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A DESIGN THINKING APPROACH FOR THE WORKWEAR ECOSYSTEM - IMPROVING THE ENVIRONMENTAL PERFORMANCE OF WORKWEAR TEXTILES

Lappeenranta–Lahti University of Technology LUT

Master's Programme in Mechanical Engineering, Master's thesis

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ABSTRACT

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A design thinking approach for the workwear ecosystem -

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During the recent years, the textile industry has grown significantly triggering distress relating to the future climate impact of the industry. The concern is that the dominant value chain is linear and results continuously increasing need for resources. To pivot away from the current course leading to substantial environmental burden, the industry needs to adopt new more sustainable methods of operation. Though several methods for improving the environmental performance are known, the industry has barriers to overcome before they can be implemented in a large scale.

The main objective of this thesis was to study a specific part of a workwear company value chain to identify opportunity areas for implementing practices that would result benefits in terms of environmental sustainability. The part of the value chain in scope included a workwear company, their customers, and a textile recycling facility. The research followed the principles of the design thinking methodology. In addition to the main objective, the study generated learnings from supplementary topics such as challenges and goals each stakeholder in the value chain has relating to operating in more environmentally sustainable manner, synergies between the stakeholder operations, and key barriers in the value chain for implementing certain environmentally beneficial practices. To conclude the design thinking process, solutions alternatives relating to one of the identified opportunity areas were generated and one solution alternative was developed further to a concept level proposal.

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Muotoiluajattelu näkökulma työvaateteollisuuteen -

työvaatteiden ympäristövaikutusten pienentäminen

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Lähivuosien aikana tekstiiliteollisuus on kasvanut merkittävästi aiheuttaen huolta alan ympäristövaikutuksista. Tekstiiliteollisuuden vallitseva arvoketju on lineaarinen, mikä on johtanut yhä kasvavaan resurssien tarpeeseen. Pystyäkseen siirtymään pois nykyisestä toimintamallista, joka jatkuessaan aiheuttaa merkittävän ympäristötaakan, teollisuuden on omaksuttava uusia kestävämpiä toimintamalleja. Vaikka tiedossa on monia tapoja parantaa ekologisuutta, niiden toteuttaminen suuressa mittakaavassa on haasteellista.

Tämän diplomityön pääasiallinen tavoite oli tutkia tiettyä osaa työvaateyrityksen arvoketjusta ja tunnistaa mahdollisuusalueet sellaisten toimintatapojen toteuttamiseksi, jotka tuottaisivat hyötyjä ympäristön näkökulmasta. Tarkasteltu arvoketjun osa sisälsi työvaateyrityksen, heidän asiakkaansa ja tekstiilinkierrätyslaitoksen. Tutkimus noudatti muotoiluajattelu-menetelmän periaatteita. Pääasiallisen tavoitteen lisäksi tutkimus tuotti tietoa sivuteemoista, kuten haasteista ja tavoitteista, joita kullakin sidosryhmällä arvoketjussa on ympäristöystävällisempiin toimintamalleihin liittyen, synergioista sidosryhmien toimintojen välillä ja keskeisistä esteistä arvoketjussa tiettyjen ympäristölle edullisten käytäntöjen toimeenpanemiseksi. muotoiluajattelu-prosessisin loppuun saattamiseksi tuotettiin vaihtoehtoisia ratkaisuja yhden määritellyn mahdollisuusalueen sisällä ja yksi vaihtoehtoisista ratkaisuista kehitettiin edelleen konseptitasoiseksi ehdotukseksi.

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1 Introduction

Due to the increasing environmental awareness, dwindling resources, and loss in biodiversity, increasing number of industries are moving towards more sustainable way of conducting business. According to Van Der Ven (2022, p. 7) the current supply chain system of the textile industry is largely linear, and the production and consumption of textiles is predicted to be tripled by the year 2050. An estimate by Ellen Macarthur Foundation (2017, p. 18) suggest that if scenario for 2050 transpires, the potential carbon budget usage by the textile industry could be 26 % of the amount associated with the 2°C warming limit. Considering the current state of the industry there's an undisputed call for finding ways to limit the environmental impact of the textile sector, such as augmented recycling possibilities, circularity supporting business models and finding alternative material feedstocks.

In addition to the linearity and vast growth of the entire textile industry, garment business suffers from increasing underutilization of products, meaning that clothes are discarded well ahead of their potential service life (Ellen Macarthur Foundation 2017, p. 18). Also lack of sufficient recycling infrastructure, vast number of materials and their combinations used, and the lack of incentive to utilize less environment eroding operating models add to the problem (Filho, Ellams, Han, Tyler, Boiten, Paço & Moora 2019, p. 15-16).

In this thesis the industry environmental challenges are examined from the clothing sector point of view. Specifically, from the angle of workwear textiles. Generally, environmental concerns in the workwear industry are not as severe in comparison to consumer fashion. This is due to nature of the business in which garments with high quality and long service life are preferred. Tough the nature of the workwear sector helps with many of the commonly identified environmental issues attached to the industry, there is room for improvement. To investigate the environmental aspects and pain points within the workwear industry, a case study was executed in co-operation with a service sector workwear company Touchpoint. This thesis focuses on leveraging the design thinking methodology to find opportunity areas for implementing practices that would improve the environmental performance of workwear textiles.

1.1 Motivation

The motivation for the research is derived from the environmental concerns which are gaining more and more momentum in public discussions. Individual consumers are expecting the companies they associate with to be environmentally responsible. Similarly, companies purchasing goods and services from other companies are expecting their counterparts to have a sustainable way of operating. Additionally, environmental challenges like climate change, depletion of natural resources, and biodiversity loss are fought against with new legislation. Pressure from customers and new legislation is pushing companies to adapt to increasing levels of environmental accountability.

Previous studies focusing on textile industry show that the industry is growing at a fast phase and thus using increasing amounts of resources and producing mounting levels of waste. Exhausting resources and the lack of ways to effectively maintain the material value after discarding has led to a situation in which circular business models are gaining more and more interest. Circular ways of operating are not yet common in the textile industry, but studies made by Ellen McArthur Foundation (2021, p. 20-23) show that environmental performance of operations can be improved by following the principles of circularity.

Within EU several textile relevant sustainability initiatives have been introduced. These initiatives include Circular Economy Action Plan (CEAP), EU Strategy for Sustainable and Circular Textiles (SSCT), Eco-design for Sustainable Products Regulation (ESPR), and Waste Shipment Regulation (WSR). CEAP includes the high-level strategy for circular transition within EU. SSCT describes a plan that would warrant that textiles placed on EU market are long-lasting, recyclable, use as much recycled and toxic free materials as possible, and are produced in a sustainable manner. Target year for the SSCT plan to be effective is 2030. ESPR specifies general eco-design requirements for durability and reliability. The initiative covers topics like reusability, upgradability, repairability, substances of concern, resource efficiency, recycled content, remanufacturing, recycling, carbon footprint, and expected generation of waste. WSR aims to ensure that EU doesn't export waste to third countries unless the importing country has the infrastructure for managing waste in a sustainable manner. (Van Der Ven 2022, p. 28-31.)

1.2 Research Problem

Past studies have discussed the environmental performance of textiles and introduce ways to improve the sustainability of garments on general level. However, the applicability of these improvement actions to workwear industry and how well they meet the needs of different stakeholders in the value chain, has not been covered thoroughly in the existing studies. The absence of research and lack of information about the topic leads to the research problem of this thesis: What are the opportunity areas for implementing environmentally sustainable practices in the value chain of a workwear company and what are the barriers precluding practices to be put in place?

1.3 Objectives and Research Questions

To support the research problem and the main goal of identifying opportunity areas for implementing environmentally sustainable practices in a workwear company value chain, a set of research questions was formed and are listed below.

1. How do the perspectives and priorities of different stakeholders in the value chain differ regarding sustainable workwear practices?

2. What kind of synergies can be identification between the stakeholders in the value chain?

3. Can the synergies be exploited to generate initiatives that would improve the environmental performance of workwear and serve the needs of different stakeholders at the same time?

The first question relates to acknowledging that the needs and challenges might be different throughout the value chain. The objective of the question is to gain an understanding of the different viewpoints to support the work around the second research question. The second question is formed to find a way to account the needs of different stakeholders so that a framework can be established for facilitating the generation of holistic environmental

performance improving actions. The last question is about turning the input from the first two questions into concrete concepts, operating models, and ways of working which could be implemented in practice.

1.4 Research Methods

The case study made in co-operation with Touchpoint relies on the design thinking process, methodology, and tools described in detail in Chapter 3. Design thinking is an approach for problem solving that includes certain key principles of empathy, ideation, and iteration. The methodology fosters collaboration and user-focused mid set to find practical and innovative solutions. The process and tools are used to obtain deep understanding of the problem at hand. This forms a strong foundation for idea generation and later supports the refining of the generated ideas to implementable solutions.

Due to its versatility and applicability to various type of situations, design thinking has been utilized in many fields to find solutions for vast number of different types of challenges. In this study the design thinking methodology is first used to gain an understanding of the environmental sustainability related pain points and challenges within a workwear company value chain. This is followed by defining the key barriers that prevent further implementation of more sustainable ways of operating. The problem definition leads to idea generation aiming to come up with solutions to overcome the identified barriers.

1.5 Scope

The scope of the research is outlined by the industry sector the co-operation company Touchpoint operates in and limited opportunities to impact the supply chain and manufacturing methods of the products. The fact that clothes intended for workwear usage have higher expectancy on terms of quality and durability limits the project scope to materials and processes relevant to workwear thus making results at least partly nonapplicable for companies making consumer textiles. Manufacturing related improvements were left out of scope since to be able to effectively study the operations at manufacturing sites, travelling to the production sites and material manufacturers would be needed. Most of the manufacturing sites are located abroad, which made visiting them

unfeasible for this study. Considering these limitations, the study focuses on parts of the value chain happening after the products are distributed from Touchpoint. What is also noteworthy is, that the results might not apply to companies with different operating models and value chains in comparison to Touchpoint.

A comprehensive approach to sustainability would cover three dimensions, social, economic, and environmental. This study is limited to finding ways to improve environmental sustainability without sacrificing economic viability.

1.6 Contribution

In broader sense this study has potential to contribute to resolving textile industry related environmental challenges. Besides the possible generic environmental gains, the contribution of this thesis can be looked from two viewpoints, from academic angle and from the point of view of the stakeholders collaborating in the case study.

Studies focusing on textile industry and the related environmental issues have been conducted in the past, but most of these studies focus on measuring the environmental performance of various products or are theory-based calculations. Number of studies discussing practical implementation of sustainability improving actions in the textile industry seem to be limited and even more so when narrowing the scope to work wear sector. Seemingly a study in which the design thinking would have been used as the dominant research method for finding new solutions for the textile industry challenges, has not been carried out before. These things considering, this thesis has a change to showcase a design thinking approach in a new setting. Additionally, the results of the study may inspire new academic research building on the findings of this one.

From the case study stakeholder point of view the study promotes collaborations between different interested parties and deepens the understanding of partnership dynamics and thus can help with the implementation of new sustainability initiatives.

1.7 Structure of the Study

After the introduction the thesis consist of six chapters. Chapter 2 of this thesis provides background information regarding the textile industry including an overview of the environmental challenges related to the industry, ways to improve the sustainability of textiles, a closer look into workwear industry, and a comparison between consumer fashion and workwear industries. Chapter 3 describes the design thinking methodology and some of the most common design thinking tools. Chapter 4 discusses the background and stakeholders involved in the case study, and how the design thinking methodology was utilized. Result are presented and discussed in Chapter 5. Analysis is covered in Chapter 6. Conclusions from the research are given in Chapter 7.

2 Review of the Textile Industry and its Sustainability Aspects

Textile industry is a massive fast-growing field that employs more than 300 million people considering the full value chain (Ellen Macarthur Foundation 2017, p. 18). A generalized value chain of the textile industry is illustrated in Figure 1. The chain begins with fiber production and proceeds to turning the manufactured fibers to yarns which are then used in fabric manufacturing. Fabrics are generally used to produce three types of products: clothing-, furnishing-, and industrial products. Clothing includes products like shoes and other consumer fashion items, furnishing covers products such as carpets, curtains and linen, and example industrial textile products include ropes, nets etc. Technical materials like parachute materials and smart textiles are also included in industrial products. (Euratex 2022 p. 7.)
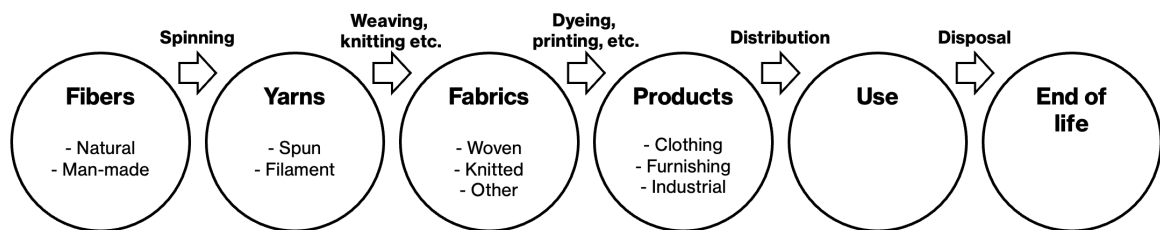
Figure 1. Generalized linear value chain of textile products (Euratex 2022, p. 7; Van Der Ven 2022, p. 23).

Since the 70's textile industry has grown significantly which is evident when observing Figure 2. In the figure fiber production since the year 1975 to present is illustrated. Additionally, the figure gives the share of different fiber types and forecast of the production volumes when the year 2030 is reached. (Textile exchange 2022, p. 9.)

Global fiber production (million tonnes)[1]
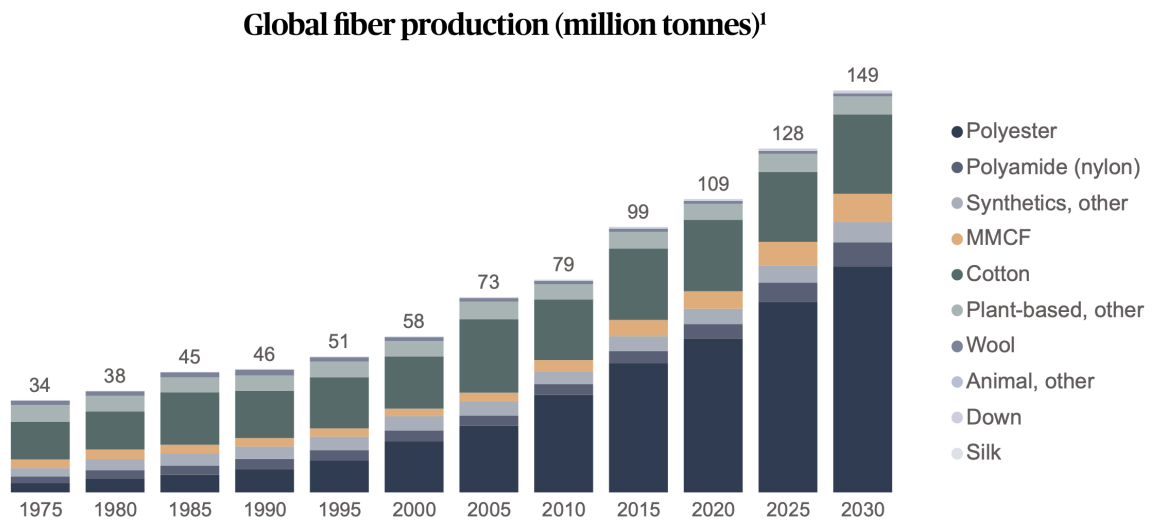
Figure 2. The growth of fiber production (Textile exchange 2022, p. 9).

From the whole textile industry, clothing represents more than 60 %. Clothing industry has been rapidly growing with the rest of the industry. Between the years 2000 and 2015 the number of produced clothing units approximately doubled, as it can be seen from Figure 3. The figure also presents how clothing utilization and GDP have developed during the same period. (Ellen Macarthur Foundation 2017, p. 18.) GDP stands for gross domestic product, total market value of all finished goods (Fernando, 2022).
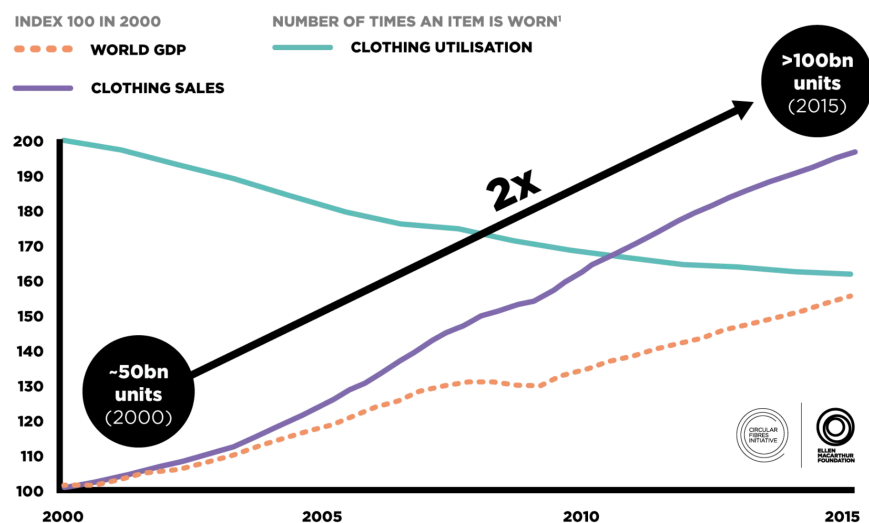
Figure 3. Increase in clothing unit sales compared to world GDP and clothing utilization
(Ellen Macarthur Foundation 2017, p. 18).

When comparing the Figure 2 and Figure 3, the increase in clothing unit sales is in line with the fiber production increase during the same period. The growth of the clothing part of the textile industry is driven by two main factors: global growth of middle-class population and increased per capita sales in mature economies (Ellen Macarthur Foundation 2017, p. 18).

2.1 Environmental Concerns of the Clothing Industry

From the environmental perspective textile sector is among the industries causing the most concerns. From the life cycle perspective, textiles are the fourth most polluting products. The of pollution happens in multiple forms such as greenhouse gasses, energy usage, used chemicals, used nutrients, and land usage. Greenhouse gases emitted during the manufacturing and use of textiles account for 3 % of the global total. (Nørup, Pihl, Damgaard & Scheutz 2018, p. 8.) The green-house gases emitted by the industry exceed 3.3 billion metric tons per year, which is more than all the international flights and maritime shipping combined (Notten 2020, p. 19). Additionally, the amount of energy, water, chemicals, and nutrients used have an environmental cost as well. Also, some fiber types, like cotton, have concerns relating to land use required for the cultivation of fibers. (Nørup et al. 2018, p. 8.)

The Figures 4-6 present the environmental impact of the clothing industry from different perspectives. The results illustrated in the graphs are based on a UNEP life cycle assessment and are using the World Apparel Life Cycle Database as data source. The baseline year for the study is 2016. (Notten 2020, p. 20.) UNEP stands for UN Environment Program, a global authority driving the sustainable development within UN (UNEP, 2023). The assessment follows the peer reviewed IMPACT 2002+ VQ2.2 LCA method. The study considers the following fiber types: polyester, cotton, other natural fibers, and cellulosic fibers. The study assumes all the fibers are produced conventionally according to the linear system illustrated in Figure 1. (Notten 2020, p. 18-20.)

Climate impact for the global apparel value chain is presented in Figure 4 and shows the environmental impact of different stages of the value chain. It can be seen from the graph that the energy intensive manufacturing phase contributes the most to the impact. Especially the large volumes of heated water required for the dyeing and finishing processes consumes a lot of energy. This is especially true in locations in which fossil-based energy sources are the majority. Use phase of clothing accounts for the second biggest environmental impact

due to the electricity needed for washing and drying. Fiber production has he third biggest impact. The primary reason for this is the fossil fuels used in the synthetic fiber production. The study shows that globally the impact of end-of-life phase is minimal. The reason for this is that the current recycling rate is low and is in fact downcycling to lesser value products like insulation and cleaning cloths. For this type of downcycling energy intensive processing is not required. Textiles that are not recycled are typically incinerated or they end up in landfill. Incineration and landfill have greenhouse gas emissions associated with them, but the impact is low in relation to emissions from other phases of the value chain. (Notten 2020, p. 19, 22.)
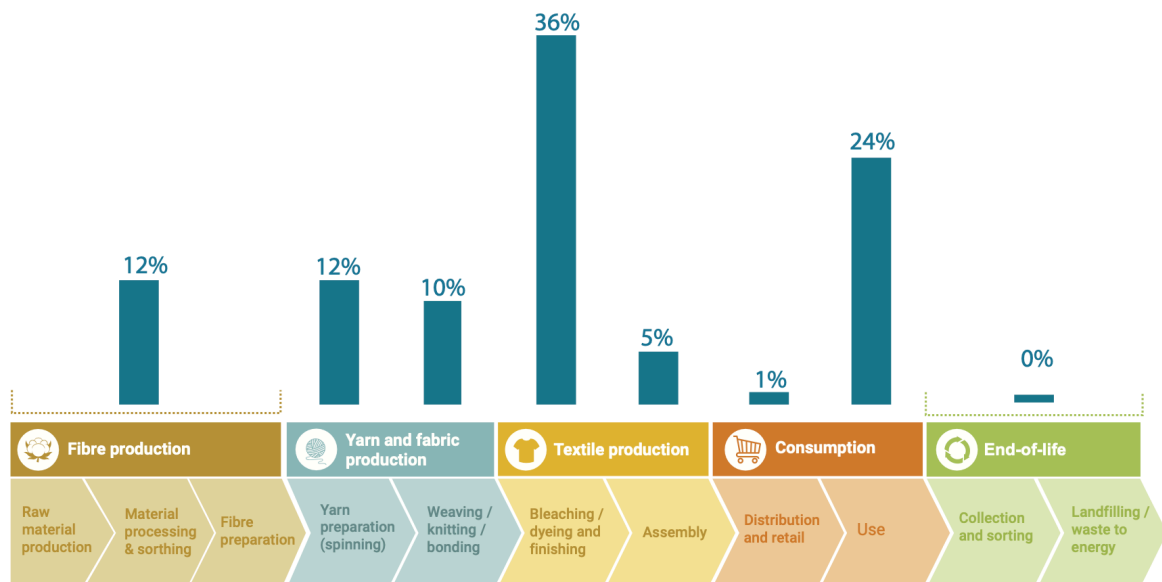
Figure 4. Climate impact across the global apparel value chain. Distribution of LCA impact (Notten 2020, p. 22).

The Figure 5 illustrates the use of fresh water across the stages of the clothing value chain. The largest consumption of water happens during the usage phase due to repeating laundering of apparel. As mentioned previously, the bleaching and dyeing operations require substantial amount of water, which shows as a second highest hotspot in the graph. The third spike in water consumption relates to fiber production and is largely due to cotton farming. Man-made fibers and other natural fibers, like wool, don't require as much water in their production. (Notten 2020, p. 22.)
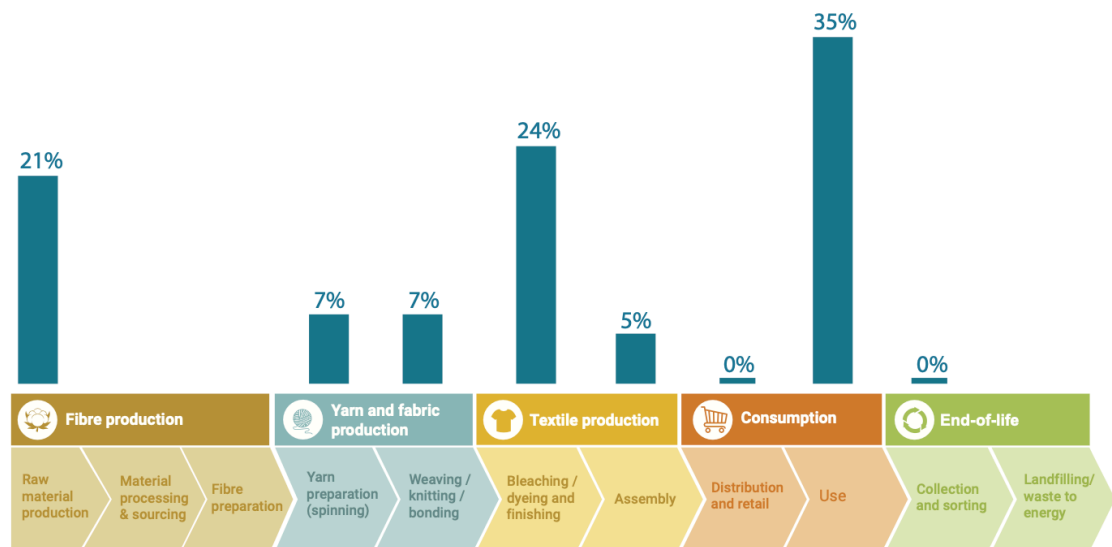
Figure 5. Freshwater use across the global apparel value chain (Notten 2020, p. 24).

Land use is an important dimension in environmental footprint to be observed as it's one of the main phenomena causing loss of biodiversity world-wide. The impact of clothing industry on land use is illustrated in Figure 6. The land use in the value chain is mostly related to the fiber production part of the chain. Like the water consumption, the land usage is driven by cotton cultivation that takes up to 2.5 % of the world's arable land. Part of the land usage is due to cellulosic fibers, but the scale is much smaller. The production of animal-based natural fibers, like wool, have markable land footprints as well. What complicates the calculation with animal-based fibers is that the fiber production is often a by-product of meat. In in many cases, pasturage happens on land unsuitable for growing crops. (Notten 2020, p. 26.)
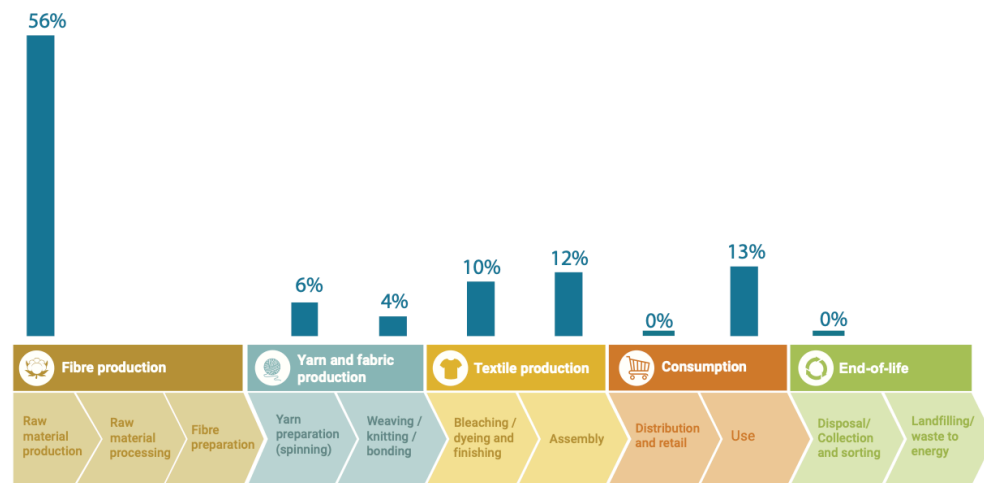
Figure 6. Land use impact across the global apparel value chain (Notten 2020, p. 26).

It should be noted that the study considers global averages. This means that the local country specific results might look different depending on the maturity of the industry, sources of energy, environmental legislation, consumer behavior, available end of life options etc. (Notten 2020, p. 18-20.)

2.1.1 The Key Environmental Concerns Associated With the Clothing Industry

Ellen Macarthur Foundation (2017) has divided the clothing industry related environmental concerns into three key issues: underutilization, immense footprint, and catastrophic future potential. The concern related to increasing underutilization of clothes was already touched in the Figure 3. Another concerning fact visible from the figure is that while the sales of clothing items has been increasing, the time clothes remain in use has gone down close to 40 % during the same period. Phenomena which have led to this are quicker turnaround of new clothing styles and trends, increased number of fashion collections introduced each year, and offering of inexpensive low-quality clothing. These phenomena together have resulted that globally 460 billion US dollars of value is wasted annually by discarding clothing before they reach the end of their life span. (Ellen Macarthur Foundation 2017, p. 19-21.)

The second key concern relating to the environmental footprint relates on the fact that the current supply chain of the clothing industry is majorly linear and largely based on non-

renewable resources (Ellen Macarthur Foundation 2017, p. 20). Majority of the fibers used in clothing are synthetic and their production is based on fossil-based feedstock (Notten 2020, p. 18). Though renewable sources for making polymer based synthetic fibers, like biobased polyester, are available, the production volumes are still insignificant. For example, share of the bio-based polyester from the whole polyester production in 2022 was only 0.002 % (Textile exchange 2022, p. 78). The lack of currently feasible renewable material feedstock and low utilization level of recycled materials has resulted a wasteful linear system that in 2017 used 98 tons of non-renewable resources (Ellen Macarthur Foundation 2017, p. 20).

The linearity of the dominant clothing industry supply chain model together with the increasing number of manufactured clothing units, rise concerns about the future environmental impact of the industry. This according to Ellen McArthur Foundation (2017, p. 21) is the third key issue relating to the industry. An estimation by the Foundation predicts that with the current growth rate and without significant changes on how the industry operates, textile business could use more than 26 % of the global carbon budget associated with the 2°C warming limit by the year 2050.

2.2 Improving the Environmental Sustainability of Clothing

To reduce the environmental impact of clothing industry, there are many initiatives that can be taken across the value chain. In Figure 7 these initiatives are color-coded and divided into three categories which are: narrowing the loop, closing the loop, and slowing down the linear system. The categorizations are made by the basis of relations between production and consumption. (Van Der Ven 2022, p. 27.)
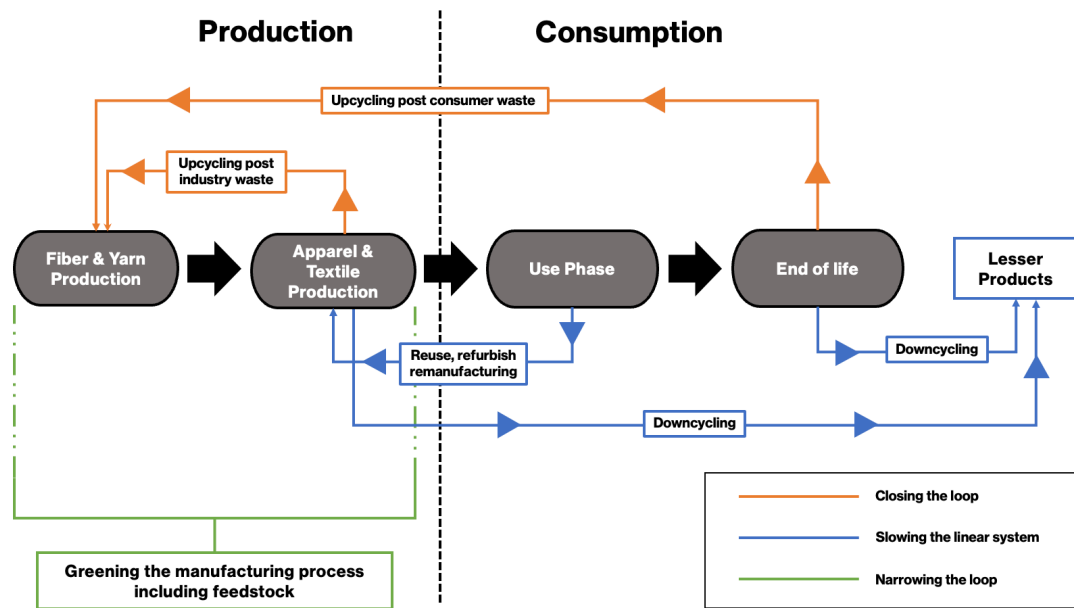
Figure 7. Ways to reduce the environmental impact of textiles (Van Der Ven 2022, p. 27).

In this context narrowing down the loop is about making sustainability initiatives in the production phases of the value chain. In practice this mean using renewable and environmentally safe inputs in fiber, yarn, fabric, and clothing production. Slowing down the linear system means utilizing the materials and products in a way they remain useful for longer but doesn't necessary offer new solution for the final end-of-life. Slowing down also covers downcycling activities which result materials to be used in lesser products than the original product being recycled. Closing the loop stands for actions which enable materials to be used circularly. Circularity means being able to utilize the material in production of new products of comparable quality. (Van Der Ven 2022, p. 27.)

2.2.1   Narrowing the Loop

Narrowing the loop or greening the manufacturing system consist of the aspects of raw material selection and manufacturing methods. Right material choices in the early phases of product design can help with reducing the environmental impact of the end product as well as a right material choice can open up possibilities for slowing down and closing the loop. Favoring eco-friendly processes in different phases of production on have a positive effect on the total impact of the value chain as well.

Raw Material Selection

The key things to consider in raw material selection are the end-of-life options the selected raw material has, and the environmental footprint resulted from the manufacturing of the material. Both viewpoints should be considered at the same time as there are pros and cons in all the material options. Natural fibers are biodegradable and require less energy in their production in comparison to synthetic fibers but have a bigger environmental impact in terms of water and land usage and typically consume fertilizers and pesticides. Materials mixing multiple fiber types should be avoided thus separating the materials during recycling process is problematic. (Nayak, Singh, Panwar & Padhye 2019, p. 2-3.)

Though small in scale for the time being, synthetic fibers from renewable sources might offer solutions for some textile applications in the future. Polylactic acid (PLA) fibers for instance, are commercially available, have biobased feedstock, and are biodegradable. (Nayak et al. 2019, p. 3.) Challenge with these types of fibers is the lack of effective and systematic collection of waste and sorting the material from other fiber types. Without these systems in place, the benefits offered by the biodegradability are deficient. (Sourcing journal, 2021.)

Textile exchange follows the global fiber market and in their preferred fiber and materials report they define preferred material as materials which result benefits in terms of environmental and/or social sustainability compared to conventional production. What this means in practice depends on the fiber type. Generally, fibers that are recycled or come from biobased feedstock meet the definition, but also materials which follow sustainable production programs and standards such as Cotton 2040, Cotton Connect, Responsible Wool Standard etc. can be considered as preferred. Market share of recycled and otherwise preferred materials is still relatively low. The share of all recycled fibers in 2021 was 8.5 % of which recycled polyester contributed the most with the share of 15 % of the entire polyester market. In the same year recycled wool had 6 % market share within the wool fiber market and cotton 1 % within the cotton market. Other fiber types had a share between 0.2-3 % of their markets. The most used fibers coming from different sustainable production programs are cotton and polyester. Preferred cotton had the market share of 24 % from the entire cotton market, which is combination of recycled material and sustainable production. (Textile exchange 2022, p. 2, 12, 20, 23, 37, 79.)

The most feasible material choice from the environmental point of view depends on the application and what are the end-of-life options at the location the product is expected to reach the end of its service life. Material should be selected so that it enables as long service life as possible and is recyclable with the infrastructure available at the location the product is intended to be used. (Nayak et al. 2019, p. 2-3.)

Adoption of Green Production

Yarn and fabric production is energy intensive, generates waste, and is associated with noise nuisance as well. Percentual energy consumption split in yarn and fabric manufacturing is spinning 34 %, weaving 23 %, chemical processing 38 %, and other processes 5 %. There is pressure to find more eco-friendly solutions along the whole supply chain which in the context of yarn and fabric production has led to the development of less power consuming, higher efficiency machinery and new production techniques in addition to increased use of renewable energy. (Nayak et al. 2019, p. 4-5.)

Part of the environmental impact in textile production is caused by chemical processing or wet processing due to substantial use of energy, water, and chemicals. Traditional wet processing creates effluent that contains hazardous organic materials which are problematic to separate in post treatment of the effluent. The issue can be tackled by using non-hazardous dyes and investing on higher efficiency post treatment systems. As the needed investment on new systems can be cost intensive, consideration of alternative greener dyeing techniques ,such as water-free techniques, are being consider. (Nayak et al. 2019, p. 5.)

Though the processes in garment manufacturing differ from the ones used in yarn and fabric manufacturing the methods of making the production more environmentally durable are similar. Source of energy and energy efficient machinery are in key role in increasing the sustainability of production. In addition, attention should be paid on efficient material usage and minimizing the use of packaging materials on produced garments. (Nayak et al. 2019, p. 6.)

2.2.2 Slowing the Linear System

Slowing down the system comes down to reducing material usage by extending the useful life of clothing. Primary way to achieve is to take the durability, ease of reuse, refurbishing, and material utilization at end of clothing lifecycle into consideration early in the design process. Up to 80 % of the environmental impact of clothing is defined by the choices made at design stage of the garment. (Botta, Cabral, Abraham, Backs & Roma. 2021, p. 5-9.)

Durability and Reusability

Durability of clothing has two dimensions to it: functional- and emotional durability. Functional durability is ensured by making informed sustainable selections in terms of manufacturing, supply chain, and material choices. This involves acknowledging, that the selections might impact on how the consumer needs to maintain the garment during its usage. There are many aspects in material selection and manufacturing that play a role in the quality level of products. Such aspects include choice of fiber, fiber dimensions, thickness of the material, yarn number and density of the fabric, weaving technologies, and seaming methods. On the product finalizing side conscious design choices should be made regarding printing methods and application of hardware such as buttons and zippers, as these might impact the recyclability of the product. Also, the individual quality of the used hardware is to be accounted for. (Botta et al. 2021, p. 13.)

To produce clothing with high emotional quality means avoiding the designing and manufacturing of garments that support the fast-fashion phenomenon. This phenomenon and its stakeholders benefit from short fashion cycles in which certain style of clothing remain popular for a short period and are then replaced by another. In this model, there's no incentive for brands and manufacturers to invest in the quality of their products as in many consumers eyes, they become obsolete after a new trend emerges. This effect is bolstered by the low quality and cheap prices associated with the fast-fashion phenomenon. In other words, consumers are not emotionally invested in the garments. (Botta et al. 2021, p. 13.)

Increasing the functional- and emotional quality has a lot of potential to reduce the environmental impact of the industry as it can be seen from Figure 8. The figure presents the results of a study researching reasons behind clothing disposal among men, women, and

teenagers/children. When looking at the reasons of disposal among adults, the most common reasons are related to low quality. Nearly half of the disposals are related to change in appearance. These include quality issues like worn appearance, broken zippers, ripped seams, loose buttons etc. For these types of situations, investing in high quality materials and hardware would reduce the need for disposal. In the figure, disposal reasons relating to emotional quality include taste related unsuitability and fashion or style changes. Together these form a third common reason why adults decide to discontinue using their clothing. Change in taste and fashion are hard to separate from each other as sometimes people don't recognize that the change in fashion has an impact on their preference in clothing. Another noteworthy aspect related to taste and fashion is that it mainly concerns only certain type of clothing like shirts, jeans, and jackets. Garments like socks or underwear rarely get disposed due to these reasons. (Laitala, Boks & Klepp, 2015.)
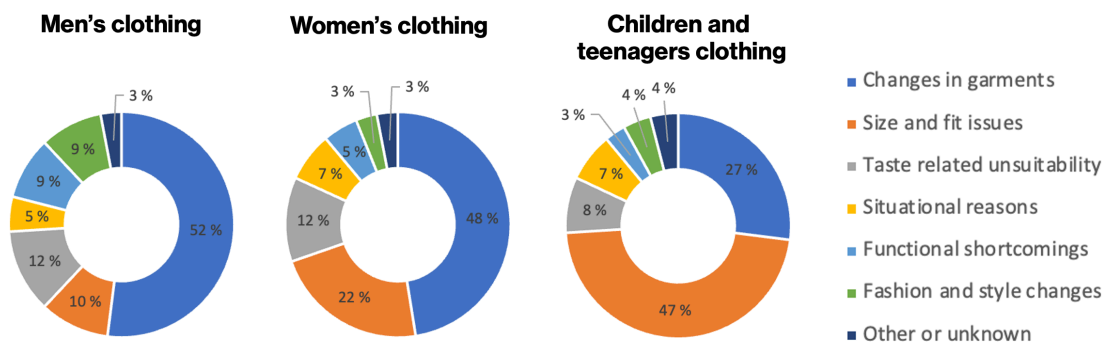
Figure 8. Clothing disposal reasons divided by gender and age (Laitala et al., 2015).

Reusability of clothing, which slows down the linear system, is strongly linked to their functional and emotional durability as the lack of durable textiles on the market makes it improbable to have a second-hand market. In addition, to have significant portion of clothing available for reusing, effective business models for redistribution are required. (Botta et al. 2021, p. 13.)

Repairability

The fundamental requirement for repairability is that the functional and emotional durability are on high enough level so that repairing the garment becomes a viable option for replacing it with a new one. Secondly, the garment and the system around it should be designed for repairability. The system refers to the planned availability of spare parts and possible repairing services the brand, manufacturer, or store might offer. For the garment itself, design for repairability might mean easy disassembly of certain components or a decision to use off-the-shelf components instead of custom-made buttons etc. to make it easier to find suitable spare parts. (Botta et al. 2021, p. 13.)

2.2.3   Recycling, Downcycling and Upcycling

Recycling can have a slowing down impact on the value chain, or it can enable having a circular closed loop system. Recycling that slows down the system is referred as downcycling and recycling resulting closed loop system is upcycling. Downcycling of textiles means utilizing the materials in somewhere else than making new textile products. Typical applications for textile downcycling include furniture filling, insulation, panel filling and rags. Though not optimal, utilizing the material in production of lower value products is a better option than incineration or landfill. (Botta et al. 2021, p. 8.)

Closing the loop is achieved by upcycling which is a form of recycling where post-consumer or post-industry materials are collected and used again in the same or similar production cycle. In other words, using materials again for producing products of equal quality for which the material was initially planned for. (Botta et al. 2021, p. 8.) In the textile industry the closed loop system is not effectively utilized as less than one percent of textiles are recycled into new textiles. The actual percentage of recycled fibers from the total fiber production in 2021 was 8.5. It's noteworthy that 7.9 % was due to recycling of plastic bottles. (Textile Exchange 2022, p. 12.)

Textile Recycling Methods

An overview of the different ways of textile recycling is presented in Figure 9. It should be noted that the illustration describes the possibilities for textile recycling in cases in which proper infrastructure is in place.
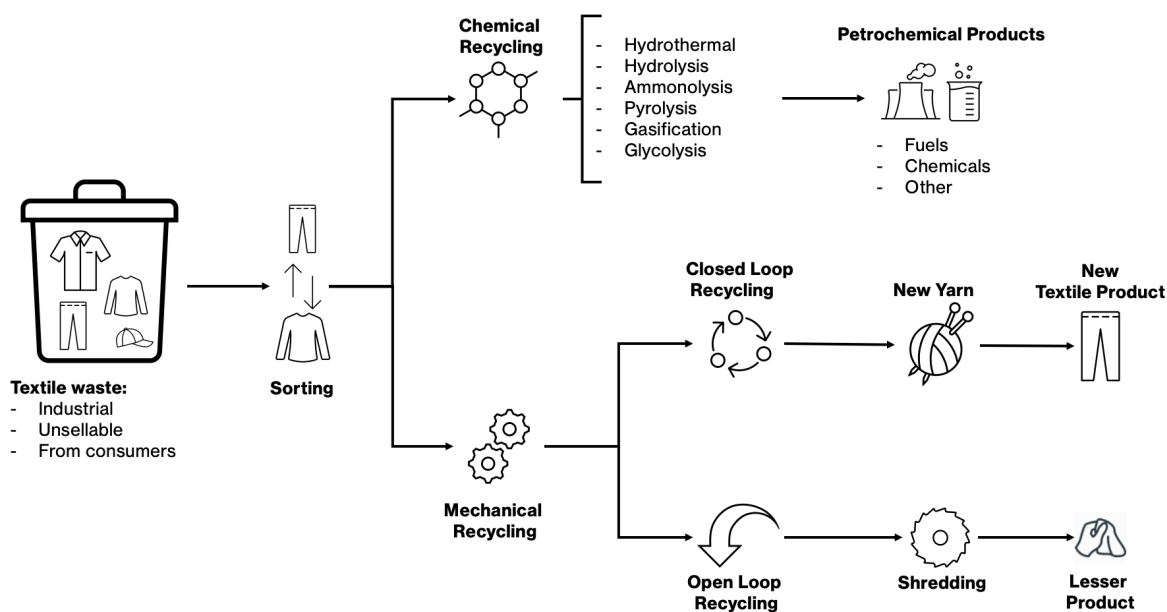
Figure 9. Different paths of textile recycling (Damayanti, Ho-Shing Wu, Wulandari, Bagaskoro & Rianjanu 2022, p. 7-13).

Textile recycling starts with collection of textile waste from industrial sector, retail, or consumers. The collected waste goes through a sorting process for which multiple technologies are available. In cases where textiles are mixed with other type of waste textiles must be separated first before further sorting, based on fiber type, can take place. Typically, the first step of sorting is separating metal from the rest of the waste mass using metallic sensors. This is followed by a step in which remaining waste mass is further separated to dry and wet waste by using capacitive sensors. Textiles can be detected from the dry waste and sorted to synthetic-, plant based-, and animal-based fibers. In addition to manual sorting, different infrared technologies have proven to have the capability to separate the most common textile materials with above 90 % accuracy. (Damayanti et al. 2022, p. 5-8.)

After the sorting process there are two paths for textile recycling, chemical and mechanical. The mechanical recycling path includes open loop recycling (downcycling) and closed loop

recycling (upcycling). The path a specific textile product is suitable for depends on its material. Products made from mono material, meaning they contains only one type of fiber, are easier to recycle and have more value due to the better quality of the extractable fiber resulted from the recycling process. Textile waste containing unspecified number of fiber types and mixes is not feasible for closed loop recycling as the quality of the resulted material can't be controlled. (Damayanti et al. 2022, p. 9.)

Regardless of the mechanical recycling path the first phase of the process involves removal of metallic components like buttons and zippers by mechanical ripping. (Damayanti et al. 2022, p. 9.) After the removal of non-textile elements, textiles are shredded to smaller pieces followed by fiber extraction by carding with garnett machines. Garnett machines tear the fabric with sharp steel teeth mounted on several opposing cylinders which rotate on a parallel axis. Since shredding and carding operations shorten the fiber length, thus reducing fiber strength and quality, virgin fiber is often mixed in with recycled fiber to achieve sufficient quality to be used in new textile products (closed loop recycling). For open loop applications like fillings for insulation, rags and carpets, recycled fiber can be used without mixing in virgin fiber. (Saha, 2020.)

In addition to mechanical recycling, chemical recycling is also an option. As Figure 9 presents, there are multiple technologies available for chemical recycling. In a generalized sense the chemical recycling is degrading or dissolving the of the material into smaller molecules using chemicals and various processes (Saha, 2020). Output products of the process can be used in the production of new fibers or various petrochemical products (Damayanti et al. 2022, p. 13). The output product depends on the type of fiber that enters the chemical recycling process and the specific recycling method used. Cases in which chemical recycling is followed by production of new fibers, there's most often no loss in physical properties in comparison to virgin fibers which is a clear advantage over mechanical recycling (Saha, 2020). On the other hand, many of the chemical recycling methods are associated with high energy consumption, slowness, and use of toxic chemicals (Damayanti et al. 2022, p. 13).

To increase the recycled fiber usage, the industry has few barriers to overcome. The six main barriers are: economic viability, composition of textile products, material availability, technology limitations, lack of information and public participation, and insufficient policies. The root cause of recycled fibers not being a cost-efficient alternative to virgin

fibers is the additional processing of recycled fibers. The recycling process itself combined with increased need of transportation drives the cost up thus limiting the possible applications for the fiber. The second barrier relates to vast number of material combinations used in textile products which are challenging to separate in recycling process. The third barrier is that there's insufficiency in suitable textile waste that is accessible to recycling. The lack of recyclable material and recycling infrastructure limits the availability of recycled fibers even for application for which their properties would be sufficient. The fourth barrier to overcome are the recycling technology limitations themselves as most of the available recycling methods are incapable of sorting and separating materials and contaminants. The lack of information refers to situations if which policies and infrastructure are in place, but the information that would support the stakeholders to recycle their waste is insufficient. The last of the six main barriers is that a well-coordinated framework and policies defining the practices of textile recycling is missing. This has led to a situation in which different parties of the value chain work independently and often with conflicting interests. (Filho et al. 2019, p. 15-16.)

2.2.4 Business Models Supporting the Reduction of Environmental Footprint

There is a lot of potential for reducing the environmental impact of the clothing industry by shifting towards loop narrowing and closing operating models, but the potential is capped without business models that support them. The business models suitable for the purpose fall under three categories: more use per user, more users per product, and beyond physical products. The first two being more feasible in the short term as going beyond physical products requires shift in consumer behavior in which they would use digital, non-physical products to fulfil their fashion aspirations. (Ellen MacArthur Foundation 2021, p. 13.)

The business model types which support the categories of more use/user and more users/product are resale, rental, and repair. The combined potential of these models in reducing the environmental impact of the industry is substantial. If these business models would cover 23 % of the market share by 2030 the overall CO_2e emissions of the fashion industry could be reduced up to 16 %. (Ellen MacArthur Foundation 2021, p. 18.) Examples of the potential of cases of reselling, renting, and repairing are collected in Table 1. The potential impact on emissions is estimated in CO_2e.

Table 1. Potential of environmental impact reducing business models (Ellen MacArthur Foundation 2021, p. 20-23).

	Potential impact on emission compared to linear model			
Case	**Production**	**Logistics**	**Use phase**	**End-of life (EoL)**
Resale: Product sold after 20 uses, used 20 times and sold again followed by another 20 uses vs. item disposed after 20 uses.	**Up to 67 % reduction** Assumes reduction on needed items translates directly to production emissions.	**No change** Decrease in initial logistics but increased reverse logistics and local transport.	**Up to 13 % increase** Additional processing per resale and increased washing cycles/product.	**Up to 67 % reduction** Assumes lower production translates directly to lower EoL emissions.
Rental: A product is rented for 100 uses vs. item disposed after 20 uses.	**Up to 80 % decrease** Assumes reduction on needed items translates directly to production emissions.	**Up to 60 % increase** More transports needed/product due to 100 renting cycles.	**Up to 80 % increase** Industrial cleaning and drying after each rental. Additional washing by the customer after every other use.	**Up to 80 % decrease** Assumes reduction on needed items translates directly to production emissions.
Repair: Product brakes after 20 uses and is repaired to extend its life for another 15 uses vs. item disposed after 20 uses.	**Up to 43 % decrease** Assumes reduction on needed items translates directly to production emissions.	**No/very small change** Decreased initial logistics, but repairing related logistics might be necessary.	**Up to 6 % increase** Increase due to additional uses provided by repairing.	**Up to 43 % decrease** Assumes reduction on needed items translates directly to production emissions.

Though in some regards estimated emissions go up significantly, reduction in total emissions compared to the linear model is achieved in all the example cases. Resale approximately 50 % reduction, for rental approximately 40 % reduction, and for repair approximately 30 % decrease. (Ellen MacArthur Foundation 2021, p. 20-23.)

2.3 Workwear Industry Compared Consumer Clothing Industry

The amount of scientific literature discussing the workwear industry, and sustainability aspects relating to it, is limited. Information was gathered from the customer company of

this project, limited literature, and texts discussing the textile industry in general. Workwear industry uses comparable materials and manufacturing methods as the rest of the garment industry which makes it feasible to assume the environmental concerns and solutions for them are similar as well.

Though there are similarities between the textile industry as a whole and the workwear subsection of it, there are a few differentiating things worth considering. The differences are evident when comparing the simplified value chains of the consumer fashion industry and the workwear industry presented in Figure 10 and Figure 11. The value chains are simplified in a sense that production and logistics related activities are removed for the sake of clarification and the fact that production parts of both value chains are very similar. The purpose of the figures is to illustrate the typical way of operating within the two industries. Other type of business models, like renting clothing to consumers or repairing services exist, but are left out.

The common way of conducting business in the consumer fashion industry is that fashion companies produce garments and sell them to retail companies which then distribute the products to individual consumers (Badger, 2019). How a specific consumer decides to handle the end-of-life of the product they have purchased is up to them and the recycling infrastructure available in the area they are located. Due to the lack of infrastructure the most common end-of-life option for clothes is that they end up in commercial waste and are incinerated or transported to landfill. This can be concluded from the low recycling rate of fibers mentioned earlier in the Chapter 2.2.3.
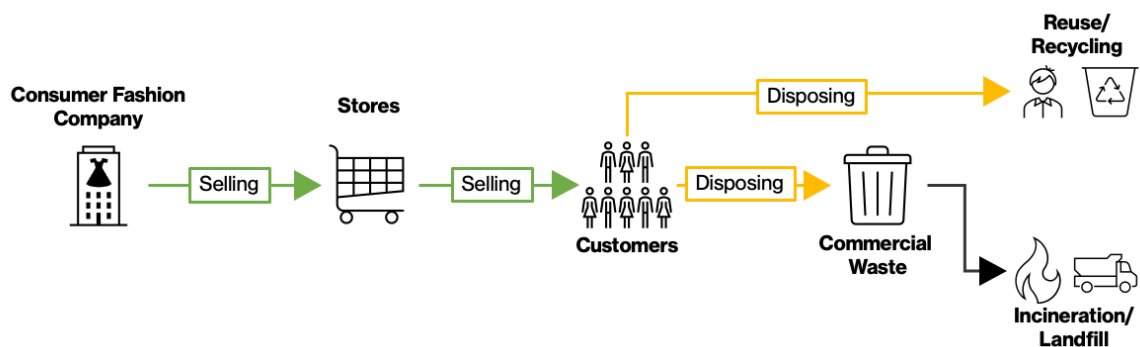

Figure 10. Typical simplified value chain of the consumer fashion industry (Badger, 2019).

The way workwear companies operate is less linear compared to the typical way of working of consumer fashion companies. Different ways, how the value chain of a workwear company might work is illustrated in Figure 11. Commonly workwear companies sell their products directly to customer companies in need of workwear or clothing maintenance companies who lease the products to other companies that take care of washing, ironing and sometimes repairing of products. Companies using workwear might give or borrow the garments to their employees who, depending on the way of operating, maintain their workwear themselves or return them back to their employer who takes care of the process. Disposal of products might happen in various phases of the value chain. This depends on which of the stakeholders identifies that the workwear is no longer in usable condition. If the disposal happens by the maintenance company or the company using the workwear there's an option to centralize the disposal, meaning that the disposed clothes can be systematically collected and disposed. (Malinverno, Schmutz, Nowack & Som 2022, p. 4.)
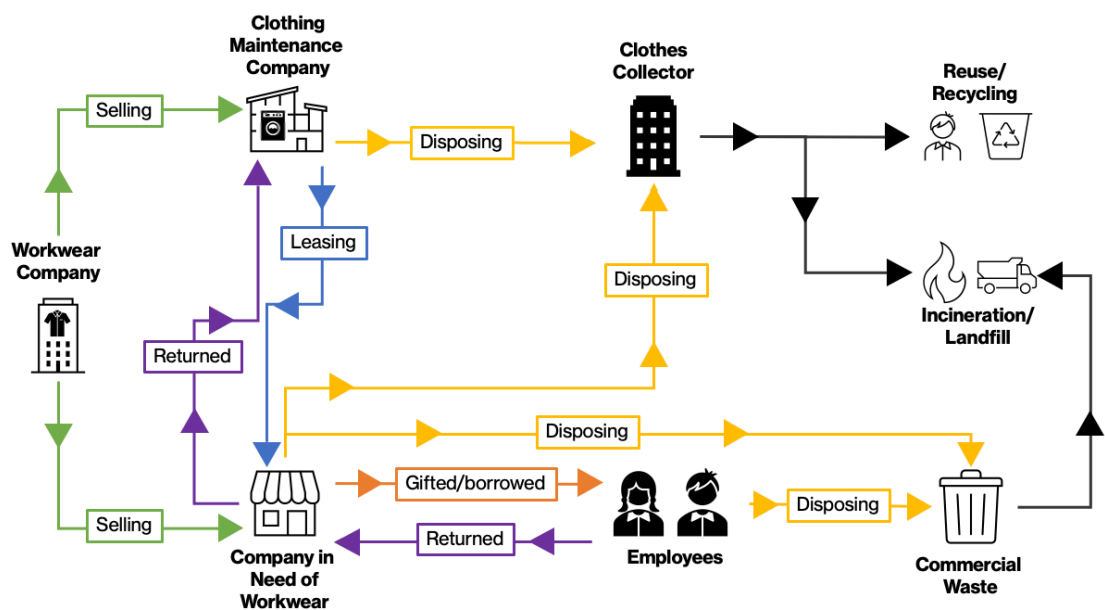

Figure 11. Typical simplified value chain possibilities of the workwear industry (Malinverno et al. 2022, p. 4).

The Figure 11 is made by the basis of a study made in Switzerland by Malinverno et al. (2022). The study only involved companies located in Switzerland, but material flow seems to be valid in wider context as Finnish companies Touchpoint and Lindström report they are

operating similarly. In their 2021 sustainability report Touchpoint announces that 33 % of their business comes from selling their products to clothing maintenance companies and the rest from selling directly to companies in need of workwear (Touchpoint 2021, p. 18). Lindstörm has a subsidiary called Comforta that they use for providing maintenance services instead of using third party maintenance companies (Lindström, 2023).

The different nature of operating models results some environmental benefits workwear industry has over consumer fashion. When selling larger baches of clothing to companies instead of single pieces of clothing to consumers, there's more control over the product and where the product ends up after it's no longer needed. More control over the product itself refers to two things, the quality, and the number of products produced. During its lifecycle, workwear goes through more washing and cleaning cycles in comparison to consumer products which sets higher quality and durability requirements. Control over the number of products refers to the fact, that workwear is produced based on the needs of the customer company, which means that the amount of excess production and resource usage is kept at minimum. Compared to consumer fashion industry, workwear sector has more visibility over where the products are located, in what condition they are, and what kind of materials they contain. This leads to enhanced possibilities for controlled end-of-life of the products. When handling bigger batches of products for which used materials are known, the sorting and recycling processes become easier and more economically viable. (Malinverno et al. 2022, p. 2.)

2.3.1 Workwear LCA Studies

From the perspective of lifecycle assessment, a direct comparison between workwear and consumer fashion is challenging to make as topic is not widely studied and the functional units for products are different. In essence, functional unit is a quantified description of the performance requirements that the product system fulfils. To make a reasonable comparison between product systems, the functional units need to be defined in a same way. (Consequential LCA, 2015.) Workwear is often made to last longer compared to consumer products which results that the reasoning behind material choices and overall product quality in general are different. As the two types of products are intended to be used in a different

way and are made for different purposes, the feasibility of such comparison would be questionable.

A few studies have been made to assess the environmental impact of workwear. Some studies focus only on production part of the value chain leaving the use-phase out. Only couple of studies in which the entire lifecycle was considered were able to be found. One by Cartwright, Cheng, Hagan, Murphy, Stern & Williams. (2011) and another by Laursen, Hansen, Wenzel, Larsen & Kristensen (2017).

The study by Cartwright et al. (2011) was done for a uniform rental company and aimed for identifying environmental hotspots in the rented garment lifecycle and making proposals to improve the company operations from environmental point of view. The specific garment studied was a button up shirt made from 65 % polyester and 35 % cotton. During its lifecycle the shirt was washed 52 times using industrial laundering facilities and then discarded in a landfill. (Cartwright et al. 2011, p. 3.) Summary of the LCA results covering energy usage, carbon emissions, and water usage is presented in Figure 12.
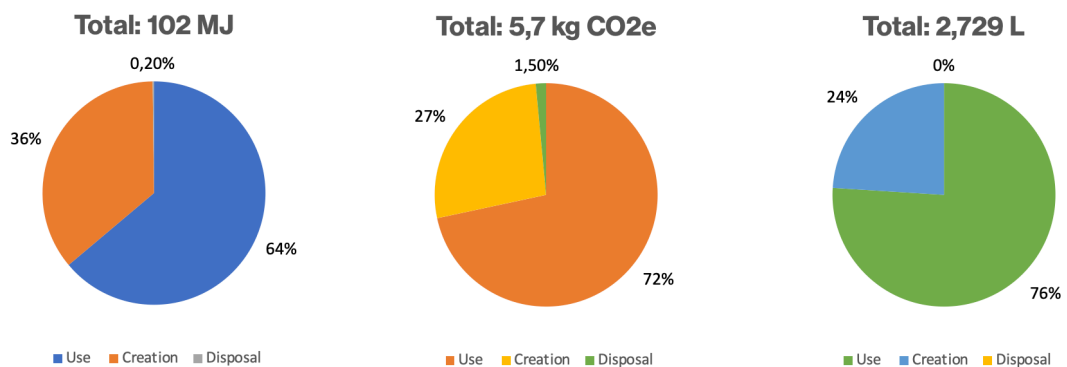

Figure 12. Summary of the LCA made for rental work shirt (Cartwright et al. 2011, p. 3).

The study by Laursen et al. (2017) includes a lifecycle assessment for a work jacket among other types of clothing. Like the button up shirt, the material of the jacket was 65 % polyester and 35 % cotton. Additionally, the jacket materials included ten brass buttons, one brass zipper, and a polyester zipper. One use cycle was 40 days followed by a washing with an industrial laundry machine. The use cycles were continued after three years after which the product was disposed by incineration. The results covered energy consumption, resource

consumption and toxicity. The results are summarized in Figures 13-15. (Laursen et al. 2007, p. 136.)
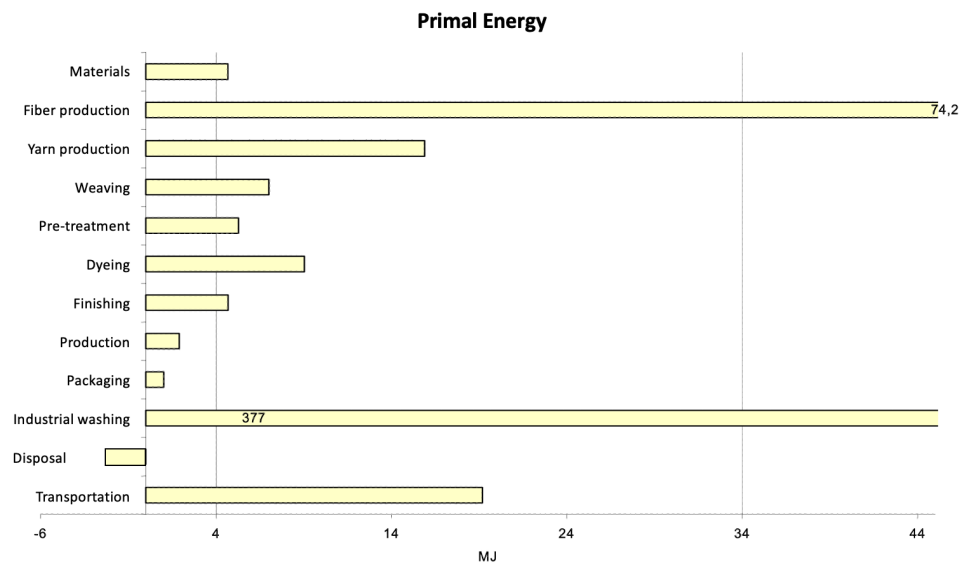

Figure 13. Work jacket LCA. Consumption of primary energy per functional unit (Laursen et al. 2007, p. 142).
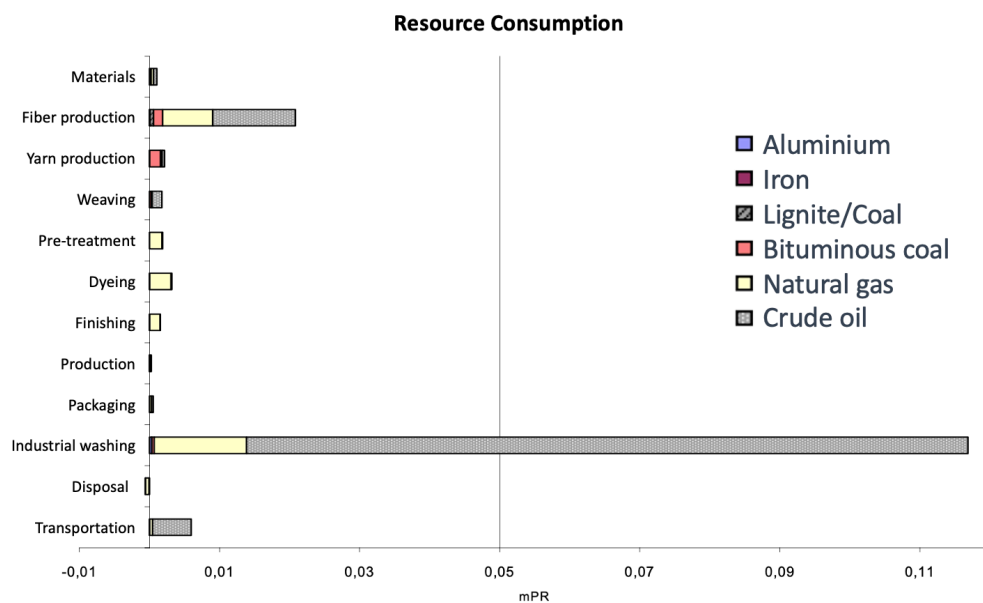

Figure 14. Work jacket LCA. Resource consumption (Laursen et al. 2007, p. 142).
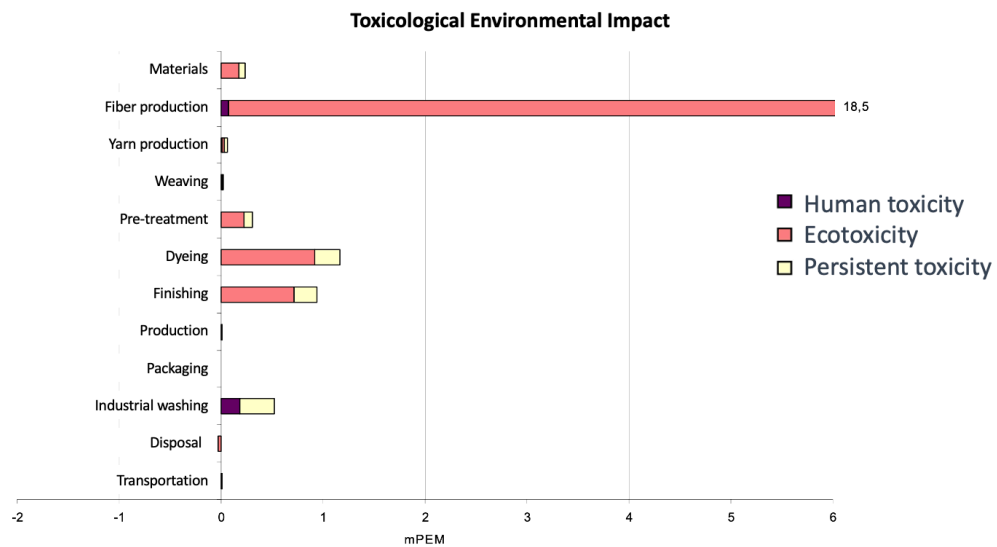
Figure 15. Work jacket LCA. Toxicological environmental impact potentials per functional unit (Laursen et al. 2007, p. 143).

The results from both studies show that the use phase has the biggest environmental impact. This is a result of high number of washes the garments go through during their lifecycle. This phenomenon doesn't apply only on workwear as in the study by Laursen et al. (2007) a regular consumer shirt was also analyzed and the results show that with enough washes, this is true for consumer fashion as well. The dominant impact of the use phase should not be misinterpreted so that by shortening the lifetime of the product, environmental benefits could be gained. In the Laursen et al. (2007) study alternative scenarios were also considered, and the results showed that by increasing the lifetime from 3 year to 10-12 years, significant reduction in environmental footprint can be achieved as less product are needed to meet the functional unit of work jacket usage over 10-12 years. (Laursen et al. 2007, p. 150.)

3 Design Thinking Methodology

Design thinking is a way of approaching problems that is different from the scientific research method traditionally used for problem solving. The design thinking methodology consist of certain steps that many designers take naturally when creating new products and solving problems. These steps have been used to formulate a process that enables designers, engineers, and other groups to make their design process more intentional. A process that can be purposefully utilized has given the opportunity to use the methodology and tools outside the traditional design work in which the outcome is often a tangible object. Nowadays the methodology is used as a problem-solving tool in wide variety of industries and purposes. Some examples include planning how a new organization should look, how to better understand your customer base, or how to create an effective learning environment. (Clarke 2020, p. 12-14.)

Design thinking can be understood as an iterative approach to problem solving that uses certain methodology and tools to achieve its goals. For the sake of clarity, in the following chapters design thinking is presented as a linear sequence of process steps and activities. In some cases, a project might follow this linear model, but in usually the linearity doesn't serve the project well nor its desired. The design thinking approach leans on the principle of generating many potential solutions quickly and accepting that the initial ideas and solutions might be flawed. The initial ideas are studied to learn more about the problem and eventually used for creating better versions of the solutions or discard them as new more feasible ideas emerge. The approach relies on iteration and going back and forth with different project activities, such as research, ideating, and prototyping, is common. (Swan, Luchs, Griffin & Luchs 2015, p. 28.)

3.1 Fundamentals of Design Thinking

Figure 16 gives an illustration of the typical nature of a design thinking process. In the early phases of the process the outlook on the project is messy, there's a lot of uncertainty, and many alternatives for the path the project might take. As the process goes on, problem definition and project scope become increasingly clarified. The early phases of the process

are dedicated to research, understanding the user, and defining the problem. The later part focuses on creating justified solutions for the defined problem. The core of the design thinking methodology is to uphold certain principles which support the process of finding an optimal solution. These principles include, flexible thinking, integral working, empathizing, cooperating, being visual, and experimenting. (Dekker 2020, p. 19.)
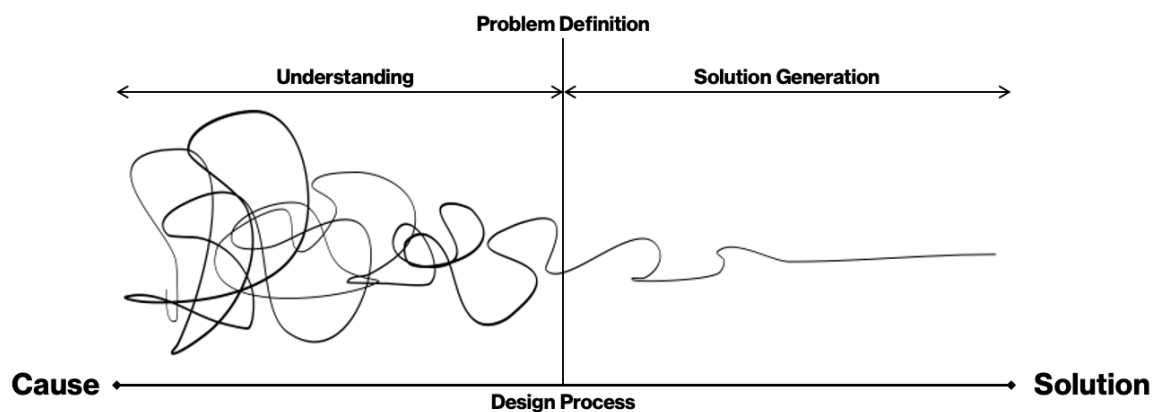

Figure 16. Design thinking process (Dekker 2020, p. 49).

In the context of design thinking, the principle of thinking flexibly means aiming to observe the problem from multiple perspectives. Being openminded regarding how and from which angle to approach the problem supports the process of gaining profound comprehension of the situation at hand. Commonly this approach involves analyzing and synthesizing. The concept of analyzing and synthesizing is illustrated in Figure 17. In design thinking analyzing means turning complex concepts in to smaller easier to comprehend parts and forming new ideas based on the information gained from the process. The aim is to understand the big picture before diving into details, though the two are considered equally relevant. When looking at something from distance, relationships and connections between things are easier to comprehend. Focusing on details offers an opportunity to see subtleties in the connections. (Dekker 2020, p. 21-24.)
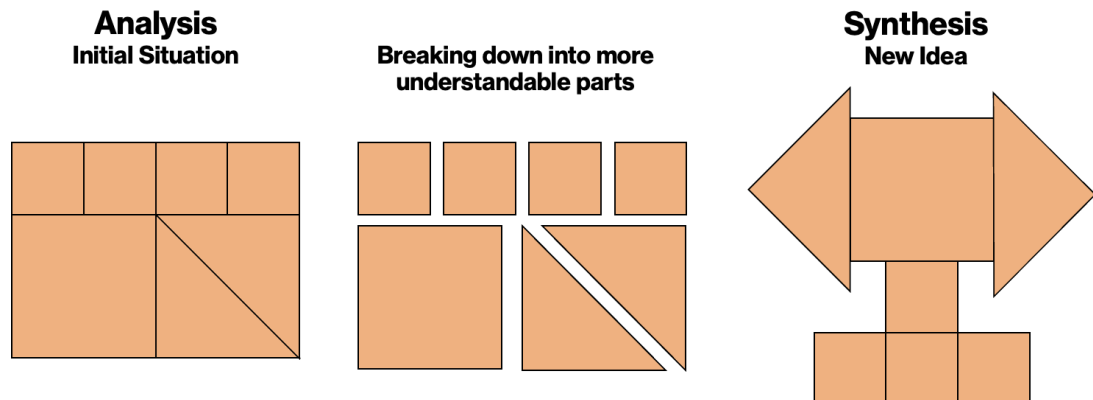
Figure 17. The concept of analyzing and synthesizing (Silverman, 2013).

Integral working means being user centric. Instead of having the focus on technologies and products, the process puts experiences, values, and needs of users in the center of focus. Technology can be part of the solution and an enabler of the outcome but is something that follows the people's needs rather than something that is the starting point of the solution development. (Swan et al. 2015, p. 29.)

Entering the user's world and being interested about them are at the core of the principle of empathizing. Design thinking highlights the importance of getting hands on experiences about how the intended user of the solution thinks, feels, and what their needs are. One of the most effective ways to achieve this is to do field work. Field work includes spending time with the target users of the product and making observations. This facilitates immersion to the mindset of the user. Disconnecting from the user's world is seen as vital as well as observing the user from the distance eases the comprising of the motivations and driving forces behind the user's actions. (Dekker 2020, p. 30-31.)

As much as design thinking encourages to communicate with customers, cooperation and communication within the design teams is as important. The most fruitful results from cooperating are achieved when the team is formed from individuals with versatile backgrounds. The versatility within the team supports having viewpoints from different perspectives and therefore feeds the idea generation. Subject matter experts outside the project team may be involved to support widening the perspective. (Swan et al. 2015, p. 29.)

Design thinking utilizes visualizations throughout the process. Sketches, prototypes, videos, mind maps, and such are all forms of visualizing. Using these tools to communicate ideas and solutions helps with making sure that everyone involved in the project has the same perception about the topic. Verbal communication alone causes individuals to make their own mental visualizations, which might be vastly different from each other. (Liedtka & Ogilvie, 2018.)

In the context of design thinking, experimenting aims for early recognition of errors. The phrase "fail fast" is often used. In this philosophy even ideas that might seem initially ineligible are given a change and they are tested for conformity. It's common for organizations to lean towards safe solution and avoid errors, but there are advantages in experimenting without prejudice. Firstly, experimenting clarifies the collective thinking of the design team by proving or disapproving assumptions. Secondly, though experimenting might require time and money, the cost is likely insignificant compared to launching a product that is rejected by consumers. Finally, experimenting offers certainty along the design process and keeps the design moving in the right direction. (Dekker 2020, p. 41-42.)

3.2 The Concept of Diverging and Converging, and the Double Diamond Model

There are two interrelated concepts often associated with the design thinking methodology, the concept of diverging and converging, and the double diamond model. The principle of diverging and converging is given in Figure 18. Diverging means exploration during which options are generated. After several options are generated, converging takes place and options are limited to the most feasible ones. The double diamond model is a design process formed by two consecutive diverging and converging phases. (Elmansy, 2021.)
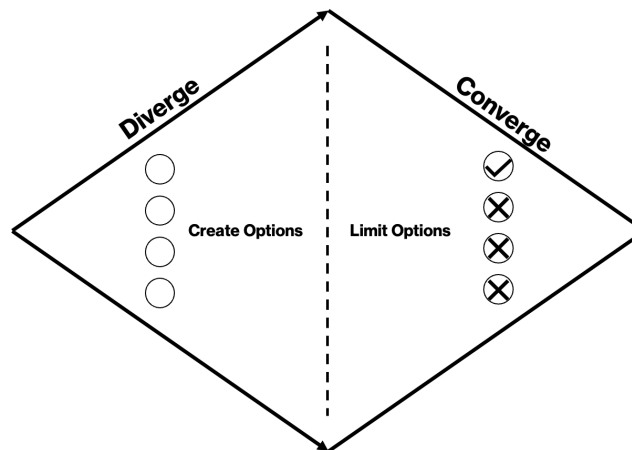
Figure 18. Principle of diverging and converging (Elmansy, 2021).

The double diamond process laid on top of the design thinking process is presented in Figure 19. The first diverging-converging phase focuses on the problem. Diverging during the first phase aims to understand the challenge at hand by conducting root cause analysis, desk research and field research. Information from the research is used to identify problems in the use scenario that are worth solving with a new product or a service. During the first converging part of the double diamond model, all the information gathered about the challenges is considered to form a clear definition of the problem that the project aims to solve. (Elmansy, 2021.)

The second diverging-converging phase devotes to finding the most feasible solution to the defined problem. Diverging phase contains solution ideation and verifying the applicability of the generated ideas. The outcome is usually several solution alternatives. The final converging phase is about filtering down the alternatives and delivering a verified working solution. Learnings from the diverging phase are studied to develop the final solution. Commonly this involves utilizing different insights from the entire process to come up with means to test the solution with users before delivering the final version of it. The level of prosperity of the final solution is monitored and feedback is collected to be able to improve the solution in the future. (Elmansy, 2021.)
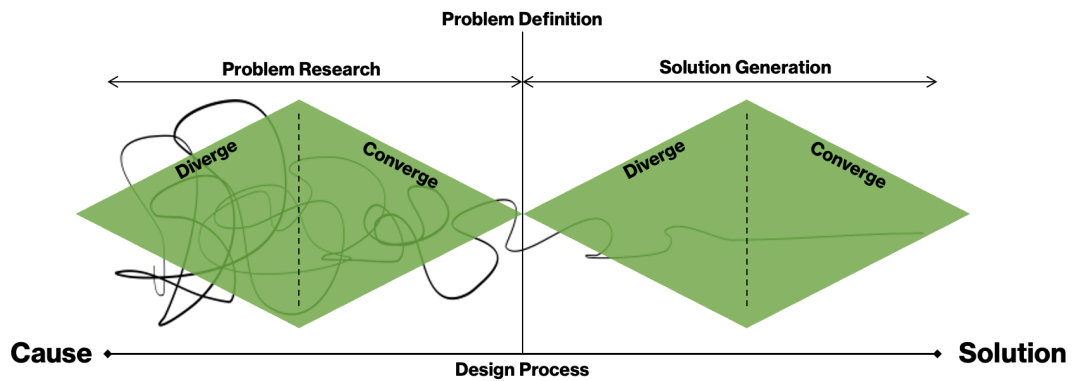
Figure 19. The double diamond model fitted to design thinking process (Dekker 2020, p. 49; Elmansy 2021).

3.3 Design Thinking Process Steps

According to Clarke (2020, p. 18) a harmonized process description for design thinking has not been established. Process steps are described in various ways depending on the source. Three examples of differently defined design thinking process steps from different sources are illustrated in Figure 20. As it can be seen from the figure there's variation in naming and the number of process steps.
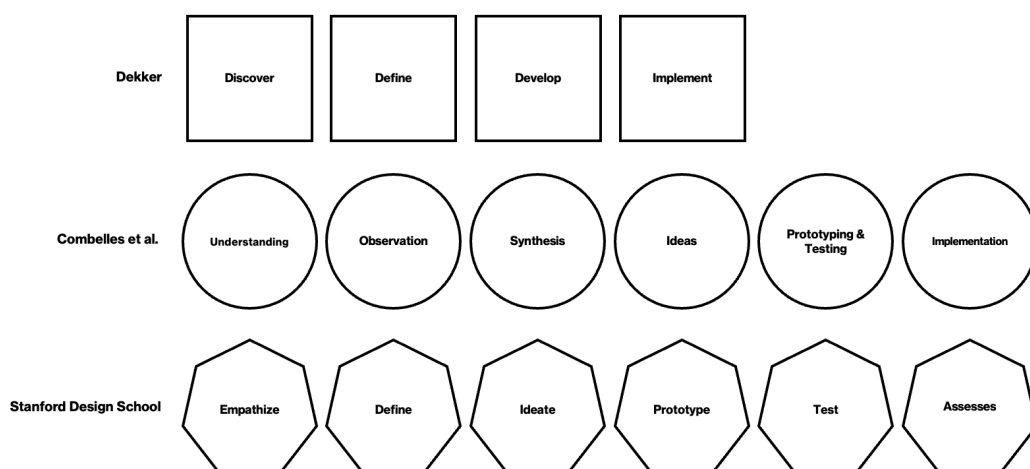

Figure 20. Design thinking process examples (Dekker 2020, p. 56; Combelles, Ebert & Lucena 2020, p. 21-24; Doorley, Holcomb, Klebahn, Segovia & Utley 2018, p. 2).

As also established by Clarke (2020, p. 18), though the wording and description of each step may differ from one source to another, certain common nominators can be identified. These commonalities as Clarke have defined them are collected in Table 2 and include, empathic discovery phase, problem definition phase, idea generation phase, and evaluation phase. Regardless of the source, all the design thinking process variants seem to have these process steps included in one form or another.

Table 2. Identified commonalities in different design thinking descriptions (Clarke 2020, p. 18).

Process step	Short description
1. Empathic discovery phase	Research the topic and gather information
2. Problem definition phase	Clarification regarding the key problem to be solved
3. Idea generation phase	Generating solution alternatives for the identified problem
4. Generation phase	Testing different solutions in practice to refine and validate ideas and to justify the final solution selection
5. Evaluation phase	Follow up, how the solution works

The generalized design thinking process steps are illustrated together with the double diamond model in Figure 21. From the figure it can be observed where the different process steps land on the double diamond model. Though the process steps are often presented linearly for the sake of clarity, typical design thinking projects are nonlinear.
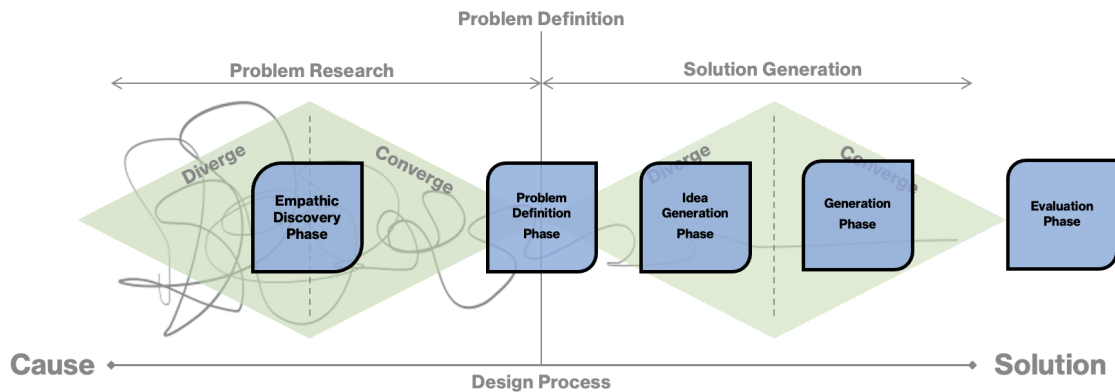
Figure 21. Generalized design thinking steps in relation to the double diamond model (Dekker 2020, p. 49; Elmansy, 2021; Clarke 2020, p. 18).

The nonlinearity of the process has a logical explanation. During research, ideation, and testing understanding of the situation grows and new viewpoints and learnings are often revealed. New perspectives might overturn some initial idea and make it necessary to go back to some previous step and repeat it considering the new insights. This might happen multiple times during a project making the process iterative in nature. (Swan et al. 2015, p. 28.)

3.3.1 Empathic Discovery Phase

Typically design projects following the design thinking methodology start with the empathic discovery phase. This phase could also be called the research phase. Research phase in the context on design thinking means establishing a broad understanding about the problem and what is the cause why new a design or solution is necessary. The design thinking methodology puts an emphasis on data collection and avoidance of starting to focus on possible solutions too early in the process. (Dekker 2020, p. 87.)

The empathic discovery follows the principle of diverging and converging and covers the entire problem research phase as illustrated in Figure 22. Diverging in this context can be divided into an immersion phase and an analysis and synthesis phase. The immersion phase can be divided further into two sub-phases: preliminary and in-depth immersion. Typically,

preliminary phase contains reframing, exploratory research, and desk research. (Vianna, Vianna, Isabel, Brenda & Russo 2011, p. 22.)
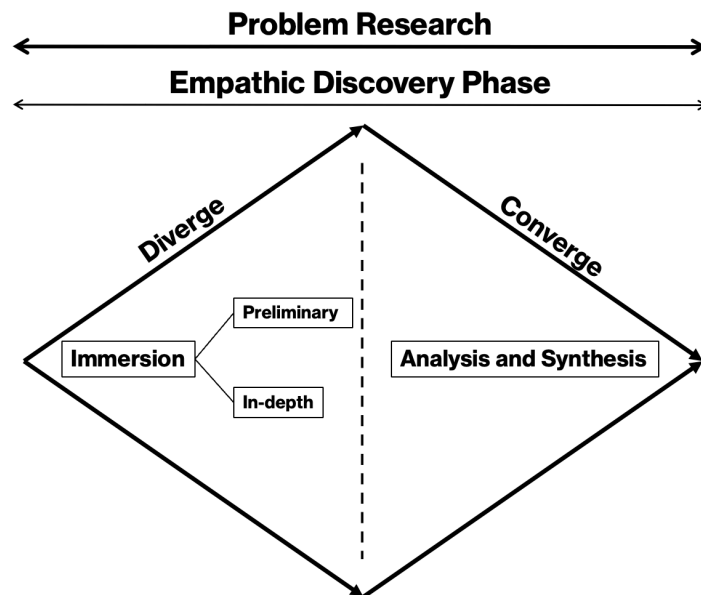

Figure 22. Problem research phase (Vianna et al. 2011, p. 22).

During reframing, the project team and other stakeholders aim to make a preliminary definition of the unsolved problems and project boundaries. During reframing the problems are viewed from numerous angles with the purpose of breaking down previously established thought patterns and assumptions, which initially opens the thought process for new more innovative solution possibilities. (Vianna et al. 2011, p. 22-24.)

During the preliminary immersion phase research is done with and without input of the end user. Exploratory research covers the first of these two and is about doing field work and approaching end user's reality. Goal is to understand the users' objectives and needs, and to provide information what to focus on in desk research. Purpose of desk research is to find information from sources other than the end users themselves. Desktop research is effective for identifying trends, visiting studies made by others, and gaining understanding about phenomena's which are challenging to observe during field work. For example, events that happen in remote locations. (Vianna et al. 2011, p. 28, 32.)

In-depth immersion aims to provide answers to the questions: What do people say? How do they act? What do they think? and How do they feel? This part of the research is qualitative and attempts to focus on the human dimension of the problem rather than providing exact tangible knowledge. In-depth immersion includes visiting the intended target users of the product in the context of use. Goal being to develop empathy by gathering answers to the questions mentioned above. (Vianna et al. 2011, p. 36.)

The second half of the empathic discovery phase includes analysis and synthesis. The data compiled from the immersion phase is arranged to patterns to identify challenges in the intended use of the product (Vianna et al. 2011, p. 64). These diverged challenges are then put into order and prioritized forming multiple paths to take the project on (Dekker 2020, p. 62).

3.3.2   Problem Definition Phase

Problem definition happens at the end of first set of diverging and converging and aims to achieve an understandable and well justified problem. The final problem is a result of a converging process that aims to answer questions like: Who is the specific customer? Who those persons are? How they experience things? What kind of limits does the customer organization impose to us? How do the limits impact our opportunities? By answering these questions, a problem that is workable within the requirements of the customer organization, can be derived. At the end of the definition phase a design brief, summarizing the key information, is created. (Dekker 2020, p. 62.)

3.3.3   Idea Generation Phase

The first diverging and converging phase focused on the problem at hand and the second one finding solutions for it. As illustrated in Figure 23, the idea generation phase covers the first half of the solution generation. The purpose is to come up with numerous solution alternatives within the boundaries set in the problem definition. (Vienna 2011, p. 99.)

Solution Generation

Idea Generation   Generation

Diverge   Converge
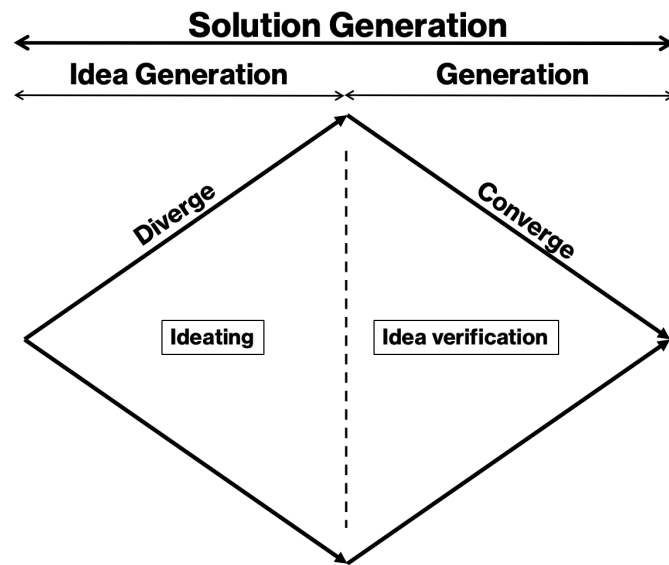
Ideating   Idea verification

Figure 23. Idea generation phase (Vienna 2011, p. 99).

The solution generation aims for large number of distinct ideas which are used to generate a heterogenous pool of solution alternatives. Generating as much as possible without filtering results a mixture of different ideas. This increases the probability of finding something interesting. The key is to remain open minded and to avoid generating multiple versions of the same solution or steering the ideation towards certain direction too early and thus risking some alternatives not being considered at all. (Dekker 2020 p. 66.)

3.3.4   Generation Phase/Prototyping & Testing

Generation phase includes prototyping and testing of the ideas which are considered to have the most potential for being the final solution implemented at the end of the project. Selecting ideas for further development and prototyping is an important and risky step in the project as making wrong choices can cost time and money. (Dekker 2020, p. 67.) Often the idea selection for the prototyping is made in co-operation with the users and the client organization. Including all the stakeholders to the process ensures more objective filtering of the ideas. (Vienna 2011, p. 100.)

Prototyping offers input for the project in two different ways. Firstly, while working on the prototype, the project team needs to focus deeply on the solution being prototyped thus

increasing the fidelity of it. Secondly, testing the prototype with intended customers of the solution generates more accurate feedback than presenting them ideas without tangible content. The information gathered during the prototyping and testing reduces the uncertainties by offering reasoning for abandoning ideas that wouldn't be well received. (Vianna et al. 2011, p. 124.)

Fidelity levels in prototyping refer to the effort and time put into prototyping. Commonly prototypes are divided into three fidelity levels: low, medium, and high. Low fidelity level prototypes represent a rough version of the idea and are made quickly with low cost. Low fidelity prototype examples include paper or clay prototypes. Medium fidelity prototypes are more defined, but still coarse. High fidelity models are high quality representations of the final solution. For instance, functional 3D-prints or simulations of a service. (Dekker 2020, p. 69.)

3.3.5   Evaluation Phase

Evaluation phase includes gathering and analyzing feedback from prototyping phase. Though evaluation is presented as a final step of the process, often the gathered information results going back to earlier steps of the process as more research is many times needed to create the next iteration of the solution. Iteration rounds are continued until an acceptable solution is found. There are often two kinds of activities included in one evaluation round. First being the presentation of prototypes to target users of the solution and collecting feedback. This is followed by analyzing and synthesizing of the feedback. First the feedback is categorized into manageable parts that represent different elements of the solution and then new version is created based on them. (Swan et al. 2015, p. 27-28.)

3.4 Design Thinking Tools

Each design thinking process step has a set of recommended tools to support the design process and interactions between project stakeholders. There are various tools and methods that might be used of which some of the more common ones are described in this chapter and listed in Table 3 under the design thinking process step, they are typically associated with.

Table 3. Common design thinking tools divided under project phases

Empathic Discovery Phase	Problem Definition	Idea Generation	Generation Phase	Evaluation Phase
Design project roadmap	Design brief	Brainstorming	Paper prototyping	
Exploratory research		Brainwriting	Volumetric model	
Desk research		COCD box	Staging	
Reframing		Decision matrix	Service prototyping	
Interviews				
Questionnaires				
Cultural probes				
Generative sessions				
A day in the life				
Observations				
Insight cards				
Affinity diagram				
Conceptual map				
Guiding criteria				
Personas				
Empathy map				
Customer journey map				
Mood board				

Though in Table 3 tools are divided under different steps of the design thinking process, they might prove to be useful in other phases of the project as well. The decision which tools are utilized and when depends on the nature of the project. For example, a project that aims to create a new type of service might use different tools in comparison to a project generating a physical object.

3.4.1 Design Project Roadmap

At the beginning of a design project making a visualization how the project is intended to be carried out helps with providing guidance to the design team and stakeholders (Dekker 2020, p. 92). An example of a project roadmap is given in Figure 24.
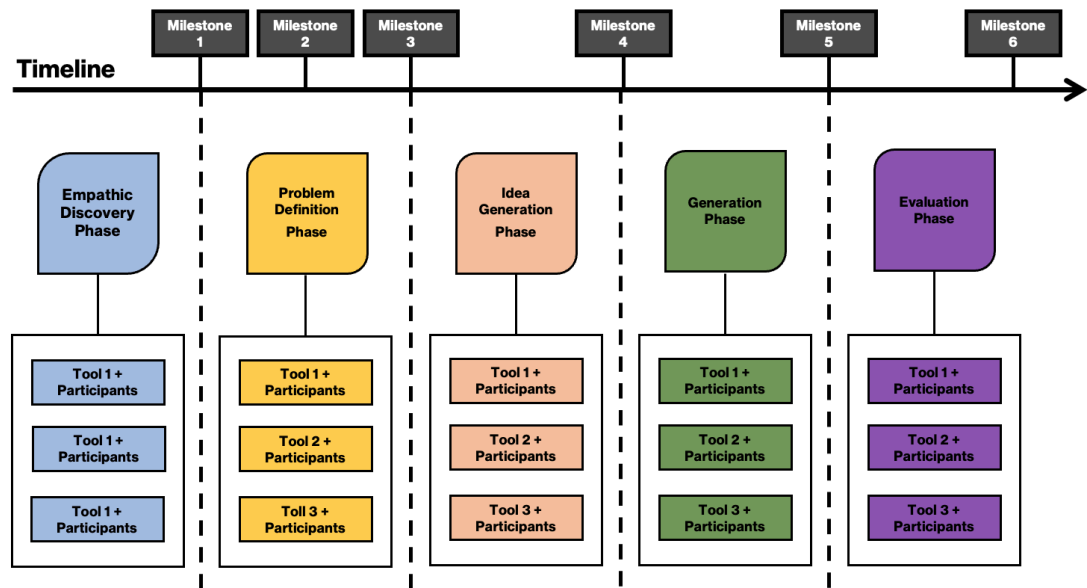
Figure 24. Example of a design project roadmap (Dekker 2020, p. 92).

In a design project roadmap, all phases of a design thinking process are mapped together with information regarding the schedules, milestones, design thinking tools, and who to include in each phase. The number of milestones and tools to be used in different phases of the project varies from project to project. (Dekker 2020, p. 92.)

3.4.2   Exploratory Research

Exploratory research is a qualitative research technique that relies on observing people in situations relevant to the project context. This includes field research during which product/service usage is studied for information about the users and usage environments in different phases of the product lifecycle. The obtained information helps with identifying topics for desk research as well as understanding the user profiles. (Vianna et al. 2011, p. 28.)

3.4.3   Desk Research

Gathering information from sources like books, blogs, and articles is called desk research. Findings from desk research supports exploratory research by providing input from sources

that are not directly in contact with the project. Desk research is particularly helpful with identifying bigger trends relevant to the project topic that might be challenging to spot in exploratory research. Findings from desk research are combined with the input from exploratory research to help with identifying areas of opportunity and patterns that should be focused on in upcoming project phases. (Vienna 2011, p. 32.)

3.4.4 Reframing

The incentive to use a tool like reframing is to deconstruct the assumptions and biases stakeholders might have (Vianna et al. 2011, p. 24). A simple example of a problem being reframed is a situation in which an elevator is perceived as tool slow. The obvious solution would be to install a new faster elevator or to replace the engine to accelerate the elevator speed. By looking at the problem from different angles and aiming to understand the root of the issue, a platform for alternative solutions can be achieved. In the elevator example this might mean, that people feel annoyed by the long wait and get bored even if the waiting time would be within the normal limits. For boredom a new solution, that doesn't require a shake-out of the entire elevator system, might be offered. Such solution might be placing a screen showing daily news in the elevator lobby to help pass the time. (MJV, 2022.)

Reframing happens in three stages which are, capturing, transformation, and preparation. During the capturing phase information about the purpose of the solution is gathered. This includes assumptions and beliefs from stakeholders. In the transformation phase the collected data is used as a base line for finding new perspectives for the situation. These new angles are then presented to stakeholders as a starting point for preparing new type of solutions. (Vianna et al. 2011, p. 25.)

3.4.5 Interviews

Interviews can be used as an empathizing tool in multiple phases of a project to connect with potential users and customers. Conducting an interview happens in five phases which are recruiting, planning, conducting, documenting, and synthesizing. (Dekker 2020, p. 164.) The five phases with short descriptions are presented in Figure 25.
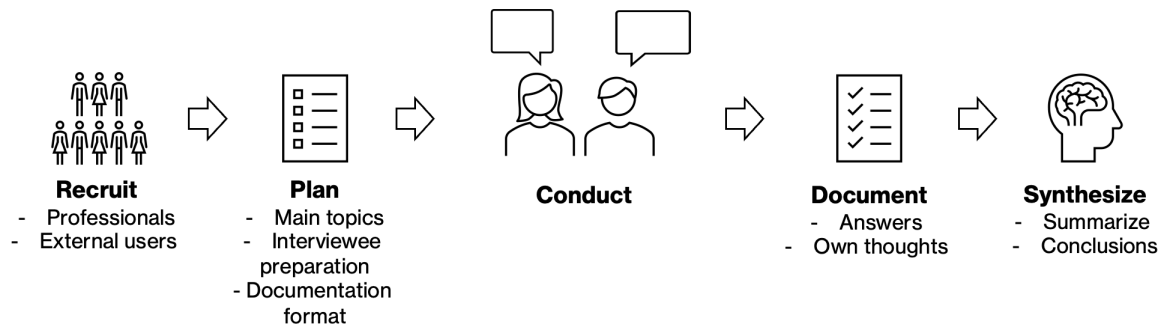
Figure 25. Phases of an interview process (Dekker 2020, p. 164).

The process starts with considering who are the people worth interviewing for the project. Interviewees can be divided into two main groups, internal and external stakeholders. Internal stakeholders include professionals within the customer organization who know what is required from the potential solution to make it feasible to implement. External stakeholders consist of current and potential users of the solution. Current users can help with identifying the strengths of the existing solution as well as what the existing solution is lacking. Potential users, not familiar with the current solution, can provide a fresh look into the topic. (Dekker 2020, p. 164.)

Part of the interview planning is to define the main themes to discuss during the interview sessions. Direct questions are not recommended since they might narrow down the coverage of the interview session. Planning also includes preparing the interviewees for the upcoming session by providing them possible background information, schedules, and informing them how the responses from the interview will be used. (Dekker 2020, p. 164-165.)

In the conducting phase, when the interviews take place, the role of the interviewer is observatory. This means that the interview should be conducted in a neutral manner without any biases. The point of neutrality is to understand the cause-effect relationships without skewing the result with interviewers' own opinions. (Dekker 2020, p. 165.)

Documenting the results of an interview should be done in way that the information supports the design process and is easily understandable by the stakeholders who are not directly involved in the interview process. There are several good documenting practices. For instance, recording the interviews enables going back to the answers if needed. It's also recommended to make notes during the interview in addition to the actual received answers.

Self-reflection after the interview brings clarity which topics provoked conversation and which topics need more explaining. Self-reflection helps with being able to facilitate better interviews in the future. (Dekker 2020, p. 166.)

Synthesizing the results is not about generalizing the results and forming recommendations based on them. Obvious and general answers shouldn't be ignored, but they rarely provide support when trying to come up with solutions with novelty value. The focus should be on finding unique angles and distinctive details that can function as fuel for generating new ideas and solutions. (Dekker 2020, p. 166.)

3.4.6 Questionnaires

One option to gather information from stakeholders is to conduct a survey or a questionnaire. Surveys are particularly useful when the intended number of respondents is too high for individual interviews, or the geographical location of the respondents is challenging. The usefulness of results and success of the survey depend heavily on how the questions are formed. (Dekker 2020, p. 109.) The key factors for conducting a questionnaire are collected in Table 4.

Table 4. Key factors for conducting a questionnaire (Dekker 2020, p. 109-110).

Phase	Key factors
Preparation	Purpose? What is wanted to achieve? Which assumptions to be tested?
	Who to question?
	Clear instructions: Purpose, time needed to answer, explanation where and how the results will be used, guarantee for confidentiality.
	Short enough questionnaire as long surveys decrease the number of responses.
	Digital or physical questionnaire?
Questions	Logical order from respondents' point of view
	Specific questions, professional and difficult terminology to be avoided
	Ask one thing per question
	Don't steer the answer with how the question is formed
	Give context to questions
	Avoid negative questions such as "What were you dissatisfied with"

If the questions are not clear and there's room for misinterpretation, the answers received might be skewed and lead to wrong conclusions. Another important factor is the wide enough

distribution of the questionnaire as too narrow distribution doesn't offer comprehensive representation of the population. (Dekker 2020, p. 109.)

3.4.7 Cultural Probes

Cultural probes are a way of obtaining data from users without directly interfering in their activities. Typically observed individuals report on their activities, experiences, and emotions without the presence of an observer. The method is exceptionally useful when the phenomenon being observed happens within a longer time span or the subject of observation is in a remote location. Additional benefit of the method is that it guides the focus of observants. By asking to report on specific tasks and situations, more attention can be guided to things that are normally faced without considering the details of what is happening. To support the reporting participants can be provided with instructions and reporting forms with prefilled topics to report on. (Vienna 2011, p. 39.)

3.4.8 Generative Sessions

Informal yet planned meetings in which participants gather to express their viewpoints on decided topics are called generative sessions. Goal of a generative session is to gain in depth knowledge on how different stakeholders are experiencing the topic being investigated. To achieve this, participants are often engaged in activities that support creativity and help participants to reflect on their memories and past experiences. Often participants are sent a cultural probe style pre-read material and exercises. The purpose of pre-reads and exercises is to encourage participants to spend time thinking about the topic before the actual session takes place. Activities during the session can include storytelling, re-enactments, group work etc. (Vienna 2011, p. 43.)

One example of a generative session activity Vianna et al. (2011, p. 44-47) gives includes participants telling stories from specific point of views. For example, from the point of view of safety or difficulty. After this the people are divided into smaller teams each focusing on certain viewpoint and creating a mood board from the group specific angle. Mood boards are presented to the rest of the group, who right down solutions to the identified issues. After

all the presentations, teams regroup to work on a topic that is different from the one they made a mood board for and summarize the learnings from that topic.

3.4.9 A Day in the Life

A day in the life in the context of design thinking refers to a research method in which a project team member assumes the role of a user for a certain time. During this, the member interacts with surroundings and other people as the user being simulated would. A day in the life is used to see the world from users' perspective and use the experience to develop empathy towards them. The insight from the exercise helps with gaining thorough insights of the user's world. This fuels solution ideation in later phases of the project. (Vienna 2011, p. 49.)

3.4.10 Observations

Observing is a qualitative research method in which perceptible behavior of users is studied and recorded. Though observing can be conducted in various ways, the four techniques covering large part of the typical behavior interesting to design projects are: counting occurrences, timing durations, diagramming social interactions, and mapping movement. Counting occurrences is an approach focusing on the number of occasions a defined action happens. Counting how many bypassing people wear a certain garment, for example. Timing durations is about observing how much time users need to perform a certain task or how long certain behavior is exhibited. An example of timing durations is observing how long it takes to place an order after a customer have started to read the menu of a restaurant. Diagramming social interactions is an observation technique focusing on mapping relationships between people and what kind of impact the relationships have. For instance, researching how does student's seat in a classroom impact the number of interactions with other students and the teacher, and does it have a correlation with the grade a student gets. Keeping track of meaningful motions in physical interactions is called movement mapping. For example, observing what kind of routes people take in a department store while they are doing their grocery shopping. (Dekker 2020, p. 103-105.)

3.4.11 Insight Cards

Documenting findings in standardized way throughout a project helps with keeping the project on its course by making sure the most crucial information is easily obtainable and convenient to communicate. Insight cards serve this purpose and are commonly used during the research phase to materialize key insights. Key insights are them used as input for definition phase. (Dekker 2020, p. 162-163.) An example of an insight card is given in Figure 26.

INSIGHT CARD

Project Name:

Date:

Insight:

Important Additional Info:

Most Important Internal People:

Most Important External People:

Information source:

Important for Definition Phase:

Figure 26. Insight card example (Dekker 2020, p. 163).

Typically, insight card includes basic information of the project. This information includes description of the insight with a visualization, past experiences about the topic, stakeholders, source of the information, and how the insight might affect definition phase of the project. (Dekker 2020, p. 162-163.)

3.4.12 Affinity Diagram

One way of utilizing insight cards is to use them to form an affinity diagram. In an affinity diagram insight are grouped based on their themes and similarities (Dam & Siang, 2022a). In the template in Figure 27, four categories are identified and insights relating to each category are placed under them. To increase the readability of the diagram, categories are typically color-coded.
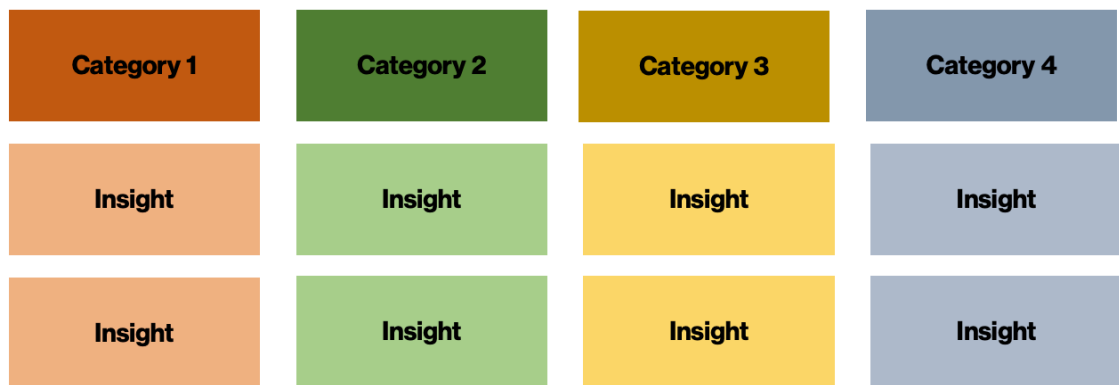

Figure 27. Template for affinity diagram (Dam et al., 2022a).

The purpose of grouping insights together based on their affinities is to form macro areas of the topic being investigated. The method is effective for making sense of large amount of data and for supporting thought organization. (Dam et al., 2022a.)

3.4.13 Conceptual Map

Conceptual maps are graphic visualizations providing information regarding how different data items are linked. Purpose of conceptual maps is to tie information together so that new connections and meanings from the data can be observed. (Vianna et al. 2011, p. 74.) An example conceptual map is given in Figure 28.
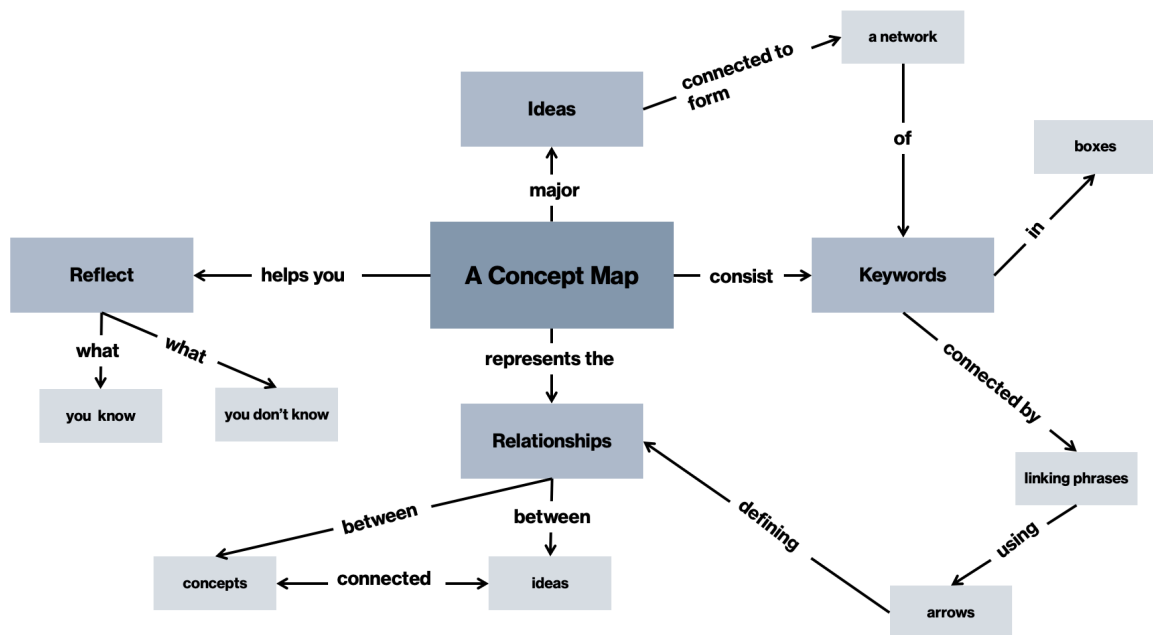
Figure 28. Example conceptual map (Morgan State University, 2023).

Unlike typical mind maps, conceptual maps are more structured and hierarchical. Typical starting point of a concept map is to decide on a topic to investigate or to form a question for which answers are required. This starting point is the primary element of the map. Secondary and tertiary elements are added on the map and connected to each other with labelled lines. Common labels for connections include: "leads to", "is part of", "requires", etc. (Elmeshain 2021, p. 9.)

3.4.14 Guiding Criteria

During the empathic discovery phase, when the project team is immersing into the topic, certain themes arise from the research forming the boundaries inside which the future solution must fit. These themes are called the guiding criteria of the project. Guiding criteria is used to determine the purpose of the project, to guarantee that the ideas the team brings forward meet the basic criteria, and to ensure that the project doesn't accidently pivot away from its purpose. (Vianna et al. 2011, p. 78.)

3.4.15 Personas

Personas is a tool that helps with defining an ideal user or user group for the solution being developed and ensuring that the solution serves the needs of that person or group. In the big picture, personas is a tool for creating consumer centric products. Ideal projects, for which the tool can be utilized, are such in which the product being developed has features that user interacts and experiences with. (Swan et al. 2015, p. 45.) An example persona profile is given in Figure 29.
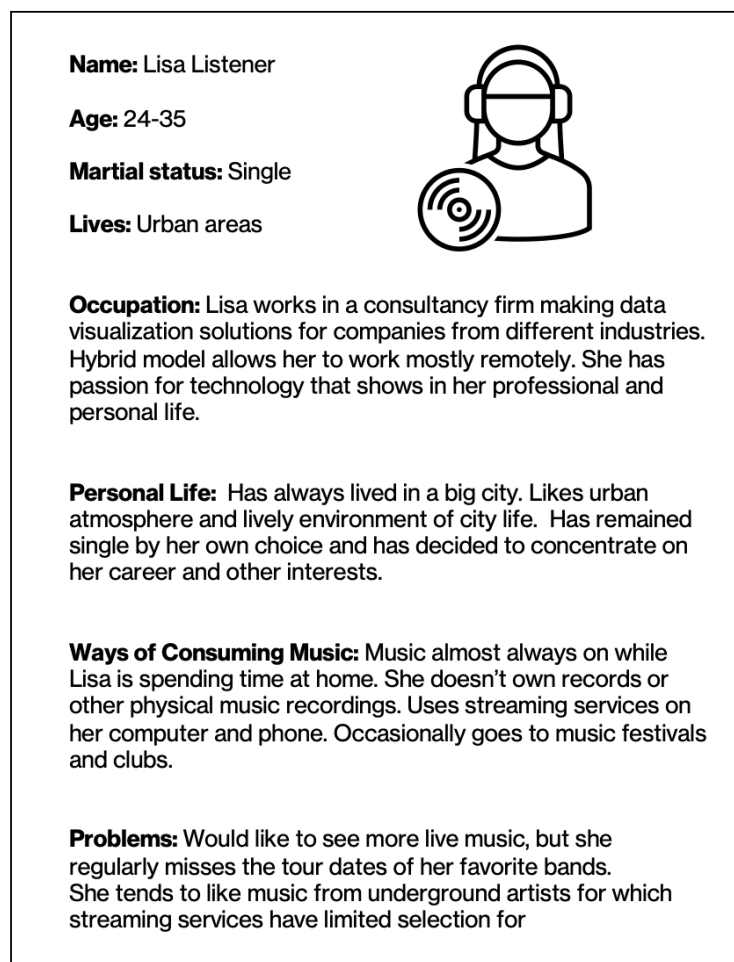
Name: Lisa Listener

Age: 24-35

Martial status: Single

Lives: Urban areas

Occupation: Lisa works in a consultancy firm making data visualization solutions for companies from different industries. Hybrid model allows her to work mostly remotely. She has passion for technology that shows in her professional and personal life.

Personal Life: Has always lived in a big city. Likes urban atmosphere and lively environment of city life. Has remained single by her own choice and has decided to concentrate on her career and other interests.

Ways of Consuming Music: Music almost always on while Lisa is spending time at home. She doesn't own records or other physical music recordings. Uses streaming services on her computer and phone. Occasionally goes to music festivals and clubs.

Problems: Would like to see more live music, but she regularly misses the tour dates of her favorite bands. She tends to like music from underground artists for which streaming services have limited selection for

Figure 29. An example of a persona profile

Representation of an ideal user is based on the behavior and motivations of actual people. The purpose is not to document ideal users based on assumptions and stereotypes, but

preferably study the real users and use the input from the research to identify key problems they have with specific products or situations. In some cases, defining an anti-persona or a persona the solutions is not aimed for, might prove to be useful. For example, if the project aims to create a solution for casual consumers, needs and issues that experts and professionals are having with the same user scenario might not be relevant. In this case, the casual consumer represents the ideal user and experts the anti-persona. (Swan et al. 2015, p. 46.)

3.4.16 Empathy Map

Empathy map helps with comprehending, how someone else feels and thinks while facing a certain situation. An example template for an empathy map is given in Figure 30. The template is divided into different sections each covering a certain aspect of the user's experience regarding a predefined situation. Half of the sections relate to the situation itself and the other half to the personal aspects in user's life. (Dekker 2020, p. 95-96.) The sections are not set in stone and can be reworked to suit the situation at hand. A recommended starting point is to cover aspects from four main categories, which are: what the user said, what the user did, what the user thought, and what the user felt. (Dam & Siang, 2020b.)
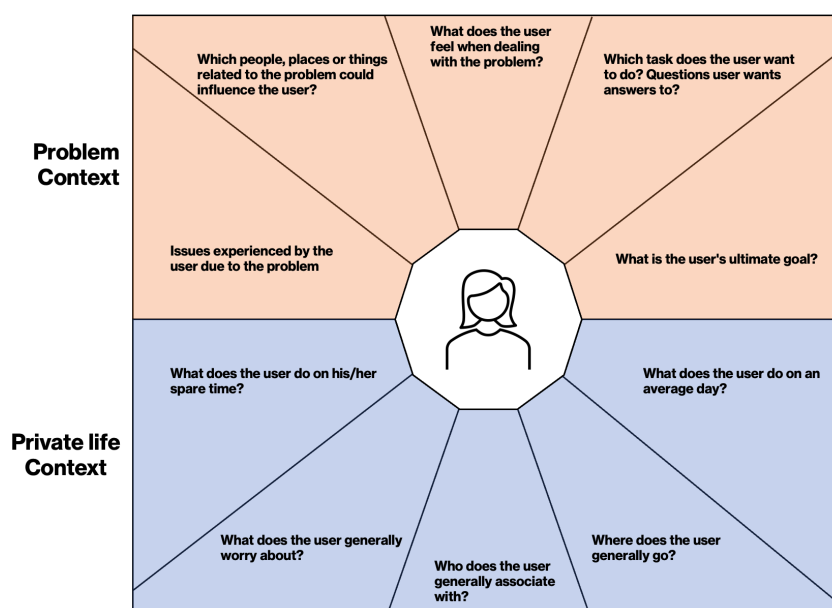
Figure 30. Empathy map template (Dekker 2020, p. 96).

Creating empathy maps serves the purpose of understanding the people for whom the solution is going to be created for. The tool is suited for documenting engagements with individuals during field research and using the collected data in the creation of broader persona profiles. Additionally, the tool offers guidance where to focus attention during observations and other interactions. (Dam et al., 2020b.)

3.4.17 Customer Journey Map

Phased visualizations representing how a user experiences a specific event or a usage situation are called customer journey maps, for which an example is presented in Figure 31. A map is usually presented as a sequence of activities which together form a holistic view of what the users does, how they feel, and how the activity connects to the product or service being developed. The tool is deployed when user perspective is needed about a particular problem. Enhanced with visual support material, customer journey maps can be an effective communication tool when identifying potential areas for solution generation. Additionally, the tool can be used for comparing different solution alternatives and testing them with stakeholders. (Dekker 2020, p. 90.)

Figure 31. Customer journey map template (Dekker 2020, p. 90).

In the figure, phase refers to a single activity relating to the usage scenario. For example, the first phase could be the moment a product is being purchased, and the last phase when the same product is being disposed. Other activities represent what happens in between. For each phase, a description of the activity and user experience are documented together with the way the activity connects to the product/service being developed. Finally, the highlights and difficulties users have with each phase are defined.

3.4.18   Mood Board

Mood boards are an effective way to communicate an emotional point of view or a feeling. Essentially, mood boards are collections of images and text that represent a certain atmosphere the creator of the board wants to capture. (Dekker 2020, p. 102.) In the example in Figure 32 colors, materials, and feeling of an interior design project are captured in a mood board format.

Figure 32. Mood board for interior design (Raft, 2022).

Mood boards can be used to define the desired style of the final design before actual design work takes place. Visual representation is a more powerful tool for reaching a consensus

among project stakeholders compared to verbal or written descriptions. This makes mood boards useful in the early phases of the project and something to revisit along it to ensure the aesthetics of the design remain on the right track. (Chapman, 2023.)

3.4.19 Design Brief

In a design thinking project, design briefs are used to communicate the project goal and to reach an alignment between different stakeholders. Design brief is a document covering answers to the five fundamental questions relating to the project: Who, what, when, how, and why. A well written design brief helps with transforming the criteria from different stakeholders into measurable and actionable concepts. Generally, the content of a design brief document falls under three headlines: strategy, performance, and context. Each headline covers three specific topics given in Figure 33. A description of the content of specific topics are given in Table 5. (Swan et al. 2015, p. 33-36.)
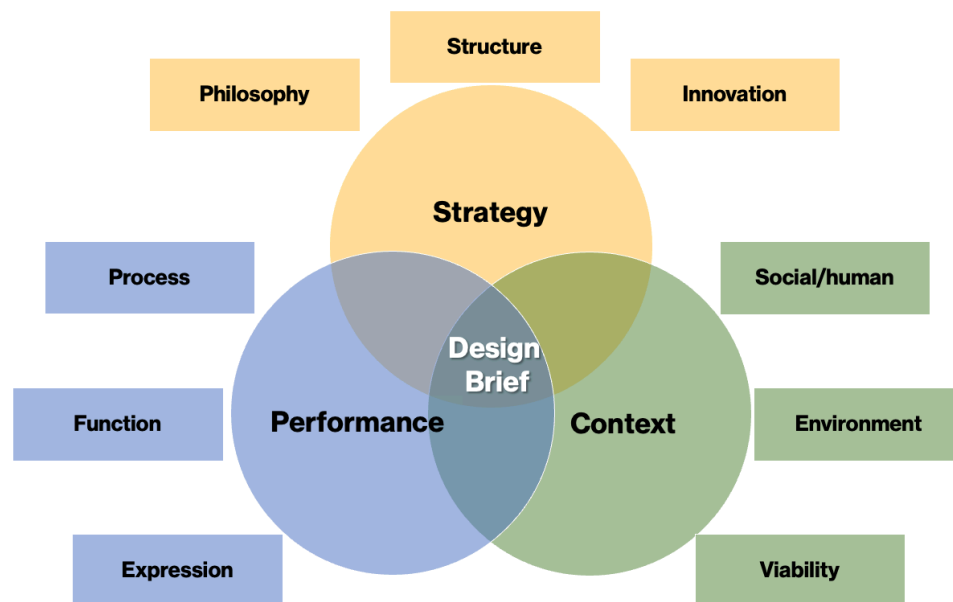
Figure 33. Content of a design brief (Swan et al. 2015, p. 35).

Table 5. Explanations for topics to be covered in a design brief document (Swan et al. 2015, p. 34-36).

Group	Topic	Description
Strategy	Philosophy	History, values, belief, vision, mission, and strategy of the company/client
	Structure	Domain, business model and competitive advantage of the company/client
	Innovation	Area and type of innovation of the company/client
Context	Social/human	Needs and activities of intended users
	Environment	Requirements and expectations for environmental aspects of the solution
	Viability	Expectations regarding economic performance of the solution
Performance	Process	Budget and schedule of the project
	Function	Nature of deliverables
	Expression	Aesthetics of the solution

Design brief summarizes the most important boundary conditions for the design project, such as budget, schedule, scope, and deliverables. Other benefits of creating a design brief include, giving designers a change to understand the nuances of the customer, building trust between the customer and the design team, and giving a foundation for the project which can be returned to in case the project drifts off course. (Asana, 2022.)

3.4.20 Brainstorming and Brainwriting

Both brainstorming and brain writing rely on the principle that quantity of ideas leads to a qualitative result. In both ideation methods the scope and the boundaries, inside which ideas are to be generated, are defined first. This is followed by ideation in which the goal is to generate a lot of ideas without criticism meaning none of the ideas are initially considered bad. The power of the methods comes from the team building on each other's ideas and acknowledging that a crazy idea might have an element in it that eventually leads to something feasible. During the ideation session all the ideas are documented. Similar ideas are bundled together to form a set of themes for the solution. Themes are then voted on to prioritize them and the same is done for the ideas within the theme. Ideating can then continue with the high priority topics. (Dekker 2020, p. 86-87.)

The difference between brainstorming and brainwriting is that during brainwriting participants write down their ideas instead on expressing them out loud. The benefit brain writing has over brainstorming is that it allows participants to formulate their ideas before sharing them. This makes the session more democratic as more articulate or dominant members of the team don't as easily dictate the session. In brain writing building on other's ideas is conducted by first asking participant to write down a set number of ideas and then passing them on to another team member who reads them out loud. After all the ideas are shared, new ideas are written down and the process repeats desired number of times leading to a similar outcome as with the brainstorming method. (Dekker 2020, p. 86-87.)

3.4.21   COCD Box

COCD box is used to prioritize ideas by giving each idea value based of which category they fall in the COCD categorization. In the example template in Figure 34, there are four color coded categories under which an idea can belong. The blue category is called Now, the red category Wow, the yellow category How, and the white category Not feasible. (Dekker 2020, p. 89.)
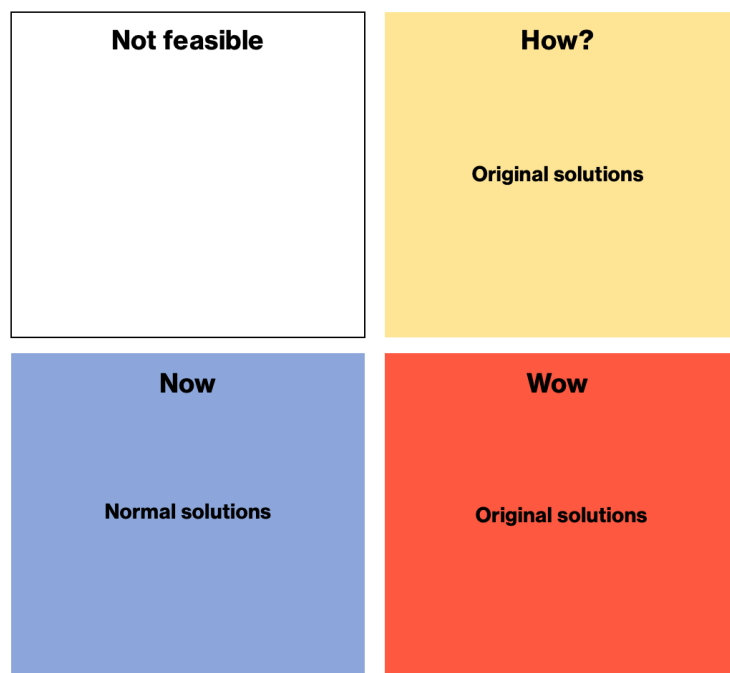
Figure 34. COCD box template (Dekker 2020, p. 89).

Ideas in the blue category are solutions for which examples are already available and are easy to implement. The red category represents ideas that are original and innovative. Additionally, these ideas are possible to take forward with existing resources. Yellow labelled How-ideas are also original, but the feasibility of implementation is unclear. Yellow ideas can be regarded as possible solutions for the future unless the project has the necessary resources for developing them the during the project. The fourth category is for ideas, not seen interesting for the project or are impossible to implement. (Dekker 2020, p. 89.)

3.4.22 Decision Matrix

Outcome of guiding criteria, personas, and other tools can be combined into a decision matrix evaluation tool. With the help of the tool an idea is assessed against different requirements and other ideas. Decision matrix aims to visualize and effectively communicate the benefits and challenges of each idea. An example how output from different design thinking tools can be combined in a decision matrix is given in Figure 35. (Vianna et al. 2011, p. 111.)

Figure 35. Decision matrix example (Vianna et al. 2011, p. 112).

In the example guiding criteria of the solution are listed in the first column and the ideas in the first row. Each idea is evaluated against all guiding criteria to see how well ideas perform. This enables a performance-based comparison between ideas. Additionally, personas or user groups, who are benefitting from the idea, can be listed at the bottom of the matrix. Personas can be replaced with some other type of decision supporting information. In the example the idea 4 meets three of the four defined guiding criteria and serves three of the defined personas, making it the most feasible idea to take forward. (Vianna et al. 2011, p. 111.)

3.4.23 Paper Prototyping

Paper prototyping is a term used for various kind of visualizations used to clarify an idea for different stakeholders taking part in a design thinking project. The fidelity level of paper prototypes varies from simple hand drawn sketches to photo realistic renderings. In the case of physical products, paper porotypes are often used in the early phases of the generation phase to initially communicate and assess the feasibility of ideas with end users and other stakeholders. Paper prototypes are also used for visualizing non-tangible products, like mobile phone app user interfaces and service models. (Vienna 2011, p. 126.)

3.4.24 Volumetric Model

Volumetric models are different fidelity level three-dimensional prototypes. Methods of creating volumetric models range from handmade paper, clay, or wood prototypes to 3D-printed CAD models. Volumetric models are often considered as a step up from paper prototyping as they offer a level on tangibility not possible with purely visual representations. High fidelity volumetric models are used to evaluate aspects like ergonomics, size, and appearance. (Vienna 2011, p. 130.)

3.4.25 Staging

Simulated interaction between individuals or between a person and a machine is called staging. Staging is used to pinpoint details and areas of improvement in a specific user experience situation. Staging aims to observe improvised non scripted scenarios. During a

staged scenario participants aim to act as naturally as possible and try to behave as they would normally do in real life. Before the scenario starts participants are assigned roles. For instance, angry consumer registering a complaint and a customer service representative taking the call. Rest of the group observes the scenario play out. After the scenario ends improvement ideas are shared and the scene can be staged again with the proposed changes. (Vienna 2011, p. 133-134.)

3.4.26 Service Prototyping

Service prototyping has similar elements to staging. The goal of both methods is to simulate one or more points of interaction in a service. The differentiating factor is that service prototyping uses actual intended users of the service instead of acting out the interactions. To conduct service prototyping a suitable infrastructure is needed to make the interactions manageable. Physical elements and props can be built in the space to enhance the interaction experience. (Vienna 2011, p. 138.)

4 Introduction to the Case Study

Literature research regarding the sustainability challenges within textile industry and the design thinking methodology form the basis for the case study made in co-operation with a workwear company Touchpoint. Chapter 4.1 covers the introduction to the project and stakeholders. Design thinking approach to the project follows in Chapter 4.2.

4.1 Case Study and Stakeholders

The core of the study is to involve three parties, a workwear company, customers, and a recycling facility, in a design thinking project in which the viewpoints of all three stakeholders are considered in mapping out possible areas for environmental performance improvements in products and operations. The purpose of this approach was to find opportunity areas that have potential to benefit multiple parties in the workwear value chain without complicating the processes of others.

Touchpoint represents the workwear company in this study. They supply workwear to various service sector companies. The brand of the company is built around sustainability, which shows in their material selections, preferred manufacturing partners, and their promotion of circular business models. How their customer base was divided in 2022 is presented in Figure 36. How Touchpoint interacts with customer companies depends on the type of the customer. Figure 11 presented in Chapter 2.3 gives alternative ways for workwear companies to operate of which all are applicable to Touchpoint. The variety of customers also shows in the number of materials used in Touchpoint products. The distribution of different materials used in 2022 is given in Figure 37.
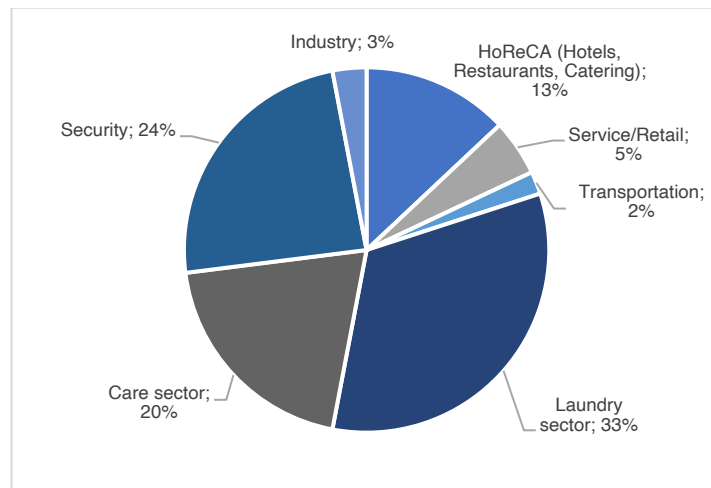
Figure 36. Touchpoint sales/customer segments in 2022 (Touchpoint 2022, p. 15).
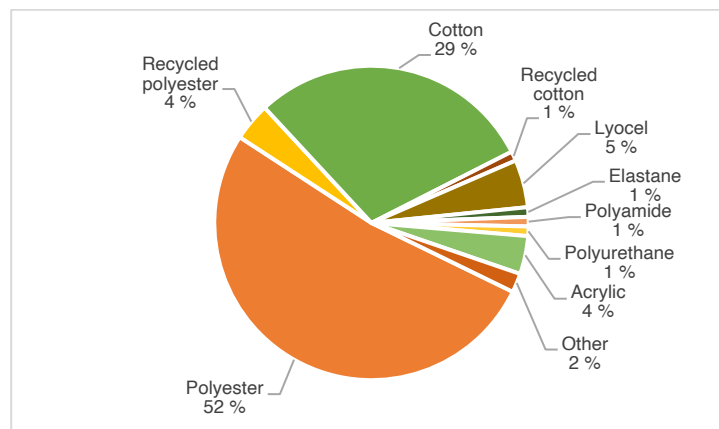

Figure 37. Material share of Touchpoint products in 2022 (Touchpoint 2022, p. 11).

The second stakeholder in the project is the recycling facility working in co-operation with Touchpoint and some of their customers. The facility mechanically recycles pre-sorted textiles into fibers which are used again mainly in new textile products, insulation applications and as filling material.

Take-back customers represent the third interested party. In the take-back operation model Touchpoint stays responsible for the products after a customer has purchased them. In practice this means that Touchpoint facilitates the proper disposal of workwear after it has been discarded by the customer. Customers can dispose an equivalent amount (kg) of textiles they purchased. In case a customer desires to dispose more, an additional fee is collected.

Some customers are only paying for the disposal service and are purchasing their workwear elsewhere.

4.2 Applying Design Thinking to Case Study

Design project roadmap including all the design thinking tools planned to be used in different phases of the project is presented in Figure 38. Project was carried out by following the principle of diverging and converging, and double diamond model discussed in Chapter 3.2.

	Empathic Discovery Phase	Problem Definition Phase	Idea Generation Phase	Generation Phase	Evaluation Phase
Research method 1	Desk research	Design brief	Brainstorming/brain writing	Visualization	N/A
Participants	Arho H	Arho H, Touchpoint	Arho H, Touchpoint	Arho H	N/A
Schedule	Feb - May, 2023	August, 2023	August, 2023	August - September, 2023	N/A
Research method 2	Customer questionnaire	Generative sessions	COCD box	Generative sessions	
Participants	Selected customers	Arho H, Touchpoint	Arho H, Touchpoint	Arho H, Touchpoint	
Schedule	July - August, 2023	August-September, 2023	August, 2023	August-September, 2023	
Research method 3	Recycling facility questionnaire		Decision matrix		
Participants	Recycling facility		Arho H, Touchpoint		
Schedule	July - August, 2023		August, 2023		
Research method 4	Touchpoint questionnaire		Generative sessions		
Participants	Workwear company		Arho H, Touchpoint		
Schedule	June - August, 2023		August-September, 2023		
Research method 5	Personas				
Participants	Arho H, Workwear company				
Schedule	August, 2023				
Research method 6	Affinity diagram				
Participants	Arho H, Workwear company				
Schedule	August, 2023				
Research method 7	Guiding criteria				
Participants	Arho H, Workwear company				
Schedule	August, 2023				
Research method 8	Generative sessions				
Participants	Arho H, Workwear company				
Schedule	February - August, 2023				

Figure38. Design project roadmap

The used design thinking tools were chosen by the basis of their potential to support and clarify the diverging and converging processes in different phases of the project. Communication with Touchpoint was handled through generative sessions meetings in which information was exchanged and next actions agreed. This communication approach was used throughout the project.

The main tools in the diverging phase of the empathic discovery part of the project included desk research, online questionnaires, and personas. Desk research included going through the fundamentals of the textile industry, related environmental challenges, and workwear specific issues. The findings of the desk research are covered in Chapter 2. To get more case study specific insights, online questionnaires were sent to Touchpoint customers, the recycling facility, and a Touchpoint representative. Questionnaires were distributed using the Zeffi online survey platform. Questions included in the surveys are listed in the Appendices 1, 2 and 3. Based on the desk research and questionnaire results three different persona profiles were created, one for each of the stakeholders.

After the creation of the persona profiles and gaining an understanding of the situation at hand from different perspectives, more design thinking tools were deployed to support the empathizing phase converging. In this phase the project started to move towards more accurate definition of the problem it was aiming to solve. In practice, information from desk research and questionnaires were used to create key insights, which were structured using the affinity diagram method. Using the created affinity diagrams as support, guiding criteria for the project was established and alternatives for the solvable problem were mapped. After the empathic discovery phase a design brief was filled out to define the problem and the goals for the idea generation phase.

Following the principle of double diamond model, idea generation part of the project consisted of diverging and converging phases. In the diverging phase of the idea generation, brainstorming and a version of brain writing were used for initial idea generation. This was followed by a converging phase, in which COCD box was used first to categorize, rank, and filter the ideas. The most interesting ideas were evaluated further with the decision matrix tool to clarify how well different ideas hold up against the guiding criteria, how they serve the needs of different stakeholders, and how much novelty they would potentially offer.

As the project was executed without a budget and in limited time, generation phase was limited to creating visualizations how the selected solution would look and work. Higher fidelity prototyping and testing would require more time and commitment from different stakeholders and likely a financial investment as well. Since the outcome of the project was a visualized concept, evaluation phase to see how well the concept performs in real life couldn't be conducted.

5 Results and Discussion

Presenting of the results begins with stakeholder specific overviews of the questionnaire results. Overviews are followed by discussion and representations, how the information gained from desk research and questionnaires are used to create persona profiles, affinity diagrams, guiding criteria, and a list of key problems. One of the key problems is selected to create ideas for. The generated ideas are evaluated using the COCD box tool and the decision matrix tool. Finally, one idea is developed further as a concept proposal.

5.1 Recycling Facility Results Overview

The survey results show that the most common fiber type the facility processes is cotton-polyester mix. Answers also show that material arrives to the facility in bags which the facility provides to their partners for textile collection. The bags are color coded for different materials. Before transportation to the facility, partners sort cleaned and dried textiles into different bags according to sorting instructions. Sometimes inhouse sorting by the facility is required to ensure that the quality requirements of the stakeholder buying the recycled fiber are met.

Based on the questionnaire answers the recycling facility has four main challenges: textiles containing more than 5 % elastane, large plastic prints, hard components, and textiles in which multiple fiber types are mixed. Relatively high percentage of elastane makes material unsuitable for the facilities' mechanical recycling process as elastane is prone to get tangled up in the machinery. If removal of plastic based prints is unsuccessful, it reduces the homogeneity of recycled fiber. Also, plastic print can start to melt in the recycling process causing problems for the machinery. Hard components, like metal buttons, are designed to be removed as a part of the recycling process, but the less hard components there are the easier processing is for the facility. The fourth challenge are the materials containing more than one fiber type. These materials are suitable for the process as such, but mixed recycled fiber has limited application and demand in comparison to materials containing only one fiber type.

The recycling facility goals derived from the survey answers were to find sufficient sources for single fiber textiles and being able to meet the future needs of their customers buying recycled fiber. Preference for single fiber textiles comes from the fact that these materials are easier to find customer for and are more valuable. Especially 100 % white cotton is sought after. The second goal relates to the fact that industries are continuously trying to find ways to utilize recycled materials and the recycling facility aims to keep their operations up to speed with the development.

5.2 Workwear Company Results Overview

Some of the challenges the workwear company is facing relate to their desire to use increasing amounts of environmentally preferred materials. When narrowing down the specification of preferred materials to ones suitable for workwear usage and furthermore to ones which Touchpoint prefers, the preferred material selection includes recycled cotton from surplus fabric and disposed clothing, recycled polyester from plastic bottles, and man-made cellulosic fibers using cellulose as feedstock. (Touchpoint 2021, p. 14.)

Challenge with using these materials is that there's sometimes mismatch between Touchpoints desire to use them and the requirements/processes their customer have. The mismatch comes in the form of new materials complicating customers current way of working and possible requirement for extra processing. For instance, cellulosic fibers could be an alternative to replace cotton, but requires different kind of processing in industrial laundering. Laundering companies are reluctant to start sorting out multiple materials for material specific processing. Besides possible processing challenges, some materials, like recycled cotton, might have increased need for maintenance. In some cases of recycled cotton, fiber shortened during recycling process tends to get fluffed-up causing need for fluff removal process to maintain the appearance of the product.

Another obstacle for using more preferred materials is customers preselecting materials for their products before consulting Touchpoint about the topic. This limits the possibilities Touchpoint has for having an impact on the choice. This challenge goes hand in hand with the problem of not having a common material database from which customers might find new alternatives for the ones they are accustomed using.

Some of the challenges the workwear company faces are more general within the industry. Such challenges include continuously developing regulation and guidelines, lack of implementation of large-scale sustainability initiatives that would shape the industry, material availability, and long lead times. Availability of more environmentally friendly materials is caused by the fact that these materials are a deviation from the standard material offering of fabric manufacturers. Conventional materials are still dominating the fabric market. Making an order for something that is not part of the standard production might result bigger than needed order quantities and long delivery times.

The overall goal of the workwear company is to offer sustainable workwear products to their customers. The main way to achieve this is to maximize the use of environmentally preferred materials in their products. This target supports their brand value and offers novelty in comparison to competition.

5.3 Workwear Customer Results Overview

The survey results show that the biggest sources of motivation for recycling workwear are environmental concerns and positive company reputation resulting from sustainable way of operating. Having an established process for getting rid of textile waste has also practical benefits as typically companies needing workwear services produce large quantities of textile waste.

According to the survey results, material selection for workwear happens by the basis of durability, suitability for the type of work they are used in, and compatibility with different maintenance processes, like washing and drying. Based on the received answers, material cost wasn't viewed as very important. Environmental reasons didn't come up as a criterion for material selection. Cotton-polyester mix is the dominant material choice among the all the respondents.

Nine out of nine respondents mentioned worn out appearance among main reasons for disposing workwear. Also stains that couldn't be removed were mentioned by four respondents. Need for a visual update on workwear, like new logos and colors were mentioned by two respondents. Though not among the top reasons for discarding, when a visual update on workwear occurs, it potentially results a large quantity of disposed textiles.

Four respondents said they could consider second-hand workwear for their company. For those who couldn't, there were multiple reasons why. These reasons included preferring to purchase new clothes and use them until the end of their effective service life, skepticism towards second-hand products being durable enough, availability of suitable second-hand products, and the fact that current workwear is designed and specified according to the specific needs of their company.

When it comes to workwear related logistics and processes, the space required to warehouse the discarded textiles was seen as a problem by four respondents and the cost associated with transportation by two. Isolated answers mention a need for smaller collection bags for more uncommon textile waste and bags better suited for stacking them on top of each other for more efficient space usage. Collecting disposed workwear was reported to be a part of normal everyday operations and no meaningful challenges in recognizing or sorting different materials were identified.

According to the questionnaire results at least three workwear related goals for customer companies can be formed. Firstly, companies need workwear that meet the needs of their employees and suits their processes. Secondly, an effective, space conserving, and sustainable way to get rid of generated textile waste. Thirdly, sustainability can be used in PR for positive company image.

5.4 Persona Profiles

One of the key functions the questionnaires had was to gather enough information to be able to create a persona profile for each of the stakeholders. Purpose of these profiles was to document the point of view of each interested party. Profiles covering each stakeholders' major issues and goals regarding sustainable workwear, were used in communicating the key findings of the survey and as input for the further phases of the design thinking project. The created profiles are divided into four sections, each containing different type of information about the stakeholder. First section defines the role in the value chain, second general information, third challenges the stakeholder faces, and the fourth, goals the stakeholder has.

The recycling facility persona profile is given in Appendix 4. The profile is based on single answer as the value chain only included one textile recycling center. The questions 6, 12, and 15 were left unanswered. Workwear company profile is presented in Appendix 5. Like in the case of recycling facility, the workwear company profile is also based on a single survey answer. After the first round of questions, additional questions were sent to obtain more detailed information regarding some of the answers. Additional questions are marked and listed together with the original question in Appendix 3. Appendix 6 shows the workwear customer persona profile. The survey, the profile is based on, was distributed to 13 take-back customers of which 9 replied. The customer persona profile is a combination of the received answers.

5.5 Affinity Diagrams and Guiding Criteria

For structuring the gathered insights from desk research and surveys, two design thinking tools, affinity diagram and guiding criteria, were used. The usage of these tools aims to summarize the most important insights in a clear and easy to digest format. Goal of using the tools was to get an overview of the situation at hand and to help with understanding the situation from multiple angles. For this purpose, two affinity diagrams and one list of guiding criteria were created. The first affinity diagram in Figure 39 covers the overall key insights and the second one in Figure 40 focuses on identified problems. Guiding criteria was formed based on the two diagrams and is listed later in the chapter.

5.5.1   Affinity Diagrams

The first step of structuring insights was to gather the key findings into the affinity diagram in Figure 39. The desk research and surveys generated a lot of insights of which the most relevant to the case study were filtered out and used in the diagram. Insights were categorized into five groups: recycling, environmental impact, materials, industry, and workwear. Each group was assigned a color to improve clarity and readability.

The other affinity diagram presented in Figure 40 uses the same data as the Figure 39 but is more focused on the challenges and goals the stakeholders have. Like in the case of the first affinity diagram, some filtering of insights was made before creating the second diagram.

For example, the problems which were not seen to be in the scope of the case study, like logistics cost or constantly updating legislation, were left out. The left-out problems might be worth revisiting and solving but, are not relevant considering the goal of the case study, finding ways to improve the environmental sustainability within the workwear value chain in scope.
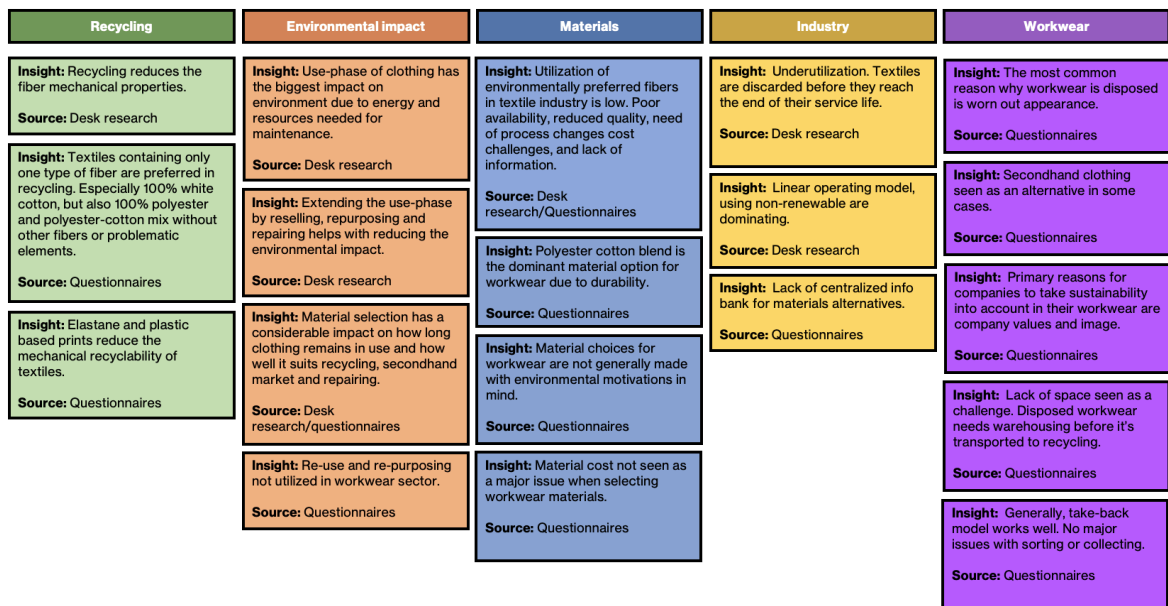

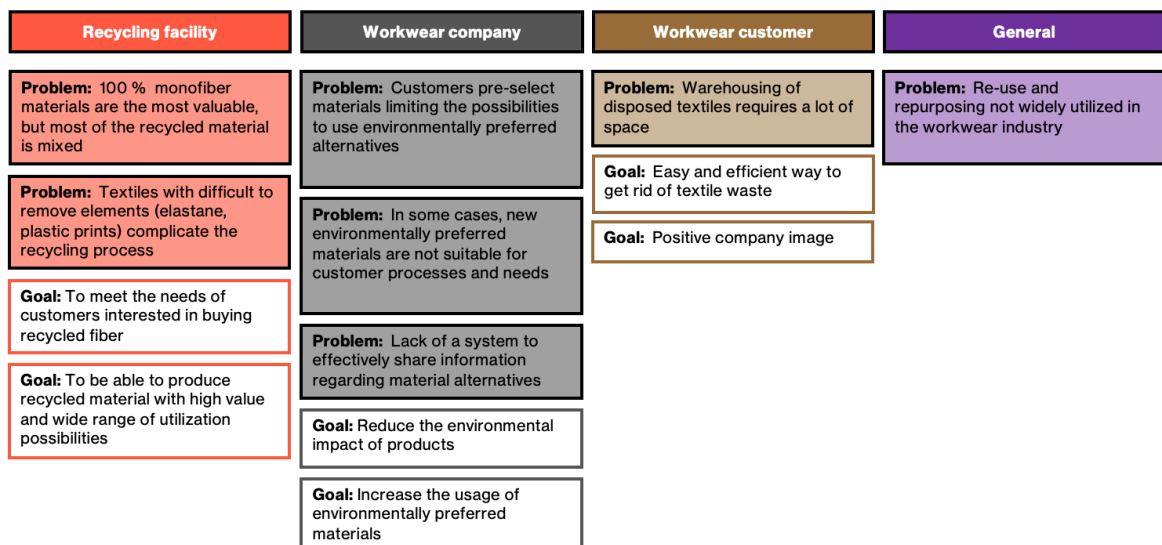Figure 39. Affinity diagram for key insights

Figure 40. Affinity diagram for problems and goals

The information represented in the two affinity diagrams and three persona profiles give an overview of the stakeholders' goals and challenges and support gaining a holistic view of the situation. The output from these design thinking tools were used to facilitate the next phases of the project.

5.5.2   Guiding Criteria

Using the data summarized in the two affinity diagrams and persona profiles, guiding criteria for the project was established. The formed criteria consist of five parts listed below.

1. Can be considered as an improvement from environmental perspective.

2. Supports the sustainability goals of the workwear company.

3. Mechanical recycling remains a possibility.

4. Doesn't complicate workwear customer processes.

5. Feasible from economical perspective.

Guiding criteria acted as a set of requirements an ideal solution would fulfil and a guideline for feasible ideas. The main principle behind defining the criteria was that an optimal solution wouldn't complicate the activities of any stakeholder, would be feasible from cost point of view, and would result betterment from environmental point of view.

5.6 Problem definition

Based on the insights from the empathic discovery phase a set of possible solvable problems was created. Target was to capture the key problems identified in the value chain regarding environmental performance. The five problem options, of which one was to be focused on in the idea generation phase, are listed below. The purpose of creating multiple paths for the next phases of the project was to emphasize that the situation could be approached from multiple perspectives.

1. How to overcome the barriers for using more environmentally preferred materials?

2. How reduce use of elastane in workwear?

3. How to make the storing of disposed textiles more space effective and optimize transportation?

4. How to incorporate re-using into workwear?

5. How to incorporate repurposing into workwear?

Different problem options were discussed together with the workwear company and evaluated against the affinity diagrams and the guiding criteria to find which problem has the most common ground with all the stakeholders and if solved, would potentially meet as many of the guiding criteria requirements as possible.

The problem options 2 and 3 were abandoned by the basis of them resulting insignificant impact considering the guiding criteria. Solving the issue the recycling facility has with elastane, would mean easier processing and higher value post recycled material. These together could improve the environmental performance through more application options for the recycled fiber, and there for longer material service life before the final disposal. Issue with the solution would be that the benefit would fall mainly on the recycling facility and not as much on the other stakeholders. The same argument of only helping one stakeholder applies also for the problem 3. Additionally, improving the space and logistics effectiveness would only result minor improvement from sustainability point of view.

The problem 1 would be an attractive option as increasing the share of environmentally preferred materials is in the interests of the workwear company, it could create added value for the customers, and in an optimal case wouldn't complicate the recycling facility processes. However, it was seen that the concrete actions to improve the situation at the moment are limited. Material options and availability are expected to be improved on their own in the future as demand for more sustainable materials increases and new legislation is applied on the industry. It was seen that there might be opportunities in regard of raising awareness about more eco-friendly material options and finding ways to promote the use of these materials. These opportunities were not seen as enough to build on for the case study but could be areas to develop in other projects.

The agreed problem for the next phases of the projects was a combination of the problems 4 and 5. The decision was driven by the fact that currently re-using and re-purposing are not leveraged in the value chain. The lack of utilization of these tools creates an opportunity for novelty ideas and solutions. Also, past studies suggest that by utilizing re-purposing and re-using in textiles can result environmental benefits through reduced need for producing new items, extended service life, and reduced waste. After the decision on the problem was made, a design brief given in Appendix 7 was filled out to create a summary of the project background, problem itself, criteria, and the target audience.

5.7 Idea Generation

The ideation was mainly carried out using a form of brainwriting method in which participants first thought-out ideas individually and then discussed them through in an ideation meeting. Some ideas came outside the brainwriting process. The generated ideas were briefly documented on virtual notes and placed on a COCD box diagram including four categories. The filled out COCD box is given in Figure 41.
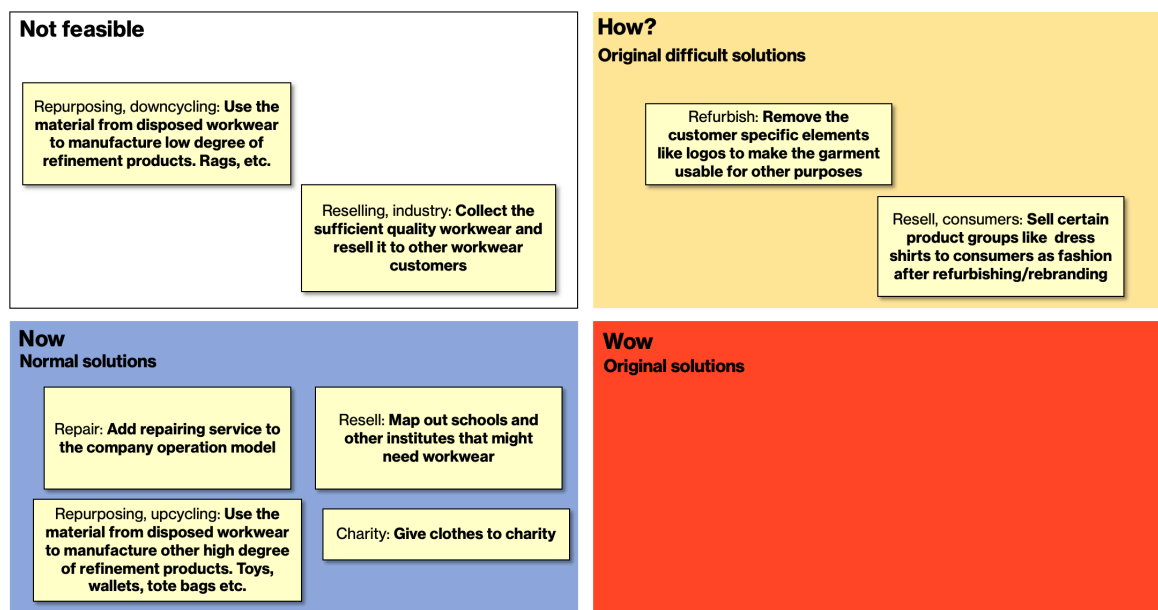

Figure 41. COCD box diagram with generated ideas

After the first categorization the potential of ideas were assessed by the basis of their feasibility and originality. Foremost, unimplementable ideas were filtered out. First being downcycling workwear into lower degree of refinement products. From the technical perspective the idea could be carried out, but he problem with the idea was that, using still usable, high-quality clothing as a material for applications with low service life expectation seemed wasteful. Reselling used workwear again for workwear purposes was also seen as not feasible. The reason being that matching the supply and demand in practice was not seen solvable. Many companies need a steady supply of workwear with consistent quality and sometimes with specific materials. Outside the clearly not feasible ideas, two normal solutions were also ranked out from the next phase. Giving clothes to charity would extend the service life of products and through that, reduce environmental impact of products, but wouldn't match with stakeholder specific guiding criteria. The other idea left out from the normal solutions category was adding repair service to the workwear company operation model. Though the idea was seen interesting, it wasn't considered as attractive due to complicated logistics and doubts of too high cost per repaired garment.

Four ideas were selected to be further evaluated against each other and guiding criteria with a decision matrix tool presented in Figure 42. Two of the selected ideas relate to reselling products to some other usage than workwear. One from normal solutions category and another from the difficult original solutions category. The reselling idea from the normal solutions category includes selling used workwear to schools and other institutes that have a need for workwear, but don't have as high quality and availability requirements as a typical work wear customer would have. The other re-selling idea seen as original, but challenging, is about taking good condition used workwear or surplus products and after a refurbishing and rebranding, sell them to consumers.

The other two ideas selected were an upcycling/repurposing idea from the normal solutions category and a refurbishing idea from the original but challenging category. The upcycling solution would utilize material from used workwear in manufacturing of other high degree of refinement products. The refurbishing idea relates to removing customer specific elements, like logos and labels to make products more usable in reselling and repurposing.
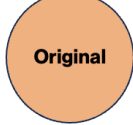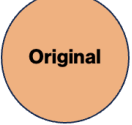
	Meets criteria ✔	Questionable ▬	Doesn't meet criteria 🚫	

	Refurbish: **Remove the customer specific elements for reselling**	Resell: **Map out schools and other institutes that might need workwear**	Resell, consumers: **Sell certain product groups to consumers after refurbishing/rebranding**	Repurposing, upcycling: **Use the material from disposed workwear to manufacture products.**
Improvement from environmental perspective.	✔	✔	✔	✔
Supports the sustainability goals of the workwear company.	▬	✔	✔	▬
Mechanical recycling remains a possibility.	▬	✔	▬	▬
Doesn't complicate workwear customer processes.	🚫	🚫	🚫	🚫
Feasible from economical perspective.	▬	▬	▬	🚫
Originality	Original	Normal	Original	Normal

Figure 42. Decision matrix

In the decision matrix in Figure 42, guiding criteria is listed in the left most column and the ideas with the most potential are in the top row. Additionally, the originality level from the COCD box tool is added on the bottom row. Each idea was assessed against the guiding criteria to form an understanding how well they meet the requirements and how different ideas compare to each other. Evaluation against guiding criteria is done on three levels. Green check mark indicates that an idea meets the criteria, yellow line means that meeting the criteria is questionable, and red stop sign indicates that the criteria is not met.

Based on the decision matrix assessment, all the ideas can be seen as an improvement from environmental perspective. Reselling solutions would extend the usage period of products and thus reduce the need for extracting new materials, manufacturing more products, and reducing the amount of waste. Repurposing the material from used workwear would similarly reduce the use of virgin materials in production of other goods. Removing customer specific elements from workwear after disposal doesn't improve the environmental performance as such but supports re-selling and re-using activities following the process.

When it comes to supporting the sustainability goals of the workwear company, the reselling ideas offers the most benefits. Selling the products in their original form or slightly modified would add value to the circular economy related goals of the Touchpoint. Repurposing the waste material could be viewed in a similar manner, but since this solution would require manufacturing of completely new products, there would be more production related emissions and waste. The idea of removing customer specific elements doesn't support the sustainability goals of the company but can open possibilities and support other activities.

In theory none of the ideas would exclude the possibility of recycling after the final disposal, but in practice challenges are foreseeable in most cases. To recycling to happen, a logistics solution to transport the goods to the facility needs to be in place. The only idea for which the established take-back model could be used is the idea of reselling products to different institutes. In such cases, a large batch of products could be collected and transported to the recycling facility in a controlled manner. In cases of selling products to consumers or manufacturing other products, the material leaves the workwear value chain and the benefit of organized sorting and collecting is lost or complicated.

The one common drawback for all the ideas is that they likely require something extra from the workwear customers. Some disposed workwear, like severely stained or torn products are not suitable for second-hand market or repurposing and should be separated from the products that are. This causes extra sorting efforts for the customers which complicates their current way of operating.

Economic angle of each idea is challenging to assess without exploring them in more detail and was assessed to be questionable in all the cases except in the repurposing solution. The economic feasibility of the reselling ideas and the refurbishing idea depends heavily on the potential customer's willingness to pay for the second-hand product as well as on the expenses of extra processing and logistics. Repurposing idea is likely to be the least attractive from cost point of view as manufacturing completely new products, instead of reusing or refurbishing, is expected to be more expensive.

5.7.1 Selected Solution

None of the ideas assessed with the decision matrix tool fulfilled all the guiding criteria. The reselling ideas showed the most potential, though both have unanswered questions relating to them. From the two reselling ideas the one aiming to market used workwear to consumers was selected to be explored more and to be developed into a concept. Selling second-hand workwear to schools and other institutes might be easier to carry out in practice, but would offer little novelty, as the solution is close to the current operation model of the workwear company.

Another factor impacting the selection was the promising future of the second-hand apparel market. A report from Threadup (2023, p. 4) states that during 2022 the global second-hand garments market grew 28 % and is expected to grow significantly during the following years. According to the Future Market Insights (FMI, 2023) the estimated compound annual growth rate of the second-hand market is 14,8 % during the period 2022-2032.

When considering the Touchpoint portfolio, there are multiple products that could fit the consumer second-hand business model. Some example products from Touchpoint estimated to fit the second-hand market are given in Figure 43.

Figure 43. Some example products from Touchpoint portfolio potentially suitable for the consumer re-sell model (Touchpoint, 2023).

Without company logos or other identifiers many of the service sector workwear garments are not recognizable as workwear. This means that the products could be of interest and serve the needs of regular consumers as well.

5.8 Concept

A flowchart presenting the principle, how the reselling of workwear to consumers would work is given in Figure 44. The chart starts from product design and has two possible end points, recycling, and second-hand market, depending on where the products end up after sorting. Different steps in the chart are color-coded. Green indicates that the step happens as it does in the current operating model. Steps marked with orange require a modification or are entirely new activities in comparison to the existing operating model.
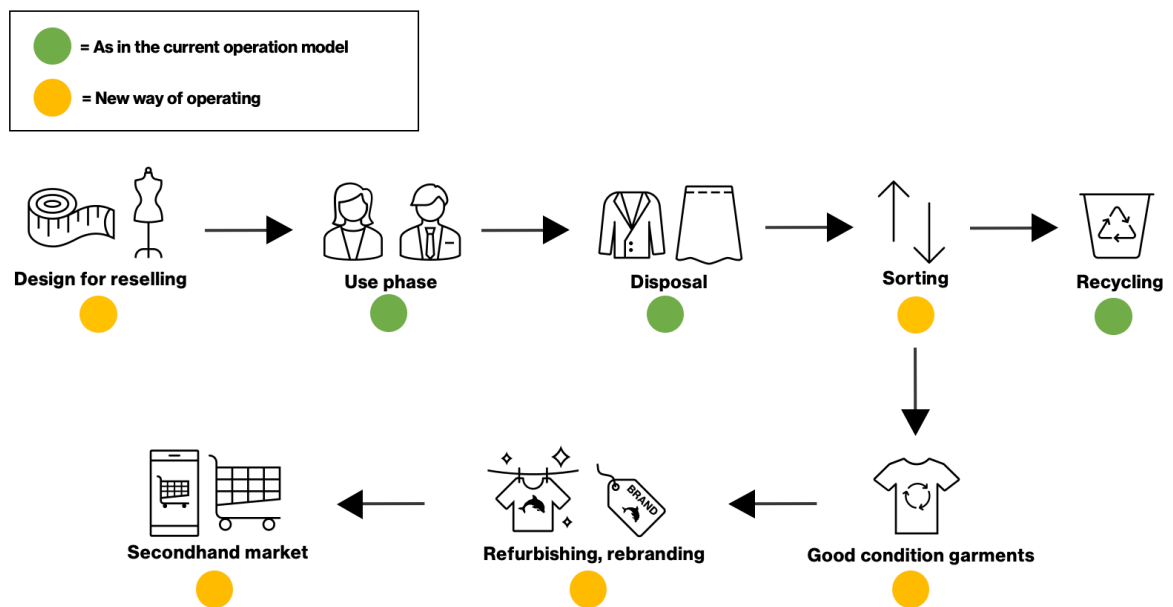
Figure 44. Concept flowchart

The first step in the flowchart that could need alteration is the product design. Touchpoint portfolio contains products suitable for the reselling model already, but to ease up the following steps in the concept, certain design guidelines could be followed. Promoting new guidelines could also increase the number of product designs suitable for consumer reselling. To make the products sellable for consumer, all the features that make them recognizable as workwear should be removed or covered. From the design perspective this could mean that labels or logos should be done in a way that they are easy to remove. For instance, favoring sewed on labels and logos over prints. Another design aspect is the color selection. Products

can possibly be made more appealing for consumers if workwear customer specific brand colors can be avoided.

Use phase taking place at the workwear customer happens in a same way as in the original operating model, but the second-hand model requires changes in how products are handled after disposal. It's assumed that not all the products are in such condition that they could be sold again. This results a need for sorting the products to ones ending up in mechanical recycling and to those in condition fit for reselling. This is an obvious drawback of the model as it requires more effort and space from workwear customers. Especially the increased space requirement is a problem as customers are struggling with lack of space as it is. Part of the solution could be to offer customers some kind of incentive. For example, a refund or discount based on the number of garments they provide for reselling.

Another new element in the reselling operation model is the refurbishing and possible rebranding of products. At the very least, the garments that are not cleaned before disposal, need to be washed and perhaps ironed. If products don't have workwear customer specific labels or other personalization, they could be sold as such. On possibility to make the products more desirable for consumers would be to rebrand them. Touchpoint is not an established consumer fashion brand, but co-operating with one could add visibility and attractiveness for the concept. Rebranding activities could be tied together with the removal or covering of workwear customer personalization. Couple of alternatives for this are illustrated in Figure 45. The first proposal uses adhesive fabric patches to cover unwanted labels or logos. These patches could also contain a new logo or brand text to replace the old one. Another option would be to sew a new label or element, like a pocket, on top of the old one. Benefit of covering up unwanted elements, instead of trying to remove them is that the process needed for the removal is taken out from the equation making the process less labor intensive.
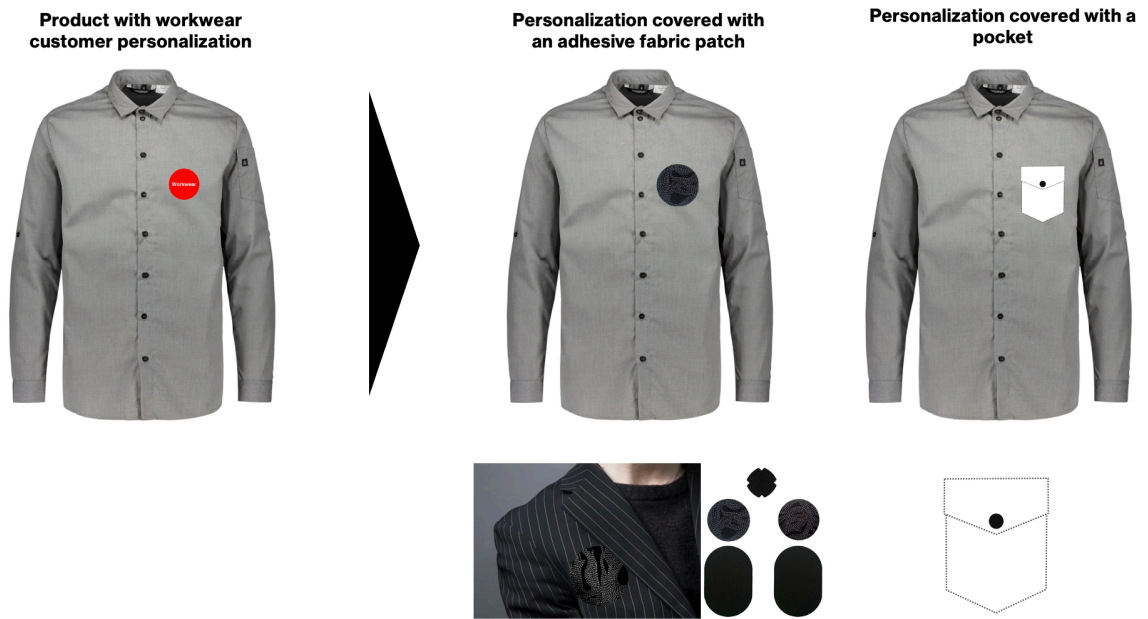
Figure 45. Ways to cover up workwear customer specific personalization (Touchpoint, 2023; Vaatelaastari, 2023).

The final step of the concept operating model is placing the products on second-hand market. Here the emphasis should be on finding a suitable channel in which to sell the products. Keeping the marketing and selling of the products entirely inhouse is an option, but without consumer awareness and known brand, attracting customers might prove to be challenging. Likely an easier path would be to leverage existing online or brick and mortar second-hand marketplaces. Second-hand online stores such as Sellpy and Emmy could be a feasible option for the operating model. Both companies operate in the Nordics and have features that could help with gaining visibility for the products. Emmy has established partnerships in which fashion brands are selling their surplus and sample products through their online store. Sellpy has a similar model in place making possible for companies or individuals to have their own pop-up online marketplace within the Sellpy site. An illustration, how the Touchpoint brand might look on the Sellpy site is given in Figure 46.
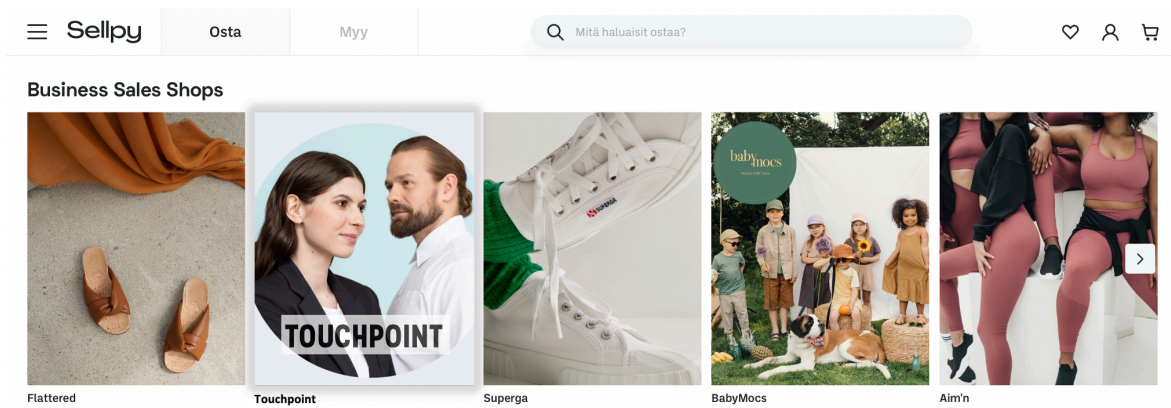
Figure 46. Touchpoint illustrated as a part of an online second-hand marketplace (Sellpy, 2023; Touchpoint 2022, p. 20).

In the COCD categorization, the idea of selling workwear as consumer fashion was considered as original but challenging to implement. Typically, ideas in this category don't have an obvious and clear path from idea to implementation. This is true for the workwear as second-hand fashion concept as well as a successful implementation requires finding new partners and training existing parties to the new way of working. To develop the concept further, another design thinking project could be carried out to systemically investigate pain points in the concept and possible solutions for them.

6 Concept Analysis

The concept has many elements for which the details need to be specified, but if a feasible way forward can be found, there's upside at least from environmental, Touchpoint, and consumer perspectives. Though, benefits could be gained on many levels, there's room for developing the concept further to make it more appealing for all the parties in the value chain.

As the idea is on concept level, the environmental benefits of it are challenging to calculate accurately. By relying on existing studies referenced in the Chapter 2, it can be concluded that extending the service life of textiles contributes to reducing emissions in the value chain. The longer use phase of textiles increases the emissions relating to the maintenance of them, but at the same time environmental benefits are gained in other phases of the value chain. In the beginning of the value chain, secondhand clothing reduces the need of extracting resources for new textile production and reduces fabric and garment manufacturing related emissions. In the lateral part of the value chain the amount of textile waste is reduced.

From the Touchpoint standpoint adding the element of reselling in their operating model contributes to their sustainability value statement and circular business model. Additionally, entering the consumer fashion market might offer increased brand awareness and business opportunities through the increased visibility from being present in sales channels not previously used by Touchpoint. Another benefit is that the concept is not only limited to second-hand products collected from customer. It could also be a new opportunity for getting rid of surplus products and product samples as well.

Consumer benefit of the concept relates to product quality required and expected from workwear garments. Fast fashion phenomenon associated with consumer fashion industry doesn't offer an incentive to invest in high quality materials and fabrics, but in workwear sector durable materials are a necessity. The second-hand operating model would offer consumers products which quality exceeds the level of typical consumer fashion garments.

The financial feasibility of the concept is among the biggest unanswered questions. There are multiple scenarios how the cost of additional processing might turn out depending on the amount of additional logistics cost, exact methods of refurbishing and rebranding, fees the

online marketplace might charge, and the consumers' willingness to pay for the products. To mitigate the risk of initially investing too heavily on the concept and to learn about the possibilities of the new operating model, a small pilot program could be carried out with a possible co-operation brand and marketplace.

A significant deficiency of the concept is that it doesn't contain obvious benefits for workwear customers and the recycling facility. Space required to store disposed textiles was seen as an issue with the current operating models and the new one doesn't offer any relief in that regard. Another problem with the concept is that it causes products to exit the workwear value chain leaving the end of life of products questionable. In the takeback operating model, textiles were systematically collected and recycled, but the same thing doesn't happen with consumer textiles. This aspect is expected to be improved in the future. In Finland there's upcoming legislation requiring municipalities to arrange collection of textile waste (Ympäristöministeriö, 2021).

7 Conclusions

The main objective of this thesis was to study a specific part of a workwear company value chain to identify opportunity areas for implementing practices that would result benefits in terms of environmental sustainability. The results of this study can be concluded by reflecting the outcome to the defined research problem and questions. Together the answers to the research problem and questions reveal the opportunity areas and help assess their feasibility.

The research problem has two dimensions to it, one regarding the opportunities for implementing environmentally sustainable practices in the workwear company value chain, and another about the barriers that are preventing the introduction of new more sustainable ways of working. The research problem was supported with three research questions. The first one relating to the point of views of the three different stakeholders in the value chain, workwear company, customer, and a textile recycling facility. Second one focusing on the synergies these stakeholders have. And a third one about leveraging the synergies in generating solutions which would have a positive impact on all the stakeholders.

The approach of including the viewpoint of three different stakeholders helped with achieving a holistic overview of the situation. The goals of the workwear company revolve around increasing the usage of environmentally preferred textile materials and implementing circular business models. The challenges they are facing relate to material availability, inability to have full control on the material selection, and matching the needs of their customers with environmentally preferred materials. Outside of embracing environmental values as a company, the customers didn't report to have workwear related sustainability goals. Generally, the workwear they need must fit their operations, meet their durability requirements, and they need an efficient way to dispose the generated textile waste. On the challenges side, customers are commonly struggling with space required to store the disposed and sorted textile waste. The main goal the recycling facility has is to acquire as much high value material for recycling as possible. High value materials include materials containing only one type of fiber, like 100 % cotton or 100 % polyester. These materials have high demand on the market due to numerous application options. According to the study, the issues the facility is struggling with are the dominance of mixed materials in

textiles, textiles containing elastane, which makes material not suitable for their processes, and garments with plastic prints and other hard to remove elements.

The study shows that the environmental sustainability improving opportunities derived from the identified goals and problems of the stakeholders are not clearly contradicting, but there are no obvious synergies either. Solving a problem for one stakeholder doesn't necessarily help the others and might even cause new difficulties. As an example, increasing the use of environmentally preferred materials helps with the work wear company achieving their goals but doesn't suit the needs of all the customers. This is due to customers having established processes for cleaning and maintaining their workwear and new materials, like lyocell, not fitting the existing process. The recycling facility doesn't benefit from the shift towards environmentally preferred materials, but it doesn't hinder their processes either. A similar situation can be seen with removing elastane or hard to remove elements from workwear. The workwear company could claim their products being more suited for recycling and the recycling facility would benefit from easier processing. At the same time the change would cause workwear to be less comfortable on workwear customer employees. Making workwear from 100 % single fiber materials has the same outcome. The workwear company and the recycling facility would benefit, but the customers are preferring mixed materials, especially cotton-polyester mix, for their durability and comfort.

The study revealed several barriers slowing down the implementation of environmental sustainability improvements. The lack of synergies between the environmental goals of the stakeholders can be seen as one since common goals across the value chain would lubricate the implementation of new ways of operating. Another identified barrier was the issues with the availability of environmentally preferred textile materials. The poor availability results two types of issues. Firstly, long delivery leads times cause challenges in garment production planning. Secondly, high minimum order quantities result a risk of material overstock and high warehousing cost over time. Also, the lack of information regarding new material possibilities was considered as a challenge. If information about the benefits and properties of environmentally preferred materials would be easily available in a centralized way, it might promote the selections of new materials over conventional ones. One further material related barrier is the preference of mixed fibers in workwear textiles. Material mixtures are popular due to comfort and durability reasons. From the textile recycling point of view, mixed fibers are not a problem, but not the ideal solution either. Typically, mixed fiber

materials are suitable for the process, but if fabrics with a single type of fiber could be used, there would be more potential for the recycled material to be used in new textile garment products thus enhancing the circularity of the industry. Though the long service life provided by the material durability might outweigh the benefits of increased circularity possibilities and should be carefully assessed. Circularity of the products could also be increased by incorporating reusing and repurposing into workwear value chain. The lack of utilizations of reusing and repurposing in the workwear value chain was considered as a barrier as well.

Considering the perspective of each stakeholder and identified barriers, the most potential areas to implement new environmental sustainability benefitting practices in the value chain were material related initiatives and new circular business models revolving around reselling and repurposing. The potential of material selection relies on the fact that it impacts heavily on the environmental footprint of workwear throughout the value chain. Finding ways to increase the use of durable and recyclable environmentally preferred materials would result benefits through reducing the use of virgin and other high environmental footprint materials, long service life of the product, and suitability for recycling. The potential of new business models leveraging repurposing and reselling comes from the absence of such initiatives in the work wear sector. Introducing new business models could provide incremental benefits resulting from extended time products and materials in them remain in use before disposal.

7.1 Comparison to Previous Studies

A direct comparison to previous studies can't be conducted as a similar design thinking approach to workwear textile sustainability hasn't been done or could not be found. However, some findings can be compared to the findings of other textile industry related studies.

The review of the textile industry revealed that the implementation of environmentally preferred materials is challenging and this true withing the workwear sector as well. The reasons behind the low utilization are similar across the textile industry as material availability, distrust towards recycled material quality, and sometimes higher cost are slowing down the usage of more sustainable materials.

Another observation is that when comparing consumer fashion industry to workwear sector, there are differences in garment utilization and reasons behind discarding them. Studies show that due to fast fashion phenomenon the utilization of clothing is declining, but in the workwear sector long service life is preferred and is something to invest in. This is partly enabled by the fact that the emotional durability doesn't play a role in workwear. In consumer fashion changes in fashion and personal preferences causes clothes to be discarded before the end of their service life. According to the survey results obtained in this study, such factors are not among the reasons why workwear is disposed.

7.2 Impact

This study can be considered to have an impact from different viewpoints. The three main perspectives are the theoretical and practical point of view and the impact the study has in wider social context.

One theoretical contribution the study has is the demonstration of the design thinking methodology and tools in a new context. This study can be a practical example, how the methodology can be used in a development project in which the problem to be solved is ill-defined. The study shows how through research and empathizing problem can be clarified to a point in which practical solution alternatives for it can be generated. The study can promote the methodology to be used in other type of research and development projects. Another theoretical impact the study has is how it supports previous studies regarding the sustainability aspects of the textile industry with new details. The study offers detailed insights about the position different stakeholders in the workwear textile value chain have regarding sustainability. This insight can inspire new research and solution initiatives for different challenges in the value chain.

On the side of practical contributions, the study offers some benefits for the workwear company the study was made in co-operation with. Firstly, the study resulted deeper understanding of the partnerships they engage in with their customers and the recycling facility. Secondly, mapped out problems and opportunities give perspective where to focus on when planning new initiatives to enhance the environmental performance of their operations. And lastly, a second-hand workwear concept to be developed further.

The wider social impact of the study relates to how it summarizes and talks about the environmental problem associated with the textile industry. The study promotes the importance of adapting to new more environmentally friendly ways of operating to futureproof the textile sector. Not forgetting the responsibility of individual consumers, who need to stay mindful how their consumption habits effect the environment in the big picture.

7.3 Limitations

There are some aspects in this study limiting the applicability and quality of its outcome. These factors should be noted when interpreting and drawing conclusions from the results. These aspects include the scope of the study, resource constraints, sample sizes, and geographical limitations. Acknowledging these limitations lead to retrospect considerations what could have been done differently.

The scope of the study limits to workwear sector and furthermore to a specific section of the value chain of a single company. This leads to the result not being generalizable to represent the textile industry universally. Even within workwear sector there are likely differences how value chains operate and how stakeholders in them interact with each other. This would impact the type of insights obtained from them, meaning that the findings can't be universalized to portray the entire workwear sector.

Resource constraints are another factor that have an impact on how the study was conducted. One resource being the available time which limited what kind of resource methods could be used throughout the design thinking project. Time also limited the idea generation to be focused on a single identified problem. The lack of budget had a similar impact as lack of money prevented travelling necessary for the implementation of some research methods like face-to-face interviews and observations.

Sample sizes influence the reliability of the survey results. As the study was done in co-operation with a single workwear company the parties available for the surveys were limited and thus constrained the number of respondents. Collecting data from a wider range of respondents would increase the quality of the data and might lead to different conclusions.

If some of the limitations could have been removed, there are things that could have been done differently. Increasing the time and money available for the study would enable the use

of different research and data collecting methods. The study uses surveys for data collecting out of necessity as time didn't allow face to face interviews and meetings with all the stakeholders, which would have been preferred. Not being able to visit all the stakeholder facilities reduced the ability to make observations regarding their operations. This would have added another dimension to the collection of insights and would have contributed to the use of the design thinking methodology.

7.4 Future Research

There are opportunities to initiate new research and development projects based on how this study was scoped and how it was left off. One possibility for future research would be to expand the scope to entire workwear value chain covering all the stakeholders from fabric manufacturing to end of life. This would give more holistic view of the sustainability challenges associated with the workwear industry. Another opportunity would be to repeat the study with stakeholders from another company with different geographical location or some other differentiator, like possibility for chemical recycling, to see are the similarities in the highlighted issues or complementary angles to the topic.

In addition to completely new research, there are opportunities for further developing the concept level solution proposal or using parts of this study to support the ideation of new solutions for other recognized problems. The concept generated during this study is lacking information, how to commercialize it in a financially viable way and how it could be used in marketing and building the Touchpoint brand. Also, a life cycle analysis could be carried out to different resale scenarios to quantify the potential environmental impact the secondhand model has.

There's a heated discussion revolving around sustainability concerns of the textile industry and there are a lot of unsolved challenges before the industry can claim to have changed its course towards more sustainable way of operating. This study has shed some new light on the workwear related sustainability aspects and hopefully can inspire further exploration in this field.

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kierratykseen

Appendix 1: Textile recycling facility survey questions

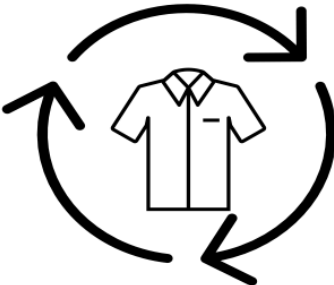|	
1	What are the primary sources of textiles your facility processes?
2	Please specify the most common fibre types your facility recycles and why.
3	re there any specific types of textiles that your facility prefers to recycle? What are they and why?
4	What are the main criteria used to determine the suitability of materials for recycling in your facility?
5	What are the main design aspects in textiles that limit the possible applications for the fibre extracted from it in the recycling process? Please elaborate.
6	How does your facility assess the quality of incoming textiles for recycling purposes?
7	How do you ensure the homogeneity of the recycled material? Sorting processes etc.
8	How does your facility handle textiles that are not suitable for recycling? Are there alternative disposal methods employed?
9	Are there any specific types of textile waste that are particularly valuable or sought after for recycling? Please specify.
10	Are there any specific industries or sectors that have shown a greater interest in purchasing recycled fibers from your facility?
11	Have you encountered any challenges or limitations in terms of market demand for recycled fibers? If yes please elaborate.
12	Are there any technical or performance limitations associated with the use of recycled fibers in textile manufacturing? If yes what are they?
13	What would you describe to be the three biggest challenges within your facility operations?
14	Considering your customer base, can you specify the five most common applications recycled fibre is used for?
15	Do you have any guidelines or recommendations for individuals or organizations looking to donate or supply textiles for recycling?

Appendix 2: Touchpoint customer survey questions

1	How would you rate the importance of implementing a recycling process for your company's workwear? 5 = very important. 1 = Not important
2	What is the biggest source of motivation for your company for recycling workwear?
3	Which materials are predominantly used in the workwear you purchase for your employees?
4	Please elaborate the reasoning behind the material choices for your workwear.
5	What are the major reasons that lead to the replacement of workwear in your organization?
6	Would you consider purchasing secondhand workwear for your company?
7	If no please provide a short description why
8	How do you currently handle the collection of discarded workwear within your company? Please provide a brief description.
9	Are there any specific challenges or difficulties you face in terms of identifying and sorting workwear made from different materials?
10	How frequently do you organize collections for the disposal of used workwear in your organization?
11	Are there any specific challenges or difficulties you face in terms of collecting and storing the discarded workwear?
12	Does your company have a dedicated logistics process in place for the collection and transportation of the discarded workwear to the recycling facility? Please describe briefly.
13	Have you encountered any obstacles or challenges related to the logistics of workwear recycling? (eg. transportation coordination)
14	What improvements or changes would you suggest to enhance the recycling process for workwear recycling?

Appendix 3. Touchpoint survey questions

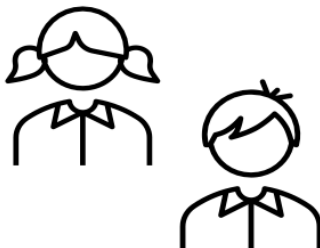|	
1	What are the primary reasons for your company to prioritize sustainability and circularity in your operations?
2	incorporate sustainability and circularity into your operations? (eg. recycling programs use of eco-friendly materials)
3	What do you perceive as the biggest challenges for a workwear manufacturer in operating in a sustainable way?
4	What would you estimate to be the primary reasons why the customers show an interest towards sustainability and recycling activities?
5	In your experience do customers in the service industry actively seek out workwear manufacturers with strong sustainability and recycling values?
6	challenges when incorporating sustainability activities in the operations of your company?
7	What would you consider to be the biggest obstacles for using more recycled material in your workwear?
8	Have you observed an increase in demand of sustainable workwear in recent years?
9	What challenges if any have you faced in effectively communicating the benefits and value of workwear made from recycled materials to potential customers?
10	obstacles in the manufacturing process when using recycled materials for workwear production?
	Additional questions
	You mentioned that you aim to use more environemtally preferred materials. Can can you elaborate what are they in this context?
	Can you specify what limits the usage of these materials in your products?
	You mentioned challenges in your take-back operating model. Can you describe the model and related challenges?

Appendix 4. Recycling facility personas profile

Profile name:
Textile recycling facility

Role in the workwear industry:
Mechanically recycles textiles from post industry sources.

General Info:

The most common fibre type the facility handles is cotton-polyester mix.

Material arrives at the facility pre-sorted according to sorting instructions by the recycling facility. Sometimes inhouse sorting is required to ensure that the quality requirements of stakeholder buying the recycled fiber are met.
Material arriving at the facility must be cleaned and dried.

Main applications for the recycled fibre are new textiles, filling for furniture, and insulation

Challenges:

Textiles containing more than 5% elastane as it gets stuck in the machinery during the recycling process.

Large plastic based prints as they are challenging to remove entirely. Additionally, plastic may start to melt during the process.

Textiles in which multiple fiber types have been mixed together as this limits the applications where recycled fiber can be utilized.

Goals:

To acquire as much monofiber materials (100% cotton, 100% polyester) for recycling as these materials are easiest to recycle and the demand for pure recycled fiber is high. Especially 100% white cotton.

Many industries are developing their processes to be better suited for recycled fiber and the facility wants to be able to meet the future needs of customers.

Appendix 5. Touchpoint personas profile

Profile name: Workwear company	**TOUCHPOINT** Sustainable Workwear
Role in the workwear industry: Sells and distributes workwear according to customer specifications and needs.	

General Info:

A workwear company having sustainability as a core value. Sustainability KPI's are carbon footprint of products, share of environmentally preferred textile materials in products and share of products for which take-back procedures are in place.

Challenges:

Continuously developing guidelines, legislation and frameworks considering the sustainability of textiles and keeping track of them.

As operating in a sustainable way isn't the dominating within the industry, implementing sustainability into the operations can be time consuming and expensive.

More environmentally friendly materials are not standard products for material manufacturers. Special orders with high volumes are needed to be made. This leading to risk of high warehousing cost and overstock of materials. Additionally, the delivery times of special orders are long.

Environmetally preferred materials might complicate customer's operations.

As the take-back system is new to the industry, implementing it has challenges.

Customers might preselect materials for their clothing which limits the possibility to use preferred materials.

Lack of centralized source of information about preferred textile materials, customers could use to support moving towards new material options.

Goals:

Offer sustainable workwear products to their customers through offering of products made from renewable, recycled or monofiber materials.

To be able to sustain workwear production in the future.

Brand recognition, competitive advantage through above par sustainable operating model

Appendix 6. Touchpoint customer personas profile

Profile name: Company using workwear Role in the workwear industry: Purhases clothes from a workwear company and after use-phase delivers clothes to a recycling facility for disposal.	
General Info:	
Take-back customer of the workwear company. Considers sustainability values as important. This shows in recycling activities, but not in the workwear material selection as such.The most common material used is polyester-cotton blends. Material selection is based on durability and suitability. Washes, dries and collects discarded workwear as part of normal way of conducting business. Workwear is sorted into large bags which are palletized before transport. Worn out appearance is the dominant reason, why workwear is disposed. Second-hand workwear worth consideration, but the are obstacles to overcome.	
Challenges:	
Typically, companies using workwear generate large quantities of textile waste and warehousing it takes a lot of space. Current materials being used go well with the excisting processes making the introduction of new materials difficult. Adjusting processes according to material requires extra work and changes in the procecces.	
Goals:	
Want's workwear that meet the needs of their employees and suits their processes. Need of an effective, space conserving, and sustainable way to get rid of generated textile waste. Sustainability can be used in PR for positive company image.	

Appendix 7. Design Brief

Project Information

Project Name: Improving the Environmental Performance of Workwear Textiles	
Customer: Touchpoint	**Brand**: Touchpoint
Contact Person: Anni Wulff-Kokko	**Date:** 2023-08-28

Client & Brand Information

Touchpoint is a workwear company offering functional, high-quality, and sustainable workwear solutions. Touchpoint has established a take-back operation model in which they commit to collect products back from their customers and ensure the proper method of disposal.

Project Background & Objectives

Touchpoint has taken actions to be one of the frontrunners in sustainable workwear. These initiatives include introducing more sustainable materials, take-back model, carbon footprint consideration in product development etc. Touch point constantly working towards improving the existing initiatives and finding new ways to further enhance their environmental performance. Objective of the project is to gather information from Touchpoint and their partners to support ideation and implementation of new sustainability initiatives.

Scope

The project is limited to a certain value chain including Touchpoint, take-back customers, and the recycling facility. Research and idea generation is to be done in this frame of reference. Goal of the project is to find ways to incorporate re-purposing and re-using into workwear ecosystem.

Target Audience

Touchpoint: Company manufacturing and distributing workwear
Touchpoint take-back clients: Companies purchasing workwear from Touchpoint
Recycling facility: Company handling the recycling process for workwear

Key Deliverables

Survey results and analysis regarding the view point each member of the target audience.
New viewpoint and solutions for increasing re-using and re-purposing in the workwear value chain.
A concept visualizing, how the value chain might work after implementing new re-purposing/re-using activities.

Budget & Schedule

Budget	**Schedule**
0 €	Study to be finalized before October 9th