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# Aging and Wear in a Circular Economy

- Creating a guide for how to design closed-loop seating furniture for the public sector

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## Abstract

The project has explored some of the potential obstacles and challenges that public furniture would face in a circular economy, with the aim of producing guidelines for how to design upholstered seating furniture for public environments that are better suited for closed-loop flows. The point of departure has been the aging and wear of furniture; aspects that are especially important in the case of closed-loop systems where furniture must withstand longer use and being recirculated repeatedly. Both theoretical as well as empirical research has been conducted. Besides a literature review about topics such as circular economy, circular business models, designing for circularity and aging and wear of materials, eleven experts and professionals in furniture design and in the furniture trade in Sweden were interviewed and field trips were conducted. In addition, a study examining how end users and experts perceive and tolerate aged and worn public seating furniture was performed.

The conclusions from these studies were compiled into recommendations, resulting in a guide for how to design public seating furniture, such as upholstered chairs, with aging and wear in mind. As a step in the development process, the guide was evaluated by designers and design students, giving it the satisfactory grade of A- on a System Usability Scale.

One of the conclusions from the empirical study was that the condition of the upholstery played a vital role in how a chair was perceived overall, and that dirty textiles could be reason enough for chairs to be thrown away.

Acceptable wear on the other hand was often what people called "natural wear". This could for example be patina or aging and wear showing how the furniture has been used and handled with care over the years, whereas unacceptable wear was explained as glaring wear that stood out from the rest of the visual experience.

Another conclusion was that furniture wear faster aesthetically than physically; as trends come and go furniture become outdated and replaced even though they still are fully functioning. To address this, designers should seek to design furniture with as high inherent value as possible (using quality materials and making a thought-through construction) that would be worth reusing and refurbishing, but also design something which the users would want to keep; in other words, strive to create classics.

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## 1 Introduction

In recent years, circular economy has emerged as an alternative model to the linear 'take-makedispose' based society that rules the market today. By offering a solution to the ever more critical problem of material depletion as well as helping to reduce waste and pollution, the circular economy paradigm has become more and more relevant. There are however still huge challenges regarding how to transition from the economic system of today towards a more circular and sustainable future. This both concerns the creation of successful circular business models, as well as designing products that fit into such a system.

One area that has garnered interest for its potential regarding circular business models is the furniture industry. Each year a vast amount of furniture in the public sector is disposed of, ending up in landfills. Vinnova (2014), the Swedish Innovation agency, claims that as much as 8000 tons of furniture is disposed of annually by the public sector in Sweden (Askew & Carlberg, 2016). According to a recent report, Sahlgrenska University Hospital in Gothenburg alone throws away more than 225 tons of furniture every year with a remaining potential value of more than 16 million SEK (von Eyben & Isaksson Drake, 2012). Often, the furniture is discarded for aesthetical reasons rather than functional, and has thus still value left (Yousef & Truijens, 2016). Instead of simply throwing away remaining value, the furniture could for instance be refurbished or remanufactured and then resold, saving both monetary and environmental resources. By reusing or refurbishing furniture, the CO2 emissions could be reduced with as much as 36-45 % in production (RISE Viktoria, n.d.).

This poses however the challenge of more accurately defining when the furniture needs refurbishing or updating. Many types of furniture, such as chairs and tables, are actively used and therefore subjected to gradual wear; others age by different means as time passes. These aspects of aging and wear are interesting in a closed-loop system as they affect the value of the furniture over time. In a buy-back system for example, where the manufacturer or reseller rebuys the furniture, it would be crucial to know what constitutes acceptable wear, and when it turns unacceptable. What's more, could the aging process even add to the initial value of the product?

## 1.1 Background

The project "Business model innovation for closed-loop furniture flows" has focused on investigating how new circular business models for the furniture industry, in combination with new constructions and material choices, can act as drivers towards a more circular economy in the public sector. It was funded by Sweden's Innovation agency Vinnova and led by the development corporation IDC West Sweden and comprised six different work packages, whereof RISE Bioeconomy was leading one about drivers and obstructions for circularity. As part of this work package, this thesis project explored how aforementioned levels of aging and wear are perceived by users, and how to take the aspects of aesthetic and physical wear into consideration when designing closed-loop furniture for the public sector.

This thesis project was also a part of the interdisciplinary thesis school TechMark Arena led by RISE Bioeconomy during the spring of 2017. The common theme uniting five thesis projects from different fields and universities was 'Cellulose-based materials in a circular economy'.

## 1.2 Aim

The aim was to assist the public sector in Sweden in a transition towards a more circular economy by providing furniture designers with guidelines for how to design closed-looped seating furniture for the public sector with aging and wear of materials in mind, as well as help improving maintenance practices for aforementioned furniture.

## 1.3 Objectives

The project objectives were to, within the given time:

- 1) Examine how users perceive aging and wear of furniture, especially upholstered seating furniture for the public sector.
- 2) Formulate guidelines based on user perception of aging and wear of said furniture for designers to use when designing closed-loop seating furniture for the public sector.
- 3) Evaluate the guidelines with the help of a group of designers or design students.

## 1.4 Research questions

- [Q1] How is the aging and wear of furniture perceived by users; which kinds of aging or wear add to the value of the furniture, and which reduce it?
- [Q2] What is "acceptable wear" and what is "unacceptable wear" when it comes to upholstered seating furniture for the public sector?
- [Q3] How should designers take aspects as aging and wear into consideration when designing seating furniture for the public sector to make it fit into a circular economy?

Regarding [Q1], learning about how wear is perceived by users could make it possible to design furniture that endures prolonged use better, for example by being easily upgraded, refurbished, remanufactured or simply able to withstand the effects of time both at a material and construction level. This would make it possible to keep the value of the furniture longer, or even increase it by allowing the furniture to age gracefully through proper care or design. Promoting more long-lived products is one step towards a more resource efficient market.

For [Q2], knowing more about where the line between acceptable and unacceptable wear goes would be useful for owners and resellers of used furniture. If the furniture for example would be a service rather than a direct ownership, it would be important to know more exactly when it is necessary to refurbish or replace to avoid doing it to still acceptable furniture, and thus wasting resources. Overall, knowing when to maintain or refurbish furniture is central when it comes to

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preserving the value of the furniture one owns or wish to sell, and is necessary to be able to design an efficient system for collecting and refurbishing used furniture.

In connection to [Q3], understanding the users' perception of wear and aging can make it possible for designers to design furniture that solves perceived problems or that takes advantage of opportunities where value is perceived to be added. By studying methods like Design for Durability, Design for Disassembly, etc., solutions for a circular design in connection to aging and wear of materials can be gathered. When producing closed-loop furniture it can lead to a more resource efficient and environmental friendly business by using less virgin materials and reducing CO<sub>2</sub> emissions.

## 1.5 Scope and limitations

- The budgeted time was 1600 man hours, divided over two students working full time during the spring semester of 2017.
- Upholstered seating furniture for indoor use in the public sector in Sweden was in focus.
- The focus in formulating the design guidelines laid on the challenge of countering or drawing advantage of the aging and wear of different materials.
- User perception of aging and wear has been in focus rather than fatigue and the physical properties of materials exposed to aging and wear.
- The goal was to make something which promotes both resource efficiency and design for circularity. The focus of the guidelines was therefore first to seek to prolong the lifetime of the specific furniture, and then to close the loop in accordance to the order presented by the EMF model (see Chapter 3.1.1).
- Public contracts were considered but not a part of this thesis project. The work was based on the assumption that public contracts will be adjusted to better fit a circular economy in the future.
- Logistics and systems concerning collection and distribution of used furniture have not been a part of the thesis, but have been explored to increase the authors' understanding for where the market stands.

## 1.6 Basic definitions and framework

With many underlying terms and concepts, the most basic ones are going to be defined in this chapter.

### 1.6.1 Seating furniture in the public sector

As the aim was to assist furniture designers in designing closed-loop seating furniture for the public sector, a short specification of what is referred to by "public seating furniture" will be presented here. There is both a big variety of seating furniture as well as of organisations operating in the public sector in Sweden, ranging from libraries, hospitals, town halls, schools, universities and courts to the military etc. In this project, all of these places were considered in the data collection phase in order to receive as comprehensive data as possible, but not all were explicitly studied.

#### Aging and Wear in a Circular Economy

To somewhat limit the system boundary, the focus during the latter part of the study was on one particular type of furniture: upholstered seating furniture for indoor use in the public sector, specifically chairs or armchairs. This could for example be conference chairs, chairs in office lunch rooms, sofas in lounges, or armchairs in waiting rooms at hospitals, see Figure 1. Office chairs have however been removed from this selection, as they both have been researched to a greater extent and were considered too technical in their nature; the aging and wear aspects would not have been as important factors in such a study since factors like functionality and ergonomics would have played greater roles.



*Figure 1: Examples of worn, upholstered seating furniture for the public sector.* 

### 1.6.2 The role of public contracts

In order to avoid corruption and inappropriate influence, public seating furniture is procured through public contracts adhering to the procurement laws in Sweden and the EU. These promote transparency and objectivity by ensuring that the most advantageous bids are selected based on a set of predetermined criteria. Examples of such criteria are among others price, colour, material quality, and how easy it is to clean underneath the product (Lundbäck, 2013).

During 2010, 18 755 public contracts were made in Sweden, whereof about five per cent were for furniture, interiors, household appliances, and cleaning products. The most common base for award of contract was "most economically advantageous" with 49 per cent of the bids, while 33 per cent constituted the lowest price (Lundbäck, 2013). Studies have shown that more centralised public contracts often yield lower prices, which is why the trend, not only in Sweden but also internationally, is moving towards more centralisation (Lundbäck, 2013).

However, as Lundbäck (2013) points out, the centralisation of public contracts can make it harder to take more intangible criteria such as design and user satisfaction into account, leading to that concrete and measurable criteria are being overvalued. To allow for proper valuation and inclusion of values that are important for the users, public furniture contracts should be regulated locally rather than on a central level according to Lundbäck (2013).

In a circular economy, criteria such as high material quality and low environmental impact must also be valued higher than they are in public contracts today. Prioritizing low prices will not lead to sustainable and durable furniture to be produced and sold, hindering or ruling out future circulation of the furniture. In this report, the authors have based guidelines and design recommendations on the assumption that public contracts in a future and more circular economy will look at the whole life-cycle of the furniture and seek to value quality and environmental criteria higher, allowing for perhaps higher prices.

#### 1.6.3 Environmental labelling

In the context of public furniture, it is also relevant to bring up environmental labelling as it today often is required as a quality and sustainability marker (SNIRI, 2002). The most common environmental labels for furniture in Sweden today are Möbelfakta and Svanen (the Nordic Swan), but the EU Ecolabel is also emerging as an alternative (Norrblom & Sjöholm, 2016).

Möbelfakta is a referencing and labelling system for the furniture industry, run by The Swedish Federation of Wood and Furniture Industry (TMF). The requirements encompass aspects related to quality, environment and social responsibility, and are based on EN-standards, the Global Compact code of conduct set by the UN, ISO-standards, and requirements set by the National Agency for Public Procurement (Norrblom & Sjöholm, 2016). Svanen is administered by the state owned, non-profit company *Miljömärkning Sverige AB* and poses demands on resources such as wood, metals, padding materials and plastics, as well as on the chemicals used in production (Norrblom & Sjöholm, 2016).

In a circular economy, environmental labelling however becomes more challenging and complex as product lives iterate and components may be refurbished or remanufactured, either by the original producer or by another. Norrblom & Sjöholm (2016) bring up the complex issue of how to approach certifications when furniture is reused or refurbished, presenting step-by-step guidelines to follow. They also call for specific labels for reused furniture; one for already labelled furniture that needs relabelling, and another for unlabelled furniture. Furthermore, they emphasise the importance of traceability; not knowing which materials a product is made of can make it impossible to relabel or even resell it.

Another issue concerning environmental labelling brought up by Askew & Carlberg (2016) is that the labelling systems of today often focus on recyclability rather than recycling; there are requirements on that the material should be able to be recycled, but no real evaluation of how much of the product that actually gets recycled in the end. They also claim that the environmental labels of today encourage linear production of products containing recycled content rather than reuse, thus providing no incentive for manufacturers to take responsibility for their products after sales (Askew & Carlberg, 2016). This would need to change in a transition to a circular economy were reuse, refurbishment and remanufacturing are central.

#### 1.6.4 Definition of Wear

In the context of furniture, wear is something everybody has experience of. Worn-out office-chair seats, scratches on a table top, or chipped corners on an armrest are just some common examples of wear resulting from frequent use. Why these types of wear occur depends on which kind of relative motion the surface in question is subjected to; whether it is a sliding, fretting, rolling, flowing or impact motion (Varenberg, 2013). To cite a more basic definition that does not distinguish between

the types of causes, wear can be defined as the "damage to a solid surface, generally involving progressive loss of material, due to relative motion between that surface and a contacting substance or substances" (ASM International, 1992).

In this project, wear is considered from a user perception perspective, and not on a material micro structure level. This means that the focus is on how wear is perceived, both as it comes to visual and tactile aspects, and how that perception influences the product value.

### 1.6.5 Definition of Aging

There exists several definitions of material related aging, but one that encompasses most of the relevant aspects states that aging is the "Gradual process in which the properties of a material, structure, or system, change (for better or worse), over time or with use, due to biological, chemical, or physical agents" (BusinessDictionary, n.d.).

As can be understood from this definition, the term aging relates to a more passive process than that of wear. By being exposed to for example heat, sun radiation, humidity or air pollution for a longer duration, the properties of a material can change over time.

The above definition notes also the fact that the changes brought on by aging can be "for better or worse", in other words can aging both improve upon and worsen the material properties. Talking about a material in the context of a product, this can lead to both value-enhancing as well as value-decreasing effects, which makes finding the difference between the types of aging highly relevant.

## 1.7 Report structure

The project has consisted of several different work packages which can be seen in Figure 2 below. Initially, the methods used for each work package, or phase, are described in the method chapter. After that, the results of the literature review are presented in Chapter 3 *Theoretical framework,* which is then followed by the *Market Analysis* results in Chapter 4. The results of the interview studies are presented in Chapter 5 and Chapter 6 *Interviews with Experts & Professionals,* followed by the Perception study procedure and results in Chapter 7. After the theoretical and empirical data collection phases, the results were translated into guidelines and a guide for *how to design with aging and wear in mind* was created, see Chapter 8. Method and result discussions followed, concluding with the project conclusions and recommendations for future research.

#### Introduction

Method	ethod			
Theoretical framework	Literature review	Theoretical research		
Market Analysis	Field trips Business interviews			
Interview study Perception study	Basic mapping Experts & Professionals Part 1 Part 2 Part 3	Empirical research		
Guideline Creation	Evaluation	Product development		
Method discussion Result discussion Conclusions		Discussion & Analysis		

Figure 2: Report disposition

Aging and Wear in a Circular Economy

## 2 Method

This chapter describes the work process of the project and the methods that were utilized with focus on the purpose of the performed activities. To begin with, an overview is given of the general work process and the different phases of the project, followed by subchapters explaining the methods and procedures of each of the phases more thoroughly.

## 2.1 Work process overview

The work process was loosely based on the Ulrich & Eppinger (2011) product development process. The focus was mainly on the pre-study stage, called *planning* by Ulrich & Eppinger, collecting data about user's needs and demands, which was then followed by a small-scale concept development, detail design, testing and refinement.

The overall work process can be seen in Figure 3. To begin with, a literature review was carried out on relevant topics. This was followed by a small market analysis and a more comprehensive interview study aimed at collecting information about the current market situation and people's opinions about aging and wear of furniture and different furniture materials, respectively. In addition, a perception study was conducted with both laypersons and experts to find out the acceptance levels of different types of aging and wear. The combined results of the interviews and the perception study was then analysed and transformed a guide for how to design public seating furniture with aging and wear in mind. To assess the utility of the guide, it was evaluated by a group of designers and design students.

The reasoning behind the use and the structure of the different stages and methods in the project are further explained in the following subchapters.



Figure 3: Overview of the work process

## 2.2 Literature review method

The literature review was conducted to get an understanding for and a foundation to build upon regarding the concepts of circular economy, circular business models, designing for circularity and designing for longevity, as well as for getting a picture of how the aging processes of furniture and furniture materials have been researched before. As several different guidelines regarding sustainability issues in product development already exist, a small benchmarking was also conducted through online searches and by studying reports and literature relating to sustainable design and material selection strategies. The purpose of the benchmarking was mainly to get inspiration for the new guide, both concerning design and looks, but also to find useful information to include.

To facilitate the transfer of knowledge between the authors, short summaries were created with the relevant details along with a literature overview in Excel with basic information like title, key words and degree of relevance. This made it possible to keep track on what had been read, what the literature was about and what was left to read, which was very helpful.

The insights and knowledge gathered from the literature review were incorporated in the guide and used as a means of organising the data collected in the later, empiric research phases of the project.

The literature reviewed consisted primarily of scientific publications, journal articles, case studies and report literature from organisations, governments and businesses. Databases as Scopus, Google Scholar and ScienceDirect were used, as well as the databases of the Linköping University library and RISE Bioeconomy's library PaperBase. The main topics and key words used in the research were circular *economy*, *circular business models*, *circular design strategies*, *Design for Durability, aging gracefully, design for emotional durability,* and about aging and wear of materials in general. Information from the literature review is summarised in Chapter 3.

## 2.3 Market analysis structure

A small-scale market analysis was performed to get an understanding of the current situation and the development of the second-hand market for public furniture in Sweden. This study was done on a general level, not focusing on details or statistics, but for gaining insight into the broad picture and the challenges and obstacles that might exist. Qualitative, semi-structured interviews with representatives for companies or organisations active in the reused furniture market were conducted as well as field trips to locations for second-hand furniture collection, refurbishment, distribution and sale. The field trips were considered relevant as they help to get a more holistic and integrated view of the studied topic, and reinforce previously gathered information by providing different kinds of sensory inputs (Berer, 2015). Further details and information gathered during the market analysis are summarised in Chapter 4.

## 2.4 The interview study method

Interviews are versatile data collection methods and can be used for collecting both quantitative as well as qualitative data (Osvalder, et al., 2010). It is the most basic method when seeking to collect information about what people think and feel, and as the project primarily is concerned with user perception and therefore highly subjective data, it was chosen as the opening data collection method to lay the foundation for later a perception study.

To be able to answer the first research question [Q1] concerning which kinds of aging and wear adds and which reduces the value of the furniture, but also get an indication of where the line between acceptable and unacceptable wear goes [Q2], interviews were conducted with interesting parties.

As part of this interview study, two different kinds of interviews were conducted with different aims. The first kind was focused on getting an overview of the topic and map interesting areas, a so called "basic mapping". The second kind was focused on "experts" and was conducted with eleven people from the different groups seen in Figure 4. More about these two different sets of interviews can be read in the following subchapters.

### 2.4.1 Basic mapping method

The basic mapping consisted of twelve short, structured interviews that were conducted at the *Stockholm Furniture and Light fair*. The five minutes long interviews gave insight into what people thought of regarding the concepts "aging" and "wear" in connection to furniture and different furniture materials, as well as their general attitudes towards reusing furniture.

An interview protocol, see Appendix A, was prepared in advance. The interview started out with a more open-ended question as a warm-up, but the rest of the questions were formulated more direct and clear, which is important in structured interviews (Osvalder, et al., 2010).

The interview data was analysed through clustering (Ulrich & Eppinger, 2011), where every answer was written on post-its and organized based on likeness and analysed. In addition to having been a way to get a general picture of the topic, the mapping acted as a scouting of what to expect in the upcoming interview studies.

Further details and information gathered during the basic mapping are summarised in Chapter 5.

#### 2.4.2 Experts and professionals study

The largest interview study of the project was the one conducted with experts of professionals in different fields connected to aging and wear of materials, specifically in connection to furniture. As part of this, designers, furniture conservators and restorers, people working in the used furniture business, quality and environmental managers at furniture companies, interior designers, and material experts were interviewed (see Figure 4). By interviewing experts, it is possible to collect analytical data based on their experience and conclusions about users' perception in their field of work, and thereby make it possible to get more general and objective data (Osvalder, et al., 2010).

To find people with relevant information to interview, snowball sampling was also used; the interviewees were asked after the interview if they knew of someone they thought would be helpful to talk to next. To minimize the risk of oversampling a particular group of people, the authors only chose to continue with those who seemed to be able to bring a new perspective on the subject.



Figure 4: Mapping of potential interviewees

The eleven interviews were conducted in person or by telephone, and both types were audio recorded. A semi-structured interview protocol with a pre-thought out logical order was prepared, but it could be changed or adjusted during the interviews depending on the interviewees' responses (see Appendix B). All questions gave qualitative data.

The results were analysed by using the method of categorical analysis as described by Gillham (2008). At first the interviews were transcribed, after which the answers were grouped in different subject areas. Key words were identified and coded and the content was analysed for common denominators and themes, and lastly summarized in text (see subchapter 6.1).

## 2.5 The perception study method

The aim of the perception study was to collect data about the perception of different types of aging and wear [Q1], as well as to collect data about what is perceived as "acceptable wear" and "unacceptable wear" [Q2] to be able to define different levels and types of wear as either acceptable or unacceptable.

Perception studies, or perception surveys, are commonly conducted to gather information about consumer opinions and impressions of companies, products or programs. The characteristic feature of such research studies is that it is seeking to identify subjective opinions rather than objective data (Worth, 2017). There is a big variation of methods as they can be performed in either written form, vocally or electronically, or through a combination, with different means of input such as visuals, audio and tactile input.

To be able to perform perceptions tests with actual, worn public seating furniture, the tests were performed in cooperation with Möbelbruket, an initiative taken by Västra Götaland Regional Council in Sweden in which public furniture that otherwise would be thrown away is refurbished and resold. The authors got access to the furniture they had collected but not yet refurbished, providing a wide range of chairs of different types and conditions to choose between. Möbelbruket also provided the venue for the tests, namely the factory of *Tre Sekel* in Tibro, Sweden, and played an important part in finding participants at the site and helping to invite them to the tests.

The tests comprised three parts focused on exploring different aspects of the research questions [Q1] and [Q2]. Part 1 sought to examine the participants' acceptance towards different kinds and levels of wear in furniture, while trying to minimize the influence of style and taste by only including chairs of the same models in the assessments (for questionnaire, see Appendix C).

The aim of Part 2 was to get an understanding for how people assess and look at furniture, in correlation to what they think is acceptable and unacceptable wear. To get their subjective opinion of the severity of the wear, questions were asked and answered verbally, see the questionnaire in Appendix D. Several different models were used in the assessment to get a broader sample of materials, furniture shapes and types of wear.

Finally, Part 3 consisted of a questionnaire (Appendix E) examining the participants' perception of the severity of different types of wear and how important it is that said wear does not occur in public seating furniture. This was done to be able to weight the answers in Part 1 in a more accurate way, and to get an understanding for which types of wear that are more accepted than others.

## 2.6 The guide development process

Answering to the final research question about how to design closed-loop seating furniture for the public sector by taking aspects such as aging and wear into consideration [Q3], the data collected in previous phases were compiled into a brief guide with recommendations aimed at designers. Interview data conclusions, perception study conclusions, market analysis insights and input from the literature and existing guideline benchmarking were condensed into the brochure (Figure 5).



Figure 5: The input used in the creation of the guide

#### 2.6.1 Guide evaluation method

As part of the guideline development process, an evaluation of the utility of the guide was performed. Both designers and design students were asked to weigh in and give feedback. A questionnaire (see Appendix F) was sent along with the guideline with questions concerning the structure, content and design of the guideline, as well as how easy it was to use and understand and whether some relevant aspects were missing. The questionnaire included questions about the guide followed by a *System Usability Scale* (SUS) evaluation (Brooke, 1996). The SUS evaluation measures effectiveness, efficiency and satisfaction (Brooke, 1996). After analysing the answers, it receives a value is between 0-100. A value over 74 is the grade B, over 80.3 is grade A and everything below 51 will result in an F (fail) (Sauro, 2011). Bangor et al states that a good product/system gets between 70-80 points and exceptional ones get 90 or more (Bangor, et al., 2008). The opinion about how many respondents are needed to get a valid result varied between authors, between two respondents (Sauro, 2011) to 50 (Fabbri, 2013) to. In this evaluation, 10 participants were involved. The results were both used as iteration during the design process and as a validation of the utility of the guide.

## 3 Theoretical framework

To build the theoretical framework necessary for the project, a literature review was performed to map out the relevant theory and explain underlying concepts and models. Focus lied on how the aspects of wear and aging can be taken into consideration and used to create more sustainable, longer lasting, closed-loop furniture for the public sector. As this project was set in the context of a circular economy, some fundamental aspects concerning the concept and its different business models are explained.

## 3.1 The Circular Economy concept

For more than half a century, the established economic model has built on producing products, using them and then discarding them: the so called throwaway culture (Bakker, et al., 2014). Having reached its end-of-life, a product is thrown away, ending up in a landfill or incinerated with little concern for any potential remaining value. In a world of finite resources, a growing problem of air and water pollution, and ever more volatile resource prices, this is not a sustainable system (Wijkman & Skånberg, 2015) (Hunter, n.d.) (EMF, 2015 b). A solution that has emerged is the circular economy: a framework based on the principle of not letting materials go to waste but to reuse resources in endless loops.

Despite its popularity in recent years, the circular economy concept has been around since the 1970's with roots in both systems theory and industrial ecology (RISE, 2014). The Cradle to Cradle framework was also a major influence with its biomimetic approach to designing closed-looped products and systems (RISE, 2014) (EMF, 2015 a). Similarly to the Cradle to Cradle model, the circular economy views waste as new building blocks or "nutrients", differentiating between the circulation of biological and technical materials (Mentink, 2014). What separates circular economy from these other models is however how it also has incorporated economic aspects, enabling the exploration of new business opportunities and opening up for environmentally as well as economically sustainable businesses (Mentink, 2014).

#### 3.1.1 The Ellen MacArthur Foundation model

The recently garnered attention to circular economy can largely be accredited to The Ellen MacArthur Foundation (EMF) that was started in 2010 (Yale University, 2016) (Mentink, 2014). The foundation has the mission of promoting and aiding governments, organisations and businesses to transition to a circular economy, providing support and tools for research and creating platforms for collaboration. According to EMF, "a circular economy is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times" (EMF, 2015 b)

To be able to do this, the aim is to first and foremost "design out" waste – simply not to create it in the first place. From the start, products should be designed for easy disassembly and reuse: material recycling should be the last resort (EMF, 2013).

#### Aging and Wear in a Circular Economy

The circular economy model created by the EMF seen below in Figure 6 is the most wide-spread one to date. It distinguishes between biological, renewable, material loops and the ones of technical, finite, materials. The biological materials, or "nutrients", seen on the left hand side are returned to nature after use where they are decomposed and regrown as part of nature's process. The technical nutrients on the right side are on the other hand restored and then reused in new life-cycles; either by maintenance, prolonging the product life, reusing or redistributing, refurbishing or remanufacturing, or recycling. Unlike today, all consumables in the circular economy are made out of biological, renewable material, while "durables" are made out of clean, un-polluted materials that are used again and again (EMF, 2013)



Figure 6: The Circular Economy System Diagram by the Ellen MacArthur Foundation (EMF, 2017). Image has been cropped for increased readability.

According to the EMF, the principles of a circular economy promote four types of value creation that can be visualised using the model in Figure 6. The first one is called "the power of the inner circle" and states that by keeping a product in the inner most treatment circles of the model (share, maintain/prolong or reuse/redistribute), the most value is saved. By trying to keep the product integrity intact for as long as possible, embedded energy, labour costs and product value is maintained to a higher degree than if the product was to be directly material recycled (EMF, 2013). Bakker et al. (2014) emphasises this hierarchy of value treatment processes, and likens the diagram

#### Theoretical framework

loops with the altitude lines of a mountain. The inner most circle of maintenance and prolonged product life is at the top of the mountain, with the rest of the processes come in falling order. The goal is to design or treat the products so that they remain as close to the top of the mountain for as long possible, since descent is associated with value loss (Bakker, et al., 2014).

The second principle refers to the "power of circling longer". This both addresses the number of consecutive cycles the product is capable of as well as the duration of each cycle. If the product life is prolonged, this saves the material, cost and energy associated with producing a new one during that time (EMF, 2015 b).

The third refers to the "power of cascaded use", where the aim is to always seek to do the most profitable out of the material. For example, cotton clothing should not immediately be shredded and made into construction insulation after its first life cycle, but first reused as long as possible as second-hand apparel, then perhaps shredded and used as fibre-fill in furniture upholstery and only then made into something of the corresponding value of stone wool insulation (EMF, 2015 b). This ensures that the most value is obtained from the material at all times.

Finally, the "power of pure inputs" raises the importance of using non-toxic and unpolluted materials for easier material collection and redistribution. This also helps keep the material quality high and therefore also has a positive influence on its durability (EMF, 2013).

There are however some that have pointed out that the EMF model is not showing the whole picture. Bakker et al. (2014) for example have observed that the treatment circles of the diagram do not necessarily need to be the same for all parts of a product. As products are refurbished or remanufactured, only some parts might be replaced while the rest remain used, resulting in that the value transformation loops blend not just between products, but also within. This makes it difficult to keep track of the materials and to compare the circularity of different products, why some kind of refinement to the model might be needed (Bakker, et al., 2014).

The butterfly diagram is also a bit unclear as most biological materials can be processed and looped in the same way as the technical ones, for example through maintenance or reuse. Bakker et al. (2014) mention this observation as well, and argue that biological material can behave like technical materials, with the advantage of it returning to the bio-sphere in the end without large, additional costs. On the other hand, technical materials cannot behave like biological materials, no matter the circumstances (Bakker, et al., 2014).

## 3.2 Circular Business Models

For businesses to be able to successfully transition to a circular economy, they need to identify which opportunities they have for net value creation. Today, the dominant business model in our linear economy is the "transactional business model", where the customer in a purchase overtakes the ownership of a product from the manufacturer or vendor (von Renswoude, et al., 2015). In such a model, the aim is to maximize the revenue from product sales, which often means producing and selling more. In a circular economy, the aim is quite the opposite. Here the basic value proposition is not founded on the idea of ever increasing sales, but to find a way to use less raw material input and instead preserve its value over time and thus maximize its utility, while minimizing waste production

#### Aging and Wear in a Circular Economy

through product and material recovery at the end of the service life (von Renswoude, et al., 2015) (Stahel, 2010) (Prendeville, et al., 2014). This could be done in a number of ways, using different, circular business models (CBM). Askew & Carlberg (2016) argues that expanding the furniture companies' system boundaries to include the whole product life cycle would naturally lead to a more circular economy. Guldmann (2016) also states that circular economy is special in the sense that it looks for value creation in places that usually is of little interest for companies in more linear economic models.

Despite these new possibilities for value creation, transitioning to CBM is no easy undertaking. As it is, most companies are built to operate in a linear economy, and changing their strategies, organization and whole value proposition is not something that is lightly done (Accenture, 2014). Many companies have however started to apply an experimental step-by-step strategy when implementing CBM, where they start out with some selected product lines at a time to test their market resilience and leveraging the risks (Guldmann, 2016).

The furniture industry in Sweden is still fairly new to this closed-loop thinking, with few businesses taking responsibility for their products after sales (RISE, 2014). According to RISE (2014), this is because the current product designs, constructions and varying material and aesthetic values pose few economic incitements for a transition from the linear models to more circular ones. To enable this transition, more would have to be done in terms of changing product designs to be more suited for closed-loop flows (RISE, 2014). The Royal Society for the encouragement of Arts, Manufactures and Commerce (RSA) driven project "The Great Recovery" was started in 2012 with the specific aim of examining the "challenges of waste and the opportunities of a circular economy through the lens of design" (RSA , n.d.).

### 3.2.1 CBM suitable for long lasting products

As mentioned, the most value is preserved by keeping the product in the innermost circles of the EMF model; *The Power of the Inner Circle*. This means sharing, maintaining or prolonging the product life before continuing to reusing or redistributing the product. Prolonging the product life is also addressed in the value proposition *The Power of Circling Longer*, which aims at keeping the product in the same circle for as long as possible or circling it as many times as possible (EMF, 2015 b). As there most often are leakages when material is recycled today, the most value would arguably be preserved by seeking to prolong the product life; or even better, design for a long life from the start. According to RISE (2014), 60 % of IKEA's CO2 footprint is caused by their raw material usage. If the product lives of the furniture were to be prolonged with increased number of use cycles, this would lead to decreased CO2-emissions.

However, designing long lasting furniture is challenging as aesthetic, functional and material values fluctuate greatly over time (RISE, 2014). Furthermore, for products like furniture to fare well in closed-loop models, they must for instance be easy to maintain and withstand the wear and tear of multiple lifecycles, which poses new demands on product design and service.

Bakker et al. (2014) identify five different business models that benefit from a product life that is longer than the average, where control over the products and materials are kept over time enabling profit generation over time. These are the:

- 1. *The Classic Long Life Model* refers to the selling of high quality products that are designed to have long lives. The primary source of income is at the point of sale, but after-sales maintenance and support is often provided as it contributes to the quality image of the brand. As examples, Bakker et al. (2014) mention the Herman Miller Aeron chair and the Vitsoe 606 Universal Shelving System.
- 2. **The Hybrid Model** is based on the idea of having a long-lasting quality product that needs consumables to function, for example a printer and toner cartridges, or razors and razor blades. This model works well for products where one or more parts need to be easily replaced due to wear and tear, while the rest endures (Bakker, et al., 2014). As it comes to furniture, BMA ergonomics' Axia office chairs are mentioned, where the CBM focuses on retrieval of used office chairs, which then are refurbished and resold to reasonably high prices due to the remaining high quality of the products.
- 3. **The Gap Exploiter Model** feeds on existing value gaps in the system, for example businesses specializing on repairing other businesses' products, or reselling used products, or making new, different, products out of old ones by "upcycling" them (Bakker, et al., 2014). An example of this is the reCreate Design Company that focuses on extending the lifespan of materials by salvaging and repurposing interior furnishing. It focuses on finding remaining value or life in existing products, and to make the most out of it.
- 4. **The Access Model** refers to any kind of business model that focus on sharing or renting a product; as Bakker et al. (2014) puts it "it is a step taken when full-time possession of a product is unaffordable and/or unnecessary". Other than the economic aspect, the decision to rent or share rather than buy a product also rests on the perception of freedom, the accessibility of the product, the status of the product and the functionality, for example how many times the user needs the product (Bakker, et al., 2014). If one only needs a trailer to move a sofa once, it is not sensible to buy one.
- 5. Lastly, *The Performance Model* refers to when the customer only is interested in the quality of a service, or the end result, rather than how it is reached. The "function does not depend on specific products" (Bakker, et al., 2014). As an interesting example of this, interior climate is mentioned. Companies uninterested in the specifics of their interior design could simply pay a service provider for "modern, relaxing office space" with maintenance and updates to the interior included as their need would change.

## 3.2.2 Three CBM identified for public furniture market

As part of the previously mentioned Vinnova financed project *Business model innovation for closed-looped furniture flows*, three CBM concepts for the furniture industry have been developed with different levels of circularity, namely:

- 1) "Furniture with buy-back opportunity and continuous repair service
- 2) Furniture without ownership
- 3) The complete solution for a sustainable work place" (Mellquist, 2016)

These three CBM are mentioned in the Askew & Carlberg (2016) report. In short, the first CBM offers the customer a discount on new furniture if they return their existing, enabling its redistribution, refurbishment, remanufacturing or material recycling. The *Furniture without ownership* model is a renting agreement, where the customer pays a fee during the time they use the furniture and then afterward returns it to the supplier. As part of the agreement, the suppliers will provide necessary maintenance and responsibility for delivering, collecting and replacing the furniture. For many companies, this could be an appealing alternative to buying new furniture as it both increases the flexibility and helps avoiding paying the full price for new procurements. The last CBM is similar in this respect, but is instead a complete service package that encompasses the whole work place and its design (Askew & Carlberg, 2016).

These three CBM match the five aforementioned CBM presented by Bakker et al. (2014). The first one fits into *The Gap Exploiter Model* and *The Classic Long Life Model*, but could also correspond to *The Hybrid Model*. The *Furniture without ownership* model is the same as *The Access Model*, and *the complete solution for a sustainable work place* corresponds to *The Performance Model*.

## 3.3 Designing for Circularity

"It has long been stated that 80% of a product's environmental impacts are determined at the design phase" (Prendeville, et al., 2014). There is in other words great improvement potential in the design phase, which also presents designers with a responsibility. How does one design products to fit into a circular economy?

As the circular economy model has evolved, so has different strategies or methods focused on aiding the development of products suited for it. At its core, design for circularity "aims to optimize the economic potential of available resources through new business models, while also restoring natural resources and enhancing human health (i.e. increasing positive impacts versus reducing negative impacts)" (TU Delft, n.d.). In many cases, the design for circularity strategies are closely linked to design for sustainability (TU Delft, n.d.), but as stated by Bakker et al. (2014), "design for sustainability" lacks the perspective of maintaining value over time.

Poppelaars (2014) identifies seven different fields of study that has connections to circular economy, namely: *Product Life Extension, Design for Maintenance, Design for Reuse, Design for Refurbishment, Design for Remanufacturing, Design for Recycling, Design for Disassembly* and *Design for Reliability*. Most of these are represented in the EMF butterfly model treatment circles (Figure 6), except for two, the *Design for Disassembly* and the *Design for Reliability* strategies, even though the first is closely linked to *Design for Remanufacturing*. *Product Life Extension* is addressed by the butterfly

diagram, as the maintenance circle has been extended to also encompass prolonging of product life. Arguably, there are however a difference in prolonging a product life, and designing a product to last longer. The first one might be a reactive attempt to prevent unnecessary waste creation, while the second proactively seeks to create as much value as possible in the product over time.

In the search for a universal "design for circularity" strategy, Poppelaars (2014) argues that "The key for obtaining the best possible reins for circular product development would be to combine all relevant guidelines without bending the core purpose of each source". Many of the mentioned topics and strategies go hand-in-hand or overlap each other, why a short overview of some of the different fields of study is presented:

### 3.3.1 Design for Disassembly & Design for Assembly

Design for Disassembly (DfDA) and Design for Assembly (DfA) are all about designing products so that they easily can be taken apart and put together. These strategies are beneficial in many of the different fields of study mentioned in this chapter; for example Design for Maintenance and Repair, Design for Remanufacturing and Design for Recycling. Some areas addressed by DfDA are *Materials, Fasteners & Connections* and *Product structure,* with recommendations such as "Minimise the number of different types of material", "Screws are faster to unfasten than nuts and bolts" and "Design parts for stability during disassembly" (Dowie & Simon, 1994) (Autodesk, n.d.).

### 3.3.2 Product Life Extension

Product Life Extension focuses on keeping the integrity of the product intact for as long as possible, suppressing "perceived reasons for obsolescence" (Poppelaars, 2014). Bakker et al. (2014) have identified six strategies for designing longer-lasting products, namely:

- 1. Design for Attachment and trust designing products that users want to keep despite wear
- 2. Design for Durability designing products so that they endure long time use and wear
- 3. Design for Standardization and Compatibility design products that work with other products
- 4. Design for Ease of Maintenance and Repair *designing products that allow for maintenance*
- 5. Design for Adaptability and Upgradability designing products that can adapt to new scenarios
- 6. Design for Dis-and Reassembly designing products that allow for recycling or remanufacturing

### 3.3.3 Design for Maintenance

In essence the same as Bakker's et al. (2014) strategy no. 4, design for maintenance is about designing products so that they allow for easy and economically viable maintenance and repair throughout the lifecycle (Poppelaars, 2014). According to Poppelaars (2014) "key elements are: (1) accessibility, (2) interchangeability (and standardisation) of parts, (3) straightforward failure diagnostics and isolation of the failure, (4) safety of the repairer, and (5) ease of final adjustments (preferably compatible with robots for removal)."

### 3.3.4 Design for Reuse, Design for Refurbishment & Design for Remanufacturing

"'Reuse' means any operation by which a product or its components, having reached the end of their first use, are used for the same purpose for which they were conceived, including the continued use

of a product which is returned to a collection point, distributor, recycler or manufacturer, as well as reuse of a product following refurbishment" (Poppelaars, 2014). "Design for Reuse" entails all measures that are taken to facilitate or enable that the product is used again; for example Design for Disassembly and Design for Maintenance.

Design for Disassembly and Design for Assembly are also essential as it comes to Design for Refurbishment and Design for Remanufacturing. While the aim of refurbishment "is to return product in adequate working conditions and original aesthetics" (Poppelaars, 2014), remanufacturing is a more thorough process where parts may be replaced or whole products rebuilt to conditions matching "as new" or even of higher quality than the original (BusinessDictionary.com, n.d.).

### 3.3.5 Existing *design for circularity* guidelines

Guidelines tackling the challenges of how to design for circularity have been developed, but many of them have different points of departure. Even though not specifically aimed at furniture or aging and wear, some of them were studied as part of the literature study to explore whether they could provide input later in the guideline development phase. A short summary of the examined guidelines follow below.

#### The Circular Design Guide

This guide was launched by EMF and IDEO in early 2017 as the first design thinking guide for the circular economy (EMF, 2017). It was developed through cooperation between design companies, design institutions and over 400 students with the aim of helping to "embed circular design thinking, enabling businesses to re-think value creation to develop more circular products, services and resilient, feedback-rich organisations" (EMF, 2017). It comprises 24 different methods and a resource bank that can be used by students, product developers as well as by change makers as tools when designing for the circular economy. The resource bank provides inspiration and examples in form of videos, worksheets, case studies and helpful links (EMF, 2017). The methods are divided into four categories: understand, define, make and release.

#### The TED's TEN

The Textile Environment Design (TED) research group is a collective of practicing designers and educators that has developed a set of ten sustainable design strategies for textile and fashion designers to use (University of the Arts London, n.d.). The aim is to reduce the increasing environmental impact of the textile industry by pro-actively designing clothes and textiles in a more sustainable and environmentally conscious way (TED, n.d.).

"Design to Minimize Waste", "Design for cyclability", and "Design to Reduce the Need to Consume" are some of the ten strategies that were considered relevant for this project.

#### Hållbarhetsguiden

*Hållbarhetsguiden,* or the "Sustainability guide", is a design guide developed 2009 by SVID, the Swedish Industrial Design Foundation. The purpose of the guide is to create a better understanding and an awareness for sustainability issues connected to design, and help businesses, designers and organisations to think and act more sustainably (Hållbarhetsguiden, n.d.).

#### Cirkulära Möbelflöden

This brochure (Arvidsson, et al., 2017) was also written as part of the Vinnova funded project *Business model innovation for closed-loop furniture flows* and provided very useful and relevant input regarding public furniture in a circular economy. Many recommendations were referred to in the resulting guide.

## 3.4 Product life time

People can mean different things when they are talking about product life spans and at which point a product life ends. In a circular economy, the materials are supposed to circulate and never have to be disposed of for good. But what does that mean for the product life? Cradle-to-cradle is a concept that is often referred to, but when it comes to circular economy the importance of the product itself has changed.

#### 3.4.1 What is a "Product life"?

In a circular economy, products can in theory circulate indefinitely with the right care and maintenance. This poses the question, where should the line between one life and the next be drawn? With possibilities, such as remanufacturing and part replacement, the product does not need to stay intact with its original parts to still live on. This would justify considering the life spans of product components more independently, separated from the product life.

A basic definition of a product life could perhaps be that as long the product fulfills its originally intended function, it lives on. One could also say that the product's life – however not the material life - is ended when it is either material recycled or biodegraded, which fits with the definition made by Investopedia (n.d.) "The product life cycle describes the period of time over which an item is developed, brought to market and eventually removed from the market.". In a circular economy however, products and materials are supposed to keep circulating, making the materials in one ending product become "raw" material to a new product (EMF, 2013). When it comes to modular design and the parts are all changed out eventually, is it still the same product? One can say both yes and no. The function it serves is the same, but the parts and materials are not. But in a circular economy the physical product is not the most important; it is the circulation, the source of the materials and keeping the value high for as long as possible during its usage. The ISO standard (ISO 14040:2006) categorize a product as a service, software, hardware and processed materials (Swedish standards institute, 2006), which can mean that the materials in a circular economy is the product, which means that the life time never ends if it is 100 per cent recyclable.

When it comes to environmental labelling and certification of recycled materials and remanufactured products, there are some big obstacles relating to the exchange of parts and components. It often comes down to not knowing that the components are made out of and if they contain banned or even hazardous substances, which make it hard or even impossible to re-certificate modified products, for example reupholstered textiles, since it is seen as putting a new product on the market (Norrblom & Sjöholm, 2016). A business which resells or refurbishes other producers' furniture could be prohibited to sell the product on the EU/EES market since there are strict requirements about supplying material and chemical information about the product, which could be hard to find in the second-hand business. It is still unclear if it the certification is still valid if the product is receiving

maintenance or updating, with some visual changes, when the product returns to the same consumer.

There are also products that fit into the cradle-to cradle concept, but not necessary the circular economy. A product that is made from recyclable materials but has a short life span is not necessary the most resource efficient, especially when it is still usable in other ways. Every time a product or component is made, energy is put into the system and the source of that energy is most often not only from renewable energy sources. This means every time a product is made it has an impact. The best option for the environment is to keep the product in use for as long as possible before material recycling, for example by sharing, maintaining, reusing and refurbishing (EMF, 2013). This is what is referred to as "long lived" products. One shortcoming to products with long lifespans is that they often require service and repair, which are services that not many companies offer even though they have products with the potential to last for a long time (Bakker, et al., 2014). Often, products are produced today without further thought about what will happen to them after sales. The increasing need for service and repair challenges companies to think further than the next launching product, which can be seen both as a challenge and an opportunity.

Ellen MacArthur Foundation model (EMF, 2013) is focusing on loops where either the materials or the products circulate back to different stakeholders such as parts manufacturers, product manufacturers or service providers. It is interesting to highlight that there is a difference between the implementation of fast loops and slow loops. One cannot deny that the market is driven by profits and margins which have led to several business strategies which is not that environmentally friendly but very profitable. Deliberately shortened product lifespans is one example of fast looping to be able to sell more new products, which can further be discussed if ethical (Chapman, 2009), but it is without a doubt the direct opposite of resource efficiency.

## 3.5 What is a timeless design?

The word "timeless" is often used to describe long-lived pieces of furniture that lasts despite changing trends, but what is it exactly that makes furniture timeless? The consensus seems to be that a timeless design has durable high-quality materials which have the possibility to last for a long time, for example natural materials (Fischer, n.d.) (Davis, 2015) (Berhin, n.d.). The design should aim for simplicity with simple and clean lines, classic proportions such as the golden ratio and the use of neutral colours and materials.

As Oliver Davis stated, "Design classics can add interest to a room without dominating it" (Davis, 2015). Timeless design pieces often have that little extra design quality which is innovative and simply a new concept (Berhin, n.d.). The opposite of innovation and timeless is to make what is trendy at the moment, which is going to be unwanted and loose its value quickly (Fischer, n.d.). Timeless pieces keep their quality for a long time, which could be a combination of choosing materials that are able to maintain through refurbishing or more simple maintenance, as well as a design which is adaptable without sacrificing the original intent of the designer (Fischer, n.d.) (Berhin, n.d.).
## 3.6 Durable or transforming materials

As material selection is such a central part of the design phase and has great impact on the circularity of the product, a short overview of basic aspects to think about is going to be presented in following subchapters. Surface finishes and maintenance of materials are also addressed briefly to acknowledge their importance regarding how products age and wear.

#### 3.6.1 Material selection

The choice of which materials to use for a product is of outmost importance regarding how it will withstand the test of time and use. "For designers, it is important to learn about materials. To know what materials are, which qualities they have, how they are sourced, and how they are processed. [...] In the context of materials selection, you cannot select what you do not know" (van Bezooyen, 2014). When designing a product, one must consider both the technical, functional, properties of the materials as well as the interactive, human, experience of the material. In a circular economy, sustainability and environmental aspects must also be considered; both to ensure that materials that can be recycled or recirculated are used, and that no pollutants or toxic materials are selected. Because of the complexity of the task, and the often-contrasting demands, many different material selection methods and tools have been developed focusing on optimizing the kind and amount of materials used, for example the Ashby method (Ashby, 2011).

However, as all things, materials are impermanent, and some more than others. It is therefore important not only to think about the materials as they are, but how they will age and alter with time, and decide whether it is desired or not. Extreme durability might not always be the best option as products can become outdated and undesired in a number of other ways; Chapman (2014) for example brings up the issue of many metals, polymers and composite materials that "grossly outlive our desire for them, largely due to their inability to change and evolve, as our needs as users change and evolve".

As it comes to aging and wear of materials, there are materials that are perceived to age more beautifully, or gracefully, than others. Rognoli & Karana (2014) note that "The positive term of maturity is usually used for natural materials such as stone, paper, wood, and leather, which over the years can acquire scents, colours, and textures: characteristics that far from diminishing their quality, instead acquire an aura of antiquity and preciousness." Materials ageing less gracefully are said to be plastics which tend to become scratched, discoloured and brittle over time. (Rognoli & Karana, 2014)

However, the perception of materials can be partly, or even entirely, driven by emotions, and therefore divide greatly. In one study conducted by Bridgens et al. (2015), they artificially wore down materials in the format of a cell phone case and used them in tactile and visual perception tests. The most prominent observation was that the participants had very diverse and contrasting perceptions about the materials. The conclusion was that the participants had "preconceived feelings about each material (regardless of context)" (Bridgens, et al., 2015). In ranking the materials regarding preference order, it was shown that there was no difference between the lightly aged vs original material, which indicates that the aging process did not affect the perception. The wear of some materials is not affecting the users' perception to a vast extent, but rather which material is selected.

This is supported by Odom et al. (2009), stating that "material qualities appear to play an extremely important role in relationships characterized by a high strength of attachment".

#### 3.6.2 Surface finishing processes

There is a broad range of surface finishing processes that can be used to improve the durability and add to the visual experience of the furniture. When deciding which materials to use, the surface treatment should also be considered, as it can have a great influence over how the material ages and withstand usage.

#### Wood finishes

On wooden materials, surface coatings such as clear lacquers and varnish; pigmented finishes such as paint; penetrating resin; oil; and wax polish are common (SNIRI, 2002) (Jewitt, 2000). Out of these, varnish and penetrating resin are the most durable, while Tung oil provides the most "natural" look and feel (HowStuffWorks.com, 2006). There are however advantages and disadvantages with all finishes, and choosing one always entails a compromise. Even though durability often is the most important factor in selecting a surface finish, one must also consider if it is water-resistant, how safe it is to use, how easy it is to apply, if it is reversible or not and if it has an environmental impact. From an aging and wear perspective, it is highly important to also consider how the look of the finish changes over time; some may change in colour or lustre. "A finish film that turns yellow with age will be noticeable with unstained, light-coloured woods, such as maple or birch. An acrylic finish, water-or solvent-based, does not have this problem. Paste wax and some catalysed finishes also will not yellow." (Jewitt, 2000)

Important is also in which conditions the finishing is made; humidity and air-borne particles can greatly affect and undermine the application and curing processes. The preparation of the wood is also of outmost importance for the end result: an old rule says that a well-polished surface is half the surface treatment (SNIRI, 2002).

#### Metal finishes

Some of the most common metal finishes are plastic coating, paint and powder coating, anodizing, brass and chrome plating (Hawks, 1987). Plastic coating protects the metal from oxidizing, and as they are durable they are also used over other finishes as a protective layer (Hawks, 1987). Paints are used for the same purposes, but scratches easily which may lead the underlying metal to rust.

Anodizing is often used on aluminium furniture to protect from oxidation. It is a very durable finish which does not scratch easily, but is very thin it can wear down (Hawks, 1987). Like anodization, chrome plating is an electroplating finish with excellent durability and corrosion resistance. Due to environmental and health issues its use is however restricted: while Cr<sup>6+</sup> is prohibited Cr<sup>3+</sup> is allowed in severe environments where the furniture is exposed to high levels of wear, for example on stackable chairs in public environments (The National Agency for Public Procurement, 2015).

#### Plastics

Plastic components are often created with their final finishes, for example injection moulded parts. In some cases, as with acrylic, they can be polished to protect against damage (Warren Design and Technology, n.d.).

#### 3.6.3 Maintenance of materials

Besides material selection and selecting appropriate surface finishes, maintenance plays an important role in assuring that products last long. Incorrect cleaning and maintenance can even damage the furniture and shorten its life span (EFG Testlaboratorium, 2014). It is therefore important for furniture producers to provide information to their buyers on how to best maintain the furniture; for example, what cleansing agents should be used, what materials the product can react to and how to best prevent damage to the product.

#### 3.6.4 How aging and wear can be value-enhancing

According to the definition of wear mentioned in subchapter 1.6.4, wear is classified as the damage to a surface stemming from frequent exposure to external forces. This is however seen from a materials engineering perspective, and not from the perspective of one looking at determining the condition and value of furniture. Despite being some sort of damage to the material of a product, wear is not always unwanted or detrimental to the actual value of the product. Aspects as aesthetics, product history, and sentimental value play important roles as they affect how wear is perceived by users, making something that by definition is "damage" into something of value. It is therefore interesting to look at what kinds of wear detract value and which adds it, and see if it is possible to define their boundaries. The designer Kristine Bjaadal made a chair called *Underskog*, with a fabric that is made to change through wear. It starts out like a one coloured fabric and with time a flower pattern appears. "Wear and tear of materials tell stories about how products have been used; about how we leave traces in our surroundings. We appreciate aging of wood, stone and leather, and call it patina. But textiles, on the other hand, we throw away as soon as the first thread breaks. Could it be possible to make a fabric that grows beautiful with wear and tear?" (Bjaadal, 2009).

#### 3.6.4.1 Patina

Patina is a word that often comes up in discussions about antique furniture, and refers to the positive effects of aging that can be seen on a surface. However, as one seeks to find a definition of the word, it proves more difficult than expected. There are many descriptions, but they often seem to use conflicting words to characterise the phenomenon, such as "mellow", "shiny", "satin finish" as well as "grime" and "dirt" (Taylor, 2016). The original meaning of patina refers to the "blue-green layer that forms on copper, brass or bronze" (Cambridge Dictionary, n.d.), but the term has come to encompass more than that. Now, it is used to describe all kinds of aging processes and on many different materials (Rognoli & Karana, 2014).

According to Chapman (2014) "patina is a necessary design consideration to assist the extension of product life spans in graceful and socially acceptable ways. Indeed, products must be designed to grow old gracefully, yet with such a multitude of variables, the question must be asked: is [...][it] really as simple as a dint here and a scratch there?" The conclusion Chapman (2014) draws is that patina is highly contingent of what is *appropriate to the genre*, in other words what material and what product it concerns. "Leather handbags are accepted when scuffed and marked, polyvinyl chloride ones are rejected, for example; cars should not be dinted and scratched, unless they are vintage cars and then its considered *charming*, etc." (Chapman, 2014). He continues to state that to be able to design long lasting products that age gracefully, specifying materials that age well is

merely a part of it, and that one should seek to challenge people's desire for products in mintcondition by designing products that through their aging offer heightened experiences (Chapman, 2014).

#### 3.6.4.2 Wabi Sabi

Wabi Sabi is also interesting to consider in the context of aging and wear. The term has roots in Taoism and Zen Buddhism (Hermitary, 2004), and is by Agneta Nyholm Winqvist (Wiklund, 2011) called a kind of anti-doctrine since there is not an exact way of practicing; it is in a way a life style. In Japanese culture, they refer to Wabi Sabi as (the perfection in) the imperfect beauty, that is continuously changing (Rognoli & Karana, 2014). It stands for imperfection, asymmetry, unfinished, broken, shattered, reassembled, temporary, simplicity, modesty, intimacy, incomplete and so on. Wabi refers to the simplicity, freshness or even silence, whilst Sabi refers to the aging process where impermanence is highlighted by patina, wear or visible repairs.

Materials that are used are organic and preferably unpolished or not cleaned up (not new looking), for example wood, metal, paper, textiles, stone, and clay (Hermitary, 2004). The shapes are often organic or natural and asymmetric or irregular. The textures are often kept rough, uneven and random. Colours used are light and subdued, often even derived from natural sources.

Wabi Sabi focuses on the holistic experience, it "promotes an intuitive feel for life where relationships between people and their environments should be harmonious" (Hermitary, 2004), and embraces the irreversible flow of life.

## 3.7 Emotional durability and product attachment

A fundamental problem with today's society is the throwaway culture we live in (Verbeek & Kockelkoren, 1998), which has at least been going on since the postmodern era. Still functioning products that are in good shape are discarded to make room for newer models. Chapman (2009) states that "The sustainability crisis is a behavioural issue, and not one simply of technology, production, and volume". The wasteful purchasing behaviours of deliberate shortened product lifespans are resulting in negative ecological impacts and the behaviour is encouraged further by "profit-focused manipulating of customer spending". Physically durable gods are all over landfills, which indicates that making even more physically durable products is not the answer since the customers lack the desire to keep them; the answer is rather to make the products more emotionally durable (Chapman, 2015).

In the search for a way to make product last for longer, different methods and concepts have taken form over the years. Aging gracefully is a term used for products that are made to last for a long time, for example through a new way of using products, a timeless design, or good quality materials. Another way to make product last longer is to create an emotional bond between the user and the product, which makes the user care for and keep it for a long time rather than buying a new substitute.

Consumption is motivated by "complex emotional drivers" (Chapman, 2014). It is more than the craving for new shinier things, it is a longing and desire towards the ideal self. Chapman (2009) conducted an empirical study about the relationship behaviours of 2154 respondents about the use

phase of domestic electronic products. The result was put into a framework which include the themes: *Narrative, Detachment, Surface, Attachment, Users are delighted by not understanding the product fully*, and *Consciousness*, see Table 1 for further explanation of all the points.

Table 1: Six-point experiential framework (Chapman, 2009)

#### "Narrative:

Users share a unique personal history with the product; this often relates to when, how, and from whom the object was acquired.

#### Detachment:

Users feel no emotional connection to the product, have low expectations, and thus perceive it in a favorable way due to a lack of emotional demand or expectation. (This also suggests that attachment may actually be counterproductive, as it elevates the level of expectation within the user to a point that is often unattainable.)

#### Surface:

The product is physically aging well and developing a tangible character through time and use (and sometimes misuse).

#### Attachment:

Users feel a strong emotional connection to the product, due to the service it provides, the information it contains, and the meaning it conveys.

Users are delighted or even enchanted by the product as they do not yet fully understood or know it, especially with a recently purchased product that is still being explored and discovered.

#### Consciousness:

The product is perceived as autonomous and in possession of its own free will. It is quirky and often temperamental, and interaction is an acquired skill that can be fully acquired only with practice." (Chapman, 2014)

Odom et al (2009) found that there were four different factors demonstrating how the relationship is between artifacts and the owner, see list below.

- 1. **"Engagement**—the extent to which an object invites and promotes physical engagement with its owner during use;
- 2. **Histories**—the extent to which the materials of an object preserve personal histories or other memories, either by explicitly showing physical signs of use or implicitly by virtue of its persistence over time;

- 3. Augmentation—the extent to which an object has been reused, renewed, modified, altered or otherwise made to be a part of something augmented beyond it original intended use and as such has become a symbol of the resourcefulness and/or creative expression of its owner; and
- 4. **Perceived durability**—the extent to which an object's owner regards an object as long lasting either in terms of function or in terms of longevity or both." (Odom, et al., 2009)

Knowing more about the user-product relationship it is possible to design emotional durable products which last longer.

#### 3.7.1 Eternally Yours

The Eternally Yours foundation is a society that was founded 1995 which states "we should not only strive for sustainability, but also for durability, by designing products in a way that stimulates longevity." (Verbeek & Kockelkoren, 1998). They advocate the gathering and distribution of experience and knowledge to make it possible to design an 'immortal' product (van Hinte, 1997). In today's society, it is accepted that products are being discarded after a short time, even being designed to not last for long.

Eternally Yours is promoting a shift of how we consume and use products. "The first is shifting from products to services as much as possible. Extensive services involving products such as repairing, upgrading, and renting can result in a more intensive use of products. This will reduce production and, thus, pollution. A second direction is eco-design, already mentioned, which tries to minimize pollution in all stages of the lifetime of products. A third direction is recycling." (Verbeek & Kockelkoren, 1998). "The fourth and least common direction is that of Eternally Yours: trying to elongate the lifespan of products." (Verbeek & Kockelkoren, 1998). The first three are also called "Shape `n' Surface", "Sales `n' Services" and "Signs `n' Scripts".

Eternally Yours has been criticized for being one-sided with its focus on extending the "psychological" lifespan by creating a bond between users and products and thereby seeing products as material objects as hardly relevant anymore. The material used is not important as long as it helps in giving the product a long life, for example high quality materials as leather rather than chromed metals (Verbeek & Kockelkoren, 1998).

## 4 Market analysis

To get a grasp of the current situation and the development of the second-hand market for public furniture in Sweden, a small-scale market analysis was performed. As part of this, interviews with business representatives for companies or organisations active in the reused furniture market were conducted as well as field trips to locations for second-hand furniture collection, refurbishment, distribution and sale. Here some of the insights used in the forming of the interview and perception studies as well as in the making of the guideline are briefly presented.

## 4.1 Outcome of conducted field trips

To increase the authors understanding of the current situation, as for example the condition of thrown away furniture, the public places it had occupied, and how it was handled upon disposal and collection, several field trips were performed.

#### Carl Malmsten Furniture Studies

*Carl Malmsten Furniture Studies*, a section of Linköping University, was contacted early in the project. This resulted in new insights and interesting perspectives on both new and old wooden furniture, such as the importance of correct surface finishes to allow for restoration. It produced beneficial contacts with designers, furniture makers and furniture restorers which came to play important parts in the interview and guideline evaluation phases.

#### Möbelbruket

A field trip was also made with representatives from Möbelbruket, a refurbishing project specializing in chairs for the public sector, to the Skaraborg Hospital in both Skövde and Lidköping during the beginning of the project. The aim of the visits was to accompany Möbelbruket as they inspected the storages of unwanted furniture at the hospital to see what would be of interest for them to take in and refurbish, and to get an understanding for what state the furniture was in. This also allowed for the authors to see which furniture Möbelbruket would select in preparation for the future perception study. During the trip, the used hospital furniture was photographed and the evaluation process observed. Unstructured interviews were held with people involved in the process.

#### Stockholms stadsmission's storage facility

The sorting and storage facility of *Stockholms stadsmission*, a non-profit organisation working to aid people in need in Stockholm, was visited in connection to an interview. They receive 31 000 tonnes of donations annually, consisting of clothes, furniture and other belongings (Gimner, n.d.). In their storage facility, furniture awaiting appraisal was observed and photographed. Even though these pieces were private, and had been donated either as part of deceased people's estates or by people needing to get rid of furniture as they were moving, they gave a further understanding for how furniture is valued and why it is discarded.

#### Designed to Last, an ArkDes exhibition

The exhibition "Designed to Last" at the Swedish Architecture and design centrum was visited as it displayed different Swedish furniture designers' creations with focus on long lasting designs and

durability. Topics such as sustainable material usage, repeated manufacturing processes and quality were addressed.

#### Återbruket, Linköping University

Linköping University has an internal system for reusing furniture and interiors called Återbruket. To explore the opportunity of performing perception tests with Återbruket's furniture, their storage facilities were visited. This furniture was however deemed to be in too good condition with barely any visible wear, which is why the perception study was decided to be performed with Möbelbruket's furniture in Tibro, Sweden.

## 4.2 Results from business interviews

To get more qualitative information about how companies and actors in the public sector view and deal with second-hand furniture, interviews were held with four people actively involved in different stages of the value-chain of reused furniture, see Table 2. The interviews focused on how they and their respective organisations work with circular furniture flows, what services they provide and why, how they work with sustainability issues, and what kind of impact aging and wear of furniture have on their work. In addition to these four interviews, documents from another three interviews that had been conducted as part of the *Business model innovation for closed-loop furniture flows project* were taken part of and used as input.

#### Table 2: Interviewed business representatives

	The interviewed representatives of businesses on the reused furniture market
R1	A Sustainable Asset Manager and business concept developer, working at one of the largest furniture companies in Europe
R2	An appraiser and antique dealer with 30 years of experience
R3	The project leader of a regional initiative for refurbishing and reselling used furniture in the public sector
R4	A retired furniture maker and conservator

In the interviews conducted with businesses operating in the second-hand or reused furniture market, it was revealed that they worked with circularity and sustainability to varying degrees. Some only resold used furniture, without mending or refurbishing them, and donated or material recycled the rest, while others had specialized in furniture restauration or providing leasing contracts on office furniture with included maintenance services.

If the selling of reused furniture is merely a service provided beside the main business, it was seen more from a quality and marketing perspective than as an actual source of income, which one of the interviewed stated is common on the market [R1]. Many decisions when it came to valuing the furniture were based on "gut feeling" or experience rather than against pre-set standards. All

interviewees were talking about quality furniture, for example design classics, as the type of furniture which wears well over time and is fruitful to keep in a circular economy (specially to reuse, maintain or refurbish). Two of the interviewed, [R2] and [R4], said that it would never be relevant to refurbish cheap furniture with poor quality. One of the interviewees [R1] was talking about the bad quality of products on the today's market and that people in general want products to be as cheap as possible, which often leads to low quality. "We must think about how to handle the leftover furniture. We should not see them as worn, but must see them as raw materials to be able to be truly sustainable".

The transition towards more sustainable thinking among consumers and businesses was also mentioned and discussed. A Sustainable Asset Manager stated that "regular offices who buy office furniture, they only buy used furniture if it is 30 - 40 % cheaper [than regular market price]." [R1]. There seems to be an increasing demand in buying used office furniture, but there are so far only a few businesses focusing on selling used or refurbished office furniture.

Cost is also a problem when it comes to the decision of being eco-friendly or not, as customers often demand low prices. Eco-friendliness often costs more than regular options, except for in the case of refurbished furniture which can and often is demanded to be cheaper than buying new pieces. A Sustainable Asset Manager stated that "We have to let sustainability cost more money." [R1], but he admitted at the same time that this often was not an option today as no one was willing to pay more. The attitude for buying sustainable products is about saving money rather doing the right thing [R1]. He states that "Sustainability isn't something that one "works with": either you *are* sustainable, or you *aren't* sustainable." [R1].

When it came to materials that last with wear, all interviewees mentioned wood and natural materials. They [R1] [R2] [R3] were also saying that some materials and furniture need maintenance, for example cleaning, waxing, polishing, to be able to last for a long time and age beautifully. A conservator [R4] stated that one should mend furniture before they break entirely, for example if you keep using an unstable chair, the joints will in time break from the pressure.

## 4.3 Conclusions of market analysis

The conclusions of the small-scale market analysis are presented in Table 3 below.

Market analysis conclusions	
Low price is very important, but sustainability costs	Customers often require a reduced price for reused or refurbished furniture, despite it being
Logistics are key to allow for circular furniture flows	There must be efficient collection, transport and distribution of the furniture that is going to be circulated.
Only viable to circulate high quality furniture	Low quality furniture is not economically worthwhile to collect, refurbish and redistribute.
There are no standards for evaluating the level of wear	Evaluations of the condition of the circulated furniture are often performed based on "experience" or "gut feeling".

#### Table 3: Market analysis conclusions

Aging and Wear in a Circular Economy

# 5 Interviews for basic mapping

This chapter presents the results of the series of interviews conducted to get an understanding for the user perception of the terms aging and wear. The interviews were held at Stockholm Furniture and Light fair with 12 randomly selected people.

## 5.1 Result of the basic mapping

Overall, the interviewees thought that natural materials, such as for example leather and wood, age and wear best - that is most beautifully - over time. The materials that in general were seen as not aging well over time were either natural materials with synthetic coatings, for example painted metals or veneer with melamine coating, or synthetic materials, such as for example different plastics. See Table 4 for a summary of the answers.

	Positive perception	Negative perception
Named several times	Leather, wood, copper, oak	Plastic, painted metal/aluminium, imitation or synthetic materials, veneer with or without melamine coating
Named once	Brass, larch	Textile materials, birch

Table 4: Summary of materials named to age positively resp. negatively

When it came to which types of wear were found acceptable and which unacceptable, the difference in the wording was quite important. Acceptable wear was light wear after regular use; marks that were self-inflicted, or natural materials aging naturally; solid wood in all stages for instance. It was never acceptable to have broken furniture in use. Other unacceptable wear was higher levels of wear, for example deep scratches, pilling on fabric, or when a material changes visually, for example plastics that changes colour or paint that is cracking. Textiles should be clean and fresh looking, making broken, dirty, marked or stained fabrics unacceptable. See Table 5 for a summary of the answers.

Table 5: Summary of the answers about what is acceptable wear and unacceptable wear

Acceptable wear	Unacceptable wear
Lightly worn, cracks in leather, scratches if self-	When paint cracks, it is broken, pilling on fabric, plastics
inflicted, leather and wood, worn but not broken,	that has changed colour, deep scratches, textiles that
wood with all types of wear, patina	are broken and dirty, marked or stained fabrics

Every one of the interviewees answered that they thought that there is a difference between how they perceive wear at home and at the work place. However, the opinion about how it is different

was divided. Some thought that the furniture at home needs to be more aesthetically pleasing, while others thought that it was more important to have good looking furniture at the work place. Several interviewees nevertheless thought that the quality of the furniture had to be higher at workplaces where the furniture is used more frequently where there are ergonomic requirements that are not required for private furniture. Depending on the type of business, it was stated that there also can be higher demands on the furniture and environment to be 'nice and neat', for example if there are clients to impress. Some of the interviewees stated however that they believed people to generally handle furniture at work or public places more carelessly than they would do if it were their own, and therefore the condition of that furniture can be worse.

## 5.2 Conclusions of the basic mapping

Some of the conclusions of the first, exploratory interview study are presented in Table 6 below.

Basic mapping conclusions	
Natural materials age more beautifully than synthetic ones	Indicated by the results, but would need further investigation
Light wear and self-inflicted scratches could be acceptable	Indicated by the results, but would need further investigation
Deep scratches, pilling of fabric, colour changes on plastics or crackling paint unacceptable	Indicated by the results, but would need further investigation
Divided view on public vs private furniture	Some had higher requirements on own furniture

#### Table 6: Conclusions of the basic mapping

#### 5.2.1 To be further investigated during the thesis work

After the basic mapping, it was considered interesting to find out more about what acceptable and unacceptable wear look like, as some of the interviewees had strong but contrasting opinions regarding the matter. Some materials were also named to last for a long time, for example natural materials, but often the examples given were not very specific. More research was deemed necessary to find out which materials age beautifully and which lose its perceived value the fastest, as well as which materials are suited for areas most exposed to the wear of public environments. Perception tests were decided on as they could help connect opinions about different types of wear with actual samples of worn or aged furniture.

Other questions that were deemed interesting to examine further were: what aspects are important to take into consideration when designing furniture for the public sector? Why are furniture thrown away? What should a chair look like for it to be kept in use for a long time? What expectations do users have of furniture in different public environments?

# 6 Interviews with experts and professionals

In total, eleven one-hour-long interviews were conducted with different professionals and experts connected to the subject of aged or worn furniture, see Table 7. This chapter summarizes what came up in the interviews and what conclusions the authors drew from this. The questions asked can be seen in Appendix B.

Table 7: Interviewed experts

	The interviewed experts' work titles and expertise areas
P1	Quality and environmental manager at a Swedish furniture company
P2	Appraiser/antique dealer with 30 years of experience
Р3	Design consultant with expertise in sustainability and environmental issues
P4	Furniture conservator/furniture designer/furniture maker
P5	Furniture conservator (specializing in natural materials)
P6	Mechanical engineer and wood expert
P7	Furniture appraiser/conservator at a Swedish company specializing in 20 <sup>th</sup> century design
Р8	Furniture and interior designer, founder of a furniture company specializing in creating sustainable furniture for the public sector
Р9	Interior designer working in the public sector
P10	Interior designer and wood expert/furniture design teacher
P11	Laboratory engineer specializing in furniture testing for one of the biggest furniture companies in Europe

## 6.1 Results of the interviews with experts and professionals

The results are summarized in the following subchapters, covering the eight different areas of interest presented in Figure 7. In the figure, it is possible to see which questions contributed to each of the areas, see Appendix B for the questions in full. Quotes and citations are referenced using the numbers P1-P11 appointed to each interviewee in Table 7.



*Figure 7: The grouping of interview questions (see Appendix B for the interview protocol) into the identified areas of interest.* 

#### 6.1.1 Consumer behavior and purchasing practices

In the public sector, economic aspects and public contracts often rule when furniture is replaced and what it is replaced with. Price is often the crucial factor when it comes to buying new furniture, given that a certain level of quality is fulfilled. Low prices have however become more important over the years, which often mean that even though companies talk about quality and being more environmentally friendly, they end up choosing a cheaper but inferior material [P11]. One experienced furniture and interior designer also stated that the development in recent years indicates that style and modern design often is prioritized over quality, leading to products with poorer durability and thus shorter lifespans. "It is often okay if the quality is poorer, as long as it looks good" [P8]. This has according to her lead to the market adjusting to these new demands, where furniture is no longer required to last for 20-30 years but perhaps only for 3-5 years, resulting in poorer textiles being chosen and chair frames of lacking quality. "Everything is expected to be so cheap and to be depreciated so fast". She also recalls the time before centralized public contracts when the purchasers often themselves were the ones using the furniture; nurses or teachers for

example. "I learned so much from them [...], but they disappeared in the 80's when they threw out all this knowledge" [P8].

Another reason for exchanging the interiors today is to get more ergonomic office furniture. Adjustable tables and more ergonomic office chairs have been introduced in most offices, making the old models obsolete [P11].

One interviewee mentioned that it was more common back in the day to design furniture for specific places (newly built offices for example) and that that kind of furniture would last longer in its intended environment [P2]. Another interviewee working at a big furniture manufacturing company stated that when the customers are public agencies or companies they often come to them with a drawing of the desired design [P11]. This design might often not be the best from a durability perspective, having a lot of sharp edges that look stylish and clean but that quickly wear down or wear on the upholstery for example. But as he put it: "it is the customer who decides and we cannot just bargain away; you know if we were to make furniture that is of optimum durability, then we might use other materials and rounded edges and so on, but then nobody would buy it. "

As it comes to companies, furniture is most often thrown away when there are reorganisations, transfers or location changes, and often regardless of in what condition the furniture is in. Aesthetic reasons and trends often rule over functional reasons; furniture more often becomes "aesthetically old or worn" before the actual material. As a design consultant [P3] put it: "companies have an image of quality and prosperity to uphold towards the clients." This often leads to furniture being replaced to match the latest trend, outdating furniture in otherwise good condition.

For private customers, trends are also important. An interior designer [P10] stated that the low prices on furniture today makes them into consumer goods, which they did not use to be. "It's the prices. If you get tired of something, you buy new since you have the economic possibility. Most of the furniture that is thrown away is not actually worn out, sadly enough. So the complex of problems doesn't actually lie in the aging and wear, but in our behaviour." The reasons to why consumers throw away furniture stated by the experts interviewed can be seen in Figure 8.



Why do you think people throw away furniture?

Figure 8: Experts' view on why consumers throw away furniture

Several of the interviewees stated that they would want a change towards longer lasting furniture, "to go back to how it was", but that it is a difficult change to make in our consumer society where trends rule.

#### 6.1.2 The attitude towards furniture in the public sector

To the question *"Is there a difference in your perception of wear and tear on furniture at home vs at work?"* all out of the eleven interviewees answered either yes or that it depended on the environments in question. What the perceived difference constituted varied however greatly. Five out of the eleven answered either that you are more careful with the furniture you own yourself or that you have a higher standard on your furniture at home, while four out of the eleven said that there is a higher standard on office furniture and that people generally are careful with them. Contrastingly, when the interviewees talked about acceptance, more people -three out of eleven - said that it was easier to accept wear at home than the other way around, which only one answered. Furthermore, this conflicting acceptance of wear at different locations did not seem to match where the interviewees perceived the most wear and tear to take place. The majority (6 out of 11) answered that public places were exposed to more serious wear and tear, while only two said that furniture at home is more exposed to wear. In these instances, they referred to families with children who act more carelessly. "At home, you have all kinds of ages and individuals which lead to different kinds of wear and tear than you would for example have in an office environment with a homogenous group of mostly well-behaved adults" [P3]

There is however big differences between different public places, and people's acceptance levels and demands depend greatly on which environment is looked at. As one designer put it: "You have a whole different level of leniency towards places that you know are tax funded. Private companies are the ones having an image to sell – they are the ones throwing out a bunch of Kinnarps furniture every year to redo their reception. It is a difficult balance, because if they suddenly make a super flashy social welfare centre it would irritate a lot of people who are asking "why are you not spending the money on helping us instead?" So we have a totally different acceptance for wear in those kinds of public environments; we might even expect them to be more and subdued and unglamorous" [P3]. This view is supported by other interviewees, stating that one's acceptance of wear and tear depend on where the money comes from. Hotels, banks and private offices are kept to higher standards than for example public schools, public libraries and police stations. Hospitals on the other hand - not only private but public hospitals as well - are expected to meet higher standards regarding furniture condition and cleanliness. Close to half of the interviewees cited hospitals as a place with high demands on the furniture, as they both had to endure a lot of wear and tear, but still also had to look and be hygienic. Scratches and wear in hospital environments are more associated with bad hygiene and a place for bacteria to grow and thrive than they are elsewhere.

#### 6.1.3 Most common types of wear on public seating furniture

Asked the question "which types of wear are most common on upholstered seating furniture?", all but one mentioned wear or stains on textile covered seats (see Figure 9). One quality manager noted that most of the wear appears on the very front end of the seat; "you don't move your bottom that much when you sit down, but your legs are moving all the time as you are crossing your legs and what not" [P1]. Another type of wear connected to the seats was padding that had given in or

become firm [P2] [P7] [P9]. Wear on armrests was the second most common, with 8 out of 11 of the interviewees mentioning it. However, only 3 named wear on seats first of all, while 5 named wear on armrests as the first thing that came to mind. Another type of wear that was frequently cited was that the structure of the chair had become rickety and unstable, leading to damages such as cracks in the frame or joints coming loose. "All surfaces that we most often come in contact with get worn out with time. [...] Seats and joints are the biggest problems" [P10]. One designer stated that in public environments, the seats and armrests become the most worn out parts [P8]. "There is a carelessness [in public spaces] that leads to frames and legs getting damaged. And then it is this with stained upholstery: everybody goes around eating stuff everywhere and drinking coffee and such, and the designers have often not chosen the right fabric for that."

Dirt and stains in general were mentioned by 7 out of 11, not only on the textile parts of the chairs but also on the armrests and on the frame, where the legs were considered especially exposed to marks and smudges. "One often notices it on the legs; there are damages and it is dirty from all the soles that have left black rubber marks" [P7].

In connection to damages related to the chairs' constructions, broken backrests were mentioned trice. A furniture restorer [P5] stated that the backs of older chairs often break as we sit differently and lean more in chairs nowadays than people used to do.



Figure 9: Most common types of wear and tear on upholstered seating furniture in public environments.

#### 6.1.4 Acceptance of aging and wear

The tendency to throw away furniture based on aesthetics that is described in subchapter 6.1.1 is however in steep contrast to what the majority answered to the question *"At what point do you need to replace seating furniture?"* Here 7 out of the 10 that were asked the question answered that chairs need to be replaced when they either are broken or if the cost of repairing them would be too high. Only 3 out of 10 said that they would throw away something because it looks dirty or ugly. There were also people of the completely opposite opinion; 3 out of 10 answered that depending on the

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chair and the mending possibilities, some chairs would never have to be thrown away. A conservator stated that "properly manufactured pieces of furniture, made by skilled furniture makers, never have to be thrown away; one only throws away furniture when the quality is bad and it is impossible to find spare parts" [P7]. This was somewhat in line with what they answered regarding what standard they expected of upholstered, public seating furniture. A clear majority answered that it could be worn, but not worn out or broken. Four out of ten also expected that the furniture should be clean, neat and tidy, and two mentioned that it must be safe to use.

When asked about when, at what point, they thought wear turned from "acceptable" to "unacceptable" in the case of upholstered seating furniture, the interviewees often answered that it depended on which type of furniture it was, where it was used, and which type of wear or damage it had. Half of the interviewees came independently up with a scale ranging from 1 to 10 and to help them explain either how their acceptance levels differed depending on if it concerned wear at home or at work, or on the type of wear. All using the scale ranked their acceptance of wear at home higher than their acceptance of wear at work; for example on a scale where 10 is "as new" and 1 "unusable", the five interviewees in average stated that seating furniture at home with a score "3" was acceptable while at work chairs would need to be at least an "8", if not more. Some signs of aging and wear also seemed more acceptable than others; it was for example acceptable that the furniture was a bit worn or sun-bleached, but dirt and stains were much severer faults, as was instability due to loosening joints. A designer said for example "the limit for upholstered seating furniture goes if it's impossible to make it clean again, or if it's worn out so that it shows of course. Sagginess it can live with for a while; but dirt and fringing – that's the limit. However, these types of damages are even more sensitive in an office environment" [P3].

Another interviewee stated that she had different standards for furniture of different qualities. "If I for example have bought something from IKEA, I've bought it with the intention of letting it wear down and then be thrown out as I either have grown tired of it or a seam has loosened or something similar. [...] But were I to buy designer furniture I'd take much better care of it, and even if it became worn with time there might still be a lot of soul and love in such a piece. If the front end of the seat was to wear down, I would re-cover it, perhaps over and over again" [P1].

An aspect noticed primarily by the interviewed conservators was that evenly, but quite extensively, worn furniture was more acceptable to people in general than furniture in an otherwise perfect condition but with some glaring scratch or mark. "Public customers leave their furniture to be restored when the wear and tear has become too noticeable, it simply looks too shabby" [P4]. "I think it irritates people if everything looks tidy and fresh and then there is this one water ring on the table top. It catches the eye "[P5]. Similarly, another interviewee mentioned that what one has to compare the wear with has a great influence on the perception of the wear. "Maybe you don't notice if the surface is a bit sun-bleached as the change happens over a long time, but if you place a chair from another room beside it you'll notice" [P11].

#### 6.1.5 Attitudes towards reusing and refurbishing

In essence, the interviewees said that people are willing to refurbish furniture for two different reasons. Either they are emotionally attached to the furniture (4 out of 8), for example a family heirloom, or the furniture has a high value from the beginning (4 out of 8) and the owner wants to maintain, or even increase, the value.

A few of the interviewees mentioned that people most of the time are not refurbishing their furniture themselves, but let a professional take care of it. There also seems to be a resistance towards taking the step to refurbish, which the interviewees say is a big obstacle to overcome. Many people prefer to buy furniture when it is already in good condition, or are willing to pay to get others to get it fixed [P2]. The thing that can motivate people to act is when the furniture breaks, which is the most common reason to contact a conservator or restorer, stated a conservator [P5].

Five out of eight mentioned chairs as the most common type of furniture to refurbish, for example by changing the upholstery, fixating loosening joints by regluing unstable parts or, not as common, exchange broken parts. One interviewee said that "the sofa is always thrown out" [P2]; the only reason people would change the textile is if it is a design piece that would not lose value after the refurbishing. Another measure that conservators do is to clean furniture and reupholster that is still intact [P4], which is a way of prolonging the life of a piece of furniture. When it comes to which types of furniture people are unwilling to refurbish, the interviewees unanimously stated cheap furniture with low quality.

The answers to the question about if anything could be lost by refurbishing furniture, the interviewees had different opinions depending on the scenario. Three out of eight said that nothing could be lost, with the exception for antiques. One of the interviewees stated that in general it is no problem since "A piece of furniture should be used" [P1], but another withheld that "there is a few types of products that you need to be mindful about, products of a cultural historic perspective" [P2]. A furniture appraiser and conservator [P7] said that "Furniture is a form of document one can say, a source to our history". Nevertheless, six interviewees stated that some aspects could be lost by incompetent refurbishment, but that nothing should go lost if the conservator or restorer is experienced and careful and respects the designer's original vision.

At the same time, an interior designer [P9] highlighted the price difference between new and refurbished second-hand furniture. Consumers and procurers always expect a lower price for refurbished or remanufactured furniture, regardless if it is in the same pristine condition as new furniture.

In total, six of eight interviewees were mentioning the importance of preserving antiques by treating them carefully, and in some cases doing nothing to them. An appraiser stated that "if you have an object that is 200 years old with wear that is 200 years old and that is an original design piece, you simply do not touch that!" [P2]. Another interviewee said however that in some situations it is better doing something rather than nothing: "even if you are doing a drastic refurbishing it could be better than to throw something away" [P9].

Five out of eight people thought that it was important to be able to track the origin of the furniture after refurbishment. One interviewee found it not important [P2], and another thought that it could

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be good to know, but not very important [P7]. Three interviewees were talking about the historic or cultural value and that the furniture in a way is an expression of the time when it was made, which is not to be lost or erased. Two interviewees mentioned the importance of traceability from a constructional perspective, as it could allow for more knowledge about the product which would aid refurbishing or restoration that often can be tricky without information. Five interviewees were mentioning that some kinds of tags, stamps or documents with information about recommended restoration techniques or even a stamp historic stamp that informs about where it has been used. A conservator [P4] stated that their customers find a value in getting information about the history of the furniture. To for example being able to find a tag on the furniture that tells you that it originates from a mansion in Småland in south of Sweden, adds character and a story to the furniture.

To the question about remanufacturing or refurbishing furniture without the designer's or manufacturer's knowledge, all eight interviewees answered that they think it is good to take care of what is left and prolonging that life. When a manufacturer has sold the furniture, royalties have already been distributed [P8]. This means that it is up to the owner to do as he or she pleases; "Then you are free to do whatever you want with the furniture." [P8].

Two out of five interviewees said that it is always interesting to buy refurbished furniture [P6] [P5]. One of them said that it is possible to take "an old skeleton [or frame] to build on and create a fresh feeling." [P5]. One interviewee stated that designer furniture could be interesting, especially if it is "outside the trend cycles and has an intrinsic value by itself" [P3]. Three of the interviewees discussed the environmental upside to recycling and that it is a very current topic, and one [P1] even thought that the Swedish government and parliament in the future should make an example out of themselves and use pre-owned or refurbished furniture.

#### 6.1.6 Furniture that keeps or increases its value over time

Regarding what type of furniture can increase in value over time, the types of answers given can be divided into design and quality furniture, furniture that tells a story about its life as for example family heirlooms or other pieces that have an affective value for the owner, and antiques.

Most of the interviewees (7 out of 11) mentioned furniture from well-known designers that has become design classics, and how this furniture even after usage has a high retail value. The furniture often needs to be in pristine condition, but the value can also rise with tasteful, natural wear that has created patina. One interviewee [P4] describes the difference between natural wear and unnatural wear as "The natural wear stems from arms and hands and so on, whereas unnatural wear is created if you have an old chair which is made for a dining room, but instead you choose to use it in a public environment where people sit and rub their shoes against it, leaving black rubber marks behind, tearing it up and leaving discolorations." Two out of the interviewees said that design furniture keeps having a high value due to its often good materials and thought-out design. Five interviewees were talking about the importance of quality furniture, not necessarily by well-known designers but also by skilled furniture makers. One interviewee [P6] said that "Furniture that is workmanlike with decent material selection, construction and production: those types of furniture ages most often with much more dignity".

Some of the interviewees were talking about the trends today; at the moment, it is trendy to buy old classic design pieces, both to have at home and in public places, with the requirement that it needs

to be in good condition. This requirement is often connected to the fact that some of the models still are being produced and is therefore possible to get in mint-condition. An interior designer [P9] said that it often comes down to design: a good design is about the level of ambition that is put into the furniture and that the producers are trying to make something that has a lasting value.

Four out of the eleven interviewees were talking about furniture that has a story behind the aging and wear. One of the interviewees said "if you for example have an big old French peasant-style table that was made out of solid oak, people are willing to pay substantial amounts of money if it shows how previous owners have been chopping pieces from the table with a kitchen axe, or that oysters have been opened against the edge of the table or so on. The more it shows, the cooler it is" [P3]. The story behind an original, unaltered piece of furniture can be read as a document according to the interviewee, and can be seen as a type of provenance.

This is corroborated by that three of the interviewees named furniture made in old peasant society of Sweden as furniture that ages particularly well. The aspect of aging and wear was not seen as something unwanted in this case, and an appraiser [P5] even stated that the "furniture may even look worn out". Some furniture needs to look old to be able to sell; furniture made from massive pinewood for instance "should be a little bit dirty and grey, and really have a grey shimmer all over" [P5] to make it desirable on the Swedish market.

There is also an affective and emotional factor to take into consideration. Four out of the eleven interviewees mentioned heirlooms with affective values, and how memories surrounding the furniture affects the perceived value and making the owner want to hold on to it.

One conservator and appraiser [P7] stated that all antiques keep having value. The same person stated that it was a difference between how furniture conservators and antique dealers evaluate the condition of furniture, including degrees of wear, and how they handle them. "We often work with things that are going to be continued being used" [P7], whereas antique dealers often do not want any alterations at all. Both agree however on not removing patina and natural wear.

One of the interviewees [P10] said that materials that usually age well and get patina are wooden materials or metals. Another interviewee [P11] said that solid wood pieces which have an oil coating usually are perceived to change to the better with time and get patina. In general, solid wood was named several times regardless of the context for the furniture and its age.

A conservator and appraiser [P7] was talking about today's problem when it comes to wear on furniture from around the 50's-80's, as most of the wear is erased on demand from the buyers, which means that all patina is removed. "Many people keep making the same mistake we have been making throughout the ages, which is to refurbish objects too harshly and not let it age in peace." [P7]. "In 100 years we will curse as much over this [as when we removed paint from old peasantry furniture]" [P7].

#### 6.1.7 Material experience

As choice of material is fundamental when talking about aging and wear, the interviewees were asked both how they think materials in general age and wear as well as materials in a furniture context. Overall, natural materials were preferred over synthetic as they were perceived to age and wear better and felt more "authentic". Solid wood along with leather were materials consistently named as having the potential to improve with age, though some remarked that leather might not be the best option from an ethical point of view. Some natural fibre textiles, such as wool, and metals, like brass and copper, were also identified to be able to age gracefully, while plastics and some synthetic textiles like Polyester were said to age more poorly. Also mentioned by many of the interviewees was the fact that surface finishes have a great impact on the aging process and how materials wear over time, along with environmental factors such as temperature, humidity and exposure to sunlight.

In the following subchapters, the results of the interviewees' views on different materials are presented, first with focus on materials that age and wear well, and then on different advantages and disadvantages with materials that emerge over time.

#### 6.1.7.1 Materials which age well or value enhanced

The materials that were specifically named to age well are shown in Table 8 (in general) and Table 9 (in the context of furniture); full tables are found in Appendix G. The bracketed numbers show how many interviewees mentioned the specific material when asked the open question about how the material types age and wear.

D.A.a.t.a.t.a.l	
Material	Ages generally in a positive way
Metals	Aluminium (1), copper (3), bronze (1), steel (1), brass (1), stainless steel (1)
Wooden materials	Surface treated wood (1), untreated wood (1), pinewood (1), hardwood (1)
Natural fibre textiles	Cotton (1), linen (1)
Synthetic fibre textiles	Acrylic (1)
Ceramics	Porcelain (1), concrete (1), window glass (1), ceramics (2), ceramic glass (1),
	glass (1), tempered glass (1), bone porcelain (1)
Stone materials	Granite (1), natural stone (1), building stone (1)
Plastic and rubber	POM (1)

Table 8: Specifically named	materials when asked	l about aging and v	wear in a general application
, , ,		5 5	5 11

Material	Age well in furniture applications		
Metals	Brass (2), bronze (1), chrome (2)		
Massive wood materials	Beech (1), birch (1)		
Fibreboards and wood composites	Veneer (3), MDF (2), chipboard (1), plywood (2)		
Natural fibre textiles	Wool (2), linen (2), wool (2)		
Synthetic fibre textiles	Synthetic leather (Pegamoid) (1), nylon (1)		
Leather, skin and fur	Sheepskin (1)		
Ceramics	Concrete (1), glass (1), ceramics (3), porcelain (1)		
Stone materials	Granit (1), limestone (1), marble (2)		
Plastic and Rubber	Compact rubber (1)		

Table 9: Specifically named materials when asked about aging and wear in a furniture context

#### 6.1.7.2 Materials aging in a furniture context

The interviewees were asked how they thought the different material types seen in column 1 in Table 10 below age and wear in furniture applications. The answers have been divided between positive and negative aspects mentioned, and the bracketed numbers indicate how many interviewees mentioned the aspect. The full table can be read in Appendix H.

Material type	Positive aspects	Negative aspects
Metals	<ul> <li>Wear is barely visible, metals do not get worn the same way other materials do (3)</li> <li>Oxidized surfaces can be charming sometimes, especially brass (3) and copper (2)</li> <li>Chromed surfaces are better than painted in places exposed to</li> </ul>	<ul> <li>Painted metal can flake off and the paint can get worn down, which looks bad (6)</li> <li>Most metals oxidize which destroys the material in the long run (4)</li> <li>Can get matte surfaces (2)</li> <li>Trend sensitive -intellectual wear rather than physical (1)</li> <li>Oak and iron are not a good match since the galvanic</li> </ul>
Massive wood materials	<ul> <li>excessive wear (2)</li> <li>Ages beautifully (10)</li> <li>Wear, chipping and scratches are more acceptable on solid wood than on wood composites (4)</li> <li>Changes in colour over the years in a beautiful way (3)</li> <li>Possible to polish or sand a worn surface (2)</li> </ul>	<ul> <li>Soft wood scratches too easily (3)</li> <li>Should be surface treated (3)</li> <li>Can crack if too dry (2)</li> <li>Ugly with a yellow tone in the wood (pine) (2)</li> <li>Sensitive to moisture (1)</li> </ul>
Fibreboards and wood composites	<ul> <li>MDF is durable (2)</li> <li>Fibre boards do not move under veneers (1)</li> </ul>	<ul> <li>Age poorly (6), worse than solid wood (3)</li> <li>Veneers and lippings can come loose between layers (5)</li> <li>Bad if underlying layers are showing due to wear (3)</li> </ul>

Table 10: Su	mmarv of	positive and	d neaative	material	aspects t	for (	different	furniture	materials
10010 10. 50	i i i i i i i i i i i i i i i i i i i	positive une	incgutive	materia	uspects		ujjerene.	juiintuic	materials

Natural fibre textiles	<ul> <li>Wool has good durability, is strong, affordable and generally good furniture material (5)</li> <li>Linen is durable, good and used in furniture (4)</li> <li>A heavyweight, double-woven fabric can be reversed and used on the other side as well (2)</li> <li>Natural fibre textiles have a better tactile feeling than artificial fibres (2)</li> </ul>	<ul> <li>Textiles wear the fastest and are usually the one thing that gets replaced (2)</li> <li>Dirt and particles make them feel more worn and aged (2)</li> <li>Uneven sun bleaching is ugly (2)</li> <li>Wool can be abrasion sensitive and pilling of fabric can appear (2)</li> <li>Low quality fabrics get pilling and become ugly (1)</li> <li>Some natural fibre textiles do not resist wear as well as synthetic fibres and can begin to sag over time (1)</li> </ul>
Synthetic fibre textiles	<ul> <li>Generally, synthetic fibres do not wear as quickly as natural fibres (4)</li> <li>Choose textiles with suitable Martindale values. (2) Can be very durable (2)</li> <li>Synthetic leather, Pegamoid, is durable and has ethical advantages to real leather. (2)</li> </ul>	<ul> <li>Dirt and particles can make the textiles look more worn that they are (3)</li> <li>Plastic foam padding can pulverise with time and become dangerous to breathe in (2)</li> <li>Age more poorly than natural fibre materials (2)</li> <li>Often impregnated with flame retardants if used in public environments, which can be health hazardous (1)</li> </ul>
Leather, skin and fur	<ul> <li>Age beautifully, live long and can get patina if maintained (11)</li> <li>Aged leather is more beautiful than new (2), can increase in value over time (1)</li> <li>More hard-wearing than textile (2)</li> </ul>	<ul> <li>Can get dry and crackle (3) and must therefore be maintained and lubricated regularly (3) as it is difficult to mend</li> <li>Skin does not withstand direct sun light (2)</li> <li>One stain on otherwise clean leather destroys the overall impression (2)</li> <li>Unethical (2)</li> </ul>
Ceramics	<ul> <li>Age beautifully and slowly (4)</li> <li>Concrete ages beautifully (3) if surface treated with e.g. wax (1)</li> <li>Surface treated ceramics can bleach in a beautiful way (1)</li> <li>Possible to sand concrete (1)</li> <li>Hardened glass and ceramics do not scratch as easily (1)</li> </ul>	<ul> <li>Looks bad if it chips or scratches (4)</li> <li>Glass can crack suddenly without showing any signs of weakness (1)</li> <li>Glass can grow matte and lose its lustre (1)</li> <li>Concrete scratches easily and needs to be surface treated to withstand humidity and acids (1)</li> <li>Metals scratch glass and the combination should therefore be avoided (1)</li> </ul>
Stone materials	<ul> <li>(Barely) wear, erode and age beautifully (7)</li> <li>Granite withstands most (1)</li> <li>The surface can be impregnated with different types of soaps to make it more durable (1)</li> <li>Marble can endure many centuries and still look good (3)</li> </ul>	<ul> <li>Some stone types easily become speckled/stained, get marks and are vulnerable to acids (5)</li> <li>Porous kinds, such as marble and lime stone, need to be surface treated (1)</li> <li>Matte granite surfaces need to be oiled regularly to look fresh (1)</li> <li>Using some rare types of stone depletes the crust of the earth (1)</li> </ul>
Plastic	<ul> <li>Some plastic products and surface coatings made of plastic are very durable (4)</li> <li>High quality plastics can age well (4), e.g. POM (1)</li> <li>In many cases possible to melt down and recycle (1)</li> </ul>	<ul> <li>The material becomes brittle over time (6)</li> <li>Generally age poorly, not as durable as wood and metals (5) and can turn yellow over time (2)</li> <li>Vulnerable to sunlight and heat (4)</li> <li>Plastic foam and cold foam in paddings can harden and pulverise, making them harmful to breathe in (4)</li> <li>Some plastic coatings on fibre boards age badly, e.g. plastic paint that peel off in large flakes (3)</li> <li>Gets easily scratched and is difficult to mend (3), e.g.</li> </ul>

		PP, PS, ABS
Rubber	<ul> <li>Rubber does not get the same kind of visible scratches as plastic materials do (2)</li> <li>Rubber ages slowly in an indoor environment (2)</li> </ul>	<ul> <li>Dries, grows brittle and breaks (6)</li> <li>Vulnerable to heat and sunlight (2)</li> <li>Not possible to restore or mend (2)</li> <li>Gets easily dirty (2)</li> </ul>

#### 6.1.8 Designing furniture with aging and wear in mind

Three different aspects were frequently mentioned when asked about how to best design with aging and wear in mind: (1) a good and thought-out construction, (2) high quality materials and (3) a design or look that had the potential to become classic. In fact, everyone named construction and material choice to be crucial factors, while half also noted that those factors were of little use if the design, or look, of the furniture did not have the capacity to withstand changing styles and trends. "It is possible to make products that last for a very long time, but then you have to want to keep them as well. [...] Designing with the aim of making classics is an important part, but something only very few actually succeed with" [P11]. Another interviewee was of the same opinion: "Sustainability has a lot to do with design. The difficult thing is to create furniture that not only is sustainable in regard to its materials and structure, but also in its look and style" [P1].

Regarding what signifies a timeless, classic design, a designer said that a balanced form was central. "The essence of the furniture can be found in the shape and form, the balance, the details, the proportions, the lines and the meetings between two different materials - that's where you can tell if a product has quality; if the meetings are beautifully executed" [P8].

Material meetings and joining methods were also frequently mentioned in connection to important constructional aspects. Many mentioned that it is important that the materials are separable, both to facilitate reparation but also for recycling purposes. Especially glue is named as something to be used with caution as it often is difficult to undo. "There are many ways to construct without using glue, for example it's possible to weave a seat cover to keep the whole frame together" [P5]. Another conservator stated that the wood glue that most often is used is stronger than it needs to be, leading to the wood splitting rather than the seam making it much more difficult to mend [P7].

One interviewee mentioned that sharp edges should be avoided on the frames of upholstered furniture as they wear down the textiles. "Bigger radiuses on edges are better as they don't wear down as fast [...] but might be difficult to apply in reality as designers tend to prefer sharp lines and clear-cut edges" [P11].

Modularity in the construction was also mentioned by some, stating that this would facilitate both maintenance and refurbishment and make it possible to update the appearance of the product over time. "As a product, furniture is well suited for this as you already from the start work with components; often you look at furniture as parts you combine o to a whole. So a lot of furniture is already modular and possible to disassemble and reassemble. In the case of furniture, you also have an advantage over more complex products where you use more composite materials and build in problems from the start" [P10].

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Concerning material choice, the common opinion was that one should invest in materials that hold up over time and are of high quality. "Choose materials that are easy to restore" [P7], "use pure, unalloyed materials" [P10] and "avoid unethical materials" [P2] were also some expressed opinions. One designer argued that it is good to combine different materials in chairs for public environments, as the parts are exposed to varying levels of wear and tear. Wooden legs on chairs might not work in the most severe environments, requiring perhaps legs made out of metal. "As a designer you also have to choose the materials that work best from a sensory perspective for the one who is going to sit in the chair. Different materials can feel warm and cold to touch and so on. For armrests, one might choose wood or leather rather than textiles, as they withstand dirty and greasy hands better in the long run" [P8].

Maintenance and cleaning of furniture also play important roles. Nowadays, the cleaning companies hired by the public sector or private businesses do not have the knowledge needed to maintain and clean the furniture in the best way according to some of the interviewees. Often polishes that damage the surface finishing are used, with some containing silicon crystals that also damage the underlying furniture material. One designer maintained that there still are ways in which designers can help prevent some of the worst sullying that takes place in public environments: "by not having a gap between the seat and the back rest – something most furniture manufacturers think of and apply today – can help avoid dirt and other things accumulating there. People have a tendency to hide things there when feeling stressed or if they don't know where the closest litter bin is. We do so many funny things, which is why you should look at what people actually are doing rather than what they are saying" [P8]. The same thing goes with other parts of the furniture: one should seek to eliminate or redesign parts collecting dust and dirt. Regarding textiles, they often are the first to get dirty and unclean. To somewhat hide, or camouflage, the stains and dirt it is recommended to use patterned rather than monochrome fabrics. This goes however against current trends favouring uniform and unicolour surfaces [P8].

# 6.1.9 Summary of types of wear and how they can affect the value of the furniture

During the interviews, the experts mentioned many different types of aging and wear. Figure 10 shows all the different types of wear that have emerged in the interviews with experts and professionals as well as from previous information gathering phases such as the literature review, the market analysis and the basic mapping. In the illustration, the different types of wear are sorted according to how deep into the material they reach, which often also correlates to how severe damage they cause to the product's material. The green colour indicates that the type of aging or wear is connected to textile materials, and the purple that it might only consist of an external coating that is easily removed without any lasting effects on the material or its surface.



Figure 10: Different types of wear mentioned by interviewees

During the interviews, the term "natural wear" was often used to describe wear stemming from frequent use that was found charming rather than damaging. Specific types of wear mentioned regarding natural wear was worn armrests, for example if the surface finish had gotten patina or if wear on solid wood made the grains show. To be perceived as natural, the wear cannot be glaring, like a single scratch that is clearly visible, or damaging like a discolouration on the seat. The natural wear must also fit the style and quality of the furniture; on some furniture that are meant to be kept in mint-condition all wear is perceived negatively despite its source or nature.

A simple illustration was made based on the impression the authors got from the interview results regarding the effects on the value of the furniture of natural and other types of wear, see Figure 11. In the interview study, it was made clear that aging and wear had different effects on high-quality furniture and low-quality furniture, which was also attempted to visualise in the diagram. As can be seen, only high-quality furniture can increase its value with natural wear, while damaging wear reduces the value. As evenly worn furniture is tolerated more than furniture with glaring wear, the value loss is slowed down after the first visual signs of wear as more wear appear, hiding the glaring wear. That furniture can be refurbished and upcycled is illustrated with the dotted arrows, where removing the signs of aging and wear moves the furniture closer to its initial value, while upcycling, by changing type of upholstery or improving on the design for example, even can help increase the initial value of the furniture.



Figure 11: How value can change over time depending on the type of wear

## 6.2 Discussion of the results of the interview study

#### Consumer behavior and purchasing practices

The general trend right now has become focused on low prices as that is the consumer demand. A result is that the quality is being compromised and low-quality materials are selected. That furniture more and more has moved towards consumer goods is a serious sustainability issue; often it is bought with the intention of not lasting very long as it is going to be replaced with something new and fresh in a couple of years anyway. There are however those that are willing to pay more for quality furniture if it also lasts longer, but for circular furniture flows to play a bigger role than today, this segment must increase. Investing in a piece of quality furniture not only gives long-lasting furniture, but also the opportunity to resell it when it is not wanted or needed any more, which is not the case with cheap, low-quality furniture. To change this consumer behaviour will be a challenge for producers and retailers.

Cost is also an issue when it comes to public contracts. Often, the alternative that is the less expensive but still meets the specification of requirements is chosen. To allow for longer lasting products with better materials, the furniture must also be allowed to cost more. This makes it relevant to look over how different criteria should be valued, with greater focus on quality, sustainability and reselling value.

Organisations and businesses that understand the upsides of investing in long-lasting furniture will be able to drive the market more towards circularity. One key factor is to inform about circular opportunities and give alternative options, for example new business models for sharing furniture, to make it easier to make informed decisions. One should know all or at least some of the options before making a decision.

#### The attitude towards furniture in the public sector

The attitude seems to be based on expectations. Tax funded organisations are expected to not spend too much on furniture and interiors as that sends a message that they are not focusing on their main functions and services, while private companies and banks are required to look proper and prosperous. These expectations could be interesting to have in mind when analysing the data from the perception study. The data from the interviews could explain why people are thinking the way they are thinking, or at least it would be interesting to compare the results from the perception study with the interview conclusions. This will further be investigated during part 1 and 2 of the perception study.

#### Most common types of wear on public seating furniture

When it came to which type of wear is common on public seating furniture, dirt and wear on seats were named as the most common and the most important. The parts of the chair that were named as the most exposed to wear and tear were the armrests and the seat. This was not unexpected since those areas are contact areas frequently subjected to friction from people sitting down and touching them. What would be interesting to examine further is how big impact these common types of wear has on the users' overall impression of the chairs, and whether they are important to remedy. This was therefore further examined in the perception study.

#### Acceptance of aging and wear

It was deemed interesting to collect data about how much wear users tolerate before it is unacceptable, but this part was challenging to explore in the interview study. Without concrete examples of aging and wear to show or a context for the furniture, there was no common ground for the interviewees and interview conductors. The level of acceptance was hence decided to be further investigated in the Perception study; during Part 1 and 2 visually and in Part 3 more theoretically. The result from the interviews indicated that people have high expectations on the condition of public chairs, and that only little or no wear is found acceptable. It was considered interesting to see if the result of the perception study corroborated this.

#### Attitudes towards reusing and refurbishing

To make it possible to design furniture that will last for a long time in a circular economy, it is important to understand people's attitude towards circulating furniture by sharing, reusing or refurbishing for example.

Consumers are in general not motivated to refurbish furniture, unless it has high inherent value or an affective value. Often it is considered cheaper or more convenient to simply buy new furniture rather than refurbish it. If refurbishing is considered, it seems however to be the last resort and done only when the furniture has broken and stopped functioning properly. Companies and the public sector seem to replace rather than to fix broken furniture, which means there are both huge economic and environmental potential benefits. Adopting circular business models where unwanted furniture were resold, either refurbished or "as is", or furniture and interiors were rented and properly maintained as a service to prolong lifetimes, could provide new sources of returns for both buyers and vendors.

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#### Furniture that keeps or increases its value over time

Since all the interviewees were talking about quality furniture, particularly design classics: what do design classics have that other pieces of furniture do not? Good material choices, quality production and a good, or even timeless, design are some answers to this question. When it comes to the design it is important that the creator has made an effort and aspired to make a product that is going to last and allows for recirculation. The same goes for material selection, where it is important to choose materials that will age well and be possible to recycle once no longer fit for use. A clever design which has taken the wear and the need to replace worn or broken parts into consideration makes the material recycling process easier and therefore also more likely to take place.

Some of the experts and professionals interviewed were talking about patina. From their description, it is obtained by gentle and natural wear over many years of use. The question is if that kind of wear is suitable, or accepted, in a public sector? The experts were saying that people want the furniture at the work place to be clean with as little wear as possible, preferably in "as new" condition, no patina will have the possibility to appear. That will erase all evidence of culture and wear from the furniture's life time, and in the future there will not be any provenience left at all. That has been the case with modern design pieces from 50'-80's were people are erasing all types of wear to make it look like new again.

#### Material experience

The results show that natural materials seem to be preferred over synthetic, with most of the interviewees stating that solid wood and leather age most gracefully. This was not entirely unexpected, as the literature review had indicated the same preferences.

As the aim was to collect qualitative data without steering the interviewees in any direction, the questions were open-ended and explorative. This meant the gathered information was not able to be analyzed in a statistical way, but was rather used to point out advantages and disadvantages with the materials that emerge as time passes. Therefore, the bracketed numbers showing how many interviewees said a specific aspect should not be taken as direct indicators for the importance of the aspect, but are rather used to give the reader a feel for how wide-spread the notion was among the interviewees. Something which only one mentioned could be just as important as something many mentioned, as the others could have forgot or omitted to mention that aspect.

The interviewees' answers show that material selection is a complex task, often involving trade-offs. No materials stand out as the best for every application, why it is important when designing the furniture to think about where and how the furniture is going to be used.

#### Designing furniture with aging and wear in mind

It is no small task to make the perfect designed piece of furniture. There are many aspects to take into consideration, which is a challenge for designers. Making a good and thought-out construction with high quality materials and a design which has the potential of becoming a design classic is hard to achieve, but one can always aim for that and make mindful decisions. A lot of research has been done on making production, material selection, transports etc. more sustainable, but not much has been done with the focus on look and style when it comes to design. The interviewees stated that making a design which will still stand style-wise after decades is as important as anything else to make furniture last for a long time; if the furniture is durable but no one wants to keep it, the furniture will be thrown away despite all its good qualities. But the question is: how does one make a durable, non-time sensitive, aesthetically pleasing design?

## 6.3 Interview study conclusions

In Table 11, the most important conclusions and insights from the interviews with experts and professionals can be seen. Some of these became direct input to the guideline, while others laid the foundation for further research in the perception study (see subchapter 6.3.1).

#### Table 11: Summary of general conclusions drawn from interviews with experts and professionals

Interview results	Conclusions
Quality furniture with good materials, construction and design lasts longer and withstands multiple uses as its embedded value remains high.	Design high quality furniture without omitting any of the aspects materials, construction and design.
Market demands low prices.	Public contracts must allow for more expensive quality furniture which can last for a long time
Style and modern design is often prioritized over quality when buying new furniture + furniture is most often discarded for aesthetical rather than functional reasons.	Important to think about style and trends, but avoid designing trend sensitive furniture that easily become outdated; timeless designs or flexible furniture that can be updated over time stand a bigger chance of surviving longer.
Natural materials age better than synthetic + public environments demand more durable materials (than the natural) + requirements set on public furniture (regarding e.g. flame retardants) often makes them more difficult to recycle.	Material choice is important but difficult. Choose materials according to the needs and demands of the environment where the furniture is going to be used, and choose as uncontaminated materials as possible to facilitate recycling and reuse. Opt for less durable materials or surface finishes if they can be maintained and recycled, rather than durable but unhealthy or unrecyclable materials or finishes.
Glaring wear is unacceptable.	Repair or refurbish as soon as glaring wear appears to keep the furniture in acceptable condition.
Contact surfaces such as seats and armrests wear faster.	Either use more durable materials, thicker layers or design for easy reupholstering and refurbishment on contact surfaces.
Users have higher requirements regarding the freshness of textiles and upholstery than for other parts.	Make sure seats are in clean and good condition to avoid user dissatisfaction.

Dirt and stains can be at least as damaging	Keep the furniture clean and tidy as this greatly
to the user perception as actual wear and	improves user perception and can help prolong the
tear, but are often easier to remediate.	initial lifespan.
Natural wear and tear can sometimes help	In contexts where mint-condition is not a
tell the history of a piece of furniture, and	requirement, natural wear and patina can add value
in the right context this can add value.	to furniture and should not be removed.
The general attitude toward refurbishment	More opportunities for circular furniture flows will
and reuse is positive and the trend is	arise, requiring the design and manufacture of
moving towards more circularity.	furniture that is able to withstand repeated
	circulation.
The maintenance and cleaning of furniture	Design furniture that endures detergents or that is
is often causing damage to its surfaces.	easily cleaned without strong cleaning products. Self-
	cleaning designs can allow for the furniture to be
	cleaned less often.

#### 6.3.1 To be further investigated in perception study

One of the most reoccurring comments was that wear was no longer acceptable if there was some sort of damage that stood out from the rest, for example a deeper scratch, a circle stain from a mug or a ragged part of a textile covering. Furniture that was evenly worn or aged was more tolerated, even though the wear and tear was quite extensive, but glaring wear could ruin the whole piece. For this reason, it was deemed interesting to further examine what constitutes glaring wear and at what point acceptable wear turns unacceptable. It was to make observations and interviews during the perception test to catches where people tend to look when examining the condition of furniture. More about this can be read in Chapter 7. It is further interesting to get an understanding for what glaring wear looks like in practice, and how much visual wear makes the furniture stand out.

Another aspect that became apparent in the interview study was that different types of wear were tolerated to varying extents. It was therefore decided that the perception study also should include a part where the participants would grade how severe they perceived different types of wear to be. This would allow for more accurate evaluation of the results as the answers could be weighted accordingly.

Natural wear is from contact areas from the user, for example from hands and arms. Is that accepted by users in a public sector? Is patina interesting for a public sector? What do people think about wear that is described as patina by experts and professionals? Do they have the same way of looking and appreciating aging and wear on furniture?

When it comes to user perception and experience, do experts and professionals focus on same types of visual wear as in theory, from the interviews, as the participants during the perception tests?

# 7 Perception study

This chapter will describe the perception study and its three different parts. The procedure for the perception tests as well as the results will be presented, followed by analysis, discussion, and conclusions.

## 7.1 Study design

To be able to study people's more "objective" perception of variations in levels of wear and tear and at the same time examine as many different types, materials and types of wear as possible, it was decided that the perception tests would be divided into separate parts. In order to determine how important the participants regarded the different types of aging and wear to be when assessing the condition of furniture, it was also decided that the study should be concluded with a questionnaire examining the importance, or severity, of the different types of aging and wear. This resulted in three parts, see Figure 12. Each of the parts was designed to be performed individually by the participants, one participant at a time. All three parts where conducted on the same day, in some cases the order of Part 1 and Part 2 was switched due to time constraints, but every participant ended with Part 3. All participants did however all the parts. More information about the three parts can be seen in the following subchapters.



Figure 12: The three parts of the perception study

#### 7.1.1 Part 1: Same model

Part 1 sought to examine the participants' acceptance towards different kinds and levels of wear in furniture, while trying to minimize the influence of style and taste by only including chairs of the same models in the assessments. This was done in the hope that the variations in the opinions about the different chairs would only relate to their condition and not also to their style. Two different models of upholstered chairs for public environments were chosen, with the aim of covering as many materials and types of aging and wear as possible. The first model was a painted (three in white, four in red), wooden chair without armrests and with synthetic upholstery and the second model was a clear-coated, wooden chair with armrests and a textile covered seat (see Figure 13). Within each model, seven chairs with varying kinds and levels of wear and tear were chosen, resulting in a total of 14 chairs to be assessed in Part 1. The chair models were placed separately, seven chairs in each group. For more detailed descriptions of the chairs, see Appendix I.







To quickly find out how acceptable the participants found the different chairs, the assessment begun with a simple task of selecting chairs in answer to the question of "Which chairs would you consider choosing, in their current state, for a workplace in the public sector?" The selected chairs were noted by the observer and then followed with the question of whether the decision was based on style preference or on the condition of the chairs. After this, each participant examined each chair individually and fill out a form (see Appendix C) assessing how acceptable they found different types of aging and wear to be that occurred on the chair in question. These types of aging and wear were divided between if they were located on the frame or on the seat of the chair in order to get as complete answers as possible. Finally, each chair was assessed on their overall appearance, giving it a grade from 1-5 where 5 would be excellent and 1 very poor.

#### 7.1.2 Part 2: Different models

Part 2 was to get an understanding for how people assess and look at furniture, in correlation to what they think is acceptable and unacceptable wear. To get their subjective opinion of the severity

#### Perception study

of the wear, questions were asked continuously by the observer. Eight different models of upholstered chairs for public environments were used in the assessment to get as broad a sample as possible of different materials, furniture shapes and types of wear. A compilation of the chairs can be seen in Figure 14; for more detailed descriptions see Appendix J.



Figure 14: The eight different chairs used in Part 2

Like in Part 1, the test commenced with the question "Which chairs would you consider choosing, in their current state, for a workplace in the public sector?" After the observer had noted the answer, the participant got to look at each chair individually and explain why he or she did or did not chose the chair in question, after which follow-up questions were asked. The protocol used to note the answers can be seen in Appendix D.

As a bonus, portable eye tracking glasses of the model *Tobii Pro Glasses 2* were used by the participants during the whole test to collect data about where the participants looked and what seemed to draw their attention. If time for analysis would be available, this would provide the possibility to more accurately determine where they looked and what seemed to be the most glaring wear.

#### 7.1.3 Part 3: The severity of different types of aging and wear

To get an understanding for which types of wear that are more accepted than others, a final questionnaire was made for the participants to fill out in Part 3, see Appendix E. The aim was to examine the participants' perception of the severity of different types of wear and how important it is that said wear does not occur in public seating furniture. As the interviews made clear that wear can be perceived differently depending on its location on the chair or what material it shows on, the

decision was made to separate the wear and aging related to the frame of the chair and that related to the part of the seat, as was done with the form in Part 1.

### 7.2 Subject Sample

In total, 17 people participated in the perception study. Out of these, six were considered as "amateurs" or "users" while the rest, 11 people, were considered "experts". The group experts included both participants who worked in the furniture business or who either studied or taught furniture related topics. Amateurs, in this case, were the participants without any background in the furniture business, but who daily come into contact with public furniture in some form.

Out of the 17 participants, only six were women. They were however a majority in the user group, where four out of the six users were women. Regarding the age distribution, the oldest participant was 71 years old and the youngest was 25, and the average for all participants was 48 years. For more information about the participants, see Table 12.



Table 12: The gender and age distribution of the participants

## 7.3 Results and analysis Part 1: Same model

In this chapter, both results and analysed data for Part 1 of the Perception study are presented. The ANOVA diagrams and the calculated correlations in this chapter and in Appendix K have been produced in cooperation with senior researcher and project supervisor Siv Lindberg at RISE Bioeconomy.

#### 7.3.1 Selecting acceptable chairs out of the same model

The answers to the question "Which chairs would you consider choosing, in their current state, for a workplace in the public sector?" can be seen in Figure 15. Out of the chairs 1-7, the red chairs scored much higher than the white ones with 26 votes in total compared to thee for the white ones. Chair 6 was the most preferred one with 12 votes, followed by chair 4 with eight. Concerning chairs 9-15, chair 12 was the clear winner with nine votes, almost double as many votes as the other chairs combined.
Perception study



Figure 15: Chosen chairs, Part 1

When asked about what the selection was based on: style, condition or both aspects, style was the ruling reason for chairs 1-7 while condition was the main reason for chairs 9-15, see Figure 16. This combined with the fact that chairs 1-7 received more than double the votes the chairs 9-15 did (see Figure 15), could indicate that the participants from the start preferred the 1-7 model (especially the red type), while they did not especially like the 9-15 model and did not choose as many of them for that reason, only the one in the best condition. Chair 1-7 had a divided result when it came to the reasoning behind the selection, as nine participants said style, six said condition and two said both (see Figure 16). Either the deviation in colour was a contributing factor or the participants simply had strong opinions about the visual aspects, such as style. Five out of the participants did not choose any of the chairs 9-15, while only two did not choose any of the chairs 1-7. Chairs 11, 13 and 14 that received zero votes were all in very poor condition, with torn and dirty fabrics.



Figure 16: What the participants based their votes on

### 7.3.2 Evaluating the conditions of chairs 1-7 and 9-15

A repeated measures ANOVA was performed with "type of chair" as the dependent categorical variable and the acceptance ratings of *wear, bleaching* and *dirt* on the seat (prefix "T") and *wear, scratch* and *dirt* on the frame (prefix "B"). In Figure 17 and Figure 18, mean values and 95 % confidence intervals are plotted for each variable. The chairs varied a little more regarding the condition of the seats than they varied regarding the condition of the frames, as can be seen from the generally flatter curve and larger confidence intervals in Figure 18. In general chairs 1-7 have gotten higher scores than chairs 9-15. This matches the authors' assessment of the general conditions of the two different models; chairs 9-15 were generally in poorer shape, many with torn fabrics. Overall, chairs 4 and 6 have gotten the highest scores, and are significantly better regarding bleaching on the seats (T\_bleach) than the others. There are however overlapping regarding the variables wear on seats (T\_wear) and dirt on seats (T\_dirt) with the chairs 5, 7, and 12. On the frames, chair 1 was significantly worse than chair 4 and 6 with respect to wear and scratches (B\_wear and B\_scratch), and chair 8 and 10 was judged to be dirtier than the highest rated chairs (B\_dirt) (Figure 18).



Figure 17: ANOVA of the chair seats of Part 1. "5" denotes a "very good" condition and "1" is "very poor".

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Wilks lambda=,16756, F(91, 1355, )=4,9413, p=0,0000 Vertical bars denote 0,95 confidence intervals

Figure 18: ANOVA of the chair frames of Part 1

Comparing the chairs the participants first selected as acceptable for a work place in the public sector (Figure 15) with the mean values and variations shown in Figure 19 for the overall assessments of the chairs, they conform to one another. Chairs 4 and 6 were the highest rated regarding overall condition, however in reversed order, and out of chairs 9-15 numbers 12 and 15 received the highest scores. However, in the total assessments chair 5 got much higher grades than would have been expected considering it only got picked once in the selection task. This might be due to it – despite being in a similar condition to chair 6 at least wear-wise - not showing the graining of the wood like chair 6 which many found attractive, leading to chair 4 (which was in better condition) and chair 6 to get picked over it.

Concerning chair 2, they received a similar or lower grading on their overall condition than the other white chairs 1 and 3, despite being the only one of them to be selected. This might be due to the aspect of "even wear" mentioned by the interviewees: despite being as or even more worn than chairs 1 and 3, chair 2 does not have the same types of glaring wear as chair 1 (single white mark on seat) and chair 3 (half a circle mark on the seat) (note: not all participants looked at the back of the chairs where chair 2 had glaring marks). Corroborating this idea is the fact that one participant while selecting the chair stated that he thought the furniture was "nicely worn".



Figure 19: ANOVA of the total assessments of the chairs 1-15

The Likert scale (an ordinal scale) that was used in the questionnaires, requires Spearman Brown rank correlations to be calculated, see Table 13 (see Appendix K for correlations for each chair). The overall conclusion from this is that dirt on the frame (B\_dirt) has the highest correlation with the total assessment. This is surprising as the interview study pointed more towards the necessity of clean and tidy upholstery than a clean frame, but the fact that chairs 9-15 were extraordinarily dirty on the frames could have influenced the overall correlations for all chairs.

Dirt and wear on the seats (T\_dirt & T\_wear) had however the highest correlations to the total assessment after dirt on the frame. The only variables not showing significant correlation with each other were bleached seat (T\_bleach) and wear on the frame (B\_wear).

All Groups S	All Groups Spearman Rank Order Correlations (CM_Mom2_1_15) MD pairwise deleted Marked correlations are						
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total
T_wear	1,000000	0,390985	0,771446	0,350748	0,380039	0,623287	0,667928
T_bleach	0,390985	1,000000	0,441083	0,065870	0,170954	0,202947	0,263873
T_dirt	0,771446	0,441083	1,000000	0,394078	0,369971	0,661021	0,680684
B_wear	0,350748	0,065870	0,394078	1,000000	0,659305	0,499958	0,594709
B_scratch	0,380039	0,170954	0,369971	0,659305	1,000000	0,595763	0,619017
B_dirt	0,623287	0,202947	0,661021	0,499958	0,595763	1,000000	0,804414
Total	0,667928	0,263873	0,680684	0,594709	0,619017	0,804414	1,000000

Table 13: Spearman Brown rank correlations for all chairs (1-15)

### 7.3.3 Observations during Part 1

During the tests, observations were also performed. The way the participants looked or approached the chairs were noted, for example if they only looked at the chairs from the front or if the also looked at the backsides; if they touched them or even sat in them; and if something special was said about the chairs. One aspect that did not show in the questionnaire answers for Part 1, but that stood out during observations, was that people who tried out the chairs did not choose Chair 12 like everyone else as they could feel how rickety it was. Even though it looked like being in an acceptable condition, the ricketiness quickly made people who noticed it disregard the chair.

Another observation was that people quite quickly assessed the condition of the seats but needed more time looking at the frame for assessing its condition. As one seldom goes about turning and inspecting a chair from every angle before sitting on it, this would suggest that the seats play a more significant role for the users' initial perception of the chair. If the seat is in acceptable condition, then most users are satisfied with that and do not continue looking for faults (except when asked to like in this case). It also goes the other way around: if the condition of the seat is really poor, then that is enough for a dismissal of the whole chair.

### 7.3.4 Differences between experts and amateurs

The results show that amateurs and experts tended to differ in their overall assessments, as the experts were more lenient regarding the severity of ageing variables in Part 1. The difference between the mean values for their total assessments of the condition of the chairs are however not significant (Figure 20). The differences are significant though when it comes to bleaching and dirt on seats (see *Figure 2* and *Figure 3 in* Appendix K), as the experts rated the chairs much higher regarding these variables than the amateurs did.



Figure 20: The difference between the amateurs' (A) and the experts' (E) assessments of the overall condition of the chairs 1-15 (on the scale from 1-5, were five is very good)

### 7.4 Results and analysis Part 2: Different models

In this chapter, both results and analysed results for Part 2 of the Perception study are presented.

### 7.4.1 Selecting acceptable chairs out of different models

As can be seen in Figure 22, there was no significant difference between the chairs A-H (Figure 21) when the participants were asked to select the chairs they would accept in a lunch room or work place. The ones that were selected the most were chair C and chair H (Figure 21) with eight participants choosing them each, and the chairs chosen the fewest times were chairs B, E and F with five votes each. However, for many participants the acceptability of the chairs was not primarily based on their condition, but on other factors. Three of the participants (two amateurs and one expert) only selected chairs with armrests as they wanted them, while three others (one amateur and two experts) opted for chairs without armrests as they would be "in the way" in a lunchroom with tables. Another three (all experts) based their decisions primarily on style and whether they liked the design or not, and one expert on how comfortable he thought the chairs were.



Figure 21: Chairs of Part 2. For more detailed pictures, see Appendix J.



Overall assessments of the conditions, mean values



Figure 22: Votes per chair A-H and their assessed condition, respectively.

### 7.4.2 Evaluating the conditions of chairs A-H

The most common opinions expressed regarding the chairs A-G can be seen in Table 14.

Table 14: Most common opinions expressed for each chair. The numbers in brackets show how manyparticipants mentioned the aspect/opinion in question.

	Positive comments	Unclear	Negative comments
	Stable construction (1)	Marp fabric (F)	Loose fabric (6)
A		worn rabite (5)	Outdated fabric (4)
В	Fresh/ good condition (7)	Worn armrests (10)	Bad colour combination (4) Backrest inclination too steep (4)
C	Fresh/good condition (5)	Worn armrests (13)	Dislikes the surface finish (9)
D	Fresh/good condition (12)		Ugly design (7) Dislikes the fabric (5) Dislikes the chromed surface (4)
E	No significant answer	Worn armrests (13)	Dislikes the colour of the fabric (6)
F	No significant answer	Worn fabrics (4)	Loosening joints (14) Dislikes the fabric (4)
	In good condition avaant for		Stained fabric (9)
G	the fabric (7)	Worn fabric (6)	Boring fabric (6) Boring with the metal (5)
н	In good condition except for the fabric (9) Playful/good-looking design (8)	Worn upholstery (17)	Needs reupholstering (8)

Based on the comments and selected chairs and the ranking based on the assessed conditions of each chair, the authors attempted to create a scale of acceptance for the chairs A-H, see Table 15. It seems like loosening joints, wear on armrests, worn fabric and other types of wear or outdating relating to the seat are factors that make the condition of a chair to be seen as "worn". As opinions of the chairs differed greatly and not all made their assessments of the chairs based on their current conditions, the ranking was however difficult and only the best and the worst of the chairs were identified.

Chair		Times selected	Average (A+E) 1-5	Type of negative comment	Positive comments	Acceptance (condition based on wear)
	D	7	3,6	Style (disliked)	Fresh/good condition (12)	Most acceptable
	A	7	3,2	Condition (worn) and style (disliked)	Stable construction (4)	Somewhat acceptable
	н	8	3,1	Condition (worn)	In good condition except for the fabric (9) Playful/good-looking design (8)	Somewhat acceptable
	В	5	3,5	Style (disliked), construction and condition (worn)	Fresh/ good condition (7)	Somewhat acceptable
	с	8	2,9	Condition (worn) and style (disliked)	Fresh/good condition (5)	Somewhat acceptable
	G	6	3,0	Condition (worn) and style (disliked)	In good condition except for the fabric (7)	Somewhat acceptable
	E	5	3,0	Condition (worn) and style (disliked)	No significant answer	Somewhat acceptable
	F	5	2,1	Condition (worn) and style (disliked)	No significant answer	Unacceptable

#### Table 15: Acceptance levels of the chairs A-G

# 7.5 Results and analysis Part 3: Acceptance levels for different types of aging and wear

In this chapter, both results and analysed results for Part 3 of the Perception study are presented. The column graph with standard deviations has been produced in cooperation with senior researcher and project supervisor Siv Lindberg at RISE Bioeconomy.

Ricketiness is the type of wear which is seen as the most unacceptable, closely followed by splints in frame and tears in fabrics on the seat (see Table 16). The type of wear which is seen as more acceptable (all with mean values under 3,5) is colour changes on the frame, pilling of seat fabric, scratches on frame, wear on fabric, colour changes on textile (see Figure 23).

Interesting to point out that there was some difference between the amateurs and the experts. Amateurs thought that dirt/coating/stain on the frame was more acceptable (ranking 10) than the experts did (ranking 5), see Table 16. Experts thought that loose/flappy fabrics was more acceptable

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(ranking 10) than the amateurs (ranking 4). The amateurs' ranked soiled surface on frame, stains on seat, frayed fabrics and loose/flappy fabrics at the same ranking (ranking 4).

Table 16: Total ranking of the types of wear that are least acceptable (a high ranking mean values the type of wear is considered severer, low ranking mean values the wear is more tolerable). Red indicates that the wear appears on the frame and blue that it appears on the seats.

	Type of wear	Total ranking	Experts	Amateurs
Frame	Ricketiness	1	1	1
Frame	Splinters (chipping)	2	2	2
Seat	Tears	2	2	2
Seat	Soiled surface	4	4	4
Frame	Dirt/coating/stains	5	6	4
Seat	Stains	6	8	4
Frame	Peeling surfaces	7	10	4
Seat	Frayed fabrics	8	9	8
Frame	Crackling surface	9	5	10
Seat	Loose/flabby fabrics	10	7	10
Seat	Crackling/cracks in e.g. leather	11	11	9
Frame	Wear	12	12	12
Seat	Colour changes (e.g. sun bleached)	13	13	13
Seat	Wear	14	15	13
Frame	Scratches	15	14	15
Seat	Pilling	16	17	15
Frame	Colour changes (darkened or bleached)	17	16	17



Figure 23: The mean values and standard deviations of the severity of the different types of wear. The first eight types of wear are appearing on the frame, whereas the last nine appear on the seats/fabrics.

Since the standard deviations are overlapping, one have to discuss the tendencies based on the mean values (see Figure 23), which in this case could mean that the worst types of wear are the ones ranking 1-4 (of the total ranking), the wear that is somewhat acceptable is ranking 5-12, and the most acceptable wear is ranking 13-17 (see Table 17).

	Type of wear	Total ranking	Acceptance
Frame	Ricketiness	1	Unacceptable
Frame	Splinters	2	Unacceptable
Seat	Tears	2	Unacceptable
Seat	Soiled surface	4	Unacceptable
Frame	Dirt/coating/stains	5	Somewhat acceptable
Seat	Stains	6	Somewhat acceptable
Frame	Peeling surfaces	7	Somewhat acceptable
Seat	Frayed fabrics	8	Somewhat acceptable
Frame	Crackling surface	9	Somewhat acceptable
Seat	Loose/flabby fabrics	10	Somewhat acceptable
Seat	Crackling/cracks in e.g. leather	11	Somewhat acceptable
Frame	Wear	12	Somewhat acceptable
Seat	Colour changes (e.g. sun bleached)	13	Most acceptable
Seat	Wear	14	Most acceptable
Frame	Scratches	15	Most acceptable
Seat	Pilling	16	Most acceptable
Frame	Colour changes (darkened or bleached)	17	Most acceptable

Table 17: Overview of level of acceptance of different types of wear based on mean values and standarddeviations. Red indicated unacceptable, yellow more acceptable and green most acceptable.

### 7.6 Discussion of perception study results

The results of the perception study not only corroborated the interview study results to a high degree regarding research question [Q1], but also allowed for answering the research question [Q2]: *"What is 'acceptable wear' and what is 'unacceptable wear' when it comes to upholstered seating furniture for the public sector?"* The results of Part 3 gave an indication of what types of aging and wear that users thought were severe and which they had more tolerance towards, but as the number of participants were quite small (n=17), the results would need to be corroborated by a larger study.

Part 2 was intended to further investigate what glaring wear could look like and get an understanding for how people examine furniture. The result was very divided which made it hard to draw conclusions with certainty, especially about glaring wear, since the available data was the information that the participants said, which could be different to what they really do, in combination with observations about their interaction with the chairs. It would have been easier to analyse the data and draw conclusions if access to analysis software for the eye tracking recordings had been available, which can analyse where people look the most during the assessment.

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In the end, Part 2 showed that personal preferences, for example concerning colours and patterns but also construction, have great influence over the overall perception of the chair. More than half of the participants had their own criteria when selecting chairs they found acceptable: three for instance only chose chairs with armrests, as another three only chose those chairs without. Three others only picked the chairs they found attractive. The conditions of the chairs came second to these requirements; were their primary criteria met they assessed the condition and chose those in acceptable shapes. This selection process could however be assumed only to take place in a similar scenario when the goal is to select furniture for one's work place; if one is to sit on a chair in a lunch room with a lot of chairs of the same model, condition becomes the determining factor.

The results of Part 1 supported the results of the interview study in that the condition of the seats seem to be especially important for the overall perception of the chair. Even though "dirt on the frame" (B\_dirt) had the highest correlation with the total assessment, the observations showed that the participants often quickly assessed the seats/upholstery and then needed more time inspecting the frame to be able to assess its condition properly. This thorough assessment could have led to the high correlation with the total score. After "dirt on the frame", "dirt on the seat" and "wear on the seat" had the highest correlations with the total assessment. In Figure 17 it can for example be seen that the chairs 9, 10, 11, 13 and 14 got significantly lower points regarding dirt and wear on the seat than chair 12 which was the most selected out of chairs 9-15. Another aspect supporting the importance of the seats/upholstery is the fact that in Part 2, many of the participants stated that some of the chairs would have been fine if the textiles (that were either dirty, lose or worn down) just were replaced. One participant even stated that it would be simple for him to do it himself at home, why he selected the chair in question.

Even though the amateurs and the experts mostly were of the same opinion in Part 3, there was a clear difference in their answers in Part 1 and in Part 2. Interestingly enough, the experts seemed to be the more tolerant ones when it came to assessing the conditions of the chairs of Part 1, while they were stricter than the amateurs in their assessments of the chairs of Part 2. This might be due to the amateurs disliking the models of Part 1, while they found the Part 2 chairs more to their liking (their mean value increased with 43 per cent between Part 1 and 2, while the mean value of the experts only increased with 12 per cent). It could be that the experts are more familiar with inspecting /looking at chairs, in various of styles, which could make them assess the condition without being influenced by the style and design of the furniture. However, as the number of participants was both low and lopsided (6 amateurs against 11 experts) it is difficult to draw any reliable conclusions from this.

### 7.7 Conclusions of the Perception study

The conclusions from the perception study answering to the research questions [Q1], [Q2], and [Q3] can be read below.

#### Conclusions related to research question [Q1]

#### [Q1]: What kinds of wear add to the value of the furniture?

- Natural wear that is evenly spread and shows how it has been used (with no glaring wear). Some people think natural wear stemming from careful use can give character to the furniture and find it charming, but this wear should be consistent over a surface or the whole furniture. Glaring scratches or stains draw attention and are not appreciated. It is however also dependant on the type of furniture and its materials; the furniture must be of high quality to begin with and have a design that does not contrast with the aged look for the wear to be perceived as attractive.
- When wear turns into patina. Wear, but no peeling paint or scratches, on armrests where the user have placed their hands seem to be found acceptable by most, and even beautiful by some. One of the chairs in Part 2 (chair C) had noticeably worn armrests and was also assessed by the participants to be in be in the second worst condition of them all, but was still the second most selected chair when tasked with picking out acceptable chairs. This inconsistency indicates that the chair was found acceptable despite its noticeable wear, and could be an example of how wear stemming from use is seen as natural and attractive patina, something that was indicated by the results of the interview study.

#### [Q1]: Which kinds of wear reduce the value of the furniture?

- **Glaring wear.** When something as a scratch or a stain stand out, it draws users' attention and dominate the perception of the whole furniture. Furniture in otherwise pristine condition could be ruined by a single but glaring blemish.
- **Dirty and torn textiles** reduce the value drastically as they greatly affect users' perception of the furniture.
- Ricketiness or loosening joints. All parts of the perception study indicate this. Chair F (Part 2) had loosening joints and was deemed to be in the worst condition of them all, and chair 12 (Part 1) had loose joints between the armrests and the backrest and was directly disregarded by the ones noticing it, despite visually seeming to be in the best condition. Finally, ricketiness was deemed to be least tolerable type of wear of Part 3.

#### [Q1]: General user perception of wear and aging

- Personal preferences regarding style and colour have considerable influence on the user perception of furniture.
- At first sight, the condition of the textiles (on seats, backrest and armrest) has the largest impact on the overall perception of the chair. If a more thorough examination is performed, dirt on the frame becomes more important.

- The perception of the chair depends on personal preferences regarding the product's materials and where on the chair they are placed.
- Several types of wear together can make the condition to be perceived as unacceptable, e.g. scratches all over the frame and stains on the seat can together make the chair unacceptable.

#### Conclusions related to research question [Q2]

[Q2]: What is "acceptable wear" when it comes to upholstered seating furniture for the public sector?

- **Colour changes on frame.** This type of aging got the lowest mean value when the severity of different types of aging and wear was assessed.
- **Pilling.** Following "colour changes on frame", pilling was the least severe type of damage.
- Scratches on frame. While dirt on the frame had the highest correlation to the total assessment of the chairs of Part 1, scratches on the frame were deemed the third least severe type of wear on seating furniture.
- Wear on textiles. According to the results of Part 3, wear on textiles were not considered especially severe on public chairs, ranking the 14<sup>th</sup> in severity out of 17 types of wear and aging examined.
- Bleached textiles. Bleached textiles received about the same mean value as wear on textiles, but the standard deviation was somewhat bigger with as many participants awarding it a "2" as giving it a "5". This indicates that the opinions can vary greatly when it comes to colour changes on textiles.

#### [Q2]: What is "unacceptable wear" on upholstered seating furniture for the public sector?

- **Ricketiness.** Ricketiness was unanimously voted as the most severe type of wear or aging on seating furniture. This was also corroborated by the observations during the tests as participants quickly disregarded the chair that looked to be in the best condition when they found out it was rickety.
- **Splinters.** Splinters were not accepted on seating furniture, with no participant giving it lower points than 4 on a scale where 5 represented "very important that it did not occur".
- Torn textiles. Got the same mean value and standard deviation as "splinters".
- **Soiled/dirty textiles/seats.** A clear majority of the participants thought it was very important that there was no soil or dirt on the seat of the furniture.

## 8 The Guide for Designing with Aging and Wear in Mind

To answer the last research question [Q3]: "How should designers take aspects as aging and wear into consideration when designing seating furniture for the public sector to make it fit into a circular economy?", a guide with focus on designing furniture with aging and wear in mind was created.

This chapter will first shortly describe the development process of the guideline, and then present the result of the guideline creation phase as well as the results of an evaluation of the guideline.

### 8.1 Guideline Creation Process

All previous phases provided input to the development process. The literature review gave useful information regarding design for circularity and design for longevity, as well as inspiration and input from previous guidelines regarding circular design, design for disassembly and design for sustainability. This input was selected depending on its relevance and usefulness in connection to aging and wear in circular furniture flows. The collected information from the interview studies and the perception study was also translated into recommendations and informational examples, and the insights from the market analysis contributed to the selection of relevant background information to present in the guide. Following subchapters shortly describe how the guideline was formed regarding looks and content.

### 8.1.1 Input from the guideline benchmarking

The guideline benchmarking provided insight into what to include in the guide as well as inspiration for the guideline design. Useful sources were the Circular design guide (EMF, 2017) where information regarding *circular opportunities, material selection* and *circular flows* provided inspiration and were therefore referenced in the "read more" chapter in the end. The same with *Hållbarhetsguiden*, where the information presented about methods and earlier projects provided a foundation to build on. Sources and guides that had been explored as part of the benchmarking were referenced as "further reading".

The layout and design was both influenced by the guidelines examined as part of the guideline benchmarking and by other, unrelated graphic design and marketing guidelines found using Pinterest. The *Cirkulära Möbelflöden* brochure provided inspiration regarding the format and scope of the guide.

### 8.1.2 Content

The guideline texts were written with the aim of providing enough background information and framework for the reader to understand the current situation for furniture in the public sector, what kind of product the guide was intended for, what environment it was meant to be used in and what was meant by "aging and wear in a circular economy". The parts about circular furniture flows and

environmental labelling were mainly based upon the literature review, while the parts concerning aging and wear and public environments were based on conclusions drawn from the market analysis and the interview study. As environmental labelling gets more complicated in a circular economy and often is a requirement for furniture in the public sector, the topic was deemed relevant to highlight in the guideline.

As several of the interviewees pointed out, furniture is in its essence quite modular as it often consists of different parts that are put together. To emphasise this and to enable more directed and specific recommendations, the guideline was divided after the different parts of a chair: the seat/upholstery, the armrests, the backrest/frame and the legs. Information which is universal for all parts or which concerns the furniture as a whole was however addressed first under the headings "material selection", "product construction" and "visual appearance".

Since the guideline has a rather narrow focus - how to design public seating furniture with aging and wear in mind - the last page was reserved for links and references to other guidelines or reports addressing the aspects of circularity and sustainable furniture design in greater detail. Informing about available resources is one way of creating awareness about a subject.

### 8.1.3 Layout and graphic design

The A4 (or A3 for a spread) format was chosen as it both enables for readers to print their own copies if desired, and as it avoids the paper spillage created by a format requiring cropping upon printing. Moreover, the more quadratic 210x210 mm format that was first considered would not have been enough to synoptically fit all information that in the end was gathered.

To clarify the written information, an illustration of circular furniture flows was made based on the EMF Circular Economy System Diagram (EMF, 2017) as well as illustrations of an upholstered chair and all its separate parts. As a way to solidify the furniture focus of the guide, the chair was used as a reoccurring theme throughout the guide, and on the title page it was used to form a clock representing the time aspect of aging and wear.

Several photos of worn furniture were also included in the guide with the aim of illustrating problematic areas or types of wear. All photos of aged and worn furniture had either been taken by the authors during the field trips to the Skaraborg hospital in Lidköping and Skövde or during the perception study with the furniture of Möbelbruket at Tre Sekel in Tibro. Some open source images of office furniture and designer furniture were also included to convey the message.

### 8.2 Evaluation of the guide

The guideline was evaluated both by four practicing designers, interior designers and furniture designers, as well as by six master level Design and Product Development students at Linköping University. A questionnaire was made with questions about the content in the guide followed by a SUS (System Usability Scale) questionnaire (Brooke, 1996), see Appendix F.

### 8.2.1 Guide evaluation results

The SUS mean score was 77,8 (maximum possible score is 100) which translate to the grade A-, which says that the product is good (between 70-80 score). Since the SUS evaluation aims to assess effectiveness, efficiency and satisfaction (Brooke, 1996), the authors made the conclusion that the guide can be described as easy to use (both to complete the reading and embrace the information) and satisfactory for the users.

The results of this evaluation showed that all respondents thought the message of designing for circularity was clear, and eight out of the ten respondents stated that the focus on aging and wear came across as clear. To the question where they were asked to name three good things about the guide, five out of the ten thought that the texts were easy to read and seven out of the ten that the layout was pleasing. Six of the respondents also said that the guide was structured, based on the divided chapters, and five that the content seemed to be reliable and based on reliable sources.

Four respondents stated that the guide was a good summary of different aspects that are important to keep in mind when designing for a circular economy with focus on aging and wear of chairs, and some stated this while acknowledging that it is a very complex issue and hard to include every single aspect there is.

Since the evaluation was an iteration of the development process, the respondents were also asked about what could be improved upon to make the guide better. The most relevant improvements suggested are listed in Table 18. Some changes have been made and some improvements are still left for future development.

Comments that have been improved upon	Suggested improvements for future versions
Descriptive text about how to use and read the	Short pros and con text about different common furniture
guide	materials and surface treatments
More examples from the "real world"	Short summary at the end of the guide
Figure descriptions	More information about backrest, legs and frame, which is a
	little sparse compared to the other components

Table 18: Improvements that have been done and suggestions for future versions of the guide

### 8.3 The Result: How to design with aging and wear in mind

Excerpts from the resulting guide for *how to design with aging and wear in mind* can be seen in Figure 24 to Figure 29. For a complete version (13 spreads plus title and ending), see Appendix L.



Figure 24: Title page and following spread describing the aim of the guide.

The Product: Seating fur	niture	Aging and wear of furniture	
he 1 he 1 he 1 he 1 he 1	While hypothese studies of a solar to a high the method sector of a black of conductors of head to construct the solar of	<text><text><text></text></text></text>	
going to be eddressed separately with more part specific information and recommendations.			2

Figure 25: Spread following the Table of Contents

After the title page follows a spread describing the current situation in the public sector and the aim of the guide, see Figure 24.

A Table of Contents follows this, after which the product category the guide is aimed at is specified as well as what is meant by aging and wear of furniture, see Figure 25.



Next comes a short explanation of how circular furniture flows could work (based on the EMF model), as well as what challenges these pose upon environmental labelling, see Figure 26.

Figure 26: Circular furniture flows and environmental labelling



What users expect and tolerate regarding aging and wear in public environments are then addressed, see Figure 27.

Figure 27: Designing for public environments



General recommendations regarding material selection, product construction and visual appearance are presented on three consecutive spreads. In Figure 28 the *Material selection* spread is displayed.

Figure 28: Recommendations concerning material selection



Figure 29: Component specific recommendations

After the general recommendations follow more part specific recommendations, divided between "seat", "armrests", "backrest/ frame" and "legs". For each part, the recommendations have been divided between constructional and material related, see Figure 29.

Lastly, a spread with links for further reading is presented, followed by a Reference list.

## 9 Method discussion

In this chapter, the methods used and their implementation are going to be discussed with focus on validity and if some parts could have been done better or in another way.

### 9.1 Literature review method discussion

It was seen as a logical beginning to the project to start out reading up on relevant topics for the project. A classic literature review was conducted where a quick survey of different fields to find relevant information was followed by a more detailed review and summarizing.

One downside to literature reviews is there is no clear end to the phase; one can always read on and find more information. The feeling of not being sure about if enough information has been gathered was the case for the authors, but in retrospect the literature review performed was enough for the purpose. Another difficulty about literature reviews is staying on topic during the reading. This was dealt with both with regular short discussions and updates between the authors, and the classic post it notes on the computer screen as reminders.

Included in the literature review was a benchmarking on similar "design for sustainability" or "design for circularity" guides to learn both from the included information, but also from the layout of the guides. As any literature review, a benchmarking ensures that no obvious information and already explored areas are missed out on.

### 9.2 Market analysis method discussion

It was decided early on to do interviews and field trips to different actors in the second-hand furniture market, since they both help to give a holistic picture of the studied topic and can provide information that is not as easily accessed from other sources, for example over the internet. The companies included in the market analysis were found by internet searches and also from recommendations from people encountered during the thesis work, so called snowball sampling.

Qualitative, semi-structured interviews were conducted, in some cases in connection to the field trips. One problem with interviewing people from a company is that it is some time hard to set apart the company's policies and procedures from their personal opinion about the topic. This was dealt with both by censuring some of the companies' names as well as the names of the people interviewed, and by not relying entirely on the data from the market analysis. Interesting aspects found in the market analysis was further investigated in the literature review, the interviews and the perception study to further strengthen relevant data.

During field trips, one had to be mindful about the fact that they were not truly objective about the information they were sharing and that they wanted to share what the business was about and what kind of work they were doing there. During a field trip one should be open to all information that is given to you, but it is important to summarise and only use the information that is helpful for the chosen topic, which was sometimes a challenge for the authors.

### 9.3 Interview method discussion

The methods of the two interview studies *Basic mapping* and *Experts & professionals* are discussed in this subchapter.

### 9.3.1 Basic Mapping

There was a discussion on making a survey to receive the data for the basic mapping, but when the opportunity to go to Stockholm Furniture and Light Fair came up, the possibility of quickly getting the answers was taken. The answers from an interview can be more direct and honest than survey, as formulating a written answer gives the time and opportunity to censor before giving the final answer. A protocol was made with structured interview questions, and in that aspect, it is quite close to a survey. To analyse the data, clustering was used and the answers were grouped based on likeness, which is an easy way to see connections between the answers.

In retrospect, it could also have been fruitful to have done a survey instead, since the data served as a compass for in which direction to go, and not as an end result. Since it was a smaller number of interviews and the questions gave qualitative data, it would have been hard to analyse in another way.

### 9.3.2 Experts and Professionals

The decision to interview experts and professionals gave insightful information from their experiences, both regarding their expertise but also their experience of the users' general opinions, and in a more condensed and objective way than if only users would have been interviewed. The interviewees where selected either after ideation sessions, or by using snowball sampling; asking people who to talk to next. This was a very successful way of planning the interview study, since it can be easy to interview too many people, making it difficult to analyse the data in a short period of time. One alternative could have been to interview the users directly, or make a more comprehensive survey, but since the perception study was part of the plan from early on, users were planned to be involved there instead.

One group of experts that the authors would have wanted to interview but never got the opportunity to was however upholsterers. Many of the interviewees expressed they had no expertise when asked about textiles, why it would have been beneficial to have interviewed someone with more in-depth knowledge. Several were contacted about doing an interview, but time ran out before it was possible to arrange one. Instead, the authors had to rely on insights from the literature study.

The interviews were conducted by one interview leader and one secretary, using a pre-made interview protocol that made the interview go smoothly. It is always hard to win the trust from a person one just met or started talking to, which means that the planning and delivery is essential to get the interviewee to open up, but in retrospect this seems to have worked out most of the time as many of the interviewees opened up and came with a lot of own stories and experiences.

Analysing qualitative data takes time and so does transcribing interviews. Transcribing was done to be able to have the answers easily accessible for further analysing by grouping the questions in different subject areas that the authors found most interesting to evaluate. If more time had been

available it would have been of interest to summarise the questions one by one and discuss contrasts and correlations.

### 9.4 Perception Study method discussion

Since the project was concerned with the perception of aging and wear in the specific context of public furniture, it was decided that the perception tests ought to be performed using real examples of furniture rather than just pieces or parts showing the wear or aging that was going to be studied. It was also decided that though visual perception would be the focus of the study, photographs with proper resolution and comparability would be too hard to achieve and that physical samples of the furniture therefore were preferable. Showing the whole furniture would give the participant a context to the wear and tear that otherwise would be difficult to obtain, for example which materials that are in contact with each other and the product structure and style etc. Performing the study in a realistic, or natural, environment such as a reception or lunch room would be ideal, but due to practical considerations this was not prioritized.

The perception study was a possibility to collect data based on participants' opinion, perception and comprehension, which was the type of data that was desired for two of the research questions [Q1] and [Q2]. Finding out what is defined as acceptable wear and unacceptable wear could have been possible by doing a more comprehensive survey for example with pictures of different types of wear, or a probe where participants are doing some tasks, for example taking pictures of wear they see in their everyday life. With perception tests, one can guide the participants during the whole process and make sure that the data is correctly collected and that no steps are left out.

To examine the way users assess furniture; for instance, where they look and if there are parts they study more closely than others, Part 2 of the study was designed to allow for eye tracking equipment to be used. If time for analysis was available, the data would allow for a greater understanding of where users look when examining furniture, and perhaps also what could constitute glaring wear; something that the interview study had indicated had considerable effect on the perception of the whole furniture. The results of the eye tracking could however not be analysed, as access to the analysis software was delayed and there was no time for manual processing. Instead, the results had to rely on observations and notes taken during the assessment of the furniture, and combined with what the participants said about the furniture, the results were interpreted to identify what their decisions were based on.

In the end, the perception study was successful in collecting data about how the participants were evaluating the condition of the chairs and which chairs, and automatically, which type of wear, was seen as acceptable and unacceptable. It would have been interesting to have had more participants to be able to make more general conclusions with a higher certainty of its validity. As of now, one can see tendencies but it is not a reliable depiction of the general opinion.

During the planning and execution of the perception tests, there were a lot of new areas to get familiarized with. First of all, perception tests as a concept was new to the authors, new technical equipment had to be learnt (as eye tracking glasses were used), as well as new software and new types of analysing methods. There is not one specific way of planning and executing perception tests, therefore it was hard to know exactly if the planed perception tests would be successful in getting

the data that was wanted. With the help and supervision of two senior researchers at RISE Bioeconomy with years of experience of perception tests, the authors can say that the planning and the execution were done in an appropriate way with a successful result. The data analysis was partly done by the projects' supervisor Siv Lindberg, who calculated the ANOVA and the correlation analysis.

### 9.5 Guideline creation and evaluation method discussion

A booklet format was selected since it provides the reader with information that is both visual and easily accessible. An alternative to the guide format was a checklist, but the collected data suited a guide format better since it consisted of recommendations for how to best design circular furniture rather than a list of requirements to meet.

The creation process for the guide centred very much around what was trying to be achieved with the guide. The written content; the recommendations and informational texts, laid the foundation for the outline and format with the design built around the texts. The idea to provide recommendations for each part of the chair separately was born in the interview study with experts and professionals, as several of the interviewees emphasized the inherent modularity of furniture. This disposition and development process seems to have worked quite well, as the evaluation of the guide showed that a majority of the respondents found the structure and layout pleasing.

The evaluation setup, a questionnaire and digital version of the guide, was decided mainly because of its time efficiency and the flexibility it gave the participants. A questionnaire including a SUS evaluation was decided on since it gave both qualitative data and quantitative data. SUS is a well-known way of evaluating what the users think of the products usability and satisfaction of the usage which gives an objective result about the guide. It could have been an option to have a focus group which met up and evaluated the guide together while being able to interact with a physical prototype of the guide, and possibly use it in a small task for example. Using physical prototypes while evaluating is a great way to really get an understanding for how people interact with the product and the results would have higher validity since the situation and prototype is closer to the reality and the end product. Due to a pressed schedule, this was however not possible to arrange.

Ten respondents were decided to suffice for the evaluation, as a source stated that two respondents would be enough and 50 too many to manage timewise. The evaluation included experienced designers and design students at a Master level. The designers all had many years of experience while the design students could provide a trained but fresh eye, which was deemed important as the guide is directed towards a future market with a focus on more circular design thinking.

## 10 Result discussion

Here, earlier result discussions related to specific work packages are summarized to clarify whether the project objectives have been fulfilled and if the research questions of the project have been answered or not.

### 10.1 Fulfilment of objectives

All three objectives have been fulfilled during the project. The user perception of aged and worn seating furniture for the public sector has been examined and documented, fulfilling the first objective. The second and third objectives were fulfilled in the making of the guide for *how to design with aging and wear in mind;* guidelines based on literature as well as the interview and perception study results were formulated and as part of the development process the guide was evaluated by ten design students.

### 10.2 Answering to the research questions

All three research questions [Q1], [Q2], and [Q3] have been answered at least partially. To what extent for each question can be read below.

## [Q1] How is the wear and aging of furniture perceived by users; which kinds of aging or wear add to the value of the furniture, and which reduce it?

This thesis work has collected different types of data about the user perception of aging and wear, both through expertise gathered from interviews with experts as well as by involving users in a perception study. The results include conclusions about some kinds of aging and wear that seem to add value – or at least improve the user perception – of the furniture, and some kinds that reduce the value of the furniture, see subchapter 7.7: Conclusions of the Perception study. Which of these kinds of aging and wear that add the most value has however not been possible to specify, neither to which extent. This is too contingent on other factors such as the type of furniture it manifests on, the quality of the materials, and what expectations there are at the place the chair is standing in.

## [Q2] What is "acceptable wear" and what is "unacceptable wear" when it comes to upholstered seating furniture for the public sector?

This thesis work has partially answered this question. The most extreme ends of the acceptance scale could be identified, however not the border between "acceptable" and "unacceptable" aging and wear in the grey area between the extremes. The conclusions have been divided into "acceptable wear", "somewhat acceptable wear" and "unacceptable wear", but considering the relatively low number of test subjects (n=17), the results can only be seen as indicators of what the general opinion might be, requiring further researched to be performed. Nevertheless, it is an important first step in exploring the acceptability levels of different conditions of chairs, which will have greater influence in closed-loop furniture flows in the future.

## [Q3] How should designers take aspects as aging and wear into consideration when designing seating furniture for the public sector to make it fit into a circular economy?

The making of the guide *how to design with aging and wear in mind* (Appendix L) sought to answer this question. It was designed for furniture designers to use when designing circular seating furniture for the public sector, with focus on aspects concerning aging and wear.

Nevertheless, making a resource efficient circular design is not an easy task as there are numerous aspects to take into consideration. Even though the developed guide advocates modularity, it is not simply about designing all of the parts of the chair "right" as it does not necessarily mean that they work in conjunction and make for a balanced and great design, neither structurally nor visually. During the literature review, several of the previously developed approaches and guidelines that were studied were not formulated in a way that took all relevant aspects into consideration, and they were generally formulated in broad terms, leaving room for interpretation. This guide aimed at including as many aspects as possible, but still having a clear focus on aging and wear in combination with circular economy. According to the results of the evaluation of the guide, many thought the guide was comprehensive and relevant despite the complex topic.

### 10.3 General discussion

Previous studies focusing on the perception of aging and wear in combination with circular economy have not been found during the literature study. There has been conducted quite extensive research into aging and wear within the areas of solid mechanics and material sciences were material durability and fatigue has been the focus, but only one study has been found examining how the perception of a material changes with wear (Bridgens, et al., 2015). Several furniture manufacturers have their own testing laboratories for the mechanical properties and the durability of their furniture, but these focus also on physical durability and material fatigue. Few studies have been conducted exploring how people perceive aging and wear, making the results of this study unprecedented and therefore also difficult to verify.

In recent years, studies have been made with focus on making the public sector more sustainable, resource efficient and fit for a circular economy. Studies based on making the public sector more circular has identified several obstacles for implementation, for example prejudices related to used and refurbished furniture such as costs, resistance against implementing new business models such as renting furniture, and how to design office chairs that withstand repeated use. Some of conclusions of these studies are the same as the ones that have emerged in this thesis work, especially during the market analysis and the interviews with experts. The guide is however a step towards more circularity thinking in the public sector, hopefully enabling designers and furniture manufacturers to produce longer-lasting seating furniture that can be recirculated.

## 11 Conclusions

This chapter summarizes the conclusions from the entire thesis work and concludes with what could be a next step in a continued investigation of how aged and worn furniture are perceived by users in the public sector, and how public furniture could be designed to better withstand the increased levels of wear in a circular economy.

### 11.1 Project conclusions

### [Q1] How is the wear and aging of furniture perceived by users?

i. What is the general user perception of aging and wear when it comes to upholstered seating furniture in a public sector?

The terms "aging" and "wear" are often perceived in different ways: wear is often seen as damage to a material stemming from use, while aging has a more positive ring to it as it is associated with the gradual change the furniture goes through over time, for example colour changes in wood and patina on metals. "Natural wear" that shows how the furniture has been used and handled with care over the years can on the other hand also be seen as some kind of patina. The furniture must however be made out of high quality materials to begin with for the wear to be perceived as natural; materials of lower quality tend to show their inferiority with age.

Many of the interviewed experts said that the condition of the chairs should be clean and preferably look as new as possible when used in the public sector. The seat/upholstery is one of the areas users focus on when assessing the condition of the chair, which means that it needs to be kept in good condition, for example by allowing for easy removal for washing or reupholstering. Another aspect that emerged was that wear is perceived differently in different public environments; in tax funded places signs of aging and wear is more tolerated than in for example hotels, banks and private offices.

#### ii. Which kinds of aging or wear add to the value of upholstered seating furniture?

When durable high-quality materials get patina, they are perceived to age well. Patina is for example when the armrests on an armchair get worn where the user has had its hands. This can be achieved by natural wear that is evenly distributed, meaning there is no glaring wear that draws the onlooker's attention to it, which gives "character" to the piece of furniture.

### iii. Which kinds of aging or wear reduce the value of upholstered seating furniture?

Glaring wear, a type of wear that stands out visually, becomes a focus point which is perceived as distracting and negative by users. Textiles that are dirty or torn reduce the value drastically, and dirt and stains in general are very detrimental to the overall perception. Ricketiness and loosening joints severely compromise the reliability of the furniture and are not accepted at all.

## [Q2] What is "acceptable wear" and what is "unacceptable wear" when it comes to upholstered seating furniture for the public sector?

### i. What is "acceptable wear"?

Acceptable wear is the subtler changes of the materials - in other words no glaring wear - and could for example be uniform colour changes on the frame of the chair, some minor pilling of the fabrics, small scratches on the frame, wear on textiles to some degree, and evenly sun-bleached textiles. The materials that are stated to age the best and most beautifully are natural materials, for instance solid wood and leather that are maintained properly during usage.

### ii. What is "unacceptable wear"?

What has been identified as "unacceptable wear" is ricketiness, splinters, torn textiles and dirty/soiled textiles and seats. These can in many cases be identified as glaring wear. Other types of aging and wear that have been studied, for example crackling or peeling surfaces, were also seen as very detrimental to the furniture, but were not seen as unanimously unacceptable as the ones named first.

## [Q3] How should designers take aspects as aging and wear into consideration when designing seating furniture for the public sector to make it fit into a circular economy?

Designers should seek to balance different design aspects with the aim of creating furniture that has both a lasting style, materials that age well, and an enduring construction; and when broken or too worn down the furniture should allow for easy refurbishment and repair until material recycling is the only option left. The construction and design needs to be made for removing and replacing worn or broken parts, such as contact surfaces on seats and armrests that wear faster. During the material selection phase, the aim should be to choose sustainable and renewable materials that have as little impact as possible on the environment. The most relevant conclusions and insights regarding aging and wear for upholstered chairs are summarized in the guide *how to design with aging and wear in mind* (see Appendix L).

### 11.2 Recommendations for future research and work

During Part 2 of the perception study, eye tracking recordings were made to collect objective data about where people look while assessing the condition of aged and worn chairs. Due to lack of time and means, these were however not analysed as part of this thesis work. To analyse the material would therefore be a natural continuation of this thesis project.

As this project has focused on examining the user perception of aging and wear and identifying different acceptance levels, it would be interesting to continue this line of research but in a larger scale with more test subjects to see whether the results hold up. Some types of wear have been identified as either acceptable or unacceptable by this project, but finding out what happens between the extremes "acceptable wear" and "unacceptable wear" would be interesting and highly relevant. As more and more companies are providing furniture as services, it is of outmost importance to be able to optimize maintenance routines and to be able to ensure that the products that are provided are in acceptable condition.

#### Conclusions

It would also be interesting to further investigate the material selection part, for example what types of materials in combination with what type of surface finishes are perceived to age well by the users, or what materials are both durable and suitable in a circular economy. This would not necessarily only involve designing for the public sector, as circularity are being implemented in many other markets.

Since this project has had quite a wide scope, it would be interesting to develop a more detailed guide for how to design for a circular economy, including perhaps other types of furniture as well. It could be interesting to make a kind of checklist that designers could use during ideation, or later in the development process to evaluate concepts. Many participants during this project have stated that the topic of circular economy for furniture is both relevant and important today.

Design for disassembly is an important part of designing for circularity; to be able to recycle the materials or change out parts the product needs to be easy to take apart. Another interesting focus would therefore be to look more closely at how to construct furniture for a circular economy, for example identify and list the types of joints that are suitable and strong enough to withstand repeated disassembly and reassembly.

Today, public contracts pose a challenge for closed-loop furniture in the public sector. It would therefore also be useful to look further at how public procurement, e.g. logistics for collecting of furniture, could be managed to allow for closed-loop furniture in a future, circular economy.

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# Appendix

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## Appendix A – Interview protocol – Basic Mapping

2017-02-10 Interviews about aging and wear of furniture in public sector, Stockholm Furniture & Light Fair

Hi! We are two students from Linköping University, and at the moment we are doing our thesis project at Innventia, a research institute here in Stockholm. We are examining how users perceive aging and wear of furniture in the public sector, and if it is possible to design more sustainable furniture by taking these aspects into consideration.

- 1. What do you think of when you hear the words *aging* and *wear* in connection to furniture?
- 2. Is there a difference in how you perceive wear in furniture at home or at work? (Could for example be office chairs, but also furniture in shared spaces and receptions etc.)
- 3. Do you believe there are materials in furniture that age beautifully? Are there any that age badly? Examples?
- 4. What is your opinion about reusing furniture? (Second-hand and refurbished/ remanufactured furniture? Anything you would consider doing?)
- 5. In what condition is the furniture at your work place? (Opinions?)
- 6. Could you give examples of aging and wear that you find acceptable? (What would be unacceptable?)

# Appendix B - Interview protocol: Experts and Professionals

## Interview with experts and Professionals

**Purpose:** The interview will focus on the wear and aging of materials. We are interested in YOUR experiences and opinions on the subject.

**How:** The questions will be asked by X and in the meantime Y will take notes. With your permission we are going to record the audio of this interview, just to make sure that we don't miss anything that is said.

The Results: Interesting parts are going to be used in our Master Thesis report that will be finished in June. If you are interested in seeing the result before it is released, we can send it to you in advance. All personal information will be treated confidentially.

Interviewer: Secretary:

Name:

Date: 2017- xx-xx

Work place and responsibilities/title:

- 1. What are your tasks/assignments at XXXX?
- 2. Could you tell us how XXXX works with sustainability and environmental issues? Do you work with circularity in some way?

#### About general material properties

- 3. What materials do you think wear or age most beautifully?
  - a. What materials wear or age poorly?
- 4. How do you think \_\_\_\_ ages or wears? Could you give examples?
  - a. Metals
  - b. Wood
  - c. Textiles (Natural fibres, artificial fibres)
  - d. Ceramics (glass, concrete, cement, porcelains)
  - e. Stone
  - f. Plastics and rubber
  - g. Leather

#### Materials in furniture

- 5. What do you think about when you hear the words "aging" and "wear" in connection to furniture?
- 6. How do you think/feel \_\_\_\_ ages and wears in a furniture context? Could you give examples?
  - a. Metals
  - b. Massive wood
  - c. Composite wood and manufactured boards
  - d. Textiles of natural fibres (wool, silk, cotton, linen)

- e. Textiles of artificial fibres (polyester, viscose, modal, elastane)
- f. Skin and leather
- g. Ceramics (glass, concrete, cement, porcelains)
- h. Stone
- i. Plastics
- j. Rubber
- 7. On what grounds do consumers throw away furniture?
- 8. Is there a difference in your perception of wear and tear on furniture at home or at work? (Could be office furniture, but also furniture in public spaces or receptions and such) What do you think is the difference between at home and at work?
- 9. If we are talking about wear on a scale that starts with the furniture in mint condition, and then goes towards a more and more worn condition; at what point do you think the wear turns unacceptable? At home vs at work?
- 10. Do you believe there is a difference in the acceptance level of wear in furniture at different public places? (Libraries, receptions/lounges, lunch rooms, hospitals, government buildings, schools/universities, public transports, nursing homes etc.)
- **11.** Which kinds of furniture keep having a value with wear and aging? Why? Which type of wear?
- 12. Which kinds of furniture loose value the most with wear and aging? Why? Which type of wear?
- 13. In which situations could it be interesting to buy used or refurbished furniture? When is it not?
- 14. As a consumer, which types of furniture are you willing to refurbish/restore, and which not? Prolong product life, upcycle etc. (Willingness = it is either economically defensible or there are other types of value at play.)
- 15. Could anything be lost as one refurbishes furniture?

#### Seating furniture

- 16. Which types of wear are the most common ones on seating furniture?
- 17. When/at what point do you need to replace seating furniture?
- **18.** In what condition should seating furniture that are used in public space be? What is acceptable, and what is not?

#### Design related questions

- 19. Is it important to be able to track the origin of furniture after refurbishment?
- 20. What is your opinion of remanufacturing or refurbishing furniture without the designer's/manufacturer's knowledge? (E.g. painting over in another colour or change the upholstery)
- 21. If you were to design seating furniture for public spaces, what would you change in the designs?/ How should one design seating furniture for public spaces, taking factors as aging and wear into consideration?

#### Lastly

- 22. Who do you think we should talk to next?
- 23. Is there anything you think we missed to ask?

Do you have any questions?

Can be get back to you later if we have any questions about the answers you have given?

Thank you!



Very poor

### Appendix C - Perception study Questionnaire: Part 1



Appendix D - Perception study (	Questionnaire: Part 2
Ves Ito	What do you think about the materials? What is your overall assessment of the condition of the chair?
C Yes 110 To Yes Your decision on?	What do you think about the materials? What is your overall assessment of the condition of the chair?
What did you base your decision on?	What do you think about the materials? What is your overall assessment of the condition of the chair?
Mhat did you base your decision on?	What do you think about the materials? What is your overall assessment of the condition of the chair?

Yes 10	What did you base your decision on?		Is there any wear that stands out?	What do you think about the materials?	What is your overall assessment of the condition of the chair?	Very poor Neither Very good
Yes 110	What did you base your decision on?		Is there any wear that stands out?	What do you think about the materials?	What is your overall assessment of the condition of the chair?	Very poor Neither Very good
	What did you base your decision on?		Is there any wear that stands out?	What do you think about the materials?	What is your overall assessment of the condition of the chair?	Very poor Neither Very good
	What did you base your decision on?		Is there any wear that stands out?	What do you think about the materials?	What is your overall assessment of the condition of the chair?	Very poor Neither Very good

## Appendix E - Perception study Questionnaire: Part 3

TP no:

Age: Gender:

Below are a few words describing different types of wear. Your task is to estimate **how important** it is that different **wear and tear <u>does not</u> occur on the seating furniture** (chairs) in public environments / buildings. For each of the words, make your estimates by selecting a number. The tax rate goes from 1 to 5 where 1 is *Not important*, 5 *Very important* and 3 are neither important nor unimportant.

Estimate how important it is that these wear and tear <u>do not</u> occur (on the seat furniture).

			Wear on frame			
			Scratches			
Not important	_	-	_		_	Very important
	1	2	3	4	5	
		SI	olinters/Chipping			
Not important						Very important
	1	2	3	4	5	
			Surface wear			
Not important						Very important
	1	2	3	4	5	
		I	Peeling surfaces			
Not important						Very important
	1	2	3	4	5	
			Surface dirt			
Not important						Very important
	1	2	3	4	5	
			Crackling			
Not important						Very important
	1	2	3	4	5	
			Colour change			
Not important						Very important
	1	2	3	4	5	
			Ricketiness			
Not important						Very important
	1	2	3	4	5	

			Wear on seat			
Not immortant			Tearing			Vam
Not important	1	2	3	4	5	important
		11	11 / 61 ·			
Not important		Fla	abby/saggy fabric	0		Verv
rtot important						important
	1	2	3	4	5	
NT / • / /			Fraying			*7
Not important	1	2	3	Δ	5	important
	1	2	5	4	5	
			Pilling			
Not important						Very
	1	2	3	4	5	Important
		Crae	ckling (e.g. leath	er)		
Not important						Very
	1	2	3	4	5	important
Soiling						
Not important						Very
	1	2	3	4	5	Important
			Wear			
Not important						Very
	1	2	3	4	5	important
			Sun bleached			
Not important						Very
	1	2	3	4	5	important
			Staining			
Not important						Very
	1	2	3	4	5	important

Estimate **how important** it is that these **wear and tear** <u>**do not**</u> **occur** (on the seat furniture).

# Appendix F - Evaluation of guideline questionnaire

# Evaluation of guide

All answers from the evaluation will be anonymous and the answers will be used as an iteration in the development of the guide. We appreciate all feedback we can get, so it's optional to add comments in the PDF in addition to this questionnaire. Thank you in advance!

/Paulina Lundberg and Lisa Jangfall

#### **Evaluation questions**

Reply in the boxes to the right of the questions. When it is predetermined option for the answers, answer with a cross, otherwise the questions can be answered with free text.

	Yes	Somewhat	No
Do you think the message in the guide appears clear?			
If somewhat/no, what is unclear?			
Formulate briefly what is the message (based on your comprehension)			

Name three things that were good with	

What can be done better? Feel free to make suggestions for improvement	

	Yes	Somewhat	No
Is the information in the guide relevant?			
If somewhat/no, what is irrelevant?			

	Yes	Somewhat	No
Does the content show that there is			
focus on aging and wear?			

### SUS evaluation

<i>Please read the question carefully before answering</i>	Strongly disagree! <b>1</b>	2	3	4	Strongly agree! <b>5</b>
1. I think that I would like to use this guide frequently					
2. I found the guide unnecessarily complex					
3. I thought the guide was easy to use					
4. I think that I would need support or help to be able to use this guide					
5. I found the various components in this guide were well integrated					
6. I thought there was too much inconsistency in this guide					
<ol> <li>I would imagine that most people would learn to use this guide very quickly</li> </ol>					
8. I found the guide very cumbersome to use					
9. I felt very confident (with my doing) when using the guide					
10. I needed to learn a lot of things before I could get going with this guide					

## Conclusive questions

Is there anything missing in the	
guide?	

# Appendix G- Interview results: Materials said to age well

A few interviewees named some specific material or types of material. When there is a number after the material it means that that many interviewees gave that answer.

#### How material age and wear

Material	Positive	Neutral/Both positive and negative	Negative
Metals	Aluminium, copper (3), bronze, steel, brass, stainless steel	Steel, iron	Galvanized metal plate, oxidized aluminium, surface treated aluminium
Wooden materials	Surface treated wood, untreated wood, pinewood, hardwood	Oak, ash, birch	Oak
Natural fibre textiles	Cotton, linen	wool	Silk, wool
Synthetic fibre textiles	Acrylic		
Ceramics	Porcelain, concrete, window glass, ceramics (2), ceramic glass, glass, tempered glass, bone porcelain	Glass	Tiles, clinker, glass , everyday porcelain
Stone materials	Granite, natural stone, building stone	Marble	Limestone
Plastic and rubber	POM		PA, plastic paints, PP, PS, ABS

#### How material age and wear in a furniture context

Material	Positive	Neutral/Both positive and negative	Negative	
Metals	Brass (2), bronze,	Aluminium, chrome, iron	Lacquered metals (2),	
	chiome (2)		surfaces	
Massive wood materials	Beech, birch	Pinewood, silver birch	Pinewood, facing (blockboard)	
Fibreboards and wood	Veneer (3), MDF (2),	MDF (2), veneer,	Laminated boards, wood	
composites	chipboard, plywood (2)	chipboard	based boards, veneer, chipboard (2) , MDF	
Natural fibre textiles	Wool (2), linen (2), wool (2)	Cotton, viscose, wool	Wool, silk, rayon	
Synthetic fibre textiles	Synthetic leather (Pegamoid), nylon	Polyester	Viscos, modal, cotton	
Leather, skin and fur	Sheepskin			
Ceramics	Concrete, glass, ceramics (3), porcelain		Glass (4), Surface finishes	
Stone materials	Granite, limestone, marble (2)	Marble, granite	Limestone, asbestos cement	
Plastic			Plastic layers, foam upholstery, ABS	
Rubber	Compact rubber	Natural rubber, synthetic rubber	Natural rubber	

# Appendix H: Pros and cons with different furniture materials

Eleven interviewees were asked how they thought the different material types seen in column 1 in the Table below age and wear in furniture applications. The answers have been divided between positive and negative aspects mentioned. The bracketed numbers indicate how many interviewees mentioned the aspect.

Material type	Positive aspects	Negative aspects
Metals	<ul> <li>Wear is barely visible, metals do not get worn the same way other materials do (3)</li> <li>Oxidized surfaces can be charming sometimes, especially brass (3) and copper (2)</li> <li>Chromed surfaces are better than painted in places exposed to excessive wear (2)</li> <li>Aluminium is durable (1)</li> </ul>	<ul> <li>Painted metal can flake off and the paint can get worn down, which looks bad (6)</li> <li>Most metals oxidize which destroys the material in the long run (4)</li> <li>Can get matte surfaces (2)</li> <li>Trend sensitive -intellectual wear rather than physical (1)</li> <li>Grey aluminium looks boring (1)</li> <li>Oak and iron are not a good match since the galvanic acid leaves ugly marks on the wood (1)"</li> </ul>
Massive wood materials	<ul> <li>Ages beautifully (10)</li> <li>Wear, chipping and scratches are more okay on solid wood (4)</li> <li>Changes in colour over the years (fades or darkens) in a beautiful way (3)</li> <li>Should be surface treated (3)</li> <li>It is possible to polish or sand a worn surface (2)</li> </ul>	<ul> <li>Soft wood scratches too easily (3)</li> <li>Can crack if too dry (2)</li> <li>Ugly with a yellow tone in the wood (pine) (2)</li> <li>Sensitive to moisture (1)</li> </ul>
Fibreboards and wood composites	<ul> <li>MDF is durable (2)</li> <li>Fibre boards do not move under veneers (1)</li> </ul>	<ul> <li>Age poorly (6)</li> <li>Veneers and lippings can come loose between layers (5)</li> <li>Do not age as well as solid wood (3)</li> <li>Bad if underlying layers are showing due to wear (3)</li> <li>Boring (2)</li> </ul>
Natural fibre textiles	<ul> <li>Wool has good durability, is strong, affordable and generally good furniture material (5)</li> <li>Linen is durable, good and used in furniture (4)</li> <li>Woven fabrics out of wool are often used in public environments (2)</li> <li>Can become sun bleached, but can in some cases still look nice, as for example cotton fabrics (2)</li> <li>A heavyweight, double-woven fabric can be reversed and used on the other side as well (2)</li> <li>Natural fibre textiles have a better tactile feeling than artificial fibres (2)</li> </ul>	<ul> <li>Textiles wear the fastest and are usually the one thing that gets replaced (2)</li> <li>Age poorly. The market chooses to reupholster 70-80% of furniture textiles (3)</li> <li>Dirt and particles make them feel more worn and aged (2)</li> <li>Uneven sun bleaching is ugly (2)</li> <li>Wool can be abrasion sensitive and pilling of fabric can appear (2)</li> <li>Wool can get moth infested and pest damages (1)</li> <li>Low quality fabrics get pilling and become ugly (1)</li> <li>Cotton changes easily its shape and wrinkle badly (1)</li> <li>Some natural fibre textiles do not resist wear as well as synthetic fibres do and can begin to sag over time (1)</li> <li>Silk and Rayon are not durable enough for public furniture. Thin fabrics become fragile and fray or disintegrate (1)</li> </ul>

	<ul> <li>20% -30% of upholstered furniture made of fine natural fibres can do well for a long time (1)</li> <li>Old, flattened paddings from natural sources can be "fluffed up" again (1)</li> <li>Leather and skins made from sheepskin age beautifully (1)</li> <li>Wool is dirt repellent and keeps its shape well (1)</li> <li>Some natural fibre textiles resist wear just as well as synthetic fibres do (1)</li> </ul>	• Can begin to sag over time (1)
Synthetic fibre textiles	<ul> <li>Generally, synthetic fibres do not wear as quickly as natural fibres (4)</li> <li>Choose textiles with appropriate Martindale values.</li> <li>(2)</li> <li>Can be very durable (2)</li> <li>Synthetic leather, Pegamoid, is durable and has ethical advantages to real leather. (2)</li> <li>If it is easy to reupholster, there is a higher chance the furniture is going to be kept longer (1)</li> <li>Can be more economical to use than natural fibres (1)</li> </ul>	<ul> <li>Dirt and particles can make the textiles look more worn that they are (2)</li> <li>Polyester can be durable and hardwearing, but often becomes ugly with time(1)</li> <li>Viscose, Modal and other cellulose based materials are often fragile (1)</li> <li>Sun bleached textiles are ugly (1)</li> <li>Pilling is ugly (7)</li> <li>Plastic foam padding can pulverise with time and become dangerous to breathe in (2)</li> <li>Synthetic leather, Pegamoid, can have a plastic feel and look which many do not appreciate. It does not age as well as natural leather does (1)</li> <li>Age more poorly than natural fibre materials (2)</li> <li>Do not feel as genuine as natural fibre materials do (2)</li> <li>The more wool is mixed with other synthetic fibres, the worse it becomes (1)</li> <li>Often impregnated with flame retardants if used in public environments, which can be health hazardous (1)</li> </ul>
Leather, skin and fur	<ul> <li>Age beautifully, live long and can get patina if maintained (11)</li> <li>Aged leather is more beautiful than new (2), can increase in value over time (1)</li> <li>More hard-wearing than textile (2)</li> <li>Hold up even though worn thin (1)</li> </ul>	<ul> <li>Can get dry and crackle (3)</li> <li>Skin does not withstand direct sun light (2)</li> <li>Must be maintained and lubricated regularly (3)</li> <li>One stain on otherwise clean leather destroys the overall impression (2)</li> <li>Unethical (2)</li> <li>Expensive (1)</li> <li>Damaged leather, e.g. cracked or torn, is not possible to mend (2)</li> <li>Perforations close to corners exposed to great loads can lead to the material tearing (1)</li> <li>Can stretch badly if cut and sown wrong (1)</li> </ul>
Ceramics	<ul> <li>Age beautifully and slowly (4)</li> <li>Concrete ages beautifully (3) if surface treated with e.g. wax (1)</li> <li>Glass scratches less than plastics (1)</li> <li>Surface treated ceramics can bleach in a beautiful way (1)</li> <li>Possible to sand down concrete a couple of times without any problems (1)</li> </ul>	<ul> <li>Glass can crack suddenly without showing any signs of weakness (1)</li> <li>Looks bad if it chips (4)</li> <li>Tiles and clinker can grow matte with time (1)</li> <li>Glass can grow matte and lose its lustre (1)</li> <li>Concrete scratches easily and needs to be surface treated to withstand humidity and acids (1)</li> <li>Glass can get glass disease which makes it look milky and ugly (1)</li> <li>Metals scratch glass and the combination should</li> </ul>

	<ul> <li>Hardened glass and ceramics do not scratch as easily (1)</li> <li>Bone china does not scratch (1)</li> </ul>	<ul><li>therefore be avoided (1)</li><li>Scratched glass can be ugly (1)</li></ul>
Stone materials	<ul> <li>(Barely) wear, erode and age beautifully (7)</li> <li>Granite withstands most (1)</li> <li>The surface can be impregnated with different types of soaps to make it more durable (1)</li> <li>Marble can endure many centuries and still look good (3)</li> </ul>	<ul> <li>Some stone types easily become speckled/stained, get marks and are vulnerable to acids (5)</li> <li>Porous kinds, such as marble and lime stone, need to be surface treated (1)</li> <li>Stone can crack suddenly without showing any signs of weakness (1)</li> <li>Aged stone breaks if dropped (1)</li> <li>Matte granite surfaces need to be oiled regularly to look fresh (1)</li> <li>Using some rare types of stone depletes the crust of the earth (1)</li> </ul>
Plastic	<ul> <li>Some plastic products and surface coatings made of plastic are very durable (4)</li> <li>High quality plastics can age well (4), e.g. POM (1)</li> <li>In many cases possible to melt down and recycle (1)</li> <li>Plastics can work very well in the right application (2)</li> <li>Thin, plastic composites that are glued onto surfaces are very durable and age well. Mixing plastics with natural resins, gum Arabic, and stone dust makes them very strong (1)</li> </ul>	<ul> <li>The carbon bonds break down over time and make the material brittle (6)</li> <li>Generally age poorly and is not as durable as wood and metals (5)</li> <li>Vulnerable to sunlight and heat (4)</li> <li>Some plastic coatings on fibre boards age badly, e.g. plastic paint that peel off in large flakes (3)</li> <li>Not possible to save plastic that has begun to degrade (3)</li> <li>Plastic foam and cold foam in paddings can harden over time and pulverise, making it harmful to breathe in (4)</li> <li>Gets easily scratched and is difficult to mend, (3) e.g. PP, PS, ABS</li> <li>Turns yellow over time (2)</li> <li>Can get discoloured by strong pigments (2)</li> <li>Plastic finishes can grow matte over time (1)</li> <li>Public environments require durable surface finishes such as plastic coatings, but as they wear they are difficult to mend or restore (1)</li> <li>Plastic armrests can wither over time (1)</li> </ul>
Rubber	<ul> <li>Rubber does not get the same kind of visible scratches as plastic materials do (2)</li> <li>Rubber ages slowly in an indoor environment (2)</li> <li>Can endure 40-50 years before drying (1)</li> </ul>	<ul> <li>Dries, grows brittle and breaks (6)</li> <li>Vulnerable to heat and sunlight (2)</li> <li>Not possible to restore or mend (2)</li> <li>Gets easily dirty (2)</li> <li>Needs proper maintenance to endure: clean it in the right way and do not keep it in direct sunlight (1)</li> </ul>

# Appendix I - Overview of the chairs used in the Perception study: Part 1

This is the result from the perception study, Part 1, including pictures of the chairs, close-up pictures on the visual wear and a summary of the result with both mean value and median of the scores. High value means good condition (little or no wear) and low means poor condition (severely worn).

#### Section 1: Chair 1-7

Chair 1



**Description:** Stains on seat. Scratched off paint at the front of the frame. Dirt and scratches at the bottom off the legs.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	2,91	3,29	2,35	2,03	2,24	3,03	2,38
Median	3	3	2	2	2	3	





**Description:** Stains on seat. Peeling and scratched off paint at the bottom of the legs (front and back). Scratched off paint at the front of the frame. Scratched off paint at the back of the backrest.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	2,76	3,13	2,03	2,35	2,29	2,76	2,35
Median	3	3	2	2	2	3	

#### Chair 3



**Description**: Stains on seat. Gap between seat and frame in the front. Scratched off paint at the front of the frame. Dirt and deep scratches at the bottom off the legs. Peeling paint at the back of the seat. Scratched off paint at the top of the backrest.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	2,85	2,74	2,06	2,71	2,78	2,85	2,78
Median	3	3	2	2,5	2,75	3	





**Description**: Worn off paint and scratches at the front of the frame. White paint marks at the back of the backrest.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	4,32	4,32	4,12	3,53	3,35	3,44	3,74
Median	4,5	4,5	4	4	3,5	3,5	





**Description**: Bleached colour on seat. Worn edges on the seat. Worn off paint and scratches at the front of the frame and top of the backrest. White paint marks at the backrest, frame and legs (back and front). Worn down paint and black rubber marks at the bottom of the legs.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	3,44	2,85	3,06	2,85	2,94	3,24	3,12
Median	3	3	3	3	3	3	

#### Chair 6



**Description**: White paint marks on the back legs and back of the backrest. Worn off paint and scratches at the front of the frame. Loosening joints at the front of the frame.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	4,15	4,32	4,09	3,41	3,32	3,62	3,44
Median	4	4,5	4	3,5	3	3,5	

White paint marks at the back of the backrest.

Chair 7



**Description**: Bleached colour seat. Worn edges at the seat. Worn off paint and scratches at the front of the frame and top of the backrest. White paint marks at the back of the backrest, frame and legs (back and front). Worn down paint, dirt and black rubber marks at the bottom of the legs.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	3,47	3,06	3,35	3,41	3,26	3,32	3,12
Median	3,5	3	3	3	3	3	

#### Section 2: Chair 9-15

Chair 9



**Description**: Stains on the seat. Textile is worn with ripping and ragged edges at the front of the seat. Black rubber marks on back legs. Soiled/dirty at the front of the armrests.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	1,76	2,85	2,18	2,97	2,91	2,18	2,32
Median	1,5	3	2	3	3	2	

#### Chair 10



**Description**: White paint and stains on the seat. Textile is worn with ripping and ragged edges at the front of the seat. Dirt and rubber marks on back legs. Soiled/dirty at the front of the armrests. Dirt and black rubber marks on back legs.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	1,71	2,76	2,00	2,65	2,94	1,94	2,00
Median	1,5	2,5	2	2,5	3	2	

#### Chair 11



**Description**: Dirt marks on back legs. White paint on the armrest. Dirt and black rubber marks on back legs. Textile is worn with ripping and ragged edges at the front of the seat.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	1,76	3,06	2,53	2,91	2,82	2,35	2,44
Median	2	3	2,5	3	3	2,5	





**Description**: Dirt and black rubber marks on legs (front and back). Rickety armrest/backrest (not shown).

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	3,79	3,44	3,29	2,79	3,09	2,85	3,06
Median	4	3	3	3	3	3	





**Description**: Stains on the seat. Textile is worn with ripping and ragged edges at the front of the seat. Coffee drippings on the back of the legs and back of frame. Dirt and rubber marks on back legs. Soiled/dirty and scratches at the front of the armrests.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	1,44	2,65	1,94	2,47	2,53	2,09	2,18
Median	1	2	2	2,5	2,5	2	



**Description**: Dirt and stains on the seat. Textile is worn with ripping and ragged edges at the front of the seat. Dirt marks on legs (front and back). Soiled/dirty and scratches at the front of the armrests.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	1,38	2,50	1,38	2,50	2,71	2,15	1,97
Median	1	2	1	2,5	2,5	2	

Chair 15



**Description**: Textile is worn with ripping and ragged edges at the front of the seat. Dirt and rubber marks on back legs. Soiled/dirty and scratches at the front of the armrests. Dirt and deep scratches on the back legs.

	Wear seat	Bleached seat	Dirty seat	Wear frame	Scratches on frame	Dirty frame	Overall appearance
Mean	2,24	2,88	2,50	2,82	2,94	2,59	2,82
Median	2	3	2	3	3	2,5	

# Appendix J – Overview of the chairs used in the Perception study: Part 2

This is the result from the perception study including pictures of the chairs and close-up pictures on the visual wear and mean value about the chairs conditions. High value means good condition (little or no wear) and low means poor condition (severely worn).

#### Chair A



**Description:** Dust and dirt on the seat. Scratches on the frame near the legs. Zagging textile on the seat. Bleached out colours on the seat.

**Overall appetence [Mean value]:** 3,24

#### Chair B



**Description:** Dust and dirt on the textile (seat and backrest). Wear and scratches at the front of the armrests.

Overall appetence [Mean value]: 3,50

### Chair C



**Description:** Worn down and scratched off paint on the armrests. Scratched off paint both on frame and legs. Legs have black rubber marks.

**Overall appetence [Mean value]:** 2,88

### Chair D



**Description:** Deep scratches on the front and back of the armrest.

Overall appetence [Mean value]: 3,59

#### Chair E



**Description:** Indentations in the textile seat from stacking. Scratched off paint on the armrest (front and middle) and at the top of the backrest.

Overall appetence [Mean value]: 3,03

#### Chair F



**Description:** Indentations in the textile seat from stacking. Scratches and marks on the seat. Loosening joints at the front of the armrest. Scratches on the armrest. White paint marks on the legs. Peeling paint at the end of the legs.

Overall appetence [Mean value]: 2,06
#### Chair G



**Description:** Stain on the seat. Deep scratches on the back of the backrest.

Overall appetence [Mean value]: 3,00

#### Chair H



Description: Wear on the edges of the seat. White paint marks on back legs.

Overall appetence [Mean value]: 3,06

#### Appendix K - Perception study results: Part 1

#### All chairs (1-15), Correlation Spearman Brown (Rank correlation)

Biggest correlation to total assessment for all chairs: dirt on the frame (B\_dirt).

All Grou	All Groups Spearman Rank Order Correlations (CM_Mom2_1_15) MD pairwise deleted Marked correlations are significant at p <,05000										
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total				
T_wear	1,000000	0,390985	0,771446	0,350748	0,380039	0,623287	0,667928				
T_bleach	0,390985	1,000000	0,441083	0,065870	0,170954	0,202947	0,263873				
T_dirt	0,771446	0,441083	1,000000	0,394078	0,369971	0,661021	0,680684				
B_wear	0,350748	0,065870	0,394078	1,000000	0,659305	0,499958	0,594709				
B_scratch	0,380039	0,170954	0,369971	0,659305	1,000000	0,595763	0,619017				
B_dirt	0,623287	0,202947	0,661021	0,499958	0,595763	1,000000	0,804414				
Total	0,667928	0,263873	0,680684	0,594709	0,619017	0,804414	1,000000				

Chair by chair:

**Chair 1**: Dirt on the seat (T\_dirt) and on the frame (B\_dirt) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=1 Spearman Rank Order Correlations (CM\_Mom2\_1\_15) MD pairwise deleted Marked correlations are significant at p <,05000

	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total
T_wear	1,000000	0,403867	0,779726	0,261603	0,510665	0,682896	0,669813
T_bleach	0,403867	1,000000	0,557303	0,008779	0,240111	0,541833	0,459387
T_dirt	0,779726	0,557303	1,000000	0,437816	0,599864	0,744042	0,835612
B_wear	0,261603	0,008779	0,437816	1,000000	0,571650	0,264376	0,457245
B_scratch	0,510665	0,240111	0,599864	0,571650	1,000000	0,640798	0,652753
B_dirt	0,682896	0,541833	0,744042	0,264376	0,640798	1,000000	0,848087
Total	0,669813	0,459387	0,835612	0,457245	0,652753	0,848087	1,000000

Chair 2: Dirt on the frame (B_	_dirt) had the greatest influence on the total (overall) evaluation
(highest correlation).	

chair=2 Spearman Rank Order Correlations (CM_Mom2_1_15) MD pairwise deleted Marked correlations are significant at p <,05000										
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total			
T_wear	1,000000	0,415153	0,810465	0,199533	0,380950	0,744458	0,599980			
T_bleach	0,415153	1,000000	0,249475	-0,279236	0,195018	0,242041	0,047318			
T_dirt	0,810465	0,249475	1,000000	0,235212	0,356445	0,710971	0,705273			
B_wear	0,199533	-0,279236	0,235212	1,000000	0,349649	0,072638	0,353245			
B_scratch	0,380950	0,195018	0,356445	0,349649	1,000000	0,564457	0,554250			
B_dirt	0,744458	0,242041	0,710971	0,072638	0,564457	1,000000	0,838256			
Total	0,599980	0,047318	0,705273	0,353245	0,554250	0,838256	1,000000			

Chair 3: Dirt on the seat (T\_dirt) and on the frame (B\_dirt) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=3	chair=3 Spearman Rank Order Correlations (CM_Mom2_1_15) MD pairwise deleted Marked correlations are significant at p <,05000										
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total				
T_wear	1,000000	0,514486	0,816009	0,512540	0,441245	0,698220	0,703180				
T_bleach	0,514486	1,000000	0,446905	0,180782	0,185504	0,213669	0,364507				
T_dirt	0,816009	0,446905	1,000000	0,601212	0,566837	0,847897	0,788029				
B_wear	0,512540	0,180782	0,601212	1,000000	0,673222	0,613072	0,686537				
B_scratch	0,441245	0,185504	0,566837	0,673222	1,000000	0,696538	0,705885				
B_dirt	0,698220	0,213669	0,847897	0,613072	0,696538	1,000000	0,784358				
Total	0,703180	0,364507	0,788029	0,686537	0,705885	0,784358	1,000000				

**Chair 4**: Dirt on the frame (B\_dirt) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=4 Spearman Rank Order Correlations (CM_Mom2_1_15) MD pairwise deleted Marked correlations are significant at p <,05000										
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total			
T_wear	1,000000	0,833587	0,578842	0,002048	-0,076769	0,266063	0,300556			
T_bleach	0,833587	1,000000	0,793433	0,137442	0,058625	0,252516	0,459624			
T_dirt	0,578842	0,793433	1,000000	0,096145	0,164800	0,220615	0,466527			
B_wear	0,002048	0,137442	0,096145	1,000000	0,792155	0,592901	0,597712			
B_scratch	-0,076769	0,058625	0,164800	0,792155	1,000000	0,815152	0,720727			
B_dirt	0,266063	0,252516	0,220615	0,592901	0,815152	1,000000	0,837467			
Total	0,300556	0,459624	0,466527	0,597712	0,720727	0,837467	1,000000			

**Chair 5**: Dirt on the frame (B\_dirt) and wear on the seat (T\_wear) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=5 Spearman Rank Order Correlations (CM_Mom2_1_15) MD pairwise deleted Marked correlations are significant at p <,05000										
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total			
T_wear	1,000000	0,152145	0,606680	0,246973	0,461483	0,579957	0,728410			
T_bleach	0,152145	1,000000	0,229080	-0,362875	-0,147355	-0,033824	-0,230363			
T_dirt	0,606680	0,229080	1,000000	0,063242	0,066109	0,618900	0,575138			
B_wear	0,246973	-0,362875	0,063242	1,000000	0,451808	0,527181	0,641394			
B_scratch	0,461483	-0,147355	0,066109	0,451808	1,000000	0,217965	0,378350			
B_dirt	0,579957	-0,033824	0,618900	0,527181	0,217965	1,000000	0,748459			
Total	0,728410	-0,230363	0,575138	0,641394	0,378350	0,748459	1,000000			

**Chair 6**: Dirt on the seat (T\_dirt) and wear on the seat (T\_wear) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=6	chair=6 Spearman Rank Order Correlations (CM_Mom2_1_15) MD pairwise deleted Marked correlations are significant at p <,05000										
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total				
T_wear	1,000000	0,222273	0,807692	0,537671	0,312508	0,555472	0,693761				
T_bleach	0,222273	1,000000	0,110014	0,182865	0,293468	-0,052691	0,352748				
T_dirt	0,807692	0,110014	1,000000	0,537671	0,312508	0,694340	0,693761				
B_wear	0,537671	0,182865	0,537671	1,000000	0,804844	0,453106	0,643287				
B_scratch	0,312508	0,293468	0,312508	0,804844	1,000000	0,455830	0,626425				
B_dirt	0,555472	-0,052691	0,694340	0,453106	0,455830	1,000000	0,678587				
Total	0,693761	0,352748	0,693761	0,643287	0,626425	0,678587	1,000000				

**Chair 7**: Wear on the frame (B\_wear) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=7	chair=7 Spearman Rank Order Correlations (CM_Mom2_1_15) MD pairwise deleted Marked correlations are significant at p <,05000										
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total				
T_wear	1,000000	0,148432	0,639483	0,639972	0,507276	0,695807	0,717676				
T_bleach	0,148432	1,000000	0,420662	0,282927	0,158081	0,202083	0,309347				
T_dirt	0,639483	0,420662	1,000000	0,748697	0,582964	0,876016	0,706541				
B_wear	0,639972	0,282927	0,748697	1,000000	0,850453	0,888133	0,832749				
B_scratch	0,507276	0,158081	0,582964	0,850453	1,000000	0,721317	0,790280				
B_dirt	0,695807	0,202083	0,876016	0,888133	0,721317	1,000000	0,767659				
Total	0,717676	0,309347	0,706541	0,832749	0,790280	0,767659	1,000000				

**Chair 9**: Dirt on the frame (B\_dirt) and on the seat (T\_dirt) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=9 Spearman Rank Order Correlations (CM_Mom2_1_15) MD pairwise deleted Marked correlations are significant at p <,05000											
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total				
T_wear	1,000000	0,403867	0,779726	0,261603	0,510665	0,682896	0,669813				
T_bleach	0,403867	1,000000	0,557303	0,008779	0,240111	0,541833	0,459387				
T_dirt	0,779726	0,557303	1,000000	0,437816	0,599864	0,744042	0,835612				
B_wear	0,261603	0,008779	0,437816	1,000000	0,571650	0,264376	0,457245				
B_scratch	0,510665	0,240111	0,599864	0,571650	1,000000	0,640798	0,652753				
B_dirt	0,682896	0,541833	0,744042	0,264376	0,640798	1,000000	0,848087				
Total	0,669813	0,459387	0,835612	0,457245	0,652753	0,848087	1,000000				

**Chair 10**: Dirt on the frame (B\_dirt) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=10	chair=10 Spearman Rank Order Correlations (CM_Mom2_1_15) MD pairwise deleted Marked correlations are significant at p <,05000										
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total				
T_wear	1,000000	0,415153	0,810465	0,199533	0,380950	0,744458	0,599980				
T_bleach	0,415153	1,000000	0,249475	-0,279236	0,195018	0,242041	0,047318				
T_dirt	0,810465	0,249475	1,000000	0,235212	0,356445	0,710971	0,705273				
B_wear	0,199533	-0,279236	0,235212	1,000000	0,349649	0,072638	0,353245				
B_scratch	0,380950	0,195018	0,356445	0,349649	1,000000	0,564457	0,554250				
B_dirt	0,744458	0,242041	0,710971	0,072638	0,564457	1,000000	0,838256				
Total	0,599980	0,047318	0,705273	0,353245	0,554250	0,838256	1,000000				

**Chair 11**: Dirt on the seat (T\_wear) and wear on the frame (B\_dirt) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=11 Spearman Rank Order Correlations (CM_Mom2_1_15) MD pairwise deleted Marked correlations are significant at p <,05000										
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total			
T_wear	1,000000	0,514486	0,816009	0,512540	0,441245	0,698220	0,703180			
T_bleach	0,514486	1,000000	0,446905	0,180782	0,185504	0,213669	0,364507			
T_dirt	0,816009	0,446905	1,000000	0,601212	0,566837	0,847897	0,788029			
B_wear	0,512540	0,180782	0,601212	1,000000	0,673222	0,613072	0,686537			
B_scratch	0,441245	0,185504	0,566837	0,673222	1,000000	0,696538	0,705885			
B_dirt	0,698220	0,213669	0,847897	0,613072	0,696538	1,000000	0,784358			
Total	0,703180	0,364507	0,788029	0,686537	0,705885	0,784358	1,000000			

**Chair 12**: Dirt on the frame (B\_dirt) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=12	Spearman R	ank Order Co correlat	orrelations ( ions are sig	CM_Mom2_ nificant at p <	1_15) MD pair <,05000	wise deleted	I Marked
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total
T_wear	1,000000	0,833587	0,578842	0,002048	-0,076769	0,266063	0,300556
T_bleach	0,833587	1,000000	0,793433	0,137442	0,058625	0,252516	0,459624
T_dirt	0,578842	0,793433	1,000000	0,096145	0,164800	0,220615	0,466527
B_wear	0,002048	0,137442	0,096145	1,000000	0,792155	0,592901	0,597712
B_scratch	-0,076769	0,058625	0,164800	0,792155	1,000000	0,815152	0,720727
B_dirt	0,266063	0,252516	0,220615	0,592901	0,815152	1,000000	0,837467
Total	0,300556	0,459624	0,466527	0,597712	0,720727	0,837467	1,000000

**Chair 13**: Dirt on the frame (B\_dirt) and wear on the seat (T\_wear) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=13	Spearman	Rank Order ( correla	Correlations ations are sig	(CM_Mom2_ gnificant at p	_1_15) MD pai <,05000	rwise delete	d Marked
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total
T_wear	1,000000	0,152145	0,606680	0,246973	0,461483	0,579957	0,728410
T_bleach	0,152145	1,000000	0,229080	-0,362875	-0,147355	-0,033824	-0,230363
T_dirt	0,606680	0,229080	1,000000	0,063242	0,066109	0,618900	0,575138
B_wear	0,246973	-0,362875	0,063242	1,000000	0,451808	0,527181	0,641394
B_scratch	0,461483	-0,147355	0,066109	0,451808	1,000000	0,217965	0,378350
B_dirt	0,579957	-0,033824	0,618900	0,527181	0,217965	1,000000	0,748459
Total	0,728410	-0,230363	0,575138	0,641394	0,378350	0,748459	1,000000

**Chair 14**: Dirt on the seat (T\_dirt) and wear on the seat (T\_wear) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=14	Spearman	Rank Order C correla	Correlations ( tions are sig	(CM_Mom2_ Inificant at p	_1_15) MD pair <,05000	rwise deleted	d Marked
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total
T_wear	1,000000	0,222273	0,807692	0,537671	0,312508	0,555472	0,693761
T_bleach	0,222273	1,000000	0,110014	0,182865	0,293468	-0,052691	0,352748
T_dirt	0,807692	0,110014	1,000000	0,537671	0,312508	0,694340	0,693761
B_wear	0,537671	0,182865	0,537671	1,000000	0,804844	0,453106	0,643287
B_scratch	0,312508	0,293468	0,312508	0,804844	1,000000	0,455830	0,626425
B_dirt	0,555472	-0,052691	0,694340	0,453106	0,455830	1,000000	0,678587
Total	0,693761	0,352748	0,693761	0,643287	0,626425	0,678587	1,000000

**Chair 15**: Wear on the frame (B\_wear) had the greatest influence on the total (overall) evaluation (highest correlation).

chair=15	Spearman F	correla	tions are sig	nificant at p	(1_15) MD pair <,05000	wise deleted	a Marked
	T_wear	T_bleach	T_dirt	B_wear	B_scratch	B_dirt	Total
T_wear	1,000000	0,148432	0,639483	0,639972	0,507276	0,695807	0,717676
T_bleach	0,148432	1,000000	0,420662	0,282927	0,158081	0,202083	0,309347
T_dirt	0,639483	0,420662	1,000000	0,748697	0,582964	0,876016	0,706541
B_wear	0,639972	0,282927	0,748697	1,000000	0,850453	0,888133	0,832749
B_scratch	0,507276	0,158081	0,582964	0,850453	1,000000	0,721317	0,790280
B_dirt	0,695807	0,202083	0,876016	0,888133	0,721317	1,000000	0,767659
Total	0,717676	0,309347	0,706541	0,832749	0,790280	0,767659	1,000000

#### Differences between amateurs and experts:

The results show that amateurs and experts have a tendency to differ in their overall assessments, but the variations are not significant (*Figure 1*). The differences are however significant when it comes to bleaching on seats and dirt on frames, see *Figure 2* and *Figure 3*.



Figure 1: Differences in total assessments between amateurs and experts



Figure 2: Differences between the amateurs' and the experts' assessments of the seats



Figure 3: Differences between the amateurs' and the experts' assessments of the frames

#### All variables plotted against the total

In all the different variables are plotted against the total (overall) evaluation of the chairs.



Figure 4: Wear on seats (T\_wear) plotted against the total assessment of the chairs



Figure 5: Bleaching on seats (T\_bleach) plotted against the total assessment of the chairs



Figure 6: Dirt on seats (T\_dirt) plotted against the total assessment of the chairs



Wilks lambda=,16756, F(91, 1355, )=4,9413, p=0,0000

Figure 7: Wear on frames (B\_wear) plotted against the total assessment of the chairs



Figure 8: Scratches on frames (B\_scratch) plotted against the total assessment of the chairs



Figure 9: Dirt on the frames (B\_dirt) plotted against the total assessment of the chairs

#### Appendix L - Guide for designing with aging and wear in mind



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## Aim of the guide

than functional, meaning that fully functional furniture with remaining value is need to start thinking about what happens to the product after sales and how Each year, a vast amount of fur niture in the public sector in Sweden is disposed of, as trends and fashions change. To change this, designers and manufacturers Simple measures such as facilitating refurbishment and maintenance can help simply thrown away. Furniture has become consumer goods that are replaced ending up in landfills. The furniture is often discarded for aesthetic reasons rather to preserve its value over time; for example by allowing for it to be recirculated save a great deal of resources, both environmentally and financially.

over and over again. The information and recommendations presented in this This short guideline aims at asisting designers in creating public seating furniture that is more suited for a circular economy. The point of departure has been the aging and wear of furniture; aspects that are especially important in the case of closed guide are based on both theoretical as well as empirical research. Interviews with have been conducted to collect information, as well as a study examining how end users and experts perceive and tolerate aged and worn public seating furniture. loop systems where furniture has to with stand longer use and being recirculated experts and professionals in furniture design and in the furniture trade in Sweden The project was funded by Vinnova and coordinated by IDC West.

2..... œ.... .... AGING & WEAR OF FURNITURE 5 ....13 .....18 ......17 ž ENVIRONMENTAL LABELLING IN A CIRCULAR ECONOMY......4 .....15 .....11 THE PRODUCT: SEATING FURNITURE..... DESIGNING FOR PUBLIC ENVIRONMENTS..... PRODUCT CONSTRUCTION..... BACKRESTS/FRAMES..... VIS UAL APPEARANCE ..... CIRCULAR FURNITURE FLOWS. MATERIAL SELECTION ... ARMRESTS... SEAT S.... LEGS..... 0 0

If you have previous experience of designing for circularity and furniture design, the introductory chapters can be skipped. General design recommendations start at page 7, and component specific information and recommendations can be read on pages 13 and forward.



## Table of Contents

### The Product:

# Seating furniture



In addition to some general information concerning material choice, construction and aesthetics, each of the chair's different components are going to be addressed separately with more part-specific information and recommendations.

With 'upholstered seating furniture for public environments' al kinds of conference chairs, breakroom chairs and reception chairs in places that either are open for the public or are tax funded are being considered. Office chairs are however exempt as their more technical nature call for higher requirements to be met. Yet, many of the recommendations presented here are universal and can be applied on a number of products. To be able to design something that lasts, one must consider the underlying reasons to why peoplewant to get rid of or change furniture. As previously mentioned, a common reason for throwing out furniture is because it has become aesthetically outdated – furniture is replaced in such a speed that it does not have the time to become physically worn. Nevertheless, people have started to see the need for change, and more and more buyers are asking for longer lasting products<sup>2</sup>. And if the aim is to design long-lasting furniture, then aspects such as aging and wear become much more important to consider.

### Aging and wear of furniture

In the case of furniture, the terms aging and wear are perceived in quite different ways. While wear is associated with damages and deterioration stemming from frequent use, aging is often seen as the gradual change the furniture goes through over time. Wear is in other words actively created, while aging is the result of the exposure to external influences such as heat, sun radiation, humidity or air pollution for a longer duration of time. Aging often has a more positive ring to it than wear, as some of its effects can appear charming and add character to the furniture, for example patination or colour changes inwooden materials. What is often referred to as "natural wear" can also help add value, for example the kind of wear has not damaged the material but that shows its history; how it has been used and handled over the years. This natural wear is though only appealing if the furniture is made out of high quality materials to begin with, as lesser quality materials tend to show their inferiority with age<sup>4</sup>. Negative, damaging, wear on the other hand often manifests as saggy and stained chair seats, scratches and black rubber marks on chair legs, and chipped corners on armrests. These kinds of wear often lead to chairs being thrown away, and should therefore be avoided or mended as soon as possible. Interviews and perception test data are however showing that the condition of the textiles is a determining factor for how people perceive the chair as a whole. As long as the textiles are looking fresh, users seem to some extent be willing to put up with other wear.





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# Circular furniture flows





How furniture or parts of furniture can be circulated instead of directly going to a landfill, based on the EMP model.

Circular economy has in recent years emerged as a more sustainable alternative to the linear "take-make-dispose" society that rules today. This model aims at making the most of the material we produce by recirculating it as long as possible, thus saving both money and on the environment.

as possible over time, one should always seek to go furniture for functional or aesthetical reasons is so to speak, for example by reusing, refurbishing In order to keep as much of the value of the product The most value is retained by seeking to keep the This however requires furniture either with higher durability or that is easily maintained. If the not able to go on this way any more, it is time to see parts of it, for example reupholstering seats and so on. Lastly, if no other options remain, material and recycling the furniture or parts of the furniture. through the inner loops first and work outwards. integrity of the chair intact for as long as possible<sup>4</sup> for instance by sharing maintaining and reusing. I his could either concern the whole product or only [here are many different ways of "closing the loop" if refurbishment or remanufacturing is an option ecycling should be performed. The circular business models that are implemented in connection to this can have varying levels of circularity built in to them. Renting furniture or providing office interiors as a service are some examples where the supplier retains the ownership of the furniture and therefore has an incentive to own long lasting, high quality furniture.

product life and another gets muddled; where does that another company has produced with the one life end and where does the next start? In the case of environmental labelling, this complicates matters. Because what happens to the certification of a chair if it or parts of it are refurbished and then reused? Regulations and requirements change over time, for example banning materials exactly what the furniture contains can also be difficult, for example if one buys used furniture intention of refurbishing and reselling it. A product which content cannot be verified is not allowed to As the furniture starts moving more in circles than in a straight line forward, the lines between one or chemicals which once were permitted. Knowing be sold within the EU/EE%. Some guidelines regarding the labelling of recirculated furniture have been developed in the last couple of years' specifying the relabelling process depending on the circumstances: for example if the product is the company's own, if the new customer is the same or a new one, or if the product needs refurbishment or not. As of today, the big environmental labels in Sweden, Möbelfakta and Svanen, have however no direct plans regarding creating a certification system for recyclable furniture (that are possible to refurbish and resell)<sup>2</sup>. In case of such a label, requirements such as providing a declaration of contents, allowing for easy disassembly, and fulfilling a certain recovery rate would be centra<sup>2</sup>.



## Designing for

In order to design furniture that is suitable for public erwironments, one must have an understanding for its users and their needs and requirements. There are a myriad of different public environments; libraries, schools, lobbies and lunch rooms, all with different users and expectations. Most of them are exposed to high levels of wear and tear, with many different users, using them continuously. Wear ing at the front of upholstered seats, staining from people are the most common types of wear, stemming from frequent use.

Naturally, we expect different standards in different places depending on social and economic prerequisites, but generally as it comes to places that are tax funded peopletend to be more forgiving towards signs of aging and wear. A basic rule is though that wear on fabrics and surfaces stemming from use is acceptable, but dirt and strains less so. Evenly, but quite extensively, worn furniture is also more acceptable to people in general than furniture in an otherwise perfect condition but with some glaring scratch or stain. Important is though that the furniture is not damaged or broken: rickety chairs are notfound acceptable by most users<sup>6</sup>. In offices, furniture is however most often discarded for aesthetical reasons rather than because of excessive wear. Relocations of offices lead to replacements rather than transfers, and managers often want to update the interiors every five years to keep the office contemporany<sup>4</sup>.

# public environments

Since people in general are more careful with furniture they own themselves', it could be fruitful for the public sector to involve the users in the decision making, like for e.g. the "Design med Omtanke" ("Design with Care") initiative in The County Council of Västra Götaland in Sweden".

The figure below shows how severe users find different types of wear. A high value means it is very damaging to the users' perception of the chair, whereas a low value means there is more tolerance towards the specific type of wear. As can be seen, ricketiness is the least acceptable, while there is a tendency to tolerate colour change or pilling of textiles more".



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Plastics, pigments and dyes should not contain hazardous substances, such as lead, tin, cadmium, chrome, mercury, phthalates etc <sup>444a</sup> . PVC is not allowed, except for in attificial leather for heath facility environments requiring regular sterilization**
Plastic parts need to be labelled to make recycling easier. Plastic components with a weight over 50 grams must have a permanent label according to standard ISO 11469 or similar <sup>144,45</sup>
If surface treatments are applied to plastics it is not allowed to affect the recyclability of the plastic parts, to fulfil the 3vanen requirements <sup>4</sup> . Plastic parts need to be labelled to make recycling easier. Plastic components with a weight over 50 grams must have a permanent label according to standard ISO 11469 or similar <sup>144,10</sup> .
Use thicker material layers or surface finishes on faces subjected to more extensive wear, e.g. thicker veneer <sup>14,24</sup> . If surface treatments are applied to plastics it is not allowed to affect the recyclability of the plastic parts, to fulfil the 3varen requirements <sup>4</sup> . Plastic parts need to be labelled to make recycling easier. Plastic components with a weight over 50 grams must have a permanent label according to standard ISO 11469 or similar <sup>14,4,10</sup> .
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If possible, choose renewable material, e.g. sea weed for braided seats <sup>4</sup> . Natural materials often age nicely and have less environmental impact. Avoid materials that degrade over time, for example white plastics that turn yellow <sup>4</sup> . Use thicker material layers or surface finishes on faces subjected to more extensive wear, e.g. thicker vencer <sup>14,24</sup> . If surface treatments are applied to plastics it is not allowed to affect the recyclability of the plastic parts, to fulfil the <i>W</i> -amen requirements <sup>4</sup> . Plastic parts need to be labelled to make recycling easier. Plastic components with a weight over 50 grams must have a permanent label according to standard iSO 11469 or similar <sup>14,44,10</sup> .
If possible, use surface treatments that age and wear well", for example wood oil (however not in environments with severe wear) or transparent coathings <sup>12</sup> . If possible, choose renewable material, e.g. sea weed for braided seats <sup>14</sup> . Natural materials often age nicely and have less environmental impact. Avoid materials that degrade over time, for example by growing weak and brittle <sup>4</sup> . Avoid materials that become discoloured, for example white plastics that turn yellow <sup>4</sup> . Use thicker material layers or surface finishes on faces subjected to more extensive wear, e.g. thicker veneer <sup>14,24</sup> . If surface treatments are applied to plastics it is not allowed to affect the recyclability of the plastic components with aweight over 50 grams must have a permanent label according to standard iSO 11469 or similar <sup>14,14,16</sup> .
<ul> <li>By using metals of similar colour in a product or coatings with similar colour as the underlying materials, wear will appear less distinct<sup>8</sup>.</li> <li>If possible, use surface treatments that age and wear wells, for example wood oil (however not in environments with severe wear) or transparent coatings<sup>44</sup>. Natural materials that be and have less environmental impact.</li> <li>Avoid materials that degrade over time, for example white plastics that turn vellow<sup>46</sup>.</li> <li>Use thicker material layers or surface finishes on faces subjected to more extensive wear, e.g. thicker veneer<sup>14,44</sup>.</li> <li>Provid materials that become discoloured, for example white plastics that turn vellow<sup>46</sup>.</li> <li>Use thicker material layers or surface finishes on faces subjected to more extensive wear, e.g. thicker veneer<sup>14,44</sup>.</li> <li>Isurface treatments are applied to plastics fit is not allowed to affect the recyclability of the plastic components with aveight over 50 grams must have a permanent label according to standard is 0.011469 or similar<sup>14,44,10</sup>.</li> </ul>
Avoid materials containing chemicals that are untexed or likely to be prohibited later on <sup>1,10</sup> . By using materials of similar colour in a product or coatings with similar colour as the underlying materials, wear will appear less distinct <sup>8</sup> . If possible, use surface treatments that age and wear well <sup>9</sup> , for example wood oil (however not in environments with severe wear) or transparent coathings <sup>4</sup> . Natural in possible, choose renewable material, e.g. sea weed for braided seats <sup>4</sup> . Natural materials often age nicely and have less environmental impact. Avoid materials that become discoloured, for example white plastics that turn yellow <sup>4</sup> . Use thicker wear, e.g. thicker veneer <sup>10,4,4</sup> . If surface treatments are applied to plastics it is not allowed to affect the recyclability of the plastic components with aveight over 50 grams must have a permanent label according to standard is 2011469 or similar <sup>4,4,4,4,4</sup> .

What to think about regarding

# Material selection

To be able to make furniture that ages well and that with a and both the tough environments of the public sector as well as a prolonged life span due to recirculation, choosing the right materials is crucial. As there are numerous different materials and surface finishes to choose between, and with often contrasting requirements such as low price and high quality, it is no simple task. There is also a dilemma in choosing between long lasting materials and environmentally friendly materials. Expressing the are servironmentally friendly as powder coated ones, but they withstand more wear and look untouched for much longer<sup>a</sup>. Interviewed experts seem to prefer short-lived materials that are impossible to materials that are impossible to material and that allow for circulation.

### IN GENERAL:

- Follow the quality requirements set by existing standards or erwironmental labels, for example Möbelfakta, Svanen and Ecolabel<sup>2</sup>.
- Do not use unethical materials. Be aware of where the material comes from, how it is produced and what will happen to it once discarded<sup>16</sup>. Leather for example is a material most people think age well<sup>5</sup>, but one should be aware of the ethical issues that can be connected to it.
- It can be suitable to use different material on different parts depending on the level of interaction and with the user, e.g. leather or solid wood where one has their hands which is softer and warmer to the touch<sup>10</sup>.
- Choose material after application.
   Some materials are more sensitive to specific factors, e.g. many plastics are sensitive to UN radiation and become brittle and bleached with sun exposure<sup>2</sup>. If such materials are chosen, buyers should be informed of how to best keep and maintain the furniture.
- Surfaces with high shine, e.g. coated metal, is perceived to age poorer when they wear and become dull or scratched than already matte materials, e.g. rubberized surfaces or brushed metal<sup>4</sup>.
- Metals with coating are more vulnerable to be perceived as worn as small scratches or dents stand out<sup>e</sup>.
- Choose materials that are easy to keep clean and fresh looking<sup>12</sup>.

IMPORTANT ASPECTS FOR RECYCLING OR RESOURCE EFFICIENCY • There isvalue in choosing high quality

RECOMMENDATIONS:

- There is value in choosing high quality materials. "If you choose materials of high quality, you never have to throw away the furnture. The furnture can be maintained and restored, and is possible to resell as it has a second-hand value"<sup>16</sup>.
- Natural materials, e.g. solid wood, metal, leather etc., are perceived to age better than synthetic ones such as plastics and composites<sup>1</sup> 11 out of 11 interviewed experts stated that leather wear and age beautifully.
- Choose materials that are possible to renovate or mend<sup>14</sup>. Thin veneers are hard to renovate since it is easy to damage the veneer when removing the surface treatment.
- Coatings are generally impossible to remove entirely, so be mindful of the decision and its effect on the product's recyclability.<sup>2</sup> Use surface treatments that are easily maintained, restored or removed, or that age well such as wood stains and laquers<sup>2</sup>.
- Use pure/uncontaminated materials/when possible as they are easier to material recycle<sup>4,10</sup>.
- Use as few material types as possible to facilitate separation for material recycling<sup>statt</sup>
- Use materials with as little quality loss as possible when recycled, e.g. aluminium<sup>10</sup>.
- Use recycled materials if possible. If the construction contains more than 10 per cent plastics, at least 50 per cent should be from recycled plastics, to fulfil the Svaren requirements<sup>42</sup>. If furniture consists of at least 50 per cent metal in weight, at least 20 per cent for be recycled metal 50 per cent for
- Chrome is a durable finish, e.g. for stackable chairs, but only  $\mathbb{C}^{n}$  is allowed in the public sector  $^{12,4}$

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# Product construction

To design furniture that is capable of withstanding frequent use decade after decade is a challenging undertaking. It requires a well-thought-out construction with joints that both endure long time use as well as being easily taken apart to facilitate maintenance, repair and material recycling at end-of-use. Constructions can also be designed to be modular, thus allowing for continuous motionizing, part replacement due to damage or wear, or because of changing user needs. Some general recommendations on how to construct chairs for public environments are presented here.

### IN GENERAL:

- Stackable chairs facilitate transportation and storage, which is resource dficient as it saves on both energy and space<sup>a</sup>.
- Allow for the possibility to assess the condition of the chair, for example by providing standards for different conditions describing the level of wear acceptable. This could allow for more standardized maintenance and refur bishment<sup>19</sup>.
- Think about ergonomic aspects when designing and that the chair can be used by people of varying body shapes and needs?
- To allow for easy access to information about how to repair or maintain the furniture, it can be tagged using for example QR-codes, bar codes or short notes<sup>2,10</sup>. To be eligible for the Svanen certification there needs to be a permanent label with information about manufacturer, production date etc. as well as information about sub-suppliers<sup>1,2</sup>.
- Facilitate cleaning of the furniture by avoiding creating nooks and corners where dirt can collect<sup>10</sup>.



### RECOMMENDATIONS:

- A modular design can both provide aflexible functionality as well as easier separation which facilitate maintenance, repair, replacement of parts and material recycling<sup>a</sup>.
- Select joining techniques which facilitate disassembly for easier parts and material recycling<sup>4,1</sup>. Wielding rabbeting, gluing, and riveting makes separation difficult, while screws, clips, snap-fits, and Veloro are easily taken apart<sup>4,10</sup>.
- Self-locking constructions enable joining without additional fasteners that can act damagingly such as nails and pins puncturing the materials<sup>2</sup>.
- When using glue, choose appropriately strong glue. If the glue is stronger than the material, the material breaks and not the seam, making it much more difficult to mend<sup>18</sup>.
- Convex and flat surfaces on upholstery are possible to cover with textiles without the use of glue<sup>in</sup>.
- Visible joining methods make disassembly and repair easier. Hidden centre pins are for example difficult to locate, and if they come loose the chair becomes unstable. "Ricketiness is a common result of wear and tear that users do not accept, so it should be easy to repair".<sup>120</sup>.
- Make removal of worn parts easier by minimizing the number of joints and the accessibility of them – but without compromising the strength of the structure!"."
- Spare parts should be available for at least5 years after production, to be able to prolong the life of the product. This include damaged or defects that make the product completely or partially usable<sup>3</sup>.
- Use standardised screws and bolts that do not require specialised tools for removal<sup>11</sup>.
- Enable for the furniture to befastened with chucks in case of remanufacture<sup>10</sup>.

What to think about regarding

# Visual appearance

Making furniture that lasts physically is one thing, but equally important is making something that people would want to keep. As one interviewed Quality and Environmental Manager at a Swedish furniture company put it. "The difficult thing isto create furniture that not only issutainable in regard to its materials and structure, but also in its look and style". Examples of furniture that remain desirable over thine were by most professionals identified as "quality furniture" or "designer furniture"; in other words, furniture that most professionals of becomes out asyle". Examples of furniture that remain desirable over that ware by most professionals identified as "quality furniture" or "designer furniture"; in other words, furniture that skilled professionals". By taking into consideration the reasons for why furniture becomes out dated, as for example aest heft, technical, social, functional or economic changes, designers increase their chances of designing furniture that stays current and useful for a longer time. It is also important already in the design stage to decide how the chair is going to age, should there be no visible wear at all or should it age gracefully with the wear showing – take for example Kristine Bjaadai's chair Underskog\*\* where a hidden pattern emerges on the seat as the textile is worn down. Thinking through the aging process in advance can lead to a design that holds up or even increases in value over time.

"The essence of the furniture can be found in the shape and form, the balance, the details, the proportions, the lines and the meetings between two different materials that's where you can tell if a product has quality; if the meetings are beautifully executed"". Examples of timeless designs that were frequently mentioned in the interview study were Ame Jacobsen's "Syaan," "Myran" and "Svanen".

Knotted Grain by Marcel Wanders

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## RECOMMENDATIONS:

- A design that can be aftered or updated over time has a chance of surviving changing needs and trends. E.g. allowing for easy reupholstering or a modular design that can be aftered according to user needs<sup>24</sup>.
- Create a thought-out construction and design. Interviewed experts said that furniture that showed an attention to detail were more likely to withstand changing trends and fashions and become classics<sup>4</sup>.
- Dneway to prolong the products life is to create furniture that users can get emotionally attached to, furniture that ages well and has character<sup>m</sup>.
- Versattle chairs which suite different environments and settings are easier to relocate and resell. E.g big pieces of furniture are difficult to sell and resell in lager cities where people often move and have limited space<sup>a</sup>.
- Wear is not as noticeable on furniture that still has a cohesive look despite wear, e.g. furniture with same coloured metal details that age similarly, or materials with transparent or similarly coloured surface finishes<sup>4,10</sup>.
- Think about howyou execute the joining of different parts and materials, there is a lot of potential for creating interesting details "It is in the connection between two different materials you can detect if the product has quality"<sup>10</sup>.
- Even though "classic designs" have a higher chance of enduring changing trends, it is important to remember that designs considered timeless classics today were often once seen as new and innovative". Don't be afraid of being original!

MATERIAL RECOMMENDATIONS:	<ul> <li>Since the seat is especially exposed to wear, choose materials which withstand wear well<sup>6</sup>.</li> <li>Follow the required M artindale values for the application<sup>2</sup>.</li> </ul>	<ul> <li>Wool is naturally dire-repellent and keeps its freshness longer than other fabrics<sup>4,10</sup>.</li> </ul>	<ul> <li>Do not use fasteners which damage the frame or other parts with repeated changing of textiles<sup>11</sup>. E.g. do not use nails that make big holes in the material.</li> </ul>	• Thick, double woven textiles are possible to turn upside down when worn and thus "reuse" <sup>13</sup> .	<ul> <li>If possible, choose renewable materials for the upholstery, e.g. sea weed for braided seats, or straw for the padding<sup>12</sup>.</li> </ul>	<ul> <li>Use a padding material which lasts for a long time, or is easily replaced. Some types of plastic foam can grow hard with time and pulverise which can make reupholstering difficult and be</li> </ul>	dangerous to breathe inf. •	e energy annound and account of angle in construction of account of acco	<ul> <li>At the moment it is not possible to recycle many textiles, e.g. wool. Seek to instead minimise the textiles that are used<sup>10</sup>.</li> </ul>	<ul> <li>Try to use materials suited for the application which do not need coatings and chemicals to endure the environment and stress E.g. Hemp could be a possible material for padding since it carbonises rather than catches fire. Wool is more flame resistant than cotton, and is usually not treated with flame retardant for use in the public sector<sup>13</sup>.</li> </ul>	<ul> <li>The shape of the textile is a contributing factor when it comes to flame resistance e.g. thick closely woven fabrics endures better than "fluffy" fabrics<sup>9</sup>.</li> </ul>	<ul> <li>Sears with textiles should ideally have an Eco-label, Öko-Tex (Deko-Tex) Standard 100 or Svanen label to show that the material meet their demands<sup>14,14</sup>.</li> </ul>	Do not use chrome tanned leather <sup>44</sup> .	<ul> <li>Artificial leather and woven plastics are not allowed if they contain PVC-plastics<sup>13</sup>.</li> </ul>
				CONSTRUCTIONAL RECOMMENDATIONS:	<ul> <li>There should be no sharp edges under</li> </ul>	or near textiles which can pierce holes in the textiles <sup>a</sup> .	<ul> <li>Do not have a gap between the seat and the backrest where dirt can collect<sup>16</sup>.</li> </ul>	<ul> <li>If possible, construct the seat so that</li> </ul>	the textile can be taken off and washed or changed <sup>4</sup> , for example by using zippers or Velcro.	<ul> <li>Avoid gluing fabrics directly onto the padding. This is often done to get a tight fit when the foam padding has a concave shape, but convex and flat</li> </ul>	surfaces are possible to cover without the use of glue".	<ul> <li>Few textiles used in public environments today are recyclable due to high chemical contents<sup>49</sup>. If</li> </ul>	impossible to find recyclabe textiles, try to select textiles and padding materials	from renewable sources.
Component 1:	Seats	On chairs in public environments, seats are the parts most exposed to damaging wear and tear.	This stem both from people sitting on the seats crossing their legs, adjusting and moving around, but also from people spilling food and putting up	muddy shoes on them. Rough fabrics such as jeans and in outerwear can also wear severely on the upholstery.	There are higher requirements on upholstery in	public environments than there are for private consumer furniture. For example, the textiles are oftenprepared with flame retardants and chemicals	acting as dirt- and water-repellents, which can be both health harards and make reuse or recycling	amcurt, because or this, textile material research is highly relevant as it could help enable more	circularity tor furniture in the public sector. Wear and loosening textiles at the front of the seats					

MATERIAL RECOMMENDATIONS:	<ul> <li>Choose materials that either are durable or age and wear well, e.g. solid wood and leather<sup>4</sup>.</li> </ul>	• Avoid soft materials, e.g. softer plastics, on armrests that are exposed to frequent use $\infty$ it easily scratches <sup>4</sup> . Less durable materials should be easy to remove and replace when worn out.	<ul> <li>Choose materials and surface finishes that withstand moisture and oil as hands often can be both greasy and sweaty, e.g. leather or wood<sup>18</sup>.</li> </ul>	<ul> <li>Choose materials that can be cleaned from dirt due to the extensive use<sup>20</sup>.</li> </ul>	<ul> <li>Choose materials that feel nice to touch; wood and leather for example often feel nicer and warmer to touch than metals<sup>6</sup>.</li> </ul>	<ul> <li>Areasthat are in direct contact with skin should not include allergenic substances such as chrome or nickel<sup>13</sup>.</li> </ul>	<ul> <li>If the armrest includes textiles it should ideally have an Eco-label, Öko-Tex (Deko-Tex) Standard 100 or Svanen label to show that the material meet their demands<sup>16</sup>.</li> </ul>	<ul> <li>If leather is used one should not use chrome, especially Cr6+, tanned leather<sup>M</sup>. Other metals which are not allowed by Möbelfakta are lead, arsenic and cadmium.</li> </ul>	CONSTRUCTIONAL RECOMMENDATIONS:	<ul> <li>Avoid sharp edges since they chip more easily. Rounded edges with stand wear better over time?.</li> </ul>	<ul> <li>Allow for easy attachment and removal of the armrest to facilitate repair or replacement<sup>22</sup>.</li> </ul>	
		exposed to wear and tear on chairs in public erwironments	and this everyday use requires materials that both endure er to touch.		Think of whether the chair is going to be accompanied by a table or if it is going to stand	urone: y is a young to be used what a capte, armests are not always necessary but rather inconvenient. If there still should be armrests,	they should allow for the chair to be pushed in under a table without any fiction as this wears both on the table and the armrests. In the case of	a standa to ne chair where users will sit for longer periods of time, the armrests should be long enough to support more than just the elbows <sup>ad</sup> .	rease stains and scrath es.			
Component 2:		Along with the seats, arm rests are the parts most , to do not be the seats arm rest of the seat of th	finishes and leaving grease stains and smear behi finishes and leaving grease stains and smear behi wear and tear well and that feels good for the us						Typical darnages appearing on armrests; wear, g			

Component 3:

## Backrest/frame

Though often also upholstered, backrests are not subjected to as much wear and tear as the seats are. Mostly becausethey arenot learned on with the same kind of forces, but also because they are not to the same extent subjected to staining. They are nevertheless important for how the users perceive the furniture overall, and have a big influence on the comfort. Here are some recommendations for how to design backrests.



## CONSTRUCTIONAL RECOMMENDATIONS:

- The angle of the backrest should not be too steep or lean forward as this makes the chair uncomfortable to sit in<sup>6</sup>.
- Avoid sharp edges since they chip more easily. Rounded edges withstand wear better over time<sup>2</sup>.
- Make a sturdy frame and make it easy to mend if the joints loosen<sup>13</sup>

## MATERIAL RECOMMENDATIONS:

- In severe environments, it is better to make the frame out of more durable materials, like metals, while contact surfaces, for example armrests, are made of materials with better sensory qualities as for example wood, textiles or leather<sup>a</sup>.
- Make repainting the last solution since painted areas can wear poorly and are difficult to remove<sup>12</sup>
   If repainting can help save furniture from being thrown away, it is however recommended<sup>12</sup>.
- If the backrest has a neck rest it should withstand oily hair and hair products, and be able to clean
  or wash".
- If leather is used one should not use chrome, especially Cr6+, tanned leather<sup>14</sup>
- Pigments and dy es should not contain hazardous substances, such as lead, tin, cadmium, chrome, mercury, phthalates (in plastics) etc<sup>4,4,4</sup>.

Component 4: •

### Legs

In public erwironmerrts, legs are often subjected to extensive wear. Shoes kicking and rubbing off against them leaving stains and rubber marks, scuffs and scratches from people moving them around, bumping them into other things, and worn down feet after being pushed back and forth.

### MATERIAL RECOMMENDATIONS:

- Durable materials, such as metals, with stand severe environments better than softer ones and can look undamaged even after long periods of use<sup>4</sup>.
- Try to avoid paint or coatings which can chip off or get demed<sup>13</sup>.
- Chrome (Cr3+) as a surface treatment is very durable and is allowed for stackable chairs or other applications that need to endure high levels of wear and tear<sup>4</sup>. Its use is however restricted, and Cr6+ is not allowed<sup>4,4,4</sup>
- When metal legswith high shine coatings is worn unevenly, and becomes matte, it is perceived as ugh<sup>46</sup>.

mend"<sup>2</sup>.

 To keep the recyclability, use materials that do not need additional coatings such as paint, e.g. anodised auminium<sup>6</sup>.

### CONSTRUCTIONAL RECOMMENDATIONS:

- Avoid creating crossbars that collect dirt and dust, design them so that they either are self-cleaning or easy for others to clean<sup>10</sup>.
- Avoid sharp edges since they chip more easily. Rounded edges with stand wear better over time<sup>2</sup>.
- When designing legs out of wood, think about the grain direction and the shape of the leg. Karl Johan chairs for example have tapering curved legs that often are made out of Mahogary, a short grained material. This makes it difficult for the legs to hold under large loads, and once broken they are very difficult to

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iong-lasting furniture. Nevertheless, the hope is that it can help provide some insights and inspiration for designers or other people reading. To learn more about how to design for circularity, have a look at the list As this guide's focus is on aging and wear in a circular economy, it is not comprehensive enough to do more than give a short overview of all the different aspects there are to consider when designing sustainable, of links and sources below that offers more detailed and comprehensive information!

- Hållbarhetsguiden: http://www.svid.se/Hallbarhetsguiden/
- Circular design guide: https://www.circulardesignguide.com/
- Material selection: https://www.circulardesignguide.com/post/materials .
- https://www.circulardesignguide.com/post/circular-interventions Circular opportunities: •
- Design for Disassembly: http://teclim.ufba.br/jsf/ecodesign/dsgn0204.PDF .
- https://sustainabilityworkshop.autodesk.com/sites/default/files/core-page files/au to desk-sustworkshp designfordurability, pdf Design for Durability: •
- Ellen MacArthur Foundation: https://www.ellenmacarthurfoundation.org/
- EU Eœ-label: http://ec.europa.eu/ervironment/ecolabel/ .
- Möbelfakta: http://www.mobelfakta.se/ .
- Svanen: http://www.svanen.se/
- http://www.upphandlingsmyndigheten.se/hallbarhet/stall-hallbarhetskrav/kon-Sustainability requirements by Upphandlingsmyndigheten: tor-och-textil/mobler/mobler/ •













eferences	RISE Viktoria, n.d. <i>Business model innovation for closed-loop furniture flows - stage II. Ava</i> ilable at: <u>Intps://www.istoria.se/projects/business-model innovation forc bsed-loop-furniture-flows-stage-likd est ription</u>	Stated by interviewed appraiser and a sustainable asset manager at a large furniture company	Indicated by interviews study results	EMF, 2015. Towards a Circular Economy: Business Rationale for an Accelerated Transition, s.I.: Ellen	MacArthur Foundation	Norrblom & Sjöholm (2016) Guide för hantering av märkning, certifiering, och kemikalieftiggor för möbler	cirkulära system	Indicated by perception study results	45 per cent of interviewees memtioned people being more careful with their own property	VGR (2017) Design med Omtanke Jitt p//wwwZvgregion.cs.Ovriga.stio.r/Design-met-Omtanke/Design-met-Omtanke/	According to an interviewed laboratory engineer.	Ed. Rex (2017) Cirkulära möbelflöden: Hur nya affärsmodeller kan bidra till hållbar utveckling inom	offentliga mööler	Dawie & Siman (1994) Guidelines for designing for disossembly and recycling	Available at: <u>http://heclim.ufba.br/jsf/ecodes gn/dsgn0204.PDF</u>	Acarding to interviewed furniture anservator	Svanen <u>http://www.svanen.se/</u>	Möbelfakta <u>http://www.mobelfakta.se/</u>	Upphandlingsmyndighet en	http://www.upphandlings.my.ndjeheten.se/hall.barhet/stall-hallbarhet/krav/ko.mtor-och-textil/mobler/mobler/	Kersti Sandin Bülow: experienced furniture designer and founder of furniture company Materia, and since	2013 Adjunct professor at Carl Malmsten Furniture Studies.	Acoording to a quality and environmental manager at a furniture manufacuring company	Acoording to interviewed furniture anservators	According to an interviewed furniture apprais er and a laboratory engineers pecialized in furniture testing	According to an interviewed appraiser	According to an interviewed interior designer	According to an interviewed designer and a laboratory engineer specialized in furniture testing	According to conducted field studies of public environments in Sweden	http://www.kristinebjaadal.no/portfolio/underskog/	Chapman (2015) Emotionally Durable Design: Objects, Experiences & Empathy	Bakker et al. (2014) Products that Last: product design for circular business models. Defft: TU Defft Library
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