negative with their business (Allbirds 2020).

3 Case study: Reima Oy

“To drive metrics-based sustainability programs, companies in the fashion industry are increasingly looking for reliable data to make informed decisions and to prioritize their sustainability efforts” (Quantis 2020). The purpose of this thesis is to form a base for Reima to include the use phase more tightly in their lifecycle focus. To engage and encourage the customer to share the responsibility of clothing consumption and together develop more sustainable practises.

In this chapter the tools of this research and the processes are clarified. Chapter presents the research methods, consumer survey and MIPS calculation, from this research’s perspective with the results and brief conclusions. At first the research strategy is covered with the system boundary, that clarifies the area of the research in the context of garment life cycle.

3.1 Research strategy

As a research methods were selected the survey and the calculations with the MIPS method. These methods combined each other well, because the survey provided current data from Reima Club members, and their behaviour and the calculations provided numerical data about the natural resource efficiency. These two different methods brought two different point of views to the research. In addition to laundry behaviour, the survey included the set of questions about services that Reima possible could offer for their customers in the future that would support the lengthening the lifespan.

The goal for the survey and the calculations was to get accurate, relevant and reliable data about Reima outerwear use phase and its environmental impacts to develop practises in the end of garment lifecycle, that reduce environmental impact. After selecting the methods, the designing of the survey started. Survey responses were used as a base for calculations.

Research process in timewise order:

1. Defining research problem and methods
2. Theoretical base (desktop study)
3. Survey
4. Survey results, collecting data for calculation
5. Data collection (desktop study)

6. MIPS calculation based on survey and scenarios
7. Analysis and conclusions

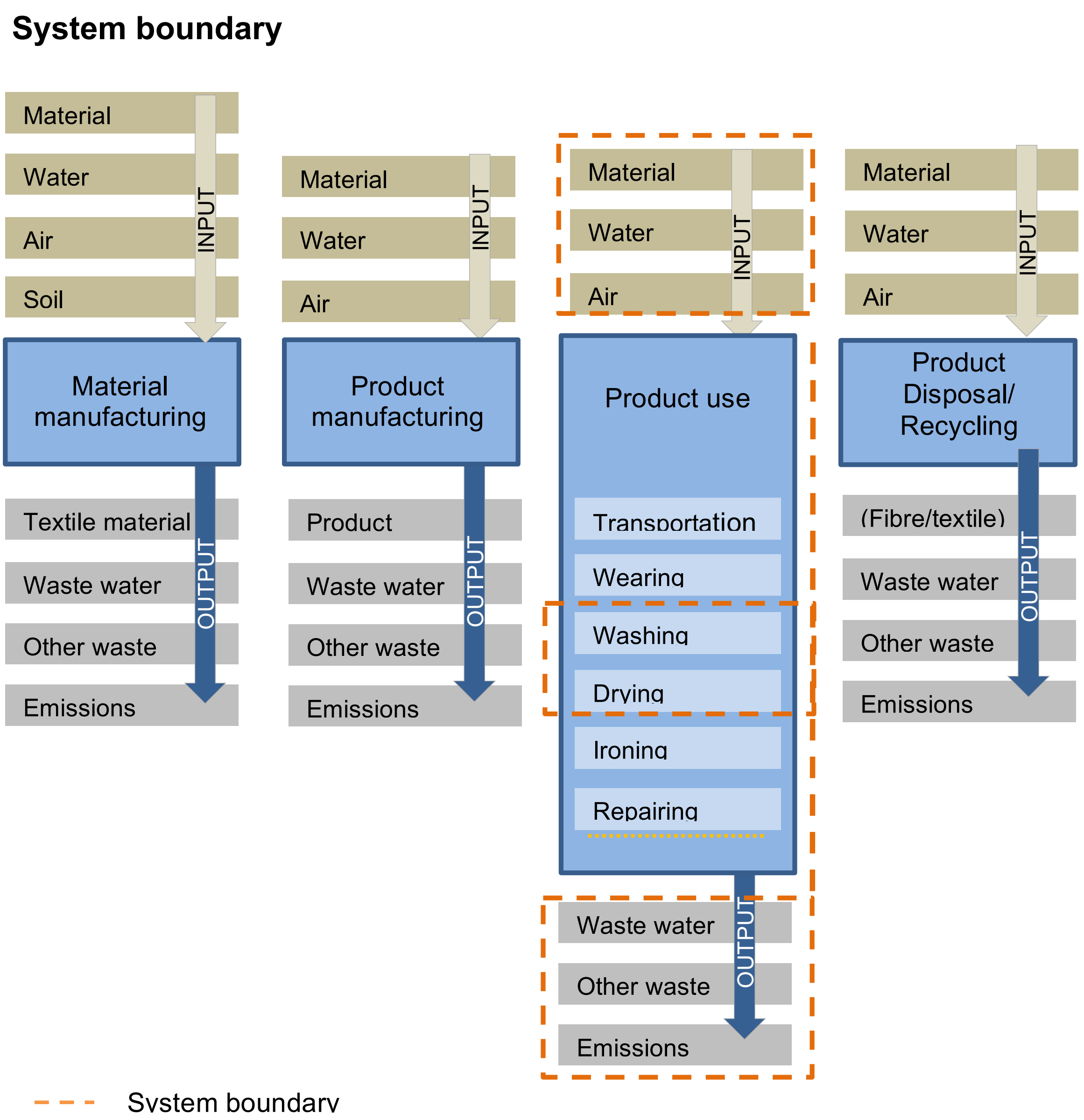

Figure 4. System boundary of the research

In this research the use phase consists the actions the user does after she has arrived her home after the purchase. Figure 4 shows the system boundary of the research. Transportation is excluded, because of limited research resources, and the ironing as well due to its importance in children's outerwear. Repairing was left out due to its complexity; consumers repair the garments themselves in multiple ways with the variety of quality and materials, as well the repairing is done by professionals with professional equipment. Repairing was only included in the survey to find out the Reima club members attitudes towards the interest towards them. Second hand re-sell service and repairing are well-known ways to lengthen the lifespan of the garment and the Reima expressed their interest to figure what their club members think about these.

3.2 Customer survey

Survey for Reima Club members was executed to get the understanding how Reima's customers and potential customers use and care the outerwear products as well as to find out their attitudes towards services that Reima could possible offer in the future to lengthen the product life cycle. In this chapter the survey design process will be covered, as well as the factor definition and the results.

3.2.1 Goal and scope definition

The aim of the survey was to receive information how Reima customers are laundering children's outerwear, what are their attitudes towards second hand garments and how they feel if Reima would offer verified second hand products or repairing service. The purpose was to get an insight about consumer behaviour, but as a secondary to engage the customers and increase the awareness about the maintenance phase.

Scope of the survey included washing and drying stages of use phase, and the second part of the survey covered briefly the end of life phase recycling. Received data needed to be accurate, and reliable because it worked as a base for future research.

3.2.2 Survey design

The survey had two parts: First the respondents were asked about their use and laundry and the second part was about attitudes toward second hand items and repairing service (appendix 1). Second part was about the second hand and repairing services that Reima could probably offer in the future. Consumer survey included 12 questions in total: seven questions about laundry, one question regarding the disposal and four questions were about the second hand and the repairing. The laundry was the main topic where the research focused.

Demographic factors in the survey were sex, age and country. Only the age was asked in the survey and the other information was from Reima Club member background information.

All the questions were multiple choice questions, and two questions asked for more than one option to select. The survey was structured to receive numerical, accurate information in a short time. In few questions there were open box as an option in case the respondent did not find suitable answer among the determined options. This provided to collect information that might not have been taken into consideration by the survey creator. As a last question there was an open box for the questions and the feedback. All the questions were mandatory for respondents except the feedback in the end.

Autumn-winter season was selected as a limitation because then the weather demands more from outerwear; more technical features are needed and more durability as well. This season was selected also because Reima is well-known for the technical outerwear. Weather circumstances in Central Europe and in Scandinavia differ from each other.

Question about disposal was included to the survey because it relates to the second hand aspect. Idea was to get information if the consumers purchase second hand items, but also do they sell the garments from their use to the others or what happens when they do not use them anymore. The length of the use would have been relevant but it was not included in the survey, because when considering children, they grow out of the garments usually in one season, and for next season new garments need to be purchased.

Survey was created with Reima's questionnaire tool in the Reima Club website where the survey was published. Reima Club is for the registered customers and the members get access to be a part of product development, receive care instructions for clothing, activity tips for the family and latest news among other (Reima 2020n). The target group was Reima Club members. Responses were handled anonymously and the respondents were informed in the beginning of the survey that responses will be collected to thesis research.

3.2.3 Results

The survey was open for 7 days and 113 replies worldwide were received. European participants were selected so the sample was 93 answers from 13 countries (figure 5 below). Amount of respondents is marked with 'n' in the figures below. 52.7 % of replies arrived from Scandinavia. Most responses were from Finland and Sweden, third most from Germany. These three countries presented 52,6 % of all responses. In this chapter all responses are viewed in general and in addition five countries with reliable amount of responses are compared (amount of respondents in brackets): Sweden (18), Finland (17), Germany (14), Norway (11) and Poland (10).

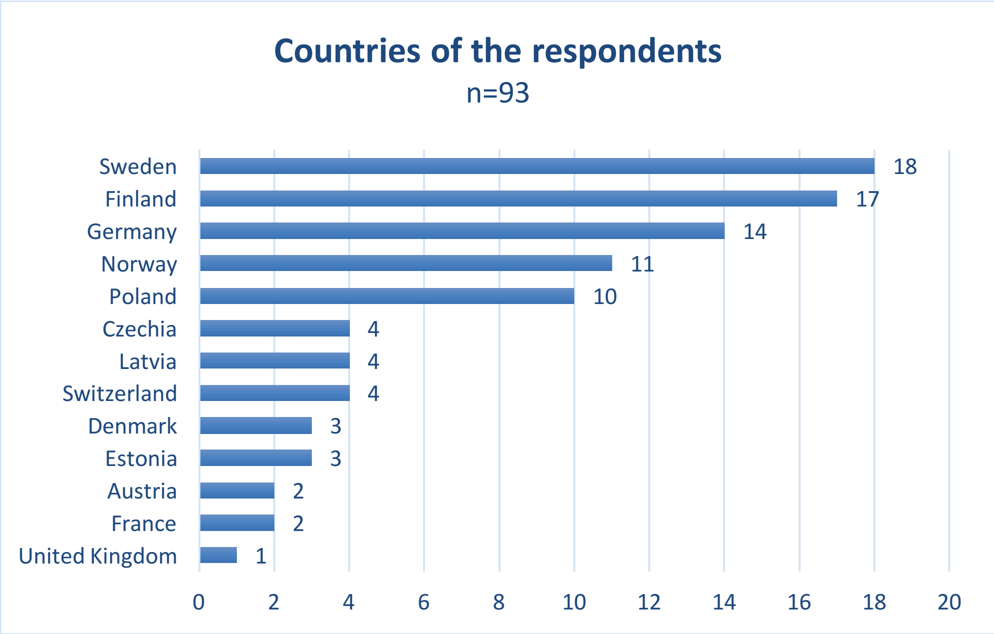

Figure 5. Countries of the respondents

Majority of respondents were female (81.1 %) and less than every fifth was male (18.9 %). Most of the respondents were age of 38-49 (56.9 %) and second most were 28-37 years old (38.7 %) (figure 6). These two age group presented 95.6 % of all the responses.

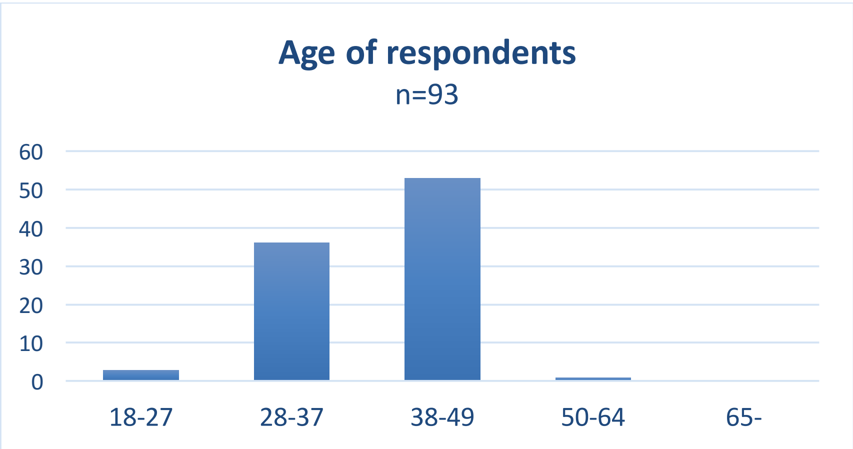

Figure 6. Age of respondents

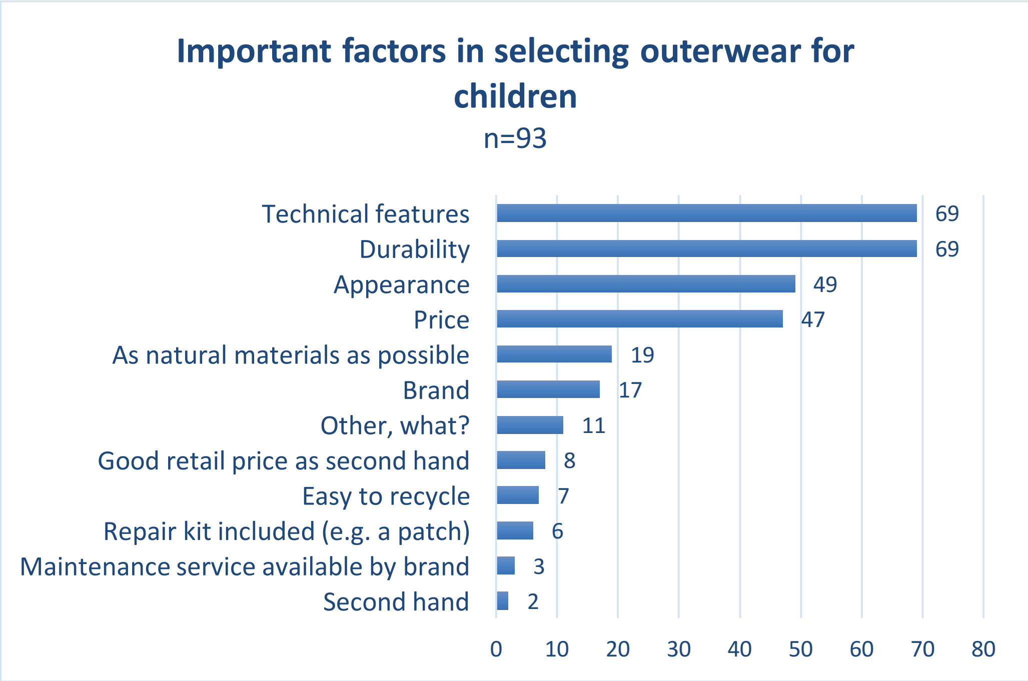

Figure 7. Important factors in selecting outerwear for a child

First part of the survey started with a questions about laundry behaviour. Participants were asked about three important factors when selecting outerwear for their children (figure 7). Technical features and durability were two most popular options (74.2 % selected), 'appearance' was in second place (52.7 %) and third was price (50.5 %). 11,8 % selected 'other' and they clarified they had meant good reflectors, easy to clean, 'Best in Test' results. Sustainable features, like 'second hand', 'repair kit availability' and 'easy to recycle' were clearly the least popular options.

Top features (table 3 above) between the countries were very similar. Technical features, durability and price exists in all five countries top lists (table 3 below). Norwegians consider factor 'as natural materials as possible' second important (36.4 %), that did no stand out in other countries, and they considered 'maintenance service available' and 'easy to recycle' clearly more important than other countries' participants; both features were selected by 18.7 % of Norwegians.

Table 3. Three the most important features per country in the terms of important factors in children's outerwear

	FINLAND	SWEDEN	NORWAY	GERMANY	POLAND
1	Technical features	Durability	Durability Technical features Price	Technical features	Durability
2	Durability	Technical features	As natural materials as possible	Durability Appearance	Technical features
3	Price Appearance	Price Appearance	Appearance	Price	Price

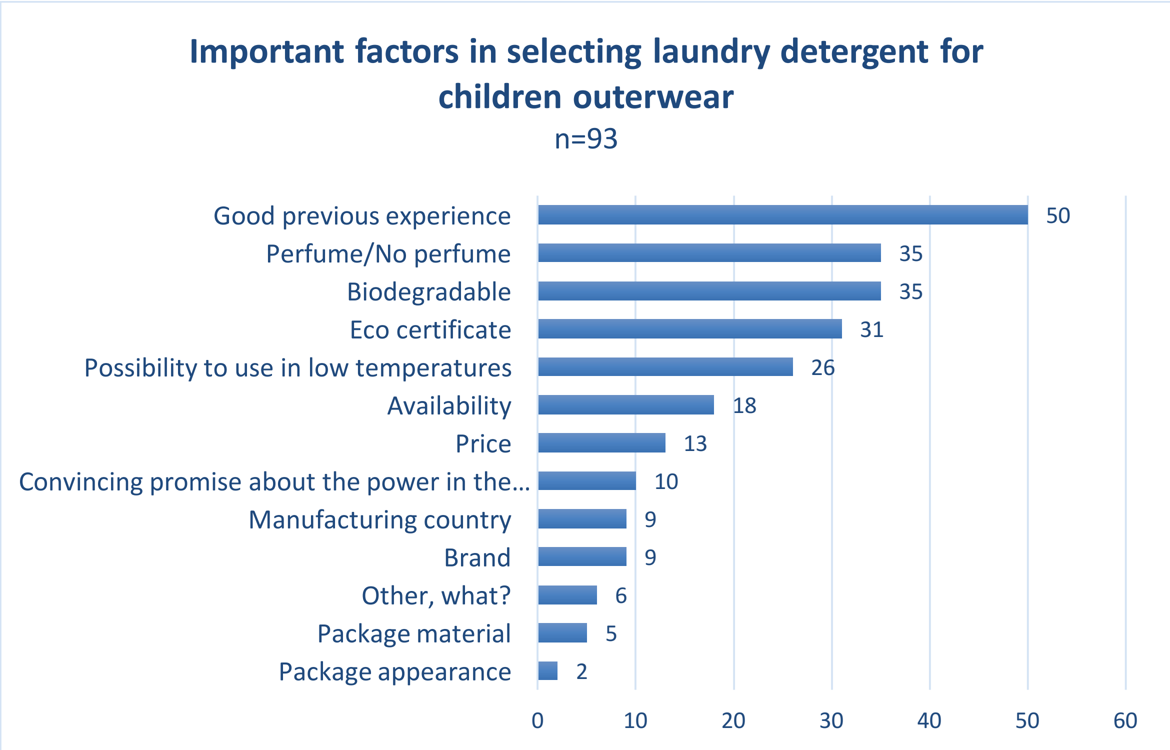

Figure 8. Important factors when selecting laundry detergent for children outerwear

Most important factor in selecting laundry detergent among all respondents was 'good previous experience' (53.8 %) (table 4 below). In shared second place there were 'perfume/no perfume' and 'biodegradability'. Third common answer was 'eco certificate'. Top three list in Finland, Sweden and Norway was very similar despite the slight changes in the order, and for Norwegians price was as important as 'good previous experience' (table x below). Respondents from other countries did not consider that as significant (5.6 %-10 % of the respondents has selected it). When viewing responses from Germany, 'eco certificate' was equal to 'good previous experience' in high importance. Responses from Germany and Poland had similarly no matter for manufacturing country of detergent. Package matters were least important for respondents. (Figure 8 above)

Table 4. Three the most important factors of laundry detergent for children's outdoor garments per country

	FINLAND	SWEDEN	NORWAY	GERMANY	POLAND
1	Good previous experience	Good previous experience	Good previous experience Price	Good previous experience Eco certificate	Good previous experience
2	Perfume/No perfume	Biodegradable	Perfume/No perfume	Perfume/No perfume	Eco certificate Biodegradable
3	Eco certificate Biodegradable	Perfume/No perfume	Eco certificate Biodegradable	Possibility to use in low temperatures	Perfume/No perfume Possibility to use in low temp. Availability Brand

Most of the participants remove dirt from children's outerwear before putting the garments to washing machine most commonly 'rarely' (47.3 %) or 'often' (44,1 %) (figure 9 below). Polish respondents do the removal most often (70.0 %).

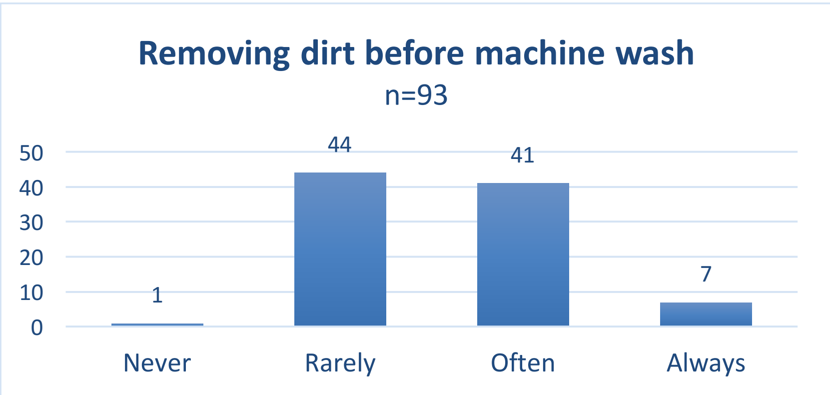

Figure 9. Removing dirt before machine wash

Most common temperature for children's outerwear was 40 Celsius degrees (61.3 %). 32.3 % of the respondents said they wash in 30 C. In Norway and Germany were few participants who answered they wash in 60 C, but none of respondents said they would wash outerwear over 60 C. Half of the Polish people and half of the Germans wash in 30 C and other half in 40 C in both countries. Only few Finnish and Swedish respondents replied they wash in cold water. (Figure 10 below)

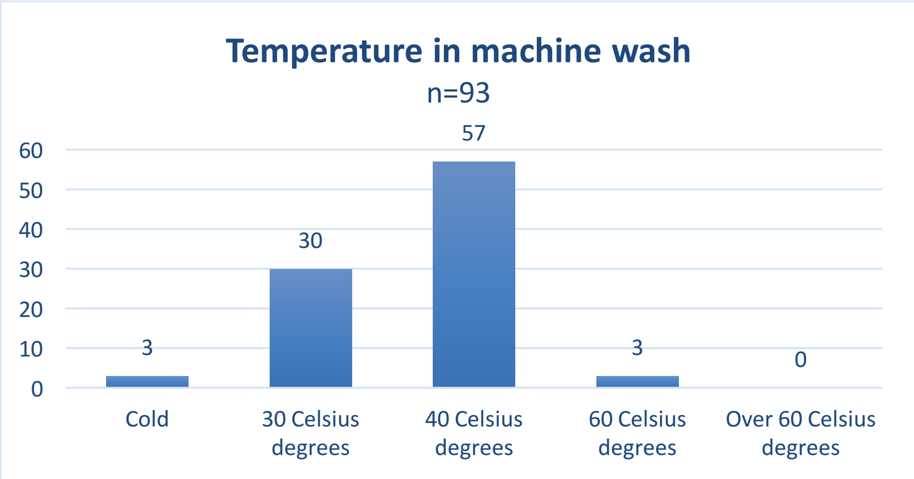

Figure 10. Temperature in machine wash for children's outerwear

The most common frequency of washing the children outerwear in machine was once a month (figure 11). Nearly as common was to wash once a week and once in every two months. Differences were small in general, but when looking more closely different countries, differences can be found: in Poland 50.0 % of the respondents said they was once a month, 30.0 % of Polish said once a week. In Germany (42.9 %) and Norway (36.4 %) machine wash for outerwear is done once a week. In Sweden the division dispersion Is bigger: 33.3 % responded they wash once in two months, but all the other options were equal popular with 22.2 % response rate.

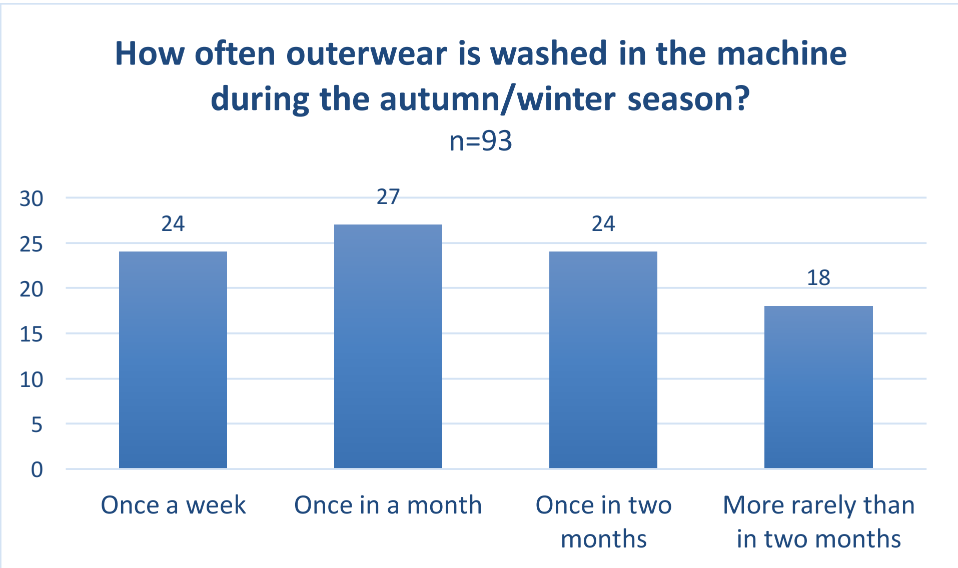

Figure 11. Frequency of washing children's outerwear in washing machine

44.1 % of the participants said on average they fill 50.0 % of the capacity up when washing children outerwear in the machine. Least popular was filling the machine with 100 % full of the capacity (2.2 %). In Finland, Sweden and Norway the most common answer was 50.0 % of the capacity is used, in German 25-50 % of the capacity and in Poland 50.0 % of the respondents estimated the 75.0 % of the capacity is used. (Figure 12 below)

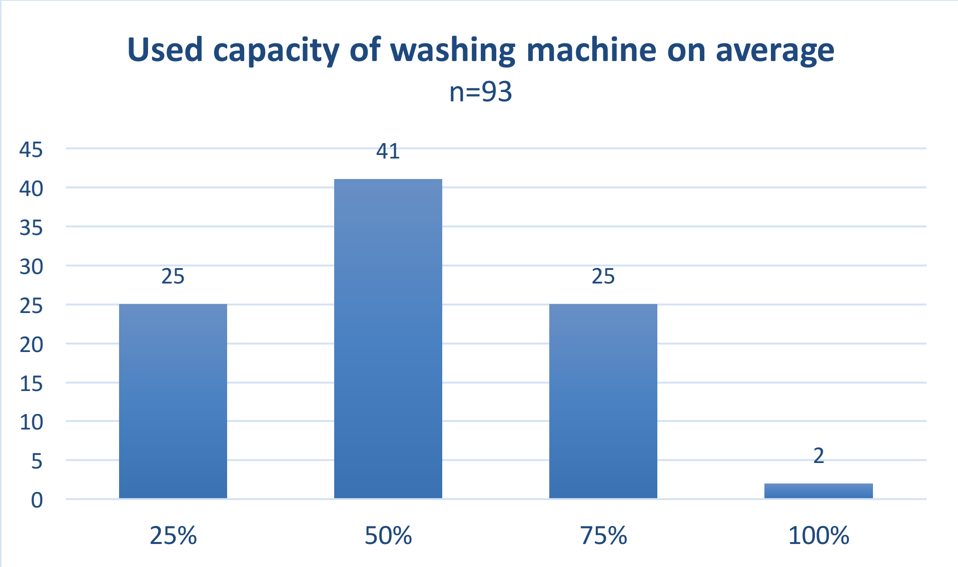

Figure 12. Used capacity of washing machine on average

Last question of the first part was about drying the laundry. Clearly the most common way of drying the outerwear laundry was in room temperature among the respondents (68.8 %). It was clearly number one in all the five countries. The washing machine with drying function and the drying cabinet were not commonly used. (Figure 13 below)

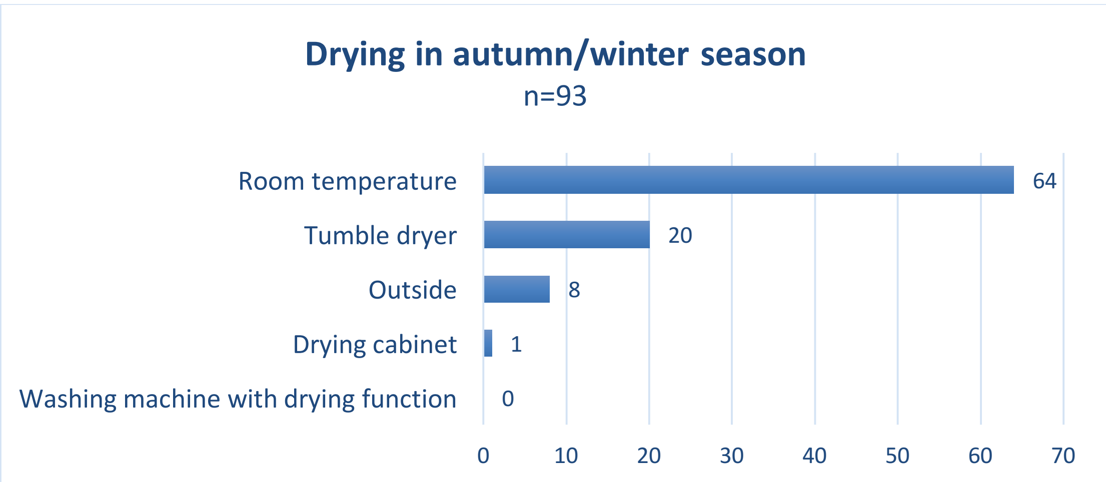

Figure 13. Drying outerwear during autumn/winter season

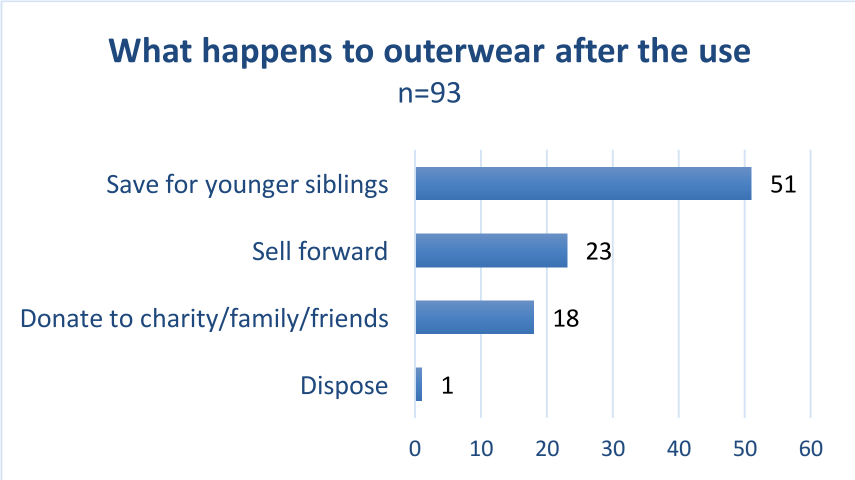

Figure 14. Outerwear destination after the use

Second part of the survey included questions related to services Reima could possible offer for their customers, like repairing and second hand services. after use. First question was about what happens after the use has ended with current user. Most of the respondents (54.8 %) replied the garments will be saved for younger siblings (figure 14 above). Basically all respondents will pass the garments forward for further use. Finland 83 % has announced number of kids and 47.0 % of them had more than one child. 85.0 % of them who had more than one child said they save the outerwear for younger siblings. Rest sell forward or donate the garments. In Norway the rate was lowest: 54.0 % had announced number of kids and 83.0 % of them had more than one child. 80 % of them who had more than one child said they save the outerwear for younger siblings. The amount of Norwegian respondents who informed they have more than one child was so low, that relevance is questionable.

Majority of the respondents replied they often buy as second hand (50.5 %). Second popular answer was ‘never’; one third of the participants said they never buy second hand garments. 1.1 % of the respondents buy second hand always. More than half of Norwegians participants answered they never buy children outerwear as second hand (54.5 %), where in Finland (58.8 %), Germany (52.9 %) and Poland (60.0 %) over half of the respondents buy it rarely. (Figure 15 below)

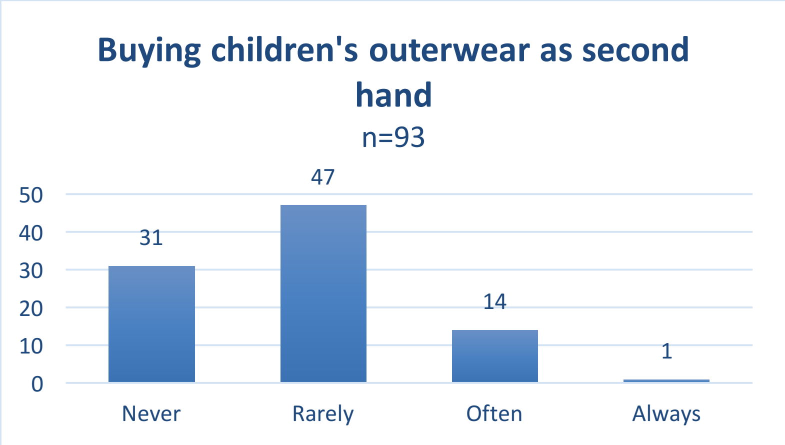

Figure 15. Buying children's outerwear as second hand

Over 80 % of the participants answered they would probably buy or for sure buy second hand if Reima would sell the items themselves after verifying the condition and technical features (figure 16 below). 53.8 % of the participants answered they would probably buy and 26.9 % were sure they would. German respondents were not so interested about this service: 23.5 % of them replied they probably would not buy or for sure would not buy verified second hand items from Reima.

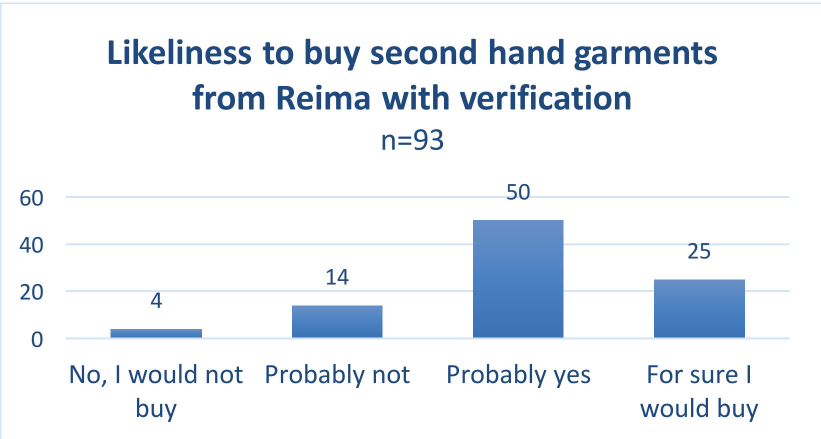

Figure 16. Likeliness to buy Reima outerwear as second hand with Reima's verification for technical features

In terms of purchasing second hand outerwear the clear majority would prefer buy it from Reima online store (57.0 %) (figure 17). 18.3 % of the respondents would like to buy garments also from physical brick-and-mortal Reima store. Few respondents said they would like to buy from friends, charity organizations, second hand platforms (Tradera, Blocket or Facebook Marketplace). Finnish and Swedish participants were the most interested online shoppers (72.2 % of Swedish respondents and 58.8 % of Finnish respondents). The least preferred place with zero responses to buy second hand in Finland was online store of

Reima's second hand co-partner, and in Poland in addition to the co-partner, Reima's physical store was not an interesting option for .

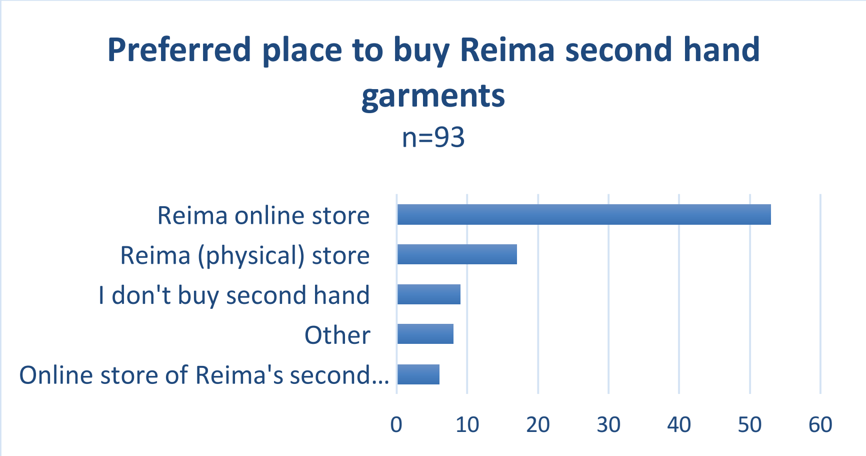

Figure 17. Preferred place to buy Reima second hand garments

Last question was about interest to buy repairing service from Reima (figure 18). 72.0 % of all European respondents said they would buy Reima repairing service 'probably' or 'for sure'. 54.8 % answered 'probably yes' and 17.2 % was sure they would buy. In Finland, Sweden, Norway and Germany more than 64.0 % of their respondents said they probably would or 'for sure' buy this service if it would be available. In Poland there were more hesitation: 40.0 % said 'probably yes' and 30.0 % said 'probably not'.

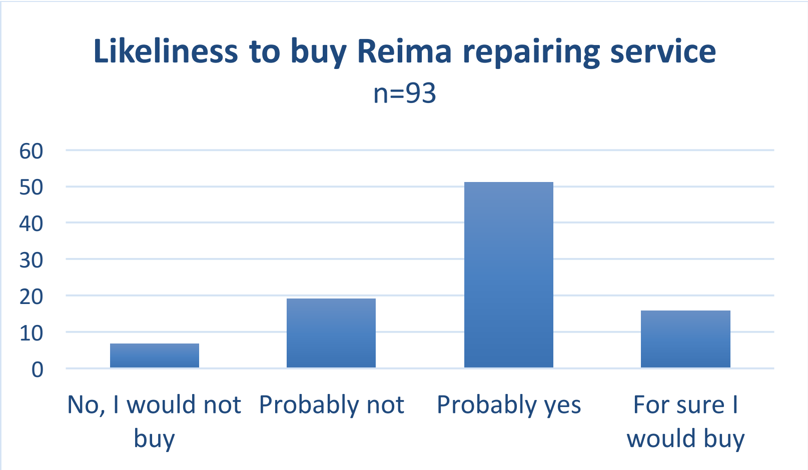

Figure 18. Interest to buy repairing service from Reima

In the feedback several respondents said the topic of the survey was good and interesting. Couple of respondents would like to have more detailed instructions with the garments to keep the garments as good condition as possible, and one participant suggested Reima could have their own laundry detergent developed especially for their products.

3.2.4 Conclusions of the survey

The good amount of total respondents abled to have many countries to be compared. Scandinavia was well represented as assumed due to the well-known Reima brand especially there.

Technical features and durability are the most important factors

The most important factors in children's outerwear are technical features, durability and appearance. Technical features are what Reima is known for and durability was expected in terms of children's wear. Durability is one of the key elements in long garment lifespan and related to sustainability. Other sustainability related factors were not popular responses. If there would have been more factors to be selected, sustainability could have raised more. Repair kit and maintenance service are likely not that common that consumers would keep it as important as a brand for example. Norwegians prefer natural materials which was special compared to other respondents.

Package of washing detergent was not important factor

The detergent package is not valued much according to the survey. Package appearance was at least favourite from all the options, but might be that if respondents would have one selection more, situation could have changed. Could be that when filling the survey, package did not feel important, but when the consumer is standing by the laundry detergent shelf, package may impact more. The biodegradability and the eco certificates were both in top 5, which is good news for the planet. Most common reply was 'good previous experience' in all five countries.

Frequency of dirt removal

Dirt removal practises divided the respondents: 44 respondents said they rarely do it and 41 respondents said they often remove the dirt from children's outerwear. The most eager group to remove it were Polish participants with 70 % saying they remove it often. Removing the dirt extends the need for washing machine and it may save the material from critical spots, like bottom and knees depending on the equipment and the water temperature. In Poland all the respondents said they do it at least 'rarely' (30.0 %), and 70.0 % replied they remove it 'often'. With this question there is clear risk of misinterpretation: what 'rarely' means to one, might mean 'often' to someone else. Numerical options would have been tricky to form as well. The question was included, because the dirt removal locally is very practical and pretty easy way to decrease the amount of the machine wash.

Washing temperature and frequency of machine wash

Over 60 % said they usually wash children outerwear in 40 C. In hot water (60 C) only few one wash, but almost a third uses 30 C program (32.3 %). Hot water spoils the technical features faster, for example taped seams will be broken more quickly if washing is done in higher temperature than the care label says.

The situation was pretty even in frequency of machine wash. 'Once a month' was slightly the most common answer with 27 respondents. 'Once a week' and 'once in two months were equal popular. 42.9 % of German wash once every week. Same amount of Germans said they rarely remove the dirt before washing, so these might be related. The need for the machine wash is bigger, if letting the stains dry and stay several days in the fabric.

While 44 % of the respondents said the washing machine is half full, the answers were equally divided with options '25% of the capacity' and '75% of the capacity'. Often the care instruction label guides the consumer to wash the garment separately from other laundry, that might effect on this. About the drying the respondents act similarly; 64 out of 93 responded dry in room temperature. None of the respondents said they would use drying program of washing machine, but apparently it is not common yet. Only 20 participants responded they dry in the tumble dryer.

Garments' location after the use

The second part of the survey was about the attitudes and the feelings towards the second hand and repairing possible offered by Reima in the future. More than a half of the participants (54.8 %) replied the garments will be saved for the younger siblings and 24.7 % will sell the garment forward. After the use nearly everyone does something else for clothing than throws it into the trash. Over half of the respondents answered they save the garment for younger siblings. This way the lifespan lengthens when the garment gets more wearing times. If taken this further, improvement from this would be to loan the garment for a child who can use it before next user is big enough. Because if the garment is stored for a long time, it's potential is wasted.

Interest towards second hand outerwear

Reima club members are pretty conscious consumers based on the survey because half of the respondents answered they buy children outerwear as second hand. Considering the environment, Reima Club, where consumers have registered and want to be part of Reima community, the second hand buying rate is quite high. Could be assumed, that major part of the members primarily buys outerwear as new from Reima because they have joined the club and likely follow their marketing channels. On the other hand, around a third had replied they never buy second hand garments.

When asked about interest to buy Reima second hand items if Reima would verify the condition of technical features, over 80 % of the participants answered they would probably buy or for sure buy second hand from Reima. Around every fifth (26.9 %) of total responses were sure they would buy with the verification. As seen in question one about the most important features in children outerwear, technical features and durability were the most common responses, and it effects on purchasing decision also when buying the second hand garments. Could be assumed, that this together with the availability and the price of Reima second hand products, are the key elements if considering to launch such a service. Germans were hesitating the most; only 23.5 % would definitely buy or probably would buy verified second hand items.

Purchasing location for Reima second hand garments

57.0 % of the respondents were interested in buying Reima second hand items from their online store. In Finland and Sweden participants were clearly preferring Reima online store instead of physical, brick-and-mortal store. Co-partner online store and the physical Reima store were the least favourite options for all five countries that were looked in details. Conclusion is, that these respondents have found Reima online store convenient place for purchasing and they find Reima as a reliable brand. Reasoning why co-partner's online store was not as good option, could be the lack of experience about second hand companies or the respondents would prefer clear navigation: from Reima online store they know they will find only Reima second hand items, not from all kind of brands mixed. Also current pandemic might have influence the responses; people are probably now more used to order online than before because going to physical store might have seemed a risk for health.

Repairing service raised interest especially in Scandinavia

Repairing service raised an interest among the survey participants. 72.0 % of all respondents said they would probably or for sure buy the service from Reima. Especially in Northern Scandinavia, Finland, Sweden and Norway, the service seemed to have an interest while 64.0 % were at least 'probably' interested. Probably Reima's brand is so appreciated that customers are willing to have an effort to keep in good condition or the repairing services are needed addition for children outerwear market. Outerwear is one of the most complex garment to repair yourself because of complicated structures and to keep the technical features. It is also the most expensive garment children usually have and financially significant investment, so consumers want to take care of it.

In Poland this service raised hesitation when a third of Polish respondents said they would probably not be interested. In Poland might be that the price of the service could be the issue, because half of Polish responses the price is one of the most important factors in children’s outerwear.

3.3 MIPS calculations

MIPS method was selected to be used as a tool for reviewing closer the material flows of laundering the children outerwear during autumn-winter season. The method was explained in chapter 2.3.2. In this chapter the goal and scope will be covered, followed by inventory analysis and limitations. After that, the calculations based on the consumer survey are explained, and also the scenario calculations with the results and finally are the conclusions.

3.3.1 Goal and scope definition

Goal for the calculations in general was to clarify the role of material input in use phase of Reima outerwear. With the calculations the possible opportunities to decrease the material flow can be identified, and develop the end of the garment life cycle more sustainable. Additionally, the relevance, reliability and accuracy were targets of the calculations.

The scope was to calculate material input (MI) for one load of washing machine and separately for one season (October-February). Firstly, these were calculated based on the survey results and followed by calculations of different laundry behaviour scenarios. In these scenarios changes, compared to survey calculation, were made by the assumed improved practises. After finishing the calculations, the impacts of those changes can be compared considering the abiotic and biotic materials, earth movements, water and air.

3.3.2 Inventory analysis

Consumer survey results were used as a base for the MIPS calculation. The typical profile of washing children outerwear was identified based on the most popular responses in the Reima consumer survey. Additional information was gathered from other sources as a desktop study (table 5).

The washing temperature appeared in the survey, but as a comparison and support, other sources were discovered in desktop study. Energy and water consumption were not asked in the survey due to the reliability issues that might have appeared. Washing machine's energy classification and selected program with additional modifications of the program effect on these values. This information was taken from external sources (table 5).

Table 5. Data for survey based calculation with MIPS method

Factor	Amount	Unit	Data	Source	Additional notes
Washing tempera-ture		-	Mostly used washing machine program temperature 40 C	Survey	
Washing tempera-ture		-	Average washing temperature is 46 C in European households	Boyano & al. 2019	
Energy con-sumption	0,83	kWh	1) Average energy consumption per cycle is 0.830 kWh in 2013 in European households, 2) A++ washing machine consumes energy the same amount with 60C program	1) Boyano & al. 2019, 2) MTP 2009; in Thomas & al. 2012, 23	
Water con-sumption	47,9	kg	A+++ washing machine consumes 10 544 litres annually so per cycle the amount is 47,9 litres	Coolblue 2020	
Washing fre-quency	Once a month	-	The majority of the survey participants responded they wash children's autumn/winter outerwear once a month: October-February includes 5 loads	Survey	
Washing machine capacity 50 %	-	-	The majority of the survey participants responded washing machine is usually 50 % full when washing children outerwear. The average capacity of the machines (in kilogrammes of cotton) is 7.04 kg in 2013 in European households. (Boyano & al. 2019).	Survey	
Drying in room tempera-ture	-	-	The majority of the survey participants responded they dry usually children's autumn/winter outerwear in room temperature	Survey	
Washing deter-gent	-	-	Good previous experience, scent, biodegradability	Survey	Challenge to find accurate data

Relevant and reliable information about water and energy consumption was challenging to find due to the different measurement and partially the age of the researches. The washing detergent data was not available because most of the brands do not publish detailed ingredient lists. Even with the list the amounts, the proportions are business secrets. Third challenge with the detergent was the MI factor data, because the ingredients were not found from Wuppertal Institute's list, and without chemist's experience it was impossible even to find similar chemicals that could have been used in the calculations.

3.3.3 Limitations and assumptions

These calculations include use during one season from October until February. This limitation was selected because one outerwear overall is often used by one user per one season when considering small children. The children outgrow fast the garment, because they are expected to grow 6-7cm per year (Cooper & al. 2013), as mentioned previously in chapter 2.1.1.

The calculations included only washing part of the use phase, because it is a process the consumer can affect the most and it is repeated regularly, when the impact increases when considering the big picture. Drying stage was supposed to be included as well, but after the survey revealed the most common way of drying is room temperature, it was removed from the factors. Drying in room temperature does not need any natural resources or produce any waste. For example, the tumble dryer or drying cabinet would have needed energy and tumble dryer produced fibre waste from the clothes.

It is also assumed in the calculations that consumer selects the standard program that has been used for determine the water and energy consumption by EU energy label. One load means one cycle of machine wash not appending on the amount of laundry. Leaving the detergent from the calculations may effect little or moderately to the MI end value.

MI factor for water consumption was selected to be drinking water in Germany. As electrical power the MI factor of OECD countries electricity (Germany) was selected. These were the closest option available. The most accurate results would have been MI factors of Scandinavian water and energy sources, because more than half of the respondents were from Scandinavian countries.

3.3.4 MIPS calculations based on the survey

MIPS calculation method was used to calculate the MI value due to the available data. Factors of washing process were based on the survey results and supplemented with the data from desktop study research.

Water and energy consumption were considered. The data received from the survey included washing temperature (40 C) and the washing frequency (once a month). The temperature was compared to average washing temperature in European households in research made by Boyano, Espinosa & Villanueva (2019), which was 46 C. Water consumption was based on washing machine with EU energy label A+++, that consumes 10 544 litres annually so per cycle the amount is 47.9 litres (220 loads per year that is determined by EU). Energy consumption was based on the average energy consumption per cycle in 2013 in European households (0.830 kWh) (Boyano & al. 2019), and also study that stated A++ classed washing machine consumes energy the same amount with 60 C program (MTP 2009; in Thomas & al. 2012, 23, 2). Comparison of the data was done to guarantee the reliability and conservative values were used in the calculations. Data set for survey based calculation is presented in table 5. Calculation chart is available in appendix 2 and the summary of it can be seen in table 6.

Capacity of the washing machine was asked in the survey, because it has on impact on environmental sustainability through the energy consumption and water consumption. It was not included in the calculations. It increases the material input for one piece of outerwear if the full capacity of the washing machine is not used. It means used material, like energy, water, detergent chemicals and attrition of washing machine, are wasted partially because with all those resources, more service could have been gained (more clothing to be washed). Material flow can be decreased by washing more dirty clothing in the same load, by using maximum capacity of the washing machine. In the longer period, also household's total energy and water consumption would decrease the more of the washing machine's capacity is used.

3.3.5 MIPS calculations of comparative scenarios

Four different scenarios were built for exploring the impacts of different laundry practises (table 6). Selected scenarios are based on practical, realistic ways how the households could impact on material flows from the laundry. These comparative scenarios were calculated to create a better understanding about the effects of changes in laundry behaviour.

In the first scenario the frequency of machine washing was decreased from once a month to once in two months which means three times instead of five when rounding up 2.5 times. In practise this could be achieved by increasing the dirt removal straight after the use, for example with wet cloth and clothing brush the snow, water and sand could be removed and this way lengthen the time between the machine washes.

In the second scenario washing frequency stayed same as in the original survey based case, five times per season if done once in every month, but the temperature was decreased from 40 C to 30 C. In practise this temperature may be too low for some dirt types but still realistic temperature. 30 C saves the material and its technical features, like coating against the wind, the rain and the snow, or other structures in the fabric.

The third scenario was again with the same washing frequency, once in a month, but the standard program of washing machine was changed into program with 10 per cent of water saving. Fourth scenario combined all previous scenarios which mean washing in 30 C temperature with 10 per cent water saving and three times per season.

Table 6. Summary of calculated scenarios

Scenario	Explanation
1	Washing in 40 C, 3 times per season instead of 5 times
2	Washing in 30 C, 5 times per season (once a month)
3	Less water consumed (washing program with 10 percent of water saving technique compared to A+++ washing machine), five washes per season
4	Combination of all three scenarios: Washing in 30 C special program that saves 10 percent more water, three times per season

3.3.6 Results of scenario calculations

Calculation results (below table 7) are presented with MI value but with Total Material Requirement (TMR). There abiotic material, biotic material and the erosion are combined. Air and water are presented separately. In MIPS method in general the amount of water is viewed separately, because water usage has very different impacts in different areas worldwide. Also, if the water would be combined with other categories, it would make viewing difficult because water value would cover the rest with its massive size. (Autio & Lettenmeier 2002, 35.)

In the MI/TMR values per load the changes were small between the different scenarios. When viewing all the MI/TMR values per season, the differences are bigger and changes in laundry impact more clearly. In the survey based calculation MI/TMR season value is the highest (320.3 kg) but scenario 2 with lower temperature 30 C, the result is nearly the same (317.7 kg).

Scenario 1, which means decreasing the washing frequency from once in a month into once in two months, has a significant change when looking the MI/TMR in season. When the washing times per season halved, the change was -40 % compared to survey based situation. In scenario 2, where the frequency has stayed the same but the washing temperature has decreased from 40 C to 30 C, the change is small in season's MI/TMR value (0.8 %). The change in water is significantly bigger with -18 %. Scenario 3 was about using water saving program, and it decreased MI/TMR by almost 10 %. When looking at the situation with air, using water saving programme during one season with 5 washes, it saved in air -64 % compared to survey based situation. It has the same impact on air, if the washing temperature is decreased from 40 C to 30 or the amount of washing loads is decreased from five to three times. When looking the water, there is a difference, especially when looking at the material input per season; with 30 C wash and 5 loads, the water usage is 36 per cent higher than if washing in 40 C three loads per season.

In the scenario 4 with the combination of all other scenarios, the values are the lowest in all categories. The change to the survey based case is not that big when looking at savings per load, but when looking at season, the change in MI/TMR is -46.4 % which is remarkable. In season also the water and air masses have decreased more than -50 %.

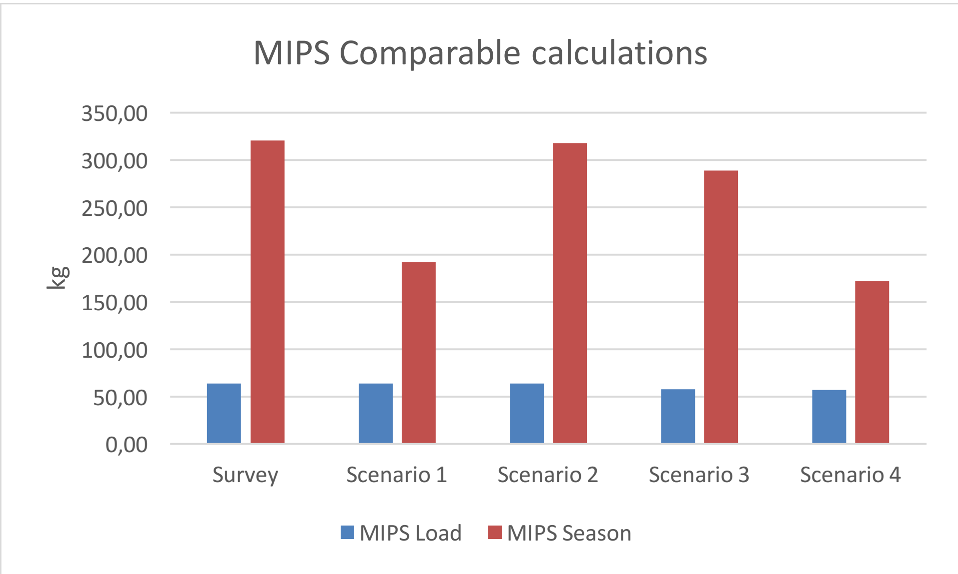

Figure 19. Comparison of MIPS value calculation results

From the figure 19 the changes, especially per season, can be clearly seen. Scenario 4 has the lowest total material requirement per season, where the survey based and scenario 2 have as high MI/TMR values. In the figure the values are MI/TMR values with abiotic and biotic material combined with the erosion.

Table 7. Summary of MIPS calculation results

Summary of the MIPS calculation results									
		Load			Season			Change % MI value (TMR)	
Source	Case	**MI value TMR (kg)**	Water (kg)	Air (kg)	**MI value TMR (kg)**	Water (kg)	Air (kg)	Cycle	Season
Survey	Washing in 40C Once a month, 5 times per sea-son	**64,06**	115,25	0,35	**320,30**	576,24	1,76	-	-
Scenario 1	Washing in 40 C 3 times per season	**64,06**	115,25	0,35	**192,18**	345,75	1,06	0,0 %	-40,0 %
Scenario 2	Washing in 30 C 5 times per season (once a month)	**63,54**	94,19	0,21	**317,70**	470,93	1,06	-0,8 %	-0,8 %
Scenario 3	Water saving washing program (-10 %), 40 C 5 washes per season	**57,79**	109,02	0,35	**288,93**	545,11	0,64	-9,8 %	-9,8 %
Scenario 4	Combination: Washing in 30 C Water saving program (-10 %) 3 times per season	**57,26**	87,96	0,21	**171,79**	263,87	0,64	-10,6 %	-46,4 %

3.3.7 MIPS conclusions

The differences are small if comparing the differences of single loads, instead the focus need to be in season consumption to see the bigger effect.

The scenario 4 with the combination of all other scenarios, have the lowest in all categories, but surprisingly in some categories the values are very close each other. For example, when looking at total MI/TMR value for season, if washing once in two months the outerwear in 40 C (scenario 1) or washing in 30 C with water saving program three times per season (scenario 4), the difference between these two in MI/TMR value is only 10 per cent for scenario 4. It seems decreasing the machine wash times impacts more to MI/TMR than decreasing the washing temperature from 40 C to 30 C. Reason behind it is the amount of water, it is such a big factor.

Adapting scenario 4 from the survey based situation takes quite a lot effort, so the change from washing in 40 C five times a season into washing three times only, would demand quite a small change with a big impact. This could be achieved by washing the dirt from the outerwear more often to be able to skip two machine washes. What is not considered here, is the increasing demand for water and detergent in case the those are needed for very dirty garments. It increases the water consumption from calculated scenario 1. If the dirt would mostly be sand, that could be cleaned by a brush, local stain removal would not increase the demand for natural resources like water, remarkably.

4 Final conclusions

The garment's life cycle is a long process and after the designer has drawn a sketch, there are several steps in many different hands before, for example the winter overall, is a ready garment in online store. And that is just a beginning of the road it goes along with its first user. Lengthening the garment lifecycle by purchasing only for the need and by taking as good care of it as possible with sustainable practises, the waste can be minimized and the natural resources, that have used to produce the item, are used efficiently. To achieve the best results, the companies and the consumers both need to know their responsibilities, and ways how to affect the environmental sustainability.

This final chapter includes the key findings of this research, recommendations for Reima Oy and the ideas for further research. Also the validity, reliability and relevance will be analysed. Feedback from commissioning company and reflection of learning chapters are included as well.

4.1 Key findings

The laundry behaviour of typical Reima customer with outerwear was found: technical features and durability most important factors in children outerwear. Washes the child's outerwear in 40 C temperature once a month and fills the machine with 50 % of the machine capacity. Drying happens in room temperature. Customer selects the laundry detergent based on good previous experience and scent, next important factors are biodegradability and eco certificates. Sometimes customer removes the dirt from outerwear instead of machine wash. Outerwear is saved for younger siblings instead of selling or disposal. Customer has an interest for Reima second hand service in online store and likely would use the service. There is an interest to use Reima repairing services.

In the MIPS calculations the differences were small if comparing the differences between the single loads, but instead when focusing on season results. Frequency of machine wash impacts more to MI/TMR than decreasing the washing temperature from 40 C to 30 C. Reason behind it is the amount of water, it is such a big factor. Changing from washing in 40 C five times a season into washing three times only, would demand quite a small change but it has a big impact. This could be achieved by washing the dirt from the outerwear more often to be able to skip two machine washes.

4.2 Recommendations for Reima

Labelling with environment measures

Labelling the products with environmental measures would bring a new aspect for the customers. It could be the carbon footprint or some other clear method, that customers would be able to easily understand. Reima could be a forerunner in fashion field to launch this, and strengthen the reputation as a sustainable, transparent brand. The labelling could be about the production phase and include the use phase, or there could be a calculator in website where the customer could test on product page what kind of impact it does for the product footprint if e.g. decreasing the washing temperature or wash more rarely. Information about the environmental effects total or for example water consumption, could be also added to the care labels next to washing instructions with the ways how to decrease them.

Verified second hand service

I recommend Reima to launch the second hand service, where the condition of the technical features have been verified. Based on my personal experience, many parents do not want to buy second hand overall for upcoming season for their child, because they would like to know how is the condition of technical features. This appeared in the survey comments as well. Reima is known for its durable, high quality outerwear and consumers trust the brand which helps when starting new service. Reima collects the garments back from their owners after the use, check the technical features and sell forward with the verification. I recommend this service to be in online store based on the survey responses. Offering this service would bring more value for the customers by covering the end of life cycle. This would engage the customers as well, because the customers could return the garments back to the store they purchased it, and in addition to buy new items, they would find also the second hand items from Reima. Loyalty towards Reima would increase as well.

New product range: Care products

Reima's care product selection would be a good addition with the high quality outerwear. This would offer a possibility to create safe, environmental friendly and washing detergent to protect the technical features in outerwear. It could include other caring products as well, like clothing brushes and conditioners to protect the finishing. This would add value for the customer, but also bring a new revenue stream for Reima. This would invite customers to take care of the garments and Reima could highlight the importance of maintenance with this product range.

Marketing tools to promote lengthening the lifecycle

A way to engage customers, would be to invite them in different marketing channels to post repairing photos. Additionally, Reima could share maintenance tips in social media and highlighting the repairing and maintenance in general. This would share the knowledge about the different ways to take care of the garments, but also sending a message that Reima encourages to lengthen to garment lifecycle. This would also strengthen the Reima's position as a sustainable brand.

4.3 Suggestions for further research

To continue with the use phase measuring, the carbon footprint calculations could be done for use phase. Calculations could be combined with the production and transportation, that Reima has already started to work on, to get covered the total life cycle. Carbon footprint is one the most used tools at the moment and customers become more familiar with it every year, so Reima could explore the possibilities to add carbon footprint to the labels and online store to help the customers estimate the environmental impacts. Reima could be forerunner, because this has not yet been covered at least in Scandinavia fashion industry.

In case of washing machine's material efficiency would like to be discovered, the MIPS calculations could be taken further by collecting data about washing machine's materials from machine producer and waste information, for example about waste water and micro plastics, so that the total efficiency of laundering could be defined. This research's calculations could be combined with the calculations of garment production, when the material intensity of the total life cycle could be covered.

Handprint could be explored further if there would be possibilities to use it as a positive communication tool about sustainability matters. Handprint is a quite new concept about measuring and communicating about the positive changes that has been done related to for example product lifecycle, services, processes, organizations or individuals. It can be created by avoiding or preventing the negative impacts or by creating positive benefits. (Pajula, Behm, Vatanen & Saarivuori 2017.)

4.4 Validity, reliability and relevance

The reliability of used sources for desktop study was very good and wide range of international academic studies were used as a base for this research. A big part of the sources was validated and widely cited. The sources in general were mostly from recent years and the studies were fresh. The relevance of the sources were considered carefully during the research.

The consumer survey was clear and neutral from its tone. The questions and the survey structure supported the purpose. The sample size was big enough (93 participants) to form assumptions about the population of Reima customers. The respondents were registered to Reima Club and are interested about Reima and likely they have experience about Reima's products as well, which mean the target group was relevant to find out Reima's customers' laundry habits. Respondents were all over the Europe so the range is wide but enough answers arrived from five countries, that were selected for a closer analysis. Several respondents gave positive feedback about good questions and no negative messages were received in the feedback box.

Topic is familiar from daily life to everybody that possible has made the responding easy for respondents. It was mentioned in the introducing text that the responses will be taken to sustainability context which may have effected respondents' answers so that they might have been attempted to round up their responses to be more sustainable than how they in daily act. The possibility for lies exist but because of topic's ordinariness the risk for that is considered as low.

Collected data was relevant and valid. Calculations were accomplished precisely and according to the process steps. The calculations could give more accurate results by adding the capacity. The ingredients of the detergent would improve that as well, but understandably those are business secrets. The sample of the survey was so wide, that the relevance of survey based calculation was good.

4.5 Commissioning company feedback

Will be added later

4.6 Reflection on learning

This study taught me a lot about measuring sustainability. My knowledge about measuring environmental sustainability increased due to the wide international material I studied. I understood already before the complexity of selecting relevant and reliable data, but now I have experienced it myself as a researcher and understand the challenges even better. Sources exist, more than I assumed when starting this project, but the difficulty is to select correct ones for your own purpose. In the future when I am working for a company in sustainability field, I will prefer partner company if possible, who is specialized in measuring the sustainability and has specific expertise. Although this research gave me tools to proceed measuring of some level by my own with the knowledge this research provided. In this project I noticed that there are much more data available for businesses, like calculators. I also learned more about time management and reporting, for example time wise the formatting and finalizing the report took longer than I estimated.

More discussing with the peer students and professionals would have given even more perspective to the study and would have clarified my focus in the middle of the process. Covid-19 pandemic had an impact on that definitely, because the face-to-face discussions about the topic were now missing totally due to the studying from home. The discussions would have brought new insights for me. Now theoretical basis expanded but more precise demarcation via peer discussions would have helped to keep the focus.

I thought the survey design carefully and got improvement suggestions, but several insights and additions appeared to my mind after the survey had closed and I was working with the results. For example, the question about the energy class of current washing machine, the most used program in washing machine for outerwear would have given more useful data for the calculations. Nothing crucial was missing and I was able to finish the research anyway.

The collaboration with Reima was easy and we had very interesting and useful discussions every time with R&D and Sustainability Director Shahriare Mahmood and Sustainability Specialist Sissi Penttilä. I am also happy about the survey structure. It was clear, consistent and size of the scope was good. I am pleased about the feedback the participants shared. Overall the thesis was a great learning experience as project management wise as sustainability study and in deepening my knowledge about the field. I am one step closer to become a sustainability professional.

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Appendices

Appendix 1. Consumer survey for Reima Club members

Survey: Use and laundry habits of children outerwear

Page 1: What the survey is about and personal information
We would like to hear how you wash children outerwear during autumn and winter season and how do you find second hand garments.
The answers of this survey will be used in Bachelor's Thesis for Reima by Katja Valovuori-Kilpi from Haaga-Helia UAS. Thesis' aim is to discover children's outerwear use phase behaviour of Reima customers in sustainability context. All the answers will be handled confidentially and the results will be presented anonymously.
Let's begin!

Your age

- 18-27
- 28-37
- 38-49
- 50-64
- 65-

Page 2: Use and laundry habits

1. What factors are important to you when selecting an outdoor garment for a child? Please select max. three options.
    - Appearance
    - As natural materials as possible
    - Brand
    - Durability
    - Easy to recycle
    - Good retail price as second hand
    - Maintenance service available by brand
    - Price
    - Repair kit included (e.g. a patch)
    - Second hand
    - Technical features
    - Other, what? (open text box)

2. What factors are important to you when selecting a laundry detergent for children's outdoor garments? Please select max. two the most important options for you.
   - Availability
   - Biodegradable
   - Brand
   - Convincing promise about the power in the package
   - Eco certificate
   - Good previous experience
   - Manufacturing country
   - Package appearance
   - Package material
   - Perfume/No perfume
   - Possibility to use in low temperatures
   - Price
   - Other, what? (open text box)

3. How often you remove the dirt from children's outerwear locally without machine wash during the autumn and winter seasons? Meaning removing stains, sand etc.
   - Never
   - Rarely
   - Often
   - Always

4. In which temperature you wash mostly children's outerwear during the autumn and winter seasons?
   - Cold
   - 30 Celsius degrees
   - 40 Celsius degrees
   - 60 Celsius degrees
   - Over 60 Celsius degrees

5. How often do you machine wash the children's outerwear on average during the autumn and winter seasons?
   - Once a week
   - Once in a month
   - Once in two months
   - More rarely than in two months

6. How full the washing machine is on average when you wash children's outerwear during the autumn and winter seasons?
    - 25 % of the machine capacity
    - 50 % of the machine capacity
    - 75 % of the machine capacity
    - 100 % of the machine capacity

7. How do you usually dry children's outerwear after washing during the autumn and winter seasons?
    - Outside
    - Room temperature
    - Washing machine with drying function
    - Tumble dryer
    - Drying cabinet

Page 3: Second hand & repairing services

8. What do you usually do for children outerwear after the use?
    - Save for younger siblings
    - Sell forward
    - Donate to charity/family/friends
    - Dispose

9. Do you buy children's outerwear as second hand?
    - Never
    - Rarely
    - Often
    - Always

10. How likely you would buy Reima second hand outerwear if Reima would have verified the condition of technical features?
    - No, I wouldn't buy
    - Probably not
    - Probably yes
    - For sure I would buy

11. Where would you like to buy Reima second hand garments?
    - Reima (physical) store
    - Reima online store

- Online store of Reima’s second hand co-partner
- I don’t buy second hand
- Other, what? (open text box)

12. How likely you would buy a repairing service from Reima in case of damage for Reima outerwear if it would be available?
    - No, I wouldn’t buy
    - Probably not
    - Probably yes
    - For sure I would buy

Page 4: Feedback and questions

Open feedback about the survey

Please give us feedback about the survey or if you any questions about the topic, please ask here and we will get back to you.

Thank you for your time!

Appendix 2. MIPS calculations

Calculation chart for the survey results

Based on survey results: Washing in 40C once a month												
			Abiotic Material		**Biotic Material**		**Earth movements**		**Water**		**Air**	
Material	Unit	Amount	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product
Washing machine												
Water consumption (Germany)	kg	47,9	0,01	0,479		-		62,27	1,3	62,270		-
Electricity consumption: (European OECD Countries)	kWh	0,83	1,58	1,311		-		-	63,83	52,979	0,425	0,35
Total				**1,79**				**62,27**		**115,25**		**0,35**

Material Input (TMR) per load	**64,06**
Water kg	115,25
Air kg	0,35
Material Footprint per season	**320,30**
Water kg	576,24
Air kg	1,76

Calculation chart for scenario 1

SCENARIO 1/4: Washing in 40 C, 3 times per season instead of 5 times												
			Abiotic Material		**Biotic Material**		**Earth movements**		**Water**		**Air**	
Material	Unit	Amount	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product
Washing machine												
Water consumption (Germany)	kg	47,9	0,01	0,479		-		62,27	1,3	62,270		-
Electricity consumption: (European OECD Countries)	kWh	0,83	1,58	1,311		-		-	63,83	52,979	0,425	0,35
Total				**1,79**				**62,27**		**115,25**		**0,35**

Material Input (TMR) per load	**64,06**
Water kg	115,25
Air kg	0,35
Material Footprint per season	**192,18**
Water kg	345,75
Air kg	1,06

Calculation chart for scenario 2

SCENARIO 2/4: Washing in 30 C, 5 times per season (once a month)												
			Abiotic Material		Biotic Material		Earth movements		Water		Air	
Material	Unit	Amount	MI-Fac-tor kg/unit	kg/unit Main product	MI-Fac-tor kg/unit	kg/unit Main product	MI-Fac-tor kg/unit	kg/unit Main product	MI-Fac-tor kg/unit	kg/unit Main product	MI-Fac-tor kg/unit	kg/unit Main product
Washing machine												
Water consumption (Germany)	kg	47,9	0,01	0,479		-		62,27	1,3	62,270		-
Electricity consumption: (European OECD Countries)	kWh	0,5	1,58	0,790		-		-	63,83	31,915	0,425	0,21
Total				**1,27**				**62,27**		**94,19**		**0,21**

Material Input (TMR) per load	**63,54**
Water kg	94,19
Air kg	0,21
Material Footprint per season	**317,70**
Water kg	470,93
Air kg	1,06

Calculation chart for scenario 3

SCENARIO 3/4: Less water consumed (washing program with 10 percent of water saving technique compared to A+++ washing machine), five washes per season												
			Abiotic Material		**Biotic Material**		**Earth movements**		**Water**		**Air**	
Material	Unit	Amount	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product
Washing machine												
Water consumption (Germany)	kg	43,11	0,01	0,431		-		56,04	1,3	56,043		-
Electricity consumption: (European OECD Countries)	kWh	0,83	1,58	1,311		-		-	63,83	52,979	0,425	0,35
Total				**1,74**				**56,04**		**109,02**		**0,35**

Material Input (TMR) per load	**57,79**
Water kg	109,02
Air kg	0,35
Material Footprint per season	**288,93**
Water kg	545,11
Air kg	1,76

Calculation chart for scenario 4

SCENARIO 4/4: Combination of all three scenarios: Washing in 30 C special program that saves 10 percent more water, three times per season												
			Abiotic Material		**Biotic Material**		**Earth movements**		**Water**		**Air**	
Material	Unit	Amount	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product	MI-Factor kg/unit	kg/unit Main product
Washing machine												
Water consumption (Germany)	kg	43,11	0,01	0,431		-		56,04	1,3	56,043		-
Electricity consumption: (European OECD Countries)	kWh	0,5	1,58	0,790		-		-	63,83	31,915	0,425	0,21
Total				**1,22**				**56,04**		**87,96**		**0,21**

Material Input (TMR) per load	**57,26**
Water kg	87,96
Air kg	0,21
Material Footprint per season	**171,79**
Water kg	263,87
Air kg	0,64