CHALMERS
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Technology development of reuse in the real estate sector

A case study of the implementation of CCBuild and its possible development to solve challenges with reuse in renovation projects

Master's Thesis in Design and Construction Project Management

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CHALMERS UNIVERSITY OF TECHNOLOGY

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Abstract

The transition of the construction industry toward circularity includes the reusage of materials, where technologies to simplify the process has recently been introduced to the market. The purpose of the study was to identify barriers and drivers of reuse and asses the development potential of the reuse technology, CCBuild, to enhance the process of reuse in renovation projects. The study is based on a qualitative research strategy including a literature review, interview study and a case study.

The research has identified quality, financial, logistical and coordination as main areas of barriers and drivers to develop the work with reuse. The areas include issues related to communication, knowledge, and time aspects. Identified drivers were involving actors, enhanced design phase and streamlining. The proposals of improvements to CCBuild include enhanced user experience, cooperation with competitive technologies and continued work with cooperation within the sector. The study will contribute to increased awareness and knowledge of reuse and allow for a more effective transition to circularity with the help of reuse.

Key words: *Reuse, construction, technology, CCBuild, barriers, drivers*

Teknikutveckling för återbruk inom fastighetssektorn.

En fallstudie om implementeringen av CCBuild och dess möjliga utveckling för att hantera utmaningar med återbruk inom renovation projekt

Examensarbete inom programmet Design and Construction Project Management

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OSCAR BERNTSSON

Institutionen för arkitektur och samhällsbyggnadsteknik

Avdelningen för Construction Management

Chalmers Tekniska Högskola

Sammanfattning

Byggindustrins övergång mot cirkularitet inkluderar återbruk av material, där teknologier för att förenkla processerna nyligen har introducerats på marknaden. Syftet med studien var att identifiera hinder och drivkrafter för återbruk samt att bedöma utvecklingspotentialen för återanvändningsteknologin, CCBuild, för att förbättra processen för återbruk i renoveringsprojekt. Studien är baserad på en kvalitativ forskningsstrategi som inkluderar en litteraturgenomgång, intervjustudie och en fallstudie.

Forskningen har identifierat kvalitet, ekonomi, logistik och samordning som huvudområden för hinder och drivkrafter för att utveckla arbetet med återbruk. Områdena inkluderar frågor relaterade till kommunikation-, kunskap- och tidsaspekter. Identifierade drivkrafter inkluderar involverandet av aktörer, förbättrad projektering och ökad effektivisering. Förslagen till förbättringar av CCBuild inkluderar förbättrad användarupplevelse, samarbete med konkurrerande teknologier och fortsatt arbete med samarbete inom sektorn. Studien bidrar till ökad medvetenhet och kunskap om återbruk samt möjliggör en mer effektiv övergång till cirkularitet med hjälp av återbruk.

Nyckelord: *Återbruk, bygg, teknologi, CCBuild, utmaningar, lösningar*

Contents

Index of figures

Index of tables

Preface

In this research, an interview study combined with a case study has been conducted with a focus on evaluating a circular strategy and improving a digital tool. The research has been conducted during the period December 2022 to June 2023. The project is a master's thesis in Design and Construction Project Management conducted at the Department of Architecture and Civil Engineering, Chalmers University of Technology. The research has been performed in collaboration with the real estate company Castellum AB.

The interview study has been an important part of the research to describe current practice on reuse in the industry. We would therefore like to thank all the companies and respondents who chose to participate in the study and shared their experiences and thoughts on the subject. Another important part of the research is the case study aimed at developing the digital tool CCBuild. The relationship with Castellum AB and the collaboration with our supervisor Maria Perzon has been key to the success of the research. We have greatly appreciated the good cooperation and our opportunity to meet many engaged people who, like us, want to change the way the construction industry works with reuse.

Finally, we would like to mention Rikard Andersson and Martine Buser, Division of Construction Management, for their efforts during the academic process of the research. They have provided guidance, support, and great engagement in the research.

It would not have been possible to carry out the research without their efforts!

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Pontus Gagner-Geeber

Oscar Berntsson

Abbreviations and Elucidations

Abbreviations and terms used in the study are defined below.

IVL	–	Swedish Environmental Institute
DfD	–	Design for Deconstruction
SME	–	Small and Medium Enterprises
RL	–	Reverse Logistics
FL	–	Forward Loistics
Klimatsmart lokal	–	Climate-smart premises

1 Introduction

The following section provide an introduction to the report. Furthermore, the problem is put in context where the statement of problem is summarized in a concrete purpose and two distinct research questions. Finally, is the research's target group and its delimitations also presented.

1.1 Background

The construction industry in Sweden has a significant impact on the environment. The construction of buildings consumes a large number of materials, where a large extent are considered as waste once a building has to be demolished. According to Boverket (2023) the sector is responsible for 40 percent of all waste produced in Sweden. In addition is the demand for real estate large in the urban areas, where the construction of new buildings is expected to grow (Naturvårdsverket, n.d). The current consumption of resources will result in an increase of total waste within the industry if actions aren't taken to minimize the wastage.

To handle the problems with waste has the concept of circular economy become a popular topic among researchers during the past decade (Geissdoerfer et al., 2017). Circular economy is described by Geissdoerfer et al. (2017) as a regenerative system, where resources are part of closed loops, to minimize both waste and the need of extracting virgin resources for new materials and products. In recognition of this, there have been efforts in the Swedish construction sector to promote reusage to move towards a circular economy. The efforts have contributed to closing the resource loops and thus contributing to a circular economy. Examples of this is pilot projects where material considered as waste have been reused in new projects (Nyhlin & Åfreds, 2022).

Despite the efforts to minimize waste by implementing reusage, there is still room for improvement. Many buildings continue to be constructed with new materials and components, where studies have shown that the sector is responsible for 50 percent of the global resource consumption (Lizárraga-Mendiola et al., 2022), which suggest a large potential of reusage. Nyhlin and Åfreds (2022) explain multiple reasons why it is hard for the industry to shift towards a circular working method by adopting reusage. The authors explain that traditions, lack of knowledge, supply, logistics, quality, and coordination, among other aspects are obstacles that must be dealt with for the industry to embrace a circular approach. It is important that the real estate industry in Sweden continue to focus on finding ways to deal with these obstacles and promote reusage so that the industry can decrease its climate impact. Especially due to the large impact the industry has on the environment which suggest that there are opportunities to minimize the climate impact to a large extent. Iacovidou et al. (2018) argues that information gaps are the main cause for many of the previous mentioned challenges with reuse, where innovative technology has been identified as a possible solution.

Technological development has had a large impact on the construction sector, ranging from the development of concrete production in the 18th century to the development of building

information models during the past decade. Technology is described by Skibniewski and Zavadskas (2013) as:

> *"The making, modification, usage, and knowledge of tools, machines, techniques, crafts, systems, methods of organization, in order to solve a problem, improve a preexisting solution to a problem, achieve a goal or perform a specific function" - (Skibniewski & Zavadskas, 2013)*

The digital development in the construction industry is slower compared to other industries (Osunsanmi et al., 2018; Siddiqui et al., 2022). Where Siddiqui et al. (2022) argues that digitalization is the future of the building sector, which suggest large innovative potential. Digital technology has the possibility to make processes more efficient which in turn could solve many of the previously mentioned challenges with reusage. However, it will require increased knowledge and collaboration to enhance the development of digital tools in the construction industry according to Fitriani and Ajayi (2022).

The construction sector is typically described as fragmented due to the low profit margins, intense competition, and its many involved stakeholders. Skibniewski and Zavadskas (2013) explain that the construction sector is thus focusing on finding innovation to enhance collaboration. Innovative technology has enhanced the collaboration within the industry for the past decade, where BIM and other planning technologies have had a large impact. However, the implementation of BIM has failed to enhance the end use stage of buildings according to Sanchez et al. (2021), which conclude that relevant information tends to be outdated or non-existing at this stage. The disassembly is therefore performed through manual procedures, which have allowed for new innovative technology to enhance this stage, which reuse is part of.

1.2 Statement of problem

The raw material supply and the manufacture of construction products generates a significant amount of carbon dioxide emissions (Andersson et al., 2022). Therefore, the real estate industry in Sweden has a major impact on the environment. Thus, it is of great importance to implement reuse to substitute newly produced products and minimize waste. The current literature has evaluated reuse within the construction industry and found multiple challenges with its implementation. Four main topics has been identified as challenging based on the literature, these are the financial, quality, logistics, and coordination perspectives (Ding et al., 2023; Knoth et al., 2022; Rakhshan et al., 2020).

The work with reuse is more demanding compared to traditional working methods which affect the financial perspective (Rakhshan et al., 2020). Demanding work methods can in most cases be simplified and enhanced by using technological tools (Nilsson, 2007). In order to achieve high quality when building with reused products, it is crucial to have flexibility in the design

phase and to ensure that standards are met. This makes technical tools essential for ensuring the technical specifications and dimensions of the reused products. (Gorgolewski et al., 2008). A deconstruction process often requires further movement and storage of materials, which challenges the logistical perspective (Chinda & Ammarapala, 2016; Dunant et al., 2018; Shaurette, 2006). Further, implementing reverse logistic (see Figure 11) is a driver for success working with reuse (Ding et al., 2023) which also could be simplified and enhanced in combination with technical tools. Moreover, the coordination perspective is also a challenge since the lack of communication and collaboration has a negative impact on the reuse process (Knoth et al., 2022). In addition, it is important to change the conservative way of thinking and the reluctance of the actors involved to share the risks which occurs when building with reused products (Knoth et al., 2022).

The existing literature on reusage in the construction industry is broad, where multiple studies have been made (Douguet & Wagner, 2021; Gorgolewski, 2008; Rakhshan et al., 2020). However, there are less studies linking the identified barriers to technology. Since innovative technologies have been proven to enhance effectivity according to Sanchez et al. (2021), it is of large importance to suite such technology to solve the existing barriers. CCbuild is one of the leading actors on the Swedish market, when it comes to technologies linked to reuse (CCBuild, n.d.-a). Since there is a lack of existing literature on CCBuild and its development and possibilities for improvement, the aim of the study was to provide specific and practical improvement proposals for the digital tool CCBuild.

1.3 Purpose

The aim of this study is to explore how reuse is implemented within the real estate industry in Sweden and to identify the opportunities and barriers they face. We thereafter assess how the CCBuild technology may be developed to support the reuse processes in circular renovation projects.

1.3.1 Questions of research

1. What are the barriers and drivers with implementing reuse in circular renovation projects?
2. How can CCBuild be developed to support the process of reuse in circular renovation projects?

1.4 Delimitations

The research has been limited by only investigating one specific project and one specific digital tool (CCBuild), since it is important that the study is focused and concise to provide concrete results. Furthermore, has the case study focused on the early stages of a tenant adaptation due to the timeframe of the study. Further is the case and interview study based on information collected nationally, while the literature review has been made with an international context.

Four areas of focus have been used throughout the study. These have been based on the existing literature and are the following: financial, quality, logistics and collaboration. The study will focus on building materials and commercial property rentals. These limitations have been taken into consideration as it is considered to contribute to a better result and fit within the timeframe of this qualitative research.

1.5 Intended audience

The research will conduct a case study of a tenant adaptation using a circular strategy. The findings and insights gained from the research are expected to benefit several groups in the building sector. There are two primary target groups. One of these is the real estate company Castellum AB. They are interested in optimizing its new circular strategy which involves CCBuild. This in turn may result in increased profitability and effectivity when performing circular tenant adaptations. Another primary target group is Svenska Miljöinstitutet (IVL), which are the organization developing CCBuild. The proposals presented to enhance CCBuild are going to help IVL to further develop the tool which may result in a better tool with more active users which in turn could introduce more actors to working with reuse.

The secondary target groups are for instance other real estate firms, architects, building contractors, environmental consultants. By providing a broad literature overview of reuse in the construction sector, and a comprehensive evaluation of the different processes involved in tenant adaptations and how technology can be applied to enhance reusage, could the insights be used by multiple actors. The study will contribute to the promotion of circularity in the building sector and thus will all stakeholders within this area be relevant target groups.

1.6 Report structure

Initially, the study presents background information needed to get an overview of the case. For instance, the new circular strategy by Castellum, "Klimatsmart lokal", is described, the specific project is presented and the digital tool CCBuild is explained. Thereafter is the literature review presented, where topics related to reuse have been introduced. Next, the chosen method is described where the literature review is firstly discussed, followed by an explanation of how the case study and the interview study was performed. Moving on to the results which is divided between the interview study and the insights gained from the case study. The results are followed by a discussion of the identified themes from previous research, the interview study, and the case study. Furthermore, a chapter on concrete proposals for improvements for the digital tool CCBuild is provided. Finally, a brief conclusion and recommendations for further research in the field are presented.

2 Case description

Castellum is one of Sweden's largest real estate companies in terms of total property value and total leased area (Arvidsson, 2022). By being business minded, engaged and brave, Castellum's vision is "Creating workplaces where people and enterprises thrive.". Castellum's strategy is based on the demands of the company, customers, and society, with a focus on enhancing relationships with customers and developing the service offering and real estate portfolio (Castellum, n.d.). They strive for sustainability and have therefore set strict goals to achieve net zero emissions by 2030 and at the same time be the leading actor in sustainability (Castellum, 2018).

"Over time, Castellum will be one of the leaders in the field of sustainability and work for sustainable development" – (Castellum, 2018)

As a step to reach their climate goals, they have recently started working with an innovative strategy called "Klimatsmart lokal" which aims to develop their renovation project from a linear to a circular approach (Castellum AB, 2022-c). CCBuild is the central digital tool that has been decided to be used in this strategy to enhance the reusage (Castellum AB, 2023). This strategy has recently been developed, therefore Castellum has chosen to apply it to a pilot project. The chosen project is a tenant adaptation in Stockholm which will be described further in section 2.2. The project will allow for the testing of CCBuild and its related processes to assess what is optimal for reusage and thus enhance their circular approach.

2.1 Klimatsmart lokal

A circular process implies creating a sustainable model that minimizes waste through continuously recycling and reusing (Stahel, 2016). "Klimatsmart lokal" designed by Castellum AB is a business strategy based on the principles of circular economy which focus on renovation and reconstruction (tenant adaptation) projects. The strategy contributes to reducing the climate impact by using reused and environmentally friendly products, where the overall ambition is to reach Castellums environmental goal (net zero emissions by 2030) and to show the industry that Castellum is taking actions that in practice contribute to a reduced climate impact (Castellum AB, 2022-c).

"Klimatsmart lokal" is based on five phases (see Figure 1). Phase one and five is before and after the project performance, called property management and phase two, three and four is during the project performance (Castellum AB, 2022-a). The figure below shows the five phases and a brief description of each phase which will be described further thereafter.

Figure 1 - The processes of "Klimatsmart lokal" and its five phases (Castellum AB, 2022-a).

2.1.1 The five phases

Phase one is the planning phase, which the property management team is responsible for. When a vacancy of a premise occurs, the first thing to do is to make an early assessment of whether it is possible to perform a circular reconstruction or not. It is important to assume that most of the products and materials can be reused. Further, the architect produces a suggested floor plan based on the reuse potential of the premises (Castellum AB, 2022-b).

The project manager is responsible for the phases during the project performance (phase two, three & four). *Phase two* is about stocktaking of reuse. The stocktaking is performed by the project manager through the digital tool CCBuild. Furthermore, the project manager, together with the new tenants, consider which materials are to be reused or kept on site, according to the next step, the climate ladder. Finally, the project manager prepares documentation of the project's climate goals (Castellum AB, 2022-b).

An important phase in the strategy "Klimatsmart lokal" is *phase three*, the climate ladder, see Figure 2 (Castellum AB, 2023). The climate ladder describes how to prioritize materials and products regarding sustainability and the environment. The first step is the most beneficial option, and the fifth step is the worst option. The first step in the climate ladder is *step one – Keep in place*, which involves keeping existing products in the same place without deconstruction. It is possible to recondition and restyle these products if needed at the existing location, for instance with painting. To achieve this step, it is important to match new tenants with the existing premises. Further, it is important to have a careful handling throughout the whole building process, so the product does not get damaged (Castellum AB, 2022-b).

Step two – Internal reuse, implies reusing products within the same project by disassembling and reassembling these construction parts. To succeed in this, temporary storage close to the premises is needed and careful handling during the construction is required to minimize damage. It is possible to recondition these products. If internal reuse within the project is not possible, reuse within the organization is possible by disassembly and storing products for future reuse. Then, a centrally located warehouse is needed where products can be temporarily stored. If neither a product can be preserved on-site, nor reused internally, is the next step to purchase reused materials and products externally (*step three – External reuse*). This can be done through various websites with a focus on reusage, for instance CCBuilds marketplace (Castellum AB, 2023).

Step four – Transforming involved recycling and transformation of products. If a product is in bad condition, it is possible to transform and upcycle the product into a new product with better function and quality. For instance, an opportunity is to upcycle existing windows with new glass to increase the functional and quality requirements (Castellum AB, 2023). The last step in the climate ladder, *step five – New products*, is to buy newly manufactured products. When new products are purchased, it is important to make careful choices based on Castellums

sustainability criteria (Castellum AB, 2022-a). Furthermore, it is of large importance that the new materials and products are suitable for reuse in the future. Finally, all products must have a renewable, bio-based or climate-efficient raw material and all wood products must be FSC or PEFC certified (Castellum AB, 2023).

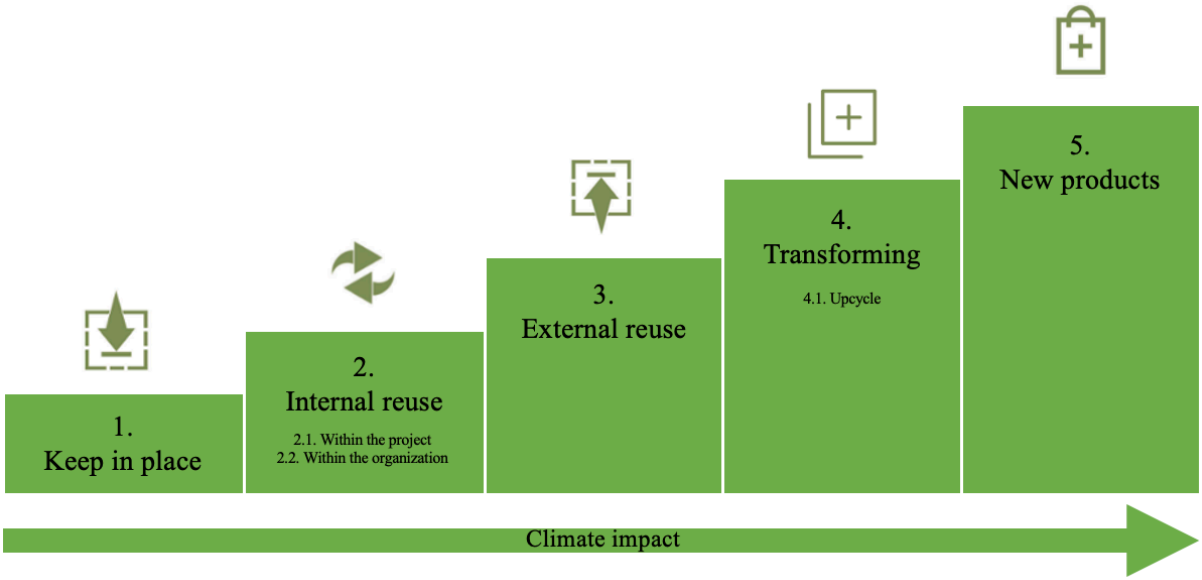

Figure 2 - The structure of the climate ladder in phase three of "Klimatsmart lokal" (Castellum AB, 2023).

Phase four is the procurement phase. The project manager uses the stocktaking of reuse and the climate ladder to adapt the project together with the architect and the customer. Then, the project manager opens up for tenders and later an entrepreneur is bought. After the final floor plan has been completed, CCBuild is updated (Castellum AB, 2022-b).

Phase five is about follow-up and evaluation, which the property management is responsible for. Those who work with property management do the follow-up work together with the project manager and all actors from the entire production chain. Since the strategy is in a development phase, the entire project should be followed up together with all stakeholders involved. For instance, the different phases are followed up internally, the quality and design are followed up together with the architect and the customer and the finances are followed up internally and together with the contractor. Finally, the project-based environmental goals are also evaluated (Castellum AB, 2022-b).

2.2 The project Kv. Färöarna

The case consisted of a pilot project that was performed according to the strategy "Klimatsmart lokal" by the real estate company Castellum. The project was chosen because of the beneficial conditions. For instance, the property was relatively small, the new client was very flexible, and the project was timely. The case was a pilot project performed in the spring of 2023. It was a tenant adaptation where the existing tenant was an animal store and clinic. The new tenant

wanted a coworking office and due to the large differences in business, adaptations had to be made to enhance the environment for the new tenant.

The rental property was 218 square meters and was located on the first floor of the building. The original floor plan can be seen in Figure 3. Due to the first-floor location, the construction process was simplified in terms of e.g., material deliveries. The property was in connection with Kista Galleria in Stockholm, which is a large mall with about 185 current businesses in the form of shops, restaurants, cinema, bowling hall and go-cart. Because the property was located next to this Galleria, many of the installations were connected to the Galleria, which was positive as the installations were linked to an existing functioning system.

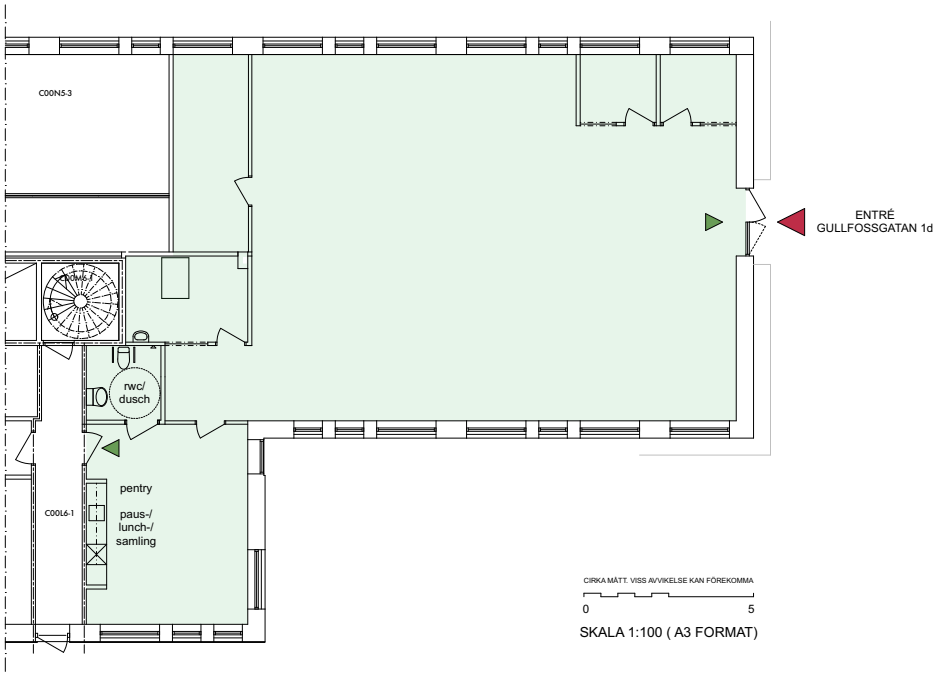

Figure 3 - The existing floorplan of rental property Kv. Färörna. (Provided by Castellum)

2.3 The technical platform CCBuild

The Swedish Environmental Institute (IVL) started the development of the technical tool, Center for Circular Construction (CCBuild), in 2015 with the vision of creating a digital platform for reusing construction products on an industrial level. The goal of the digital tool CCBuild is to become a common tool in the construction industry where all stakeholders involved coordinate and work together with the processes required to successfully build with reused products. A further goal of CCBuild is to create a network for all actors involved, where knowledge about reuse is shared, which will enhance the development of the construction industry towards more circular construction processes. Currently, about 100 organizations in the construction and real estate sector are connected to CCBuild (Svenska Miljöinstitutet, 2022).

CCBuilds digital platform consists of a website and an application. Further, CCBuild has develop three main tools, the ***"Product Bank".*** the ***"Stocktaking function"*** and the ***"Marketplace".*** All these tools are available at the website and in the application and is all connected to each other. Furthermore, CCBuild also conducts seminars and workshops on the topic to highlight the importance of reuse, as well as to enhance the knowledge among organizations and actors in the industry (CCBuild, n.d.-b).

2.3.1 The product bank

CCBuilds product bank is a digital platform used to store and share information about different products to enable reuse and circular construction. The product bank creates a digital overview of an organization's ongoing projects and its available products. The information provided for each product includes for instance esthetic and functional condition, technical specification and dimension, and the location of each product in the premises. By providing extensive information about each product, it makes it easier for architects, contractors, and other stakeholders to find and use the products for reuse with the aim of minimizing both waste and resource use.

Figure 4 illustrates the current product bank for a project. The screenshot shows three products that have been added to the project's product bank. There is a selection of information previewed for each product, such as product category, esthetic and functional condition and quantity. Furthermore, the product status is also shown, where the figure illustrates that the product "Takplatta belysning" is published as an external advertisement on the marketplace and the product "Parkettgolv, ljus trä" is not yet published. Furthermore, the blue box illustrates that all products are stocked in a building.

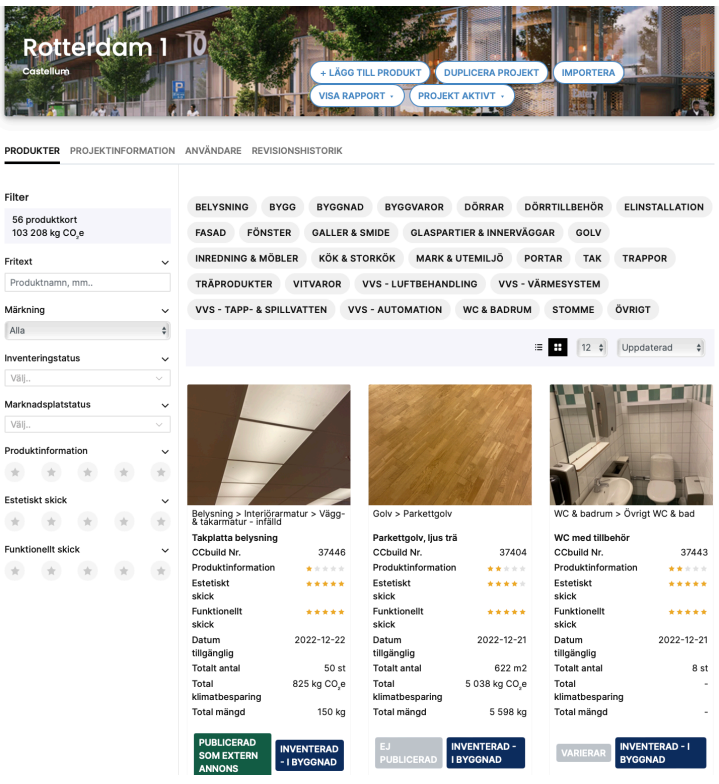

Figure 4 - T *ongoing projects.*

Moreover, there is an option to conduct value analyses based on various parameters, see Figure 5. For instance, CCBuild provides information on the estimated economic value of the products listed in the product bank. Additionally, CCBuild also calculates the amount of CO2 equivalents that can be saved by reusing the products in the product bank, as opposed to purchasing new, similar products. Both the overall savings of the entire product bank and the individual savings of specific products can be viewed. These indicators can be utilized by different projects to evaluate the success of their reuse efforts. There is of high importance to consider the amount of economic value and climate impact saved by using these reused products. A method for adding product to the product bank is the stocktaking function.

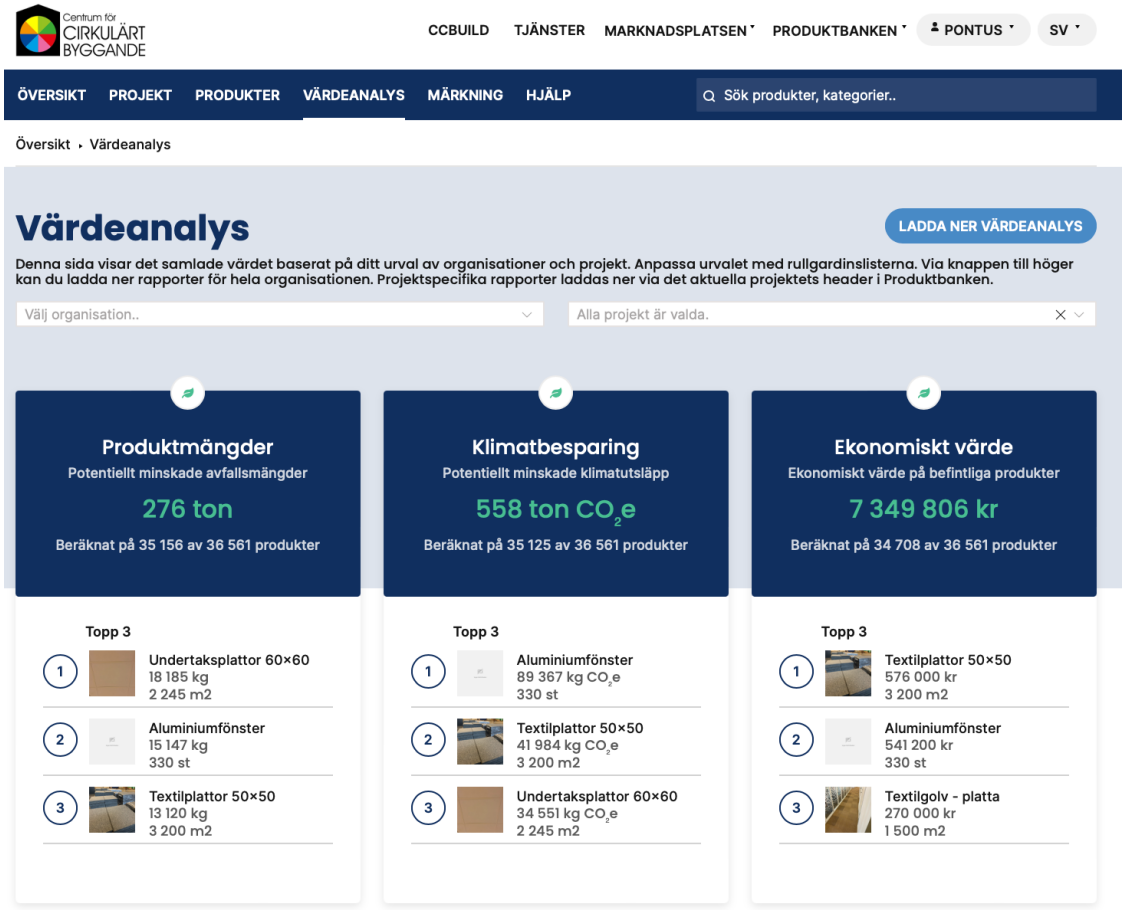

Figure 5 – The figure shows how CCBuild presents value analysis for different products in different projects

2.3.2 The stocktaking function

The aim of the stocktaking function is to conduct a stocktaking of reusable products and add them to the product bank. These products are then added to the project-specific product bank *(see section 2.3.1).* The stocktaking process is conducted before the deconstruction and refurbishment process. The function is shown in Figure 6 below.

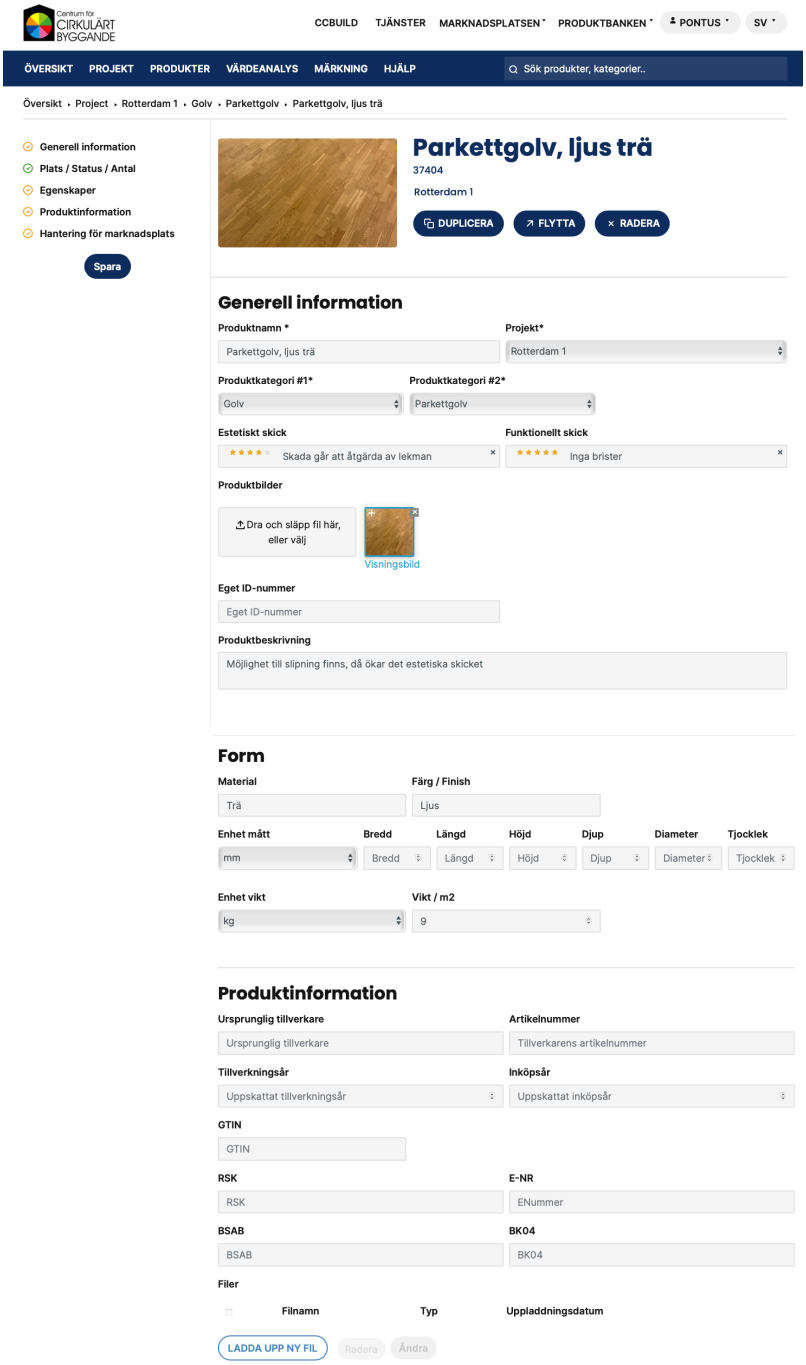

Figure 6 - The figure shows the stocktaking function of CCBuild.

The first step during the stocktaking process is to add general information about the product such as product category, esthetic, and functional condition, as well as a product description and pictures of the product. The second step is to add information about the products location, status, and quantity. The reason why it is important to add information about the products location is to be able to easily identify where the product is located at a later stage. The status of the product is linked to the marketplace, for instance a product's status may be that it is published on the marketplace, either internally or externally. The third step is to add the characteristics of the product, such as dimensions, weight, color, material, and other characteristics based on the product-category selected. In the next step, original product information should be added, such as original manufacturer, year of manufacture, and several different identification numbers. The final step involves the marketplace where the product can be uploaded and made available, either internally or externally.

2.3.3 The marketplace

The products added to the product bank can be chosen to be published on the marketplace of CCBuild. The purpose of this forum is to allow users connected to CCBuild, both sellers and buyers, to interact by both searching and requesting specific products. Products published on the marketplace are available to all CCBuild users. As shown in Figure 7 below, there are several categories and sub-categories to search within. All products available on the CCBuild marketplace are either reused or leftover materials and can either have a fixed price decided by the seller or an unfixed price. When it is an unfixed price, the seller and the buyer are supposed to agree on a fair price.

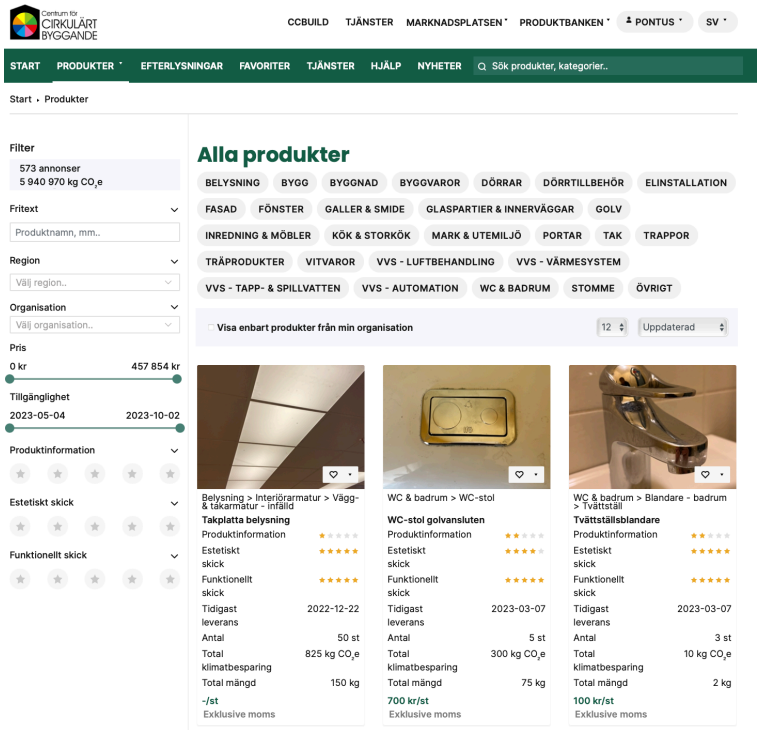

Figure 7 - The figure shows a screenshot of what the CCBuild marketplace may look like.

3 Literature review

The following section provides an overview of previous research on the topic. It primarily describes the change from linear economy to circular economy and how it affects the construction industry through different principles. Furthermore, the four identified main topics of reuse in the construction industry, financial, quality, logistics, and coordination, are presented. Additionally, barriers and drivers connected to the four main topics are analyzed and displayed.

3.1 Linear & circular economy

The traditional linear economy, is a concept that focus on a take-make-dispose approach, displayed in Figure 8 below (Upadhayay & Alqassimi, 2018). The root of the concept is according to Sariatli (2017) based on the excessive consumption in the developed regions. Since the materials was collected globally, but the consumption was concentrated within the developed regions, had the costs of materials become less than the cost of human labour. Due to this situation, had the businesses adapted models where materials substituted human labour and thus maximized the use of materials to stay competitive. The concept was successful up to the 20th century but has since faced problems with volatile and increased material costs. The material cost increased due to increased demand as well as the depletion of extraction sites. In combination with increased environmental concerns was the concept of circular economy becoming popular within research (Sariatli, 2017).

Figure 8 - Linear economy flow diagram (Upadhayay & Alqassimi, 2018)

The concept of circular economy dates back to as far as the 1960s where a cyclical process was proposed instead of the wasteful concept of the linear economy. However, the first phrasing of circular economy was made in 1989 (Sariatli, 2017). Stahel (2016) explains circular economy as a closed-loop system of production and consumption that minimizes waste and maximizes the use of resources. In this model, waste and unused materials are considered valuable resources that can be reintegrated into the production process, reducing the need for new raw materials, and preserving the environment. The circular process aims to create a sustainable and regenerative economy by designing products and business models that eliminate waste and continuously recover and reutilize resources. This contrasts with the traditional linear economy, where resources are extracted, used, and then disposed of as waste. A flow diagram of a circular economy can be seen in figure 9 below and be compared to the linear economy shown in figure 8. According to Stahel (2016) it is possible to reduce up to 70 percent of greenhouse gas emissions by implementing a circular economy globally. Sariatli (2017) continues to describe

the resource independence as a benefit of the circular economy, where companies become less affected by the fluctuations on the resource market. Finally, is the resource efficiency improved, which increases the value of each resource.

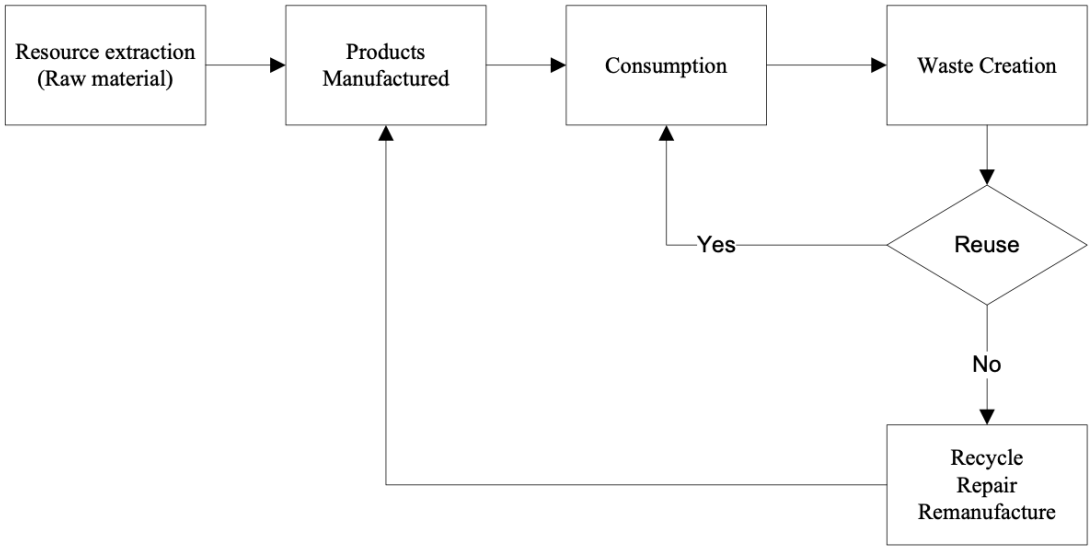

Figure 9 - Circular economy flow diagram (Upadhayay & Alqassimi, 2018)

Stahel developed the circular economy concept by introducing the performance economy. The performance economy is a model where businesses sell goods as services instead of the goods itself (Sariatli, 2017). In this kind of economy, the manufacturers are responsible for their products and rent their products to the customer. The manufacturers are thus responsible for the waste management of the products and will thus focus on enhancing the performance of their products in order to maximize their profits. Where the minimization of waste and increase in lifetime of the products become of key for the firms to stay competitive. This type of business model has been introduced within a couple of areas such as car tyres, which have been rented out to the customer and later pays according to the distance they have been used (Stahel, 2016).

Mangialardo and Micelli (2018) describes circular economy within the construction industry. Through their model seen in Figure 10, it is possible to see the most optimal order of operations to work with circular economy. The inner circles are less time consuming and less expensive, where retain is the most optimal choice. The next step is to see if it's possible to refit the product within the project followed by refurbishing the material so that the quality expectations could be met. The next step is to try and reclaim or reuse the product elsewhere. Finally, should remanufacturing be considered before recycling the product.

The design principles, to allow for a circular economy within the construction industry are also presented in the model by Mangialardo and Micelli (2018) shown in Figure 10. The first design principle "building in layers" refers to classifying components with different lifespans and building so that the ones with different lifespans easily could be replaced, without affecting those with longer lifetime. The "Designing-out waste" principle implies focusing on waste as

an asset. Through this, could materials which are considered as waste, be reused, through for instance refurbishing or remanufacturing and thus minimize waste. Design for adaptability refers to the long lifetime of a building and the need for adaptability, so that a building easily could be adapted to fulfil multiple purposes. This will minimize demolition and the need for new buildings. Design for disassembly relates to the previous principle, where adaptations may lead to the need of material and product removal. In these cases, it is important to easily be able to disassembly the materials so that it could be moved to a new building which need such products or materials. The last principle is selecting materials where it's important to select appropriate materials. By dividing materials into biological and technical categories it's possible to identify the materials that can be reused, recycled, or sent to the biosphere. Further will a detailed inventory of building components aid in finding new markets for salvaged materials (Mangialardo & Micelli, 2018).

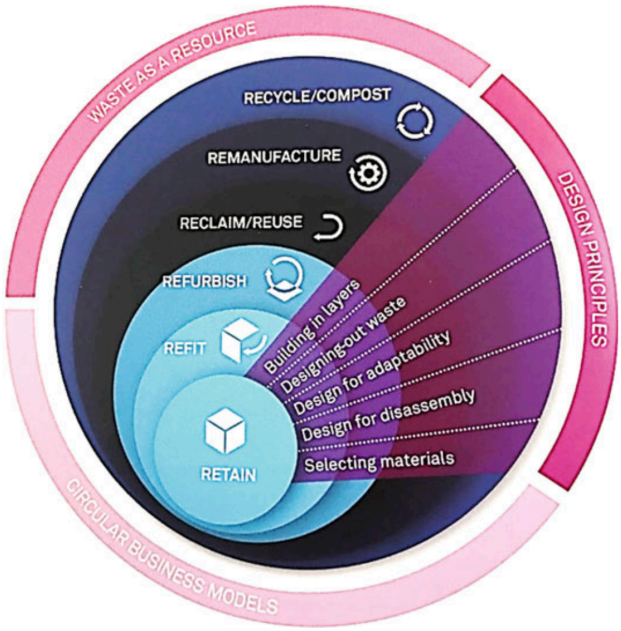

Figure 10 - Principles of circular economy within the construction industry (Mangialardo & Micelli, 2018)

3.2 Reuse in the construction industry

Reuse of materials means that a material is used more than once with the same purpose and function as it previously had. The European Commission (2010) waste framework directive defines reuse as:

> *"Re-use involves the repeated use of products and components for the same purpose for which they were recived" – (European Commission, 2010)*

It is important to separate the concepts of reuse, recycling, and transforming of products. Transforming of products is about products being converted to fulfill better functional- and quality requirements. Recycling is about using the waste resources from a material and creating

a new material. Reuse is about extending the life cycle of a material and using the material for the same purpose (Mörk & Gustafsson, 2015).

There are several benefits to build with reused materials and products. It is a construction method that enhances a building's environmental performance since fewer products and materials need to be produced. The production of materials (raw materials supply and the manufacture of materials) generates a significant amount of carbon dioxide emissions (Andersson et al., 2022). Therefore, by building with reused materials, the climate effects from the production of materials phase are eliminated (Douguet & Wagner, 2021). Furthermore, by using reused building materials, it contributes to minimizing the construction and demolition waste since many products and materials are reused instead of disposed (Bertin et al., 2022).

Despite these advantages of reuse, there are several barriers and challenges with implementing this working method in the construction industry. A selection of identified barriers is presented in the upcoming section where four main topics has been identified as challenging based on the literature. These are the financial, quality, logistics, and coordination perspectives (Ding et al., 2023; Knoth et al., 2022; Rakhshan et al., 2020).

3.2.1 The financial perspective of reuse

Several previous studies propose that working with reuse is more demanding compared to traditional working methods and the demanding work may lead to financial barriers (Rakhshan et al., 2020). Deconstruction is an important part when reusing products. According to previous studies by Dantata et al. (2005), it takes three to five times longer to deconstruct a building of 90 to 180 square meters compared to the time it would take to demolish the same building. Therefore, the deconstruction phase is one of the biggest obstacles when building with reused products in the construction industry (Dantata et al., 2005; Shaurette, 2006). More time is required during the deconstruction to be able to carefully sort the reusable products, which also will contribute to increased costs (Gorgolewski, 2008).

Numerous challenges can be taken into consideration already at the design phase of a project. By implementing the Design for Deconstruction (DfD), reuse and flexibility are considered already in the design phase of a construction project. Experiments have been conducted by Eberhardt et al. (2019) where the concrete structure of a Danish office building was designed for deconstruction and reuse. The result was a significantly easier deconstruction process, and the concrete structure had an extended lifetime. To simplify the design for deconstruction, well documented material characteristics are required, which can be collected in digital information tools, for instance CCBuild or various BIM platforms (Akinade et al., 2017). The key is to involve demolition contractors and specialists in the design with the aim of designing with materials and products that are easier to deconstruct in a time- and quality-efficient way (Akinade et al., 2017; Kanters, 2020).

Another financial barrier is the increasing costs of designing with reused materials and products. This because the architects need to spend more time finding reused products that fits the current project. Furthermore, the design needs to be more flexible if changes occur in the construction phase since there sometimes is uncertainty about the technical specification of the reused materials (Gorgolewski et al., 2008). When designing with reused materials and products, it is often necessary to claim the reused materials at an early stage to ensure that they remain, which contribute to stocking and inventory costs (Chinda & Ammarapala, 2016; Gorgolewski, 2008; Gorgolewski et al., 2008). These challenges explain why the labor cost, transportation cost, and storage cost associated with deconstruction and reuse are increasing.

In some cases, manufacturing costs for new materials and products tend to be lower compared to use reused materials. This since reused materials may need to be deconstructed, refurbished, repainted, stocked, and classified, which can result in extra labor costs (Dunant et al., 2018). Additional challenges are that the market for reusable products in the construction industry is not established enough to be cost-effective (Chinda & Ammarapala, 2016; Gorgolewski et al., 2008; Rameezdeen et al., 2016). There is a lack of supply and demand for reused materials and products. Caldera et al. (2020) explain that technology-based markets are emerging throughout the industry, where online trading could contribute to a more accessible market for reused products. If the demand for these products increases, a larger market can be established, which would contribute to less economic challenges connected with reuse (Chileshe et al., 2016). This contributes to the contractors making more money when recycling their materials, instead of selling these materials on the reused market (Yeung et al., 2017).

Financial incentives might be a solution to increase the number of companies and organizations that could implement circular construction. Examples of financial incentives are increased taxes on landfill and on new manufactured products and materials. This should provide SMEs in the construction sector with better opportunities to scale up circular initiatives (Chen et al., 2022). Moreover, this should help to establish a larger market (supply and demand) for reused products more quickly as construction contractors and real estate companies will instead make more money by selling their materials on the reuse market instead of sending the materials to landfill.

3.2.2 The quality perspective of reuse

Further barriers appear when inflexibility arises in the project. It is therefore of great importance to keep flexibility in the projects since it may be necessary to use materials of different technical specifications and dimensions (Gorgolewski, 2008). Finally, other technical obstacles that may occur during deconstruction are health and safety risks, since there is a risk of being exposed to hazardous substances, for instance asbestos (Rameezdeen et al., 2016; Yeung et al., 2015).

Some regulatory barriers occur because of the existing laws, regulations, and standards are not adapted to building with reused materials and products (Gorgolewski, 2008; Rameezdeen et al., 2016). Further, previous studies by Huang et al. (2018) suggest that the negative attitude towards reused materials may also occur since there is a lack of guarantees for these materials.

Furthermore, there is a lack of measurability. To determine the impact of building with reused materials and products, better measurement options are needed. According to Nyhlin and Åfreds (2022), there is a need for technical tools and methods to conduct these measurements on reuse in different projects to determine the exact impacts of reuse. It is of great importance that the construction industry coordinates to find a standard about which tools and methods should be used for reuse measurement. Changes are needed in the laws, regulations, and classifications that affect construction with reused materials and products. Firstly, authorities should introduce mandatory legislation and certification systems to promote circular construction, such as LEED and BREAAM for instance (Chen et al., 2022). Secondly, authorities should also evaluate the existing legislation and classification to enable and simplify construction with reused materials (Akinade et al., 2017).

3.2.3 The logistical perspective of reusage

Logistics refers to the flow of material from origin to consumer. It is defined by Christopher (2016) as:

"The process of strategically managing the procurement, movement, and storage of materials, parts and finished inventory (and its related information flows) through the organization and its marketing channels." – (Christopher, 2016).

The construction sector has been explained as ineffective and poor performing by multiple studies (Dubois et al., 2019). The fragmented nature of the construction sector is described as a reason, where the projects are typically organized differently each time, and the design and construction phases are separated. This in turn lead to the logistics becoming ineffective where lack of communication and information transfer is described as causes of inefficiency. Studies have estimated that 40% of deliveries are wrong regarding either time, quantity, location, or damage. Further has the industry been slow to implement technologies to enhance the processes linked with logistics (Dubois et al., 2019).

It's possible to divide logistics in two parts. Forward logistics (FL) and reverse logistics (RL). Forward logistics is the movement of materials to supply a customer with a product or material. Reverse logistics is the movement of materials in the opposite way, where the already used product, is moved backwards, to prolong and create value (Ding et al., 2023). Since circular economy is defined as a closed-loop system of materials will the development of RL play an important part of the transformation.

Reverse logistics has been widely implemented in the manufacturing sectors, where companies have stayed competitive by adapting the method to tackle regulations, customer demand and boost their environmental image. The construction sector is seen as an underdeveloped industry when it comes to the implementation of RL. Studies have shown that the implementation of RL has possibilities to function across different sectors where Figure 11 show how RL could be

implemented within the construction sector (Hosseini et al., 2015). Despite this have multiple articles stated challenges with the implementation of RL within the construction sector.

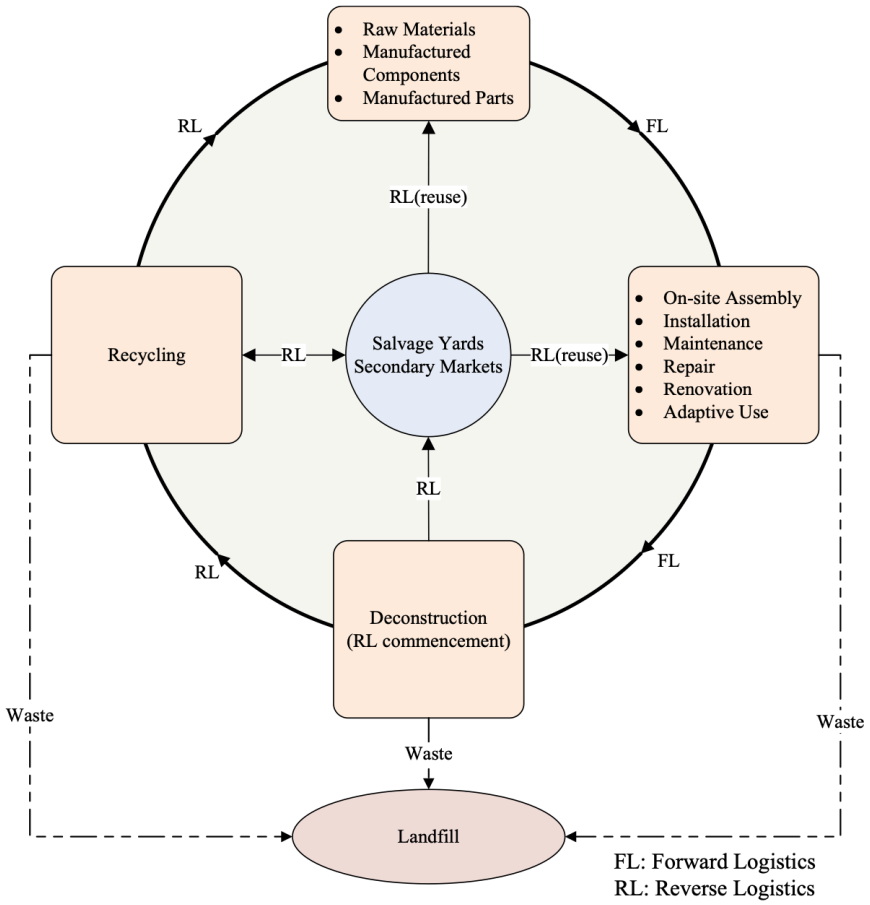

Figure 11 - Reverse logistics within the construction sector (Hosseini et al., 2015)

3.2.3.1 Barriers and drivers

Researchers have studied the barriers with implementing RL within the construction sector where Rameezdeen et al. (2016) and Ding et al. (2023) have mapped the findings of previous studies. The result suggests that many of the previously mentioned barriers of reusage are important factors with the implementation of RL aswell. Where the study of Rameezdeen et al. (2016) showed that the regulatory, economical, and organizational barriers are the largest factors affecting the implementation of RL. The study showed that there is a "circle of blame" where each involved actor, believes that the other could improve their work in adapting to RL. For instance, are designers blamed for copying specifications from earlier projects to save time and fit into the customer's budget. The same goes with the contractor and the demolition firms, who are blamed for focusing on following their budgets and minimizing risks and costs.

Ding et al. (2023) has focused more on barriers which are directly related to the logistics of RL. As previously mentioned, is design for deconstruction a common mentioned approach to increase reusage. However, Ding et al. (2023) describe that the design stage focus on the life cycle of a building, which ends at the deconstruction phase. The most common step in this area

is sorting and recycling materials, where the use of logistical approaches is scarce. The connection between available materials from deconstruction and procurement of materials for new projects is lacking. Which is described as an information gap beyond the life cycle of a building, where the supply and demand of reusable products aren't met. The author explains that it's caused by the long lifetime of buildings and that ownership tends to change when a building is decommissioned and suggest that information brokers are needed at the end stage of buildings to connect supply with demand in the secondary market of building materials.

Another key area which is highlighted by Ding et al. (2023) is the need to minimize the information gap of material inventory in existing buildings for the future use of RL. Where such information could streamline the planning of deconstruction projects, and the decisions taken by the deconstruction firms which in turn would reduce the economical barrier described by Rameezdeen et al. (2016). Further is the logistics system of reusage described as a complex matter, where the construction industry is different compared to manufacturing and retail businesses which have managed to create logistic systems for the purpose of RL. The author suggests logistics and consolidation centers to improve the transportation and secondary market of reusable materials. (Ding et al., 2023).

Finally, is logistics integration described by Ding et al. (2023), where long term collaboration and increased trust could be achieved. This would result in changing the typical project-based organizations which are established in the building sector, where the change could lead to enhanced information flows, resource sharing and synchronization of organizational goals and incentives. Where the author suggests specialized logistics actors to enhance the coordination and integration of the different actors.

3.2.4 The coordination perspective of reusage

Coordination between different actors is essential for the success of reusing building materials (Knoth et al., 2022; Rakhshan et al., 2020). Good and well-functioning coordination results in that the coordination is painless and almost invisible. Most often, the concept of coordination is discussed when a lack of good coordination occurs and cooperation between different actors does not operate optimally (Malone & Crowston, 1990). There are several different definitions of the term coordination, but the broad definition according to the Swedish Academic Dictionary is:

"Working together towards a common goal" – (Svenska Akademin, 2022)

There are also in-depth definitions with different focuses. The coordination problem in the construction sector regarding building with reused products is both complex and difficult. This is mainly since there are several different actors involved, actors who must work towards the same reusability goals (Rakhshan et al., 2020). This is reflected in the following definition of coordination:

"The joint efforts of independent communicating actors towards mutually defined goals." - (Malone & Crowston, 1990)

In addition, previous research suggests that the use of technical tools contributes to better efficiency and accuracy when building with reused materials and products (Rakhshan et al., 2020). A better coordination may occur when technical tools are used, examples of such tools are different BIM-platforms (Rakhshan et al., 2020) or software's such as CCBuild (CCBuild, n.d.-a). The fact that coordination can be streamlined by technological tools is clarified in a definition presented by (Malone & Crowston, 1990).

"Networks of human action and commitments that are enabled by computer and communications technologies." - (Malone & Crowston, 1990)

Good coordination is based on several aspects. For instance, it is essential that information and knowledge is shared between all actors involved. Furthermore, it is important that the main common goal is divided into sub-goals, where each actor has its own area of responsibility (Malone & Crowston, 1990). In addition, there are three different components within the concept of coordination, there needs to be a *common goal* where different *activities* should be performed by different *actors*. When these components exist, a coordination between the different activities performed by the actors is required to achieve the common goal. Furthermore, according to the broad definition, a work must be done, which implies that a physical or mental effort is needed to produce something that contributes to the achievement of the common goal (Malone & Crowston, 1990). Finally, effective knowledge management in the construction industry become more efficient by using technologies (Rezgui, 2001).

3.2.4.1 Barriers with coordination of reusage

There are several barriers directly linked to coordination, which are important to discuss to maintain good coordination between the actors involved. The lack of good communication and collaboration between the different actors has a negative impact on the coordination. Further, the lack of knowledge is a barrier that contributes to worser coordination between the involved actors. In addition, conservative way of thinking and reluctancy to take and/or share risks are considered as important barriers connected to coordination (Knoth et al., 2022). Furthermore, involving the whole chain is essential to implement and develop construction with reused materials and products. Engaging suppliers, architects and designers, contractors, and clients on the topic, and letting these actors coordinate regarding reuse, would contribute to increased reuse in the construction industry (Rose & Stegemann, 2018). Furthermore, Yeung et al. (2015) argues that a decision-making framework between stakeholders involved is needed to pay attention to reuse opportunities in different projects and how deconstruction and reuse should be approached.

There is a lack of knowledge among all actors involved in the construction industry about how to work with reuse in practice and what effects building with reused materials can provide (Knoth et al., 2022; Rakhshan et al., 2020). The lack of knowledge has an impact on the

skepticism that exists in the construction industry regarding reused materials and products. According to Knoth et al. (2022), the lack of knowledge is greatest among, architects, consultants and public institutions and authorities. The lack of knowledge has a direct impact on the coordination since the actors have difficulties to perform the activities with a lack of knowledge. There is some negative attitude among stakeholders involved regarding reused materials and products (Rameezdeen et al., 2016). The negative attitude may occur because some stakeholders involved believe that the visual look is worser for reused materials in comparison to new materials (Durão et al., 2014), while other stakeholders involved are not aware of all the benefits of using reused materials (Rameezdeen et al., 2016).

The results from Knoth et al. (2022) study, indicate that construction with reused materials and products could be developed if communication and collaboration between all actors involved in the value chain is enhanced. The lack of communication and collaboration can negatively affect construction projects. Furthermore, material and product suppliers need to be more involved in construction projects. It is essential that there is communication with the suppliers regarding their product development and how they can develop their materials and products to better adapting to current market practices and trends (Knoth et al., 2022). For instance, to facilitate the deconstruction process, suppliers need to develop products that are adapted to be deconstructed (Chen et al., 2022; Rakhshan et al., 2020).

Another barrier associated with coordination is the reluctance of the actors involved to share the risks that occurs when building with reused materials and products. These risks arise because reusing construction materials is uncertain in terms of the economic aspect. Furthermore, the guarantee- and quality aspect is also a risk associated with reused construction materials. Since the construction industry often consists of private "profit-driven" actors, this barrier is considered challenging since risks often are associated with the risk of lower profits. Discussions and conflicts regarding the allocation of risks between actors have a negative impact on the coordination between actors (Knoth et al., 2022).

3.2.4.2 Drivers of coordination of reusage

To overcome the knowledge gap, it is essential to conduct pilot projects of various types and involving all stakeholders to develop the knowledge of building with reused materials and products. In these pilot projects, various technical tools should be used and evaluated. By conducting pilot projects, practical skills and theoretical knowledge are enhanced. It is important to keep logbooks and data on the projects, both to be able to measure and obtain specific information on the reuse outcomes of the projects, which can help provide information on how further development can be made, and to demonstrate the positive effects of the project in terms of the climate (Knoth et al., 2022).

Communication and collaboration between stakeholders are improved by involving all actors at an early stage. For instance, early involvement of construction contractors would help to

allow them to propose innovative solutions to the problems that appear at the design stage (Knoth et al., 2022). Additional, technical tools may enhance the communication between actors involve (Rezgui, 2001). Furthermore, early involvement of suppliers could contribute to a better understanding of the problems that occur in practice, which might lead to better and faster product and material development. Early and long-term involvement of all stakeholders could also help to increase the acceptance and reduce the skepticism of those individuals who still do not have confidence in the concept of building with reused material (Knoth et al., 2022). Information and communication technologies is an enabler for effective knowledge management in the construction industry (Rezgui, 2001).

4 Method

The following section describe the methods used throughout the study and its approach. This master's thesis was based on a qualitative research strategy including three different research designs. Firstly, a literature review was performed to get a broad background knowledge about the topic. Then, an interview study with different real estate companies in Sweden was made to evaluate how the work with reuse and applying a circular approach can be made more efficient when doing tenant adaptations in the construction industry. In parallel, during the whole process, a case study of a specific tenant adaptation by Castellum was performed. The case study included both interviews, observation, and analysis of existing documents. The case study was conducted to have a real case to analyze to get more credible results.

The chosen research strategy, qualitative research, is an interpretation-oriented method, and it is of great importance how the authors interpret the respondent's perception of the subject. Furthermore, the observations made in the case are interpreted and evaluated by the authors (Bryman, 2018). Therefore, there is a risk that the result may be different depending on who is interviewed, the case, and the authors. For this study, it was of great importance that the selection of the interviewees was a purposive sample based on a few different criteria (see section 4.3.1) as the answers from the interviewees are more credible when they have a relevant professional role. Furthermore, the case was chosen because the research team sees great potential in fulfilling the purpose of the study using the chosen case. Further, there are also several positive aspects with the qualitative research since it gives the opportunity to describe a more in-depth understanding of the problem and the results is based on an interpretive approach (Bryman, 2018). For this study, it is a great advantage to conduct qualitative research since you get close contact with the interviewees, which contributes to a more credible result.

Below, the chosen method has been presented, analyzed, and discussed. Firstly, the method for the literature review was described with focus on the literature search and the credibility of sources. Furthermore, the implementation of the case study was described. Finally, the analysis method, the selection process, reliability, credibility, and ethical aspects of the interviews made during the whole process were explained.

4.1 The literature review

The literature review will consist of various types of sources from different platforms. Scientific sources such as journals will be used in combination of other sources such as textbooks and web pages. A combination of different sources was chosen to gain a more comprehensive understanding of the subject of reuse and circular approaches and how these approaches have evolved in recent years. It is of great importance to perform the literature review to give an overall understanding of the existing literature and its results (Höst et al., 2006).

4.1.1 The literature search

The literature search was performed through three overall steps. Firstly, a comprehensive search was conducted with the aim of giving a perception and understanding of the subject and its literature. In this step, databases were used with a combination of many broad keywords (Höst et al., 2006). The databases used were Google, Google Scholar, Scopus and Chalmers library and the keywords in this step was a combination of *"sustainability", "reuse", "recycling", "circular approach"*, and *"construction industry"*. The languages used were both English and Swedish to get a broader literature search and a deeper understanding of the subject, both nationally and internationally.

After the broad search of sources, the most relevant sources were selected to study them more deeply and obtain an understanding about the subject. The last and third step was a deeper and more focused search based on the selection made earlier. During this step, the previously used keywords were supplemented with words based on terminology in the area and our choice of limitations in the research. Also, synonyms were used to find additional sources (Höst et al., 2006). In this step, a combination of the following additional keywords was used: *"tenant adaptations", "logistics", "digitalization", "digital tools", "CCBuild", "stakeholders", "coordination", "development".*

4.1.2 Credibility of the sources

It is crucial to critically evaluate the literature used, since it forms the foundation of the understanding and knowledge. It is important to control the review process, who conducted it, and how it was conducted. It's also essential to identify the party responsible for the credibility of the source. It is also important to examine the research method's suitability and credibility to ensure its validity. Additionally, it's crucial to search for evidence of result being confirmed in other contexts (Kvale & Brinkmann, 2014).

All scientific publications must have passed through a scientific peer review to guarantee the publication's scientific quality. It is important that the editors are leading and experienced in the field and that the reviewers are meritorious researchers in the same field (Höst et al., 2006). This is important to ensure that the information gathered, and the knowledge provided, is credible, reliable, and trustworthy.

It is of great importance that other sources, such as textbooks and web pages are analyzed and evaluated based on the four critical questions above in order to increase the credibility of the study. There are several risks that were considered when choosing the source. For instance, journalistic material is often produced under time pressure and a source owned by commercial or political stakeholders may omit important information (Höst et al., 2006). A lot of time and effort has been invested in evaluating all the sources used, since, for instance, information retrieved from electronic websites can be published by almost anyone, and it is easy to spread misinformation by, for instance, creating a website with a credible and attractive design.

4.2 The case study

A case study involves analyzing one or more individual cases in detail, where the special nature and complexity of the individual case is in focus. (Bryman, 2018). A combined case study was performed where both a specific project and the organization Castellum was studied with the aim of drawing conclusions that contribute to answering the question of research. Castellum has developed a new circular strategy called "Klimatsmart lokal". This strategy was applied to a pilot project in the spring of 2023. The case study consists of evaluating Castellum's new circular strategy "Klimatsmart lokal" with the focus logistics management of reused materials and the coordination between different stakeholders in the approach. The case study is characterized by the holistic perspective where relationships and processes are not seen as isolated events. Instead, it is analyzed together and are connected to each other (Höst et al., 2006).

Advantages of case studies is that they often provide in-depth knowledge of a specific area. Those advantages are especially useful for this study since this research contributed with concrete improvements for CCBuild and these improvements is more trustworthy when conducting a case study. Further, the design for a case study is rather flexible since during the study, you could change and adjust the layout and questions in order to answer the study's question of research. The data collected was qualitative and the authors have chosen to interview people with different roles, age, and background to obtain different data which later was analyzed. In addition to the interviews were the authors also included in the case, by conducting tests with CCBuild and its features. This led to a better understanding as well as proposed improvements to the technology. To retrieve information from the case study was multiple tools used which will be described in the next chapter (Höst et al., 2006).

4.2.1 Case study tools

The case study tools used in this research were observations and interviews. Observations implies that different stages of the case are studied where you note and analyze what happened (Höst et al., 2006). There are two different types of observers according to Höst et al. (2006): The participating observer and the full observer. The full observer is not a part of the activity and is invisible and hidden. In this situation, data is usually collected through cameras and recordings. The advantage of this type of observer is that you can have a greater focus on the case and take notes and analyze continuously, while the disadvantage is that you risk getting too far away from the case and therefore not getting the insight that’s often needed (Höst et al., 2006). In this study, the researchers were participant observers, where the aim was to be involved in the project, without directly influencing it. The researchers were not hidden and collected data through interviews, open conversations with people involved in the project, and observations. The advantage of being a participating observer is that you are involved, create trust, and get a better overview of the case (Höst et al., 2006). It is very important to gain

credibility and be involved in the project to build a relationship with the stakeholders involved, which helped them to share more important information relevant to the research.

The observations were performed over a three-day period once every month for a total of four months. Since the observations were carried out continuously over a longer period, the researchers had the opportunity to follow the processes and the project (see explanation about the project in chapter 2.2). During the three-day periods, observations and site visits were made on the project, as well as conversations with people involved in the project. Observations were also made through participating in workshops and sessions performed by the organization behind CCBuild and Castellum. The observations were mainly documented through notes. Furthermore, after each three-day period, the notes were compiled and analyzed in order to identify interesting topics.

As part of the case study, interviews and conversations were held with people involved in the project and case. The interviews had the same principle as the interviews performed in the interview study (see section 4.3). The interviews had a semi-structured format with a mix of fixed and open questions, see the interview guides in the appendix (Bryman, 2018; Höst et al., 2006). A purposive sample was made in the same way as in the interview study, (see chapter 4.3.1). The analysis method used was "thematic analysis", see chapter 4.3.2 for an in-depth explanation of the chosen analysis method. Both credibility, reliability and ethical aspects were considered, see chapter 4.3.4 for an in-depth description of how these aspects were considered. Two official interviews were held with people directly linked to the case, both the project and the "Klimatsmart lokal" strategy. They are presented in Table 1 below.

Table 1: A table showing which actors interviewed in the case study and how they are presented in the text.

Actor	**Short description**
Project manager	Project managers working for Castellum with the pilot project in question.
Leasing manager	The leasing manager responsible for the current pilot project with the general customer contact.

Through an agreement with Castellum, the researchers had access to documents considered relevant to the project and study. These documents were analyzed and evaluated to supplement the study with important background information. Document analyzes were performed (Höst et al., 2006) which in this case is documents describing their strategy “Klimatsmart lokal”.

4.3 The interview study

The interviews conducted have a semi-structured format. The semi-structured format gives an opportunity for the interviewer to interpret what each respondent describes. It also allows the

interviewer to change the questions and their sequence if interested answers needs a follow-up question (Kvale & Brinkmann, 2014). The interviews were performed with professionals at different real estate companies to analyze different ways of working with reuse. This information will later be compared with the findings of the literature review. The companies interviewed have different sizes and places of business, which contributes to a comprehensive idea of how different companies work. A purposive sample (Bryman, 2018) was conducted to get interesting respondents for the study. Furthermore, interviews was also performed with individuals directly connected to the specific case to gather their own experiences and perspectives on working with reuse in the case. All participating people and companies in the interview study are anonymous, additional reading about this in the section "*Ethical aspects*". All interviews in the interview study were conducted according to the same interview appendix (see appendix 10.1).

4.3.1 The sample process

It is of great importance that the sampling process is well thought out and fair so the research can be accepted as credible. Throughout the study, the sampling process has been based on a purposive sampling. A purposive sampling process means, according to Bryman (2018), that the researchers has contacted relevant people who worked at companies that are considered significant for the formulated question of research. The purpose of the chosen process was that each respondent should be able to share knowledge that can be further analyzed to formulate a result based on the question of research. The contacted people work with similar tasks but at different real estate companies in order to have the opportunity to compare and analyze different strategies and processes at the different companies.

The purposive sample process was based on two sample methods, criterion sampling and snowball sampling (Bryman, 2018). Contact was made with a central person at each company where the sampling of companies was based on different criterions. The company must be a real estate company in the construction industry. Furthermore, the company must also have a clear vision of building with reused materials and work with process development of construction with reused materials. The central person at each company forwarded the email to professionals, in accordance with the snowball sampling method (Bryman, 2018). These professionals were also based on different criterions. They must have a role that includes environmental work, with focus on sustainability, and reusage, or process development of reusage.

4.3.1.1 Company and respondent description

Contact was made by email, where the purpose of the study was described. Contact was made with eight Swedish real estate companies, whereupon five, out of the eight, companies for the research agreed to participate in the study. From these five companies, a total of seven people

chose to participate in an interview. In Table 2 below, a shorter anonymous description of the companies and their respondents is presented.

Table 2: A table showing which companies and respondents participated in the interview study and how they are presented in the text.

Company A	**A real estate company in the Gothenburg region**
Respondent 1	Has worked eight years within the real estate sector, the last four years as a project manager with the focus on sustainability.
Respondent 2	Has worked with sustainability the last 11 years, started as sustainability officer at a new real estate firm one year ago.
Company B	**A real estate company operating active in the four largest cities in Sweden.**
Respondent 3	Has worked as head project manager for the past six years at with the focus on renovation projects.
Respondent 4	Has worked at a construction company before, current role is project manager within sustainability.
Company C	**A real estate company in the Gothenburg region**
Respondent 5	Working as management coordinator for internal maintenance for past three years. Before, operating technician for 13 years.
Company D	**A real estate company in the Gothenburg and Stockholm region**
Respondent 6	Head of sustainability for six years, has worked with sustainability within real estate for around 20 years.
Company E	**A real estate company active nationally throughout Sweden**

Respondent 7	Sustainability strategist for 1 years, has worked with sustainability within real estate for 14 years.

4.3.2 Method of analysis

Qualitative studies generate a lot of data that must be analyzed and evaluated by the authors, therefore it is of great importance to choose an appropriate method of analysis. In this research, a thematic analysis method has been chosen for the analysis of the collected qualitative material. For the group of researchers, the thematic analysis meant that the authors read through the material to be analyzed. Furthermore, the work of coding the material began in order to develop these codes into interesting themes (Bryman, 2018). When themes were identified, extra focus was placed on three different observations. ***Repetitions*** in the analysis material is an observation that was considered interesting for the research as repetitions may indicate that the approach, barriers, and drivers mentioned by the respondent are common. Furthermore, ***similarities and differences*** between respondents were considered as an important observation in order to formulate themes. Moreover, if questions were ***unanswered***, it was considered an interesting observation to enhance the analysis of the different real estate companies work with reuse (Ryan & Bernard, 2003). After a variety of themes were identified, the next step in the process was to rank these themes where some themes are of greater importance to the research than others. Finally, links and connections were drawn between these themes to investigate whether certain themes are related to each other (Bryman, 2018).

There are various advantages and disadvantages of "Thematic analysis". One advantage is that the authors are not limited by specific theories; instead, the authors create their own themes that are considered interesting for the current study. Another advantage is that because of the thematic approach, the authors are forced to analyze all the material, which helps to ensure that no important details are omitted. A disadvantage of this analysis method is that the analysis process is time-consuming. Furthermore, there is some criticism that suggests that this analysis method can contribute to the fragmentation of the material and the sense of context is lost (Bryman, 2018).

4.3.3 Reliability and credibility

It is of great importance to increase the reliability and credibility of the study. Therefore, both researchers participated in all the interviews, to ensure that no important information was missed, and all interesting themes and topics was further analysed by someone. To increase the credibility further, the transcription was performed shortly after the interview and all transcriptions was analysed by both researchers to allow for constructive criticism of the transcription. Further, the interviews were recorded (after the approval of each respondent), which contributed to the transcription becoming accurate and reliable. The reliability was increased by performing a respondent validation of the transcription and analysis process. Each

respondent was given the opportunity to take part of the material in order to critically review the content and comment on any misinterpretations.

Reliability of the study was further increased through triangulation. Triangulation is when three different research designs are used in a study (Bryman, 2018). In this research the following three designs was used: case study, interview study and literature review. This provided a broader data collection, which contributed to a better understanding of the topic. Further, a framework was used, developed by Spencer et al. (2003) in order to assess the authenticity, reliability and credibility of the research. A selection of the issues reviewed by the authors is presented below:

- How reliable are the results?
- How reliable is the research design and sample design?
- How well was the data collection performed?

Finally, all respondents were offered anonymity, which contributed to more truthful answers. With anonymity, the respondent experiences more simplicity in sharing a detailed description of their own experiences, thoughts and analysis (Bryman, 2018). Which in turn increases the reliability and credibility of the results.

4.3.4 Ethical aspects

The ethical problem with qualitative research is an important problem to reflect on. Violating an ethical rule or ethical principle may result in ethical harm to the respondents participating in the study. The ethical aspects are analyzed and assessed based on a number of different advice from the book "*Den kvalitativa forskningsintervjun*" written by Kvale and Brinkmann (2014) and the four main requirements: the information requirement, the consent requirement, the confidentiality requirement and the utilization requirement (Bryman, 2018; Vetenskapsrådet, 2002). Based on the requirements, all respondents participated voluntarily, and had the right to decide whether, for how long, and due to which terms, they would participate in the study. Furthermore, all respondents had the opportunity to cancel their participation (Vetenskapsrådet, 2002).

All respondents and companies who participated in the interview study were offered anonymity in accordance with the requirements (Bryman, 2018; Vetenskapsrådet, 2002). Further, the researchers have obligation to observe silence regarding the information provided by the respondents. All data provided by the interviewees was stored and protected to the extent that it was mostly impossible for outsiders to access the data. The information was deleted immediately after the research was completed. The provided information was solely used for research purposes (Vetenskapsrådet, 2002).

Furthermore, the interview guide was designed to minimize the risk of sharing sensitive information. The respondents had the opportunity to read the analyses made from the interviews in order to ensure their own integrity. Each respondent approved the recording interviews. The

recorded material from the interviews was used only to supplement the transcriptions and was deleted immediately after use, in accordance with the requirements (Kvale & Brinkmann, 2014; Vetenskapsrådet, 2002).

5 Result

The following section contains the results, where it has been chosen to divide the results into two main parts: Reusage in the real estate sector and the case. The first sub-section presents the interview study, where it is of this study's interest to focus on the different real estate companies' approach. Therefore, the results are summarized based on each company. In accordance with the previously described anonymity and to separate the different companies, the different companies are described as companies A to E (according to section 4.3.1.1). The second sub-section describes the conduct of the pilot project in general, according to interviews with stakeholders involved and observations.

5.1 Reusage in the real estate sector

The interviews conducted indicated both similarities and differences in how the different real estate companies work with reuse. The section will start with identifying the firms' current approach within reuse. The identified barriers and drivers will thereafter be described under the four identified themes of financial, quality, coordination, and logistics.

5.1.1 Current approach

Through the conducted interviews with five real estate companies (A, B, C, D, and E), was their approaches to reusing materials and products in their projects discussed. The companies shared their current practices, future goals, responsibility, and technologies used for reuse.

Company A focus on reusing materials at an individual and project level, where project managers decide which materials and products can be reused within tenant adaptations. The company has therefore not implemented a systematic approach to reusage. The company currently relies on word-of-mouth to transfer information regarding available materials for reuse and has not implemented any specific technology for stocktaking or sharing available materials. However, they are looking to integrate a systematic approach to reuse within all their projects by 2023 and are therefore currently evaluating the existing options, on how to implement a systematic approach together with existing technology.

Company B has come further with their implementation of reusage. They have requirements to evaluate reuse in every project and requires workshops to be held in each project, so that the involved stakeholders can discuss possible solutions. The workshops vary in size depending on the type of project, where large projects tend to have multiple workshops with more involved actors. Further has the company implemented CCBuild as a technology in their approach where they upload available materials for reuse so that the information is shared both inhouse and externally. The technology hasn't substituted word-of-mouth for sharing information, since this approach is still used in some cases, where the project managers have a chat to share information regarding reusable materials. The project managers are responsible for overseeing reuse opportunities in each project. To show the possibilities of reuse has the company

conducted pilot projects where the goal was to reuse 100 percent of the materials. According to their results was about 80 percent of the materials reused.

Company C has also implemented a systematic approach to reuse where they use a similar technology of CCBuild called Palats. They have further implemented incentives, standardized materials, and warehousing solutions to increase their reusage, which will be described further in the sections below. The company has a specific goal for reusage which is to save five tons of CO2 equivalents by reusing products this year. When it comes to responsibility are the project managers responsible for the reusage, but it is however the contractors which are conducting the work.

Company D has different priorities and suggest that focus should be on minimizing the need for adaptations. Where companies should prioritize selecting the right materials for their buildings based on high quality, long lifetime, and refurbishment potential. Further is the company's real estate portfolio located in the most attractive areas in which they suffer large losses if buildings are vacant. This is one of the reasons why reusage isn't prioritized, since the firm believes that the implementation will result in longer adaptations and will thus become expensive. The firm has therefore not adapted any systematic approach or technology to reusage. Instead, they try to minimize adaptations as much as possible and if they have materials available for reusage, they rather donate to simplify the process.

Company E is currently implementing reuse within their organization by working with information sharing, conducting pilot projects, and evaluating a possible approach. They are currently working with a method where retaining, refitting, and reconditioning should be considered before reusing materials in their projects. They are members of the CCBuild community but haven't implemented a systematic approach on how to work with the technology yet. The project manager is responsible for reusing materials in the projects, and they are currently communicating available materials through word-of-mouth. The company has not set specific goals for reusing materials, but they aim to be climate neutral by 2035.

The results of the company's current approach within reuse have been summarized in Table 3. The table describes if they have implemented a systematic approach and technology to enhance the reuse. Further does the table show if the companies have implemented goals and requirements within reuse, and who is responsible. Finally, is the implementation of a warehouse for the storage of reusable products shown.

Table 3 - Results of current approach with reusage.

	Company A	Company B	Company C	Company D	Company E
Systematic approach	Not yet	Yes	Yes	No	Not yet
Technology	Not yet	CCBuild	Palats	No	Implementing
Goals and requirements	No	Yes	Yes	No	no
Project manager responsible	Yes	Yes	Yes	Yes	Yes
Common warehouse	No	No	Yes	No	No

5.1.2 Financial

The interviews revealed that there are several challenges related to economics which are associated with reuse. Company A stated that it is cheaper to buy new products and materials if the climate perspective is not considered. It would be easier to justify reusage if it was economically beneficial. They also mentioned that their expertise is not within reuse, and the administrative work with reuse is large, which would take a lot of time if done in-house. It is therefore important to have enough resources and available time to handle the extra workload of reusing materials. Finally, are valid and accurate measurements of reuse needed for the firm to be able show the impact and be able to justify the extra work needed. Company C has also noticed the importance of measurements. They are therefore working closely with the technology developer Palats to enhance the measurability of reuse with the help of technology, to potentially solve the challenge of measurements.

Company B, similarly to company A, mentioned that they want to specialize in real estate and not run a shop for reusable products. Their expertise is not within the area of reuse, and they aren't keen on changing their business. Additionally, they stated that the market for reused products is not mature enough, where supply and demand are not met.

Company D have as stated earlier, strict timeframes in their projects, due to their expensive rents, which makes it not economically justified to spend time on handling reuse. Additionally,

they highlighted that the system of purchasing material is constructed in the wrong way. Contractors and suppliers earn money by adding new material to projects and are thus incentivised to minimize reusage. Therefore, do the respondent from company D believe that the entire supply chain would need to change their mindset and business models for reuse to be successful. Company E also identified challenges with the market of reused materials. Where the information transfer isn't good enough for buyers and sellers to find each other, which suggest that the market is not mature enough.

5.1.3 Quality

Through the interviews has certain challenges with quality been discussed. All the interviewed companies highlight the problem with ensuring quality requirements when implementing reusage in their projects. Aspects such as sound, fire and air requirements must be met, and products which must meet these requirements are therefore harder to reuse if information is missing. Multiple of the respondents from different companies suggest that purchasing more of the same products and materials can help standardize their materials and make information retrieval easier when reusing. Company C has already implemented a system with standardized materials, where they also point out how it is easier to find a new suitable place within the organisation for reusable materials when such a system is in place. The respondent from company C also state that appliances pose a challenge to reuse as they become more energy efficient overtime, making it sometimes more sustainable to buy new.

The respondent from Company D find the current system with CCBuild to be ineffective, taking too much time and not being suitable for their projects. More effective solutions are required to ensure that quality standards are met, and that the process becomes quicker. The respondent also emphasized that their offices must be suitable and attractive over a long period of time, which is why they want to consider this in every project. The respondent gave an example of buildings from the early 1900s that have lasted for many years due to their high quality and are still very attractive. Additionally, the respondent makes a parable to the second-hand market of clothes and furniture, where high-quality products from expensive brands are typically sold, and it's not typical to find low-quality products from fast-fashion brands. All of which supports their arguments of focusing on high quality materials which are durable and attractive for a long period of time. However, the respondent states that it's hard to know what will be attractive in the future.

5.1.4 Logistics

The interviews with the real estate firms reveal several insights into the logistics of reuse. Warehousing has been stated as a problematic area of reusage by all companies except company C. The firms aren't interested in having a warehouse themselves and believes that it would require a lot of time to handle such a warehouse. The respondents from company A, B and E suggests that a 3rd party could solve most of the aspects of reuse and allow them to focus on

their core business. They also propose a common warehouse for reuse between all real estate firms, to enhance the supply and demand of reusable products.

Company B are currently solving warehousing on a project-by-project basis, with most projects becoming the warehouse for a short period of time. They have also tried to use an external warehouse for a large project, but problems arose with the storage of materials which never found a new place. Company C is the only company working with warehousing of reusable products inhouse and is using the technology Palats, to make inventorying and keeping track of their reusable products. Their dense localization of real estate simplifies the warehousing issue which most of the other companies are experiencing.

5.1.5 Coordination

Coordination is a common theme which have been discussed in the interviews where multiple respondents have mentioned collaboration, changed mindset, and increased knowledge as key factors to improve reusage within the industry. Company A suggests larger coordination with the suppliers. Where each product supplier should be responsible for their own products, and thus have a responsibility to refurbish, and resell used products. However, the respondents believes that regulations and incentives will be needed for supplier firms to implement this.

Company B considers having a good architect as essential for increasing reuse. They have conducted workshops with their architects to enhance their collaboration within reusage. The workshop has resulted in the architects becoming more flexible when creating floor plans. Examples such as not specifying specific material choices and giving spans instead of specific dimensions to give the project managers flexibility with their choice of materials are some methods which have been implemented. The company also use early tenant adaptations in some projects, which means that the adaptation is made before finding a tenant. This results in higher risk, but also allows the company to conduct their work with reusage without a tenant interfering in the work which allow them to present the finished product to the tenant. This is something which Company D has faced challenges within, where they have very selective tenants who want specific solutions for their office. Due to their high rents, it is common for the company to apply the changes which the customer wants.

Company C has worked on the collaboration with their contractors by implementing a point system to motivate contractors to work with reuse. Where each registered reused material gives points to the contractors which will be substituted for compensation after the project. The company is also collaborating with the technology company which supplies their reusage tool Palats. Since their offices are placed close to each other are they able to work together to enhance the opportunities with the technology so that reuse becomes easier.

5.1.6 Summary

To conclude have the main insights from the interview study been summarized in Table 4 below. The results have been divided between the four main themes of study: financial, quality, coordination, and logistics.

Table 4: The following table provides an overview of the results from the interview study with the real estate companies.

Financial	- Sometimes cheaper to buy new materials. - Real estate firms want to focus on real estate, not reusage. - Reusage is time consuming. - Need for enhanced measurability for marketing and justification. - Immature market for reusable materials. - Changed system for material suppliers and contractors (earn money by adding new materials).
Quality	- Difficult to ensure that requirements are met when reusing. - Standardization of materials as a solution. - Technology improvements are needed. - Important to focus on high quality, attractive and durable material choices when purchasing new materials.
Coordination	- Increased collaboration. - Changed mindset. - Increased knowledge and competence. - Implementing innovative methods (3rd party, supplier responsibility, early tenant adaptations, incentives, improving technology).
Logistics	- Delegation of responsibility to 3rd party or suppliers. - Challenges with warehousing.

5.2 The case

The following section will present findings of the observations and results from the interviews made with actors involved. Three main processes were analyzed during the case study, these are: search of tenant, stocktaking, and search of materials which have been displayed in Figure 12 below.

Figure 12 – Case processes illustrated in a timeline

5.2.1 Search of tenant

The first process when a vacancy occur is the search of a new tenant. According to the leasing manager interviewed, the current tenant was an animal clinic. The first step in the process was that the vacancy was studied by the project manager, leasing manager and the building administrator, to identify the current state of the property. Due to the location of the property not being attractive in comparison to many other areas in Stockholm was the leasing manager at Castellum aware of the difficulties of finding a new tenant. Despite this was the leasing manager convinced of the potential in the area, and believed it had a lot of development potential.

According to the leasing manager, the next step in the process was to conduct meetings with possible tenants and by analyzing their demands and needs was the leasing manager trying to match the vacancy with the possible tenants. A new tenant was founded who working with renting office places and therefore, the new tenant wanted a coworking space for their business.

The third step in the process was to produce a new floorplan adapted to the demands by the new tenant. Based on the original floorplan (see Figure 3), the leasing manager, an architect and the new tenant collaborated in order to conduct a floor plan for the future business (the result is shown in figure 13). According to the leasing manager, the new tenant had high priorities in the adaptation being sustainable and was thus very flexible. Based on the new floor plan and the demands of the tenant was an initial look at the rental property made by the project manager to get an overview of the tenant adaptation. According to observations, no technical tools were used by the leasing manager during steps one to three of the process and the new floor plan was also flexible made since no measurements was decided.

Figure 13 - Proposed floorplan developed for new tenant in the project Kv. Färöarna

When the premises became empty, the fourth step was to conduct a brief stocktaking which was made by the project manager with the help of the technology CCBuild to identify which materials can be kept in the premises and which materials need to be replaced. Before initiating the stocktaking was a room classification created based on the floor plan so that the materials could be connected to each room. In this case, it was decided that the bathroom, some walls, doors and glass partitions could be kept within the property. Finally, were key measurements to know the specifications for the search of new materials.

5.2.2 Stocktaking

The stocktaking process was in this case performed by the help of the technical tool CCBuild. Before conducting a stocktaking, it's important to consider transportation opportunities within the property. It's a waste of time to conduct stocktaking of materials that are difficult to move. Information to consider beforehand includes the location of the materials, for instance which floor, the size of the elevator, and whether the materials can fit in the staircase or elevator.

According to observations, the process of stocktaking with the help of CCBuild was described as time-consuming. For instance, the creation of products, finding specifications and adding information and quantities in the app took long time. Further, the user interface was considered to have development potential. Another issue noticed by observations was the number of possible specifications which could be added. If all information was to be added to a product it would take a lot of time. Even though the possibility to add all the information is good, the project manager mentioned it hard to decide upon which information is important, where the time aspect had to be put against each information insert.

When adding quantities of certain products was a predetermined measurement set for each material. This became an issue for the project manager when the glass partitions should be added. The app had a fixed measurement set as the area of the partition, which required the project manager to make calculations of each partition. It was observed that this procedure was time-consuming, therefore, it was concluded that the ability to change the measurement would be a good option within the app. Additional, the picture function in the app helps the future user to get a view of the material design. It was noticed by observation that it was difficult to open the photo and the photo zoomed in, so that it was impossible to see the whole picture and the zoom settings was not able to be changed.

According to the interview with the project manager, the stocktaking of bathrooms and kitchens was time-consuming since you were forced to add each material within the kitchen and bathroom. It was observed that a picture was taken of the whole bathroom and kitchen, where the equipment was specified in the description section instead. The project manager mentioned the possibility to have a predefined bathroom or kitchen in CCBuild where the standard materials of a kitchen or bathroom adds automatically. Another time-consuming activity was the checking of correct information of the stocktaking. The materials had to be checked throughout a whole list, where each room had to be found on the list to confirm it had been added. According to observation, the project manager missed the function to filter on certain rooms to get a list of only the materials which are in a specific room.

During the case, a beta-version of the CCBuild stocktaking function was used where the opportunity to link each material to a floorplan became available. The project manager mention that the new function was a good option compared to the room-classification method. However, the function was time-consuming and had development potential. For instance, according to observation, it was not possible to add multiple quantities of the same product by adding pins. Instead, was the function developed so that a new quantity had to be added before adding a pin, which made the process more time-consuming. Further were the pins not adapted to a zoom function, which made the pins very large when adding them to the floorplan, which further suggested the flaws of the zoom functions within the app.

5.2.3 Search of materials

Based on the material needs identified during the stocktaking of the property, started the project manager a search for reusable materials to fill the need. CCBuild was used, but due to the technology being newly implemented within the organization was there no available materials, according to the project manager. Through internal meetings was another tenant adaptation within castellum identified as a possible material bank for the project.

The identified project was a large property of 2645 square meters on the fifth floor of one of Castellums buildings, which was soon to be deconstructed for a new tenant. The property is called Rotterdam and the floorplan of the property is shown in figure 14. The property consisted

of multiple office spaces, bathrooms and three kitchens, which were applicable for the pilot project Kv. Färöarna. The property was located in Värtahamnen.

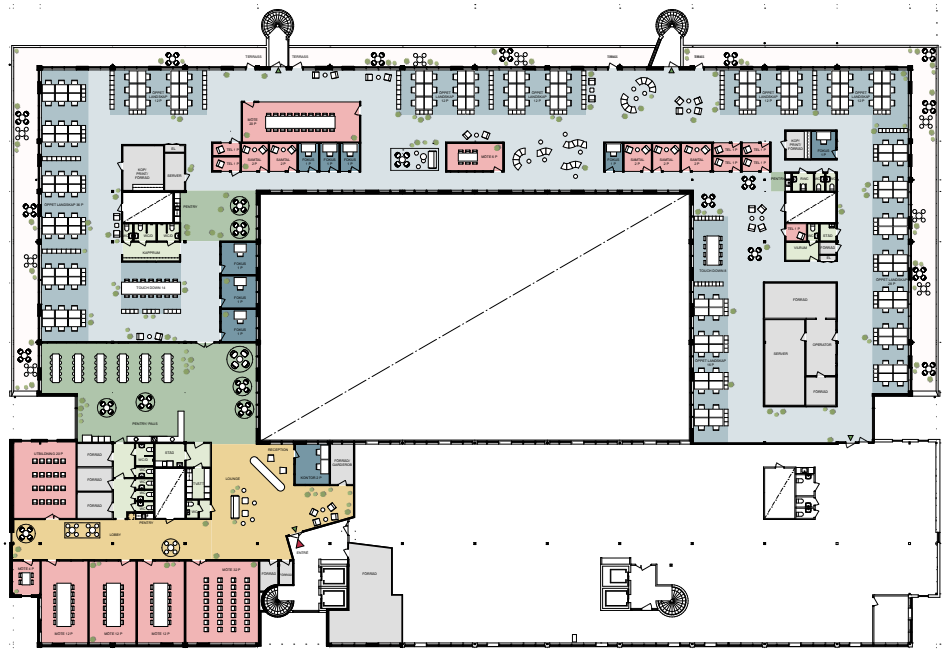

Figure 14 - Floorplan of Rotterdam floor five where materials was collected for Kv. Färöarna

A stocktaking with CCBuild was performed of the premise Rotterdam by the project manager. According to the project manager, many of the needed materials in Kv. Färöarna was found within the property Rotterdam and was thereafter marked with post-it notes. The project manager decided that using the reserve function of materials in the CCBuild app was not suitable due to other project managers being interested in material in the property aswell. Since the other project managers had not been introduced to the technology yet, was there risks of losing information, and thus was post-it notes a more suitable solution compared to a more technical one. It was observed that the lack of knowledge and issues with communication was a barrier in the case. For instance, there was issues with the communication with the tenant, which created plan changes and thus created extra changes of the materials which were to be reused. If a continuous and involved processes was held with the tenant would the time spent on these types of changes be minimal.

The materials which were chosen were glass partitions, doors, bathroom equipment, floor tiles, cable channels and kitchen equipment. Discussions were held if inner roof tiles should be reused for the Kv. Färörna project. The conclusion was to deliver them back to the supplier so that the material could be refurbished instead. During this phase, it was observed that it is of high priority to analyze the deconstruction and transport opportunities early in the process. For instance, where some products difficult to deconstruct such as glued textile carpets which was found in Rotterdam floor five. Instead, were certain areas found where the floor was constructed

with floor tiles which were easier to dismantle. It was observed that there is of high importance to evaluate the deconstruction possibilities early in the design phase.

6 Analysis

The main topics of the study, quality, financial, logistics, and coordination, pervade the discussion where interesting themes have been identified. These themes are analysed and discussed based on the interview study, the case study, and the literature review.

6.1 Quality

The literature as well as the interview study suggest that the quality aspect is a barrier within reuse. Through the interviews it became obvious that the specifications of many products and materials are missing when they are to be reused, which makes it difficult for the contractors to ensure standard requirements such as sound and fire. Further could reusable material contain hazardous substances (Rameezdeen et al., 2016; Yeung et al., 2015), which requires further quality checks. Some of the interviewed firms suggested the implementation of standardized materials as a solution, where the firm has larger knowledge over the inserted materials in each project. While the literature suggested changed regulation of reused materials, to remove the need for these considerations. However, the core issue is that the information is lost when it's time for deconstruction. The real estate companies should have stricter demands on material specification lists from contractors. Further should a functional system of sharing such documents be created. Where each property has a list with the materials and its specifications, which also must be updated when new changes are made. The result of this would be clarified specifications of all the products which could be reused, which further would serve as guarantee for the demands put by the tenant.

It is important to keep in mind that the most optimal scenario is when material and products can be kept in place for the next project according to Mangialardo and Micelli (2018) model of circular economy within the construction industry. It is therefore important to focus on the mindset of the involved actors, where the real estate providers shouldn't accept that tenants want new products and designs, if the existing building is of good quality. In line with castellums approach of prioritizing keeping material in its place. Company D elaborated this concept by describing their priority in selecting high quality materials which are durable and timeless. Further have Company B worked with early tenant adaptations to be able to keep a lot of the materials without the tenant interfering. The tenant can later see the finished product and decide if the quality is good enough for them to rent the property. Another important aspect is the search of tenants where focus should be on finding a tenant which suites the existing building. In the case was the new tenant not applicable for the existing property, where the property structure of a store needs to be renovated to be suitable for a coworking space. But if more time were to be put in the search of a new tenant which was suitable for a store, would it be possible for the real estate firms to minimize the needs for new materials.

A final quality related issue with reuse is homogeneity. Many of the customers within real estate wants the design to be homogenous, where the color and products are matching. This creates issues during larger projects which are interested in implementing reuse. The case study was a small property where materials was reused from a large property, which allowed the project manager to reuse identical products in large quantities and the issue with homogeneity was therefore not noticed. However, in larger projects would it require a larger supply of identical products, which could become an issue. It is therefore important to change the mindset of the customers. It is possible to create a nice property without homogeneity, but it could require creative architects. Another solution which will be described further in section 6.3 is the usage of consolidation centers which sorts the available materials for reuse.

6.1.1 Measurability

The literature and the interview study showed the need for accurate measurements of the impact of reuse where the industry needs to coordinate to find a standardized method which is used nationally according to Nyhlin and Åfreds (2022). Many of the technologies related to reuse has functions which calculates the economical and carbon dioxide equivalent savings of the materials which have been reused. However, it requires the correct inserts of quantities, which the case have shown to be problematic where the insert of a whole kitchen or toilet takes too long time. This affects the accuracy of the measurements, and it is therefore important to simplify this process. The benefits of measurements is the marketing opportunities it provides. Where the measurements could help convince future projects and other firms to implement reuse, further can firms study which materials have larger impact and can thus prioritize certain materials. To solve the coordination of a standard measurement within the industry is CCBuilds network an excellent place to use for workshops and discussions of how it should be developed. Further is it required for the competitors of similar technology to collaborate to find similar measurements.

6.2 Financial

The analysis of the financial perspective has been divided between two themes. These are time consuming and market, which aims to describe the barriers and drivers related to reusage.

6.2.1 Time consuming

Focusing on circular economy within the building industry is more time consuming in opposite to traditional working methods (Mangialardo & Micelli, 2018). Therefore, time consuming is both an important and interesting topic to discuss regarding reusing within the construction industry. When it is time consuming, it leads to increased costs, which affect the financial perspective of reusage in the building sector. There are several aspects affecting the time consuming. According to Dantata et al. (2005), it takes about four times longer to deconstruct a small premises compared to demolish the same premises. Therefore, it is of high importance to start designing for deconstruction. Further, it is time consuming to design with reused

material, since it requires using a flexible design which in turn, according to company A, call for increasing administrative workload. The searching of materials is a time-consuming activity, an activity responsible by either the client, architect, or the entrepreneur. Finally, the time-consuming activities leads to additional costs, such as for instance warehousing (according to company C) and stocktaking of materials (according to observations). Where Company D mention that it is not economically justified to spend time on handling reuse.

These time-consuming activities could, in many cases, be more efficient by using technical tools to enhance the process of reusing, such as the stocktaking process, designing process and, deconstruction process. Company D find the system with CCBuild to be ineffective and taking too much time and is not suitable for the projects and the respondent asks for more effective solutions that make the processes becomes quicker. According to observations, there is of high importance to develop CCBuild to meet everyone's wishes. For instance, the tool should be enhanced by more effective methods of adding materials and its characteristics, and the user interface should be developed.

6.2.1.1 Activities during the design phase

There are a lot of activities during the design phase affecting the time-consuming of reusing in the construction industry. ***Design for deconstruction*** is a method which effecting the deconstruction process (Akinade et al., 2017; Kanters, 2020). The key is to involve demolition contractors and specialists in the design with the aim of designing with materials and products that are easier to deconstruct in a time- and quality-efficient way (Akinade et al., 2017; Kanters, 2020). Design for deconstruction is a method the interviewed companies does not has approach yet, according to the interviews. The studied case showed the importance of the method. An investigation was conducted into which textile carpets should be reused. It was concluded that only one type of textile carpet was possible, which was easily glued floor tiles. The other types were too hard glued to be deconstructed without damage. This is similar to the pilot project by Eberhardt et al. (2019) where the aim was to focus on design for deconstruction. The result was that the Danish office building was significantly easier to deconstruct, and the quality of the deconstructed materials was high.

With this in mind, it is important to design and build for deconstruction. When a material is bought, it should always be controlled whether it is easy to deconstruct. For instance, material selection, construction method, and floor plan are three factors that affect the deconstruction process. CCBuild should develop a template for how to think about designing for deconstruction and share the template to all users. Further, CCBuild should also introduce a topic field to be considered in the stocktaking process. Since, according to observation, it is important to investigate already in the inventory phase whether the material is easy to deconstruct or not. Designing for deconstruction requires great coordination and affects the financial perspective since it becomes more cost effective if it is easy to deconstruct.

When ***designing with reused materials***, it is important to already in the design phase take reused materials in consideration to success with the reuse-project since it is often necessary to claim the reused materials at an early stage to ensure that they remain (Chinda & Ammarapala, 2016; Gorgolewski, 2008; Gorgolewski et al., 2008). Designing with reused materials affecting the financial perspective since the architects need to spend more time finding reused products that fits the current project and stocking costs, for instance (Gorgolewski et al., 2008). According to observations from the case, the floorplan of the premises was not correct from the beginning since the first floorplan was not adapted to the materials available. Therefore, it is of great importance that a digital tool, such as CCBuild, is used. Again, it is essential that the materials uploaded into CCBuild have the correct technical specifications and dimensions to enable designing with reused materials. It is also important that the architects and other actors involved in the design process have access to CCBuild to study possible material alternatives. CCbuild should develop, for instance, projects rooms where the coordination take place (see section coordination and communication). According to company C, standardized materials, in combination with the use CCBuild, can simplifying the process for the actors in the design phase since the choice of material is lesser. In contrary, company D and the project manager for the case argues that standardized materials are not a long-term solution since it is important to create attractive and varied premises, which according to the previously mentioned becomes difficult with standardized materials.

The design needs to be more ***flexible*** since there sometimes is uncertainty about the technical specification of the reused materials (Gorgolewski et al., 2008). Which is In line with company B, who pointed skilled and experienced architects as a key to success with designing. Further, the company conducting workshops with architects and other actors involved to enhance the collaboration and flexibilization in the design phase, and the workshops went out well. During the case study, observations was made about the first floorplan which was not flexible drawn. Later, a new floorplan was drawn together with the new tenant who was very flexible. This redrawn affect the financial perspective negatively and require a high degree of coordination to succeed with a flexible design.

6.2.2 Market

The literature and interview study showed evidence of the market for reusable materials being immature and ineffective (Chinda & Ammarapala, 2016; Gorgolewski et al., 2008; Rameezdeen et al., 2016). Caldera et al. (2020) explain that technology-based markets are emerging throughout the industry, where online trading could contribute to a more accessible market for reused products. However due to the time-consuming aspects explained previously aren't all the available materials uploaded which suggest that there is even larger supply, if made simple enough and economically justified to sell it. To increase the financial benefits of reusage was taxes discussed by (Chen et al., 2022) as a possible solution. Where the increase of taxes on landfills and new materials would enhance the economic benefits of reusage which company A suggested as a barrier to reuse. It would be possible for the emerging technologies

to enhance the market of reusable products further by integrating information of available material from competitive technologies. Through this would a larger supply of materials be available for the possible customers, which according to (Chileshe et al., 2016) would contribute to less economic challenges connected with reuse, based on the increased supply.

Company D mentioned that the whole system of building materials is constructed in a wrong way. Where contractors earn money by adding percentages to the materials which they purchase. If a client suggests reusing materials will the contractors be sceptical due to their decreased earnings and will have to demand compensation in different ways. All of which is affected by the industry's reluctance to change, which makes the process harder. The work with coordinating actors within the industry which CCBuild is currently working with is a good way to change the mindset of the stakeholders. It could be beneficial for many of the firms which feels uncertain of the contractual questions regarding procurement of projects including reuse, if CCBuild could provide a standard contract which focus on reuse. The contract would have to be beneficial for both parties of the contract.

6.3 Logistics

Even though the logistical processes of reuse haven't been included in the case, it is possible to analyze the topic based on the conditions of the case in combination with the literature and interview study. The solution with finding an inhouse property which was to be deconstructed was beneficial in terms of retrieving all of the materials from one place. However, the long distance between the two properties suggest that a developed market could've provided a more beneficial solution with less transportation needed. Ding et al. (2023) suggest logistics and consolidation centers to improve the transportation and the secondary market of reusable materials. Where a closely located consolidation center would've been a more suitable solution within the case, to minimize the transportation of materials. In larger projects will consolidation centers become even more important since it will be harder to find all of the needed materials from a single deconstruction project. If much of the available materials could be collected and distributed between a few, strategically placed consolidation centers, would a larger supply from a single place be possible. This contradicts castellums approach "Klimatsmart lokal" which suggest that reusage inhouse should be prioritized. The decision of choosing materials should be based on the most optimal solution with transportation, to minimize the need for transportation.

6.3.1 Warehouse solutions

The interview study showed that the majority of the firms has issues with warehousing when conducting work with reuse. Further has the literature expressed that the stocking of reusable materials generates extra cost due to the need of securing the material in the design phase of projects (Chinda & Ammarapala, 2016; Gorgolewski, 2008; Gorgolewski et al., 2008). The majority of the firms have no interest in handling a warehouse by themselves and are thus

suggesting a third party to solve most of their issues with warehousing. Company C is the only firm with a common warehouse, which is suitable to their business due to their densely located real estate. Ding et al. (2023), similarly to most of the firms, suggest that logistics and consolidation centers should be developed, where a third party would solve the transportation, refurbishing, sorting and distribution of reusable materials. Since there is issues with streamlining and minimizing costs would expertise within this field be required for minimizing costs according to Ding et al. (2023). This would further simply the issues with homogeneity, since all of the materials could be sorted within for example color, dimensions and other attributes. This would allow the customers to pick materials which would fit together within their projects. The solution could look similar to a normal material shop, except that the materials have been used elsewhere beforehand. The solution does however require large investment and will most likely take long time before its streamlined to the point where its profitable.

Company B have solved their warehousing on a project-by-project basis, where the project usually becomes a warehouse. Since many of the uploaded materials within the reuse technologies comes from projects which are to be deconstructed in the future, it might be possible to integrate temporary warehousing opportunities from its users. For example, was the Rotterdam property empty for over four months, and if there was a project nearby which required warehousing for a short period, it could have been used. A third option is having the suppliers and manufacturers becoming responsible for their products, where the manufacturers allow users to bring back products in order for them to refurbish or resell the product. In this case will the manufacturers become responsible for the warehouse. The supplier responsibility will be discussed further in section 6.5.

6.4 Coordination

Collaboration and communication are two important factors for a construction project to succeed in building with reused materials without compromising efficiency and the financial aspect (Knoth et al., 2022; Rakhshan et al., 2020). According to observations, poor collaboration and communication leads to, among other things, misunderstandings between actors and the project taking more time, which further affects the financial perspective negatively. To improve collaboration and communication between involved actors, it is important, for instance, to increase the flow of information, set common goals, increase knowledge among individuals, involve more actors, and share the risks that arise in the construction of reused materials. Technical tools have been identified through literature, observations, and interviews as an important aspect to improve these aspects.

6.4.1 The information flow

It is of great importance to increase the flow of information between stakeholders involved in order to increase the efficiency of construction projects and to improve co-operation between actors. A long-term partnership and increased trust between stakeholders involved would lead

to a change in project-based organizations in the construction industry, which can further lead to, for instance, improved information flows, common goals, and incentives (Ding et al., 2023). Specialized logistics actors are a solution to streamline the coordination and integration of the different actors, which would further improve the logistical problem of construction with reused materials.

For a construction project with a high degree of reused materials, it is of great importance that the information flow of the materials is efficient and accurate. For instance, according to Akinade et al. (2017), well documented material characteristics are required. The use of CCBuild is a solution to successfully document accurate information about the products. Unfortunately, it has been identified through observations that a lack of knowledge about reuse in general and CCBuild in particular leads to missing important information about the products, which can further lead to worse coordination, financial and quality. According to observations and interviews, the developers of CCBuild should simplify the use of the tool by allowing each organization to customize the number of possible specifications which could be added during the stocktaking process. This should be done to simplify the decision on which specifications are more important than others.

The use of word-of-mouth for information flow is a common problem that permeated most of the companies interviewed. Most of the company interviewed, they used word-of-mouth to transfer information regarding available materials for reuse. Company B uses word-of-mouth in combination with CCBuild, there the purpose of CCBuild was to upload materials available for reuse and share the information both inhouse and externally. According to the interview with the project manager, using the word-of-mouth often leads to misunderstandings. The above-mentioned possibility for CCBuild with integrating information of materials between competitive technologies should help to minimize the word-of-mouth problem since more materials is available online.

6.4.2 The lack of knowledge and risk sharing

To achieve good coordination, it is important that the above mentioned information flow and the further mentioned knowledge is shared among stakeholders involved (Malone & Crowston, 1990). The lack of knowledge about reuse among stakeholders is a barrier that contributes to poor coordination (Knoth et al., 2022) and a factor that affects cooperation and communication. According to the interviews conducted, increasing knowledge about reuse is a key factor in improving reuse in the industry. According to Rezgui (2001), effective management of knowledge in the construction industry is enabled by information and communication technologies. The knowledge gap could be solved by conducting pilot projects (Knoth et al., 2022) and to increase the knowledge sharing within the industry with for instance workshops, exemplified by company B. Pilot projects is a method used by several organizations in the industry, both company B, company E, and Castellum is running pilot projects with the aim of gaining more knowledge about reusing. A reflection from the observations, the workshops held

by the organization behind CCBuild is also a great solution to increase the knowledge about reusing. A success factor to increase the knowledge about reusing even more is having more engaged organization in the industry willing spread their knowledge about reusing.

The reluctant among stakeholders involved to share the risks as may occur when building with reused material are considered as an important factor affecting the collaboration and communication (Knoth et al., 2022). Both the financial, co-ordinational, and the quality perspective may be affected of this factor. One of the solutions observed is to involve authorities in the discussion about sharing risks in order to increase the collaboration among the actors since some risks is handled by the authorities. Another risk that may occur is when buying and selling reused materials through digital tools. Therefore, it is of great important to always document enough information about materials in CCBuild that proves its quality.

6.4.3 Involvement of actors

To increase the collaboration and communication, there is important that actors is involved (Knoth et al., 2022). Suppliers should be involved to be informed about which products are being reused, which products will be placed on the market, and to gain knowledge about how products are used to develop new products adapted for reuse. Demolition contractors should be involved in order to simplify the deconstruction process. To design with reused products, architects should be involved at an early stage. Furthermore, the contractor also has a responsibility to get engaged in the project in the design phase to contribute with technical solutions to challenges that occur. In the case studied, there has not been a platform where all actors have met, which has contributed to the project being fragmented. According to observations from the case, there is of great importance to involve as many actors as possible in order to gain a better coordination throughout the project.

According to Rose and Stegemann (2018), it is of great importance to involve the entire chain at an early stage when implementing reuse in construction projects. The workshops conducted by company B, whose purpose is primarily to involve as many stakeholders as possible to discuss possible obstacles and solutions, are perceived as a good method to involve the actors. Digital education on reuse in the construction industry is an important step in making stakeholders aware of the need. However, observations have indicated that there is a lack of digital tools focusing on coordination and stakeholder involvement. Therefore, there is a need for a platform developed to meet this demand. One possibility is to create project rooms where stakeholders involved in each project meet and coordinate to achieve circularity in the projects.

6.5 Supplier responsibility

Another theme to discuss is the involvement of the suppliers. The manufacturers of the products have a great responsibility, firstly, they must produce products that are adapted to be deconstructed (Chen 2022, Rakhshan 2020). The case showed evidence of this, where floor tiles was easier to deconstruct compared to carpets. There are most certainly a lot of

development possibilities in many of the products when it comes to deconstruction. Where it is important to involve both demolition contractors and design specialists in order to maximize both quality and time efficiency of deconstruction (Akinade et al., 2017; Kanters, 2020). Further is this something that customers should consider when buying new materials. Where deconstruction possibility should be a criterion which is considered by the firms.

Secondly, manufacturers can be more responsible for the products that will be reused, for instance by taking back their products in order to check, classify, and sell on the market again. This is in line with company A, B and D's suggestion that each product manufacturer should be responsible for their own products throughout the life cycle. Further is it similar to the concept of a performance economy, where the manufacturers are responsible for the waste management of their products. This would lead to the firms enhancing the performance of their products by extending the lifetime and enhancing the reusability and recyclability in order to stay competitive (Sariatli, 2017). This method was tested in the case where the project manager contacted the roof tile producers who took back the tiles for reconditioning. This process require engagement from manufacturers and could therefore require incentives to the manufacturers and technical tools to simplify and streamline the process. Digital tools can contribute to this, for instance by sending a digital notification to the respective producers when their products are published on the marketplace, which would simplify and enhance the work of the producers. Further could the users get notifications when a certain material of a specific company has been inserted in marketplace of the digital tool. If the company are able to take back their products and refurbish and resell it, could the users get this information instantly, instead of searching for the producers which was needed in the case study.

6.6 Suitability of technology

The literature suggest that technology has the possibility to make processes more efficient (Rezgui, 2001). Despite this has the case proven difficulties in implementing CCBuild as a systematic approach. Many of the previously discussed topics are reasons for a difficult implementation, which leaves the question: is technology suitable for reusage?

There are many benefits with using technology to share available materials and the marketplace function of CCBuild is thus a tool which enhances reusage within the industry. However, the processes required to fulfill a trade of material is time consuming and expensive and requires streamlining. The case has shown evidence of reluctance to change current working methods, where project managers believe that they don’t have the time to work with stocktaking and deliveries of material. Further have the interview study showed that word of mouth is still a method used to share available materials inhouse, which could mean that informal and flexible communication, is a better way to handle reuse. On the other hand, is it possible that it’s the implementation phase of CCBuild which makes the processes more time consuming, where a standardized working method and improved technology, could lead to a more effective way of

handling reuse. The study hasn't collected sufficient evidence to support either one of the theories, but the need to make the processes with CCBuild more effective is a must to ensure that reusage becomes financially justified.

7 Proposals

To enhance the efficiency of reuse in the construction industry, digital tools need to be further developed. CCBuild is a tool that can be developed to better improve and optimize the processes of reuse in circular projects. According to observations and the project manager interviewed, there are identified several proposals connected to the digital tool CCBuild.

When conducting a stocktaking with the stocktaking tool in CCBuild, there are several improvements that should be made. Firstly, the user experience should be enhanced by having dialogues with users about what and how it can be improved. This would lead, for instance, to the application being less time consuming. Secondly, it should be possible to change measurement of products added in the product bank, for instance, sometime a door will be counted in square meters and sometimes in quantity. When adding products during the stocktaking, there are a lot of possible fields to fill, for instance, RSK, BSAB, and E-number. According to observations, these fields complicate the stocktaking process due to lack of knowledge among the responsible persons. Therefore, CCBuild should allow organizations to choose which fields they consider important and exclude the fields they consider less important. This would contribute to a better continuity of the information added.

Furthermore, when larger premises are stocked, the process is simplified if it is possible to sort in different rooms when searching for products. Moreover, when stocktaking bathrooms and kitchens, it would be more efficient if CCBuild developed the possibility to insert a whole standard bathroom or kitchen, since it is very time consuming to add all single modules in a bathroom or kitchen. According to observations, it is important to investigate already in the stocktaking phase whether the material is easy to deconstruct or not. Therefore, CCBuild should introduce a topic field about that fact to be considered and added to the product information.

To increase the coordination among stakeholders, you should be able to create a project room in CCBuild for the actors involved in each project. The purpose of this forum would be to increase collaboration on circular construction for the specific project, for instance through common goals and continuous communication about project-specific challenges and opportunities. Further, to increase the market for reused materials, CCBuild should collaborate with competing tools regarding the marketplace to make more materials available, regardless of the tool or marketplace used. It would be good to increase the responsibility of manufacturers, CCBuild can contribute to this by automatically sending notifications to manufacturers when their products are posted on the marketplace. Furthermore, to increase the knowledge among stakeholders, CCBuild should develop templates about how to work with reusage. For instance, it would be great to develop a guide about how you in the most efficient way designing for deconstruction. Finally, CCBuild should provide even more education about reusage in general, as these trainings are valuable, informative and contribute to the knowledge of the industry.

8 Conclusion

The construction industry in Sweden faces several challenges in achieving sustainable development through the reuse of materials. The study has focused on four main areas which have been identified as barriers to reuse. Firstly, have quality related issues been studied, where issues such as meeting standard requirements, homogeneity and extending the lifetime of products. Drivers for these issues was identified as minimizing the need for adaptation, enhanced communication and changed mindset.

Secondly were financial issues identified, where the main issues are related to the increased time needed to work with reuse. Where methods such as design for deconstruction and increased flexibility in the design phase is considered as crucial. Thirdly were the logistical aspects of reuse observed, where warehousing is an existing barrier. Several solutions have been discussed such as consolidation centers, third party actors and supplier responsibility. Lastly was coordination investigated, where communication, lack of knowledge and mindset of the involved actors was key barriers which were found. Drivers related to the topic is enhanced cooperation.

To improve reuse in construction, has technology been identified as a tool solve many of the barriers and to support the process of reuse in renovation projects. CCBuild is one of the leading actors on the Swedish market for reuse technologies. Based on the findings of the study is there development potential for the technology. Improvements include enhancing the user experience so that the stocktaking process becomes more effective. This includes functions which allows the users to insert standard products of a kitchen or bathroom and changes to the available information inserts. Further should CCBuild cooperate with competing technologies to increase the available materials, and thus enhance the market. Finally, should CCBuild continue their work with knowledge sharing and coordination of actors.

The results of this study will contribute to the increased awareness of reuse within the construction industry, which will aid the transition of the industry towards a more sustainable practice. Proposals of improvements to CCBuild has been made to enhance the processes related to reuse and thus streamline the work with reuse. In conclusion has the study highlighted the main barriers and drivers related to reuse, to allow for further reflections and actions to enhance the work with reuse.

8.1 Future research

The study has mainly focused on the early stage of tenant adaptations. A more comprehensive study of the later stages including deconstruction, and construction with reused materials could lead to further improvements to CCBuild. This study has mainly focused on the real estate companies work. Future research could focus on other perspectives such as an entrepreneur or an architect. Finally, it would be interesting to see a similar study with focus on residential buildings instead of commercial to identify differences.

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10 Appendix

10.1 Interviewguide – Real estate companies

Personal questions

1. Can we record the interview for the purpose of the study?

2. Please tell us a bit about yourself.
   - What is your background?
   - How long have you been working in the construction- and real estate sector?
   - What is your current position?

Reuse-specific questions (renovation projects)

3. To which extent do you work with reuse?

4. Do you have a method to determine the reuse potential of a building/location?

5. How do you choose which materials to reuse?

6. Which technologies and tools do you use in your reuse work?

7. What do you consider to be the biggest challenge for reuse?

8. What is needed to further develop reuse and implement it in even more projects?

9. What are your goals with reuse?

10. Do you see differences in smaller versus larger projects when it comes to reuse?

11. Who is responsible for reuse in the projects?

12. When is reuse taken into consideration in the renovation process?

13. Do you have processes when construct new buildings to simplify the reuse of the buildings in the future?

Logistic question (renovation projects)

14. How do you manage the logistics of reuse?
    - Stocktaking
    - Deconstruction
    - Warehousing

- Transportation
- Reconditioning

15. If there are different actors, how does the coordination work?

16. What technologies and tools do you use to simplify the logistic process?

17. What do you think is needed to simplify the logistics aspect of reuse?

Coordination question (renovation projects)

18. How does the coordination work between the customer, client, contractor, and the design work?

19. What technologies and tools do you use to simplify the coordination?

20. Do you work with specific people or companies who are experts in reuse?

10.2 Interviewguide – The leasing manager

Personal questions

1. Can we record the interview for the purpose of the study?

2. Please tell us a bit about yourself.
   - What is your background?
   - How long have you been working in the construction- and real estate sector?

Case specific questions

3. Can you please explain the process from when you got the vacancy until your responsibility disappears?

4. Does this case have any specific differences from a "normal" project?

5. How would you describe the new tenant?

6. How do you search for tenants? (Are you looking for tenants that match well with the current floor plan?)

7. How is the production of the floor plan done?

8. To what extent do you use standardized materials?

9. How do you take reuse into consideration?

10.3 Interviewguide – Project manager

Personal questions

1. Can we record the interview for the purpose of the study?

2. Please tell us a bit about yourself.
   - What is your background?
   - How long have you been working in the construction- and real estate sector?

Case specific questions

3. Can you please explain the process from when you got involved in the project until now?

4. Does this case have any specific differences from a "normal" project?

5. How did the collaboration with the deconstruction firm work?

6. How has castellums approach “Klimatsmart Lokal” affected the tenant adaptation and the processes involved?

7. What are your general thoughts of reusage within the industry?

CCBuild specific questions

8. What are your general thoughts of CCBuild after using it in this project?

9. What challenges appeared during the stocktaking?

10. Are there any development possibilities of the app?

11. What did you think of the newly produced function of adding floorplans?

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