



# Scaling Reuse in the Construction Sector

The Role of Technical Consultants in the Transition Toward a Circular Construction Sector

Master's thesis in Industrial Ecology

LOVISA KAPANEN

DEPARTMENT OF ARCHITECTURE AND CIVIL ENGINEERING

Master's Thesis 2023

# Scaling Reuse in the Construction Sector

The Role of Technical Consultants in the Transition Toward a Circular  
Construction Sector

LOVISA KAPANEN



Master's Thesis in Industrial Ecology  
Department of Architecture and Civil Engineering  
Division of Architectural Theory and Methods  
Chalmers University of Technology  
Gothenburg, Sweden 2023

Scaling Reuse in the Construction Sector  
The Role of Technical Consultants in the Transition Toward a Circular Construction Sector

© LOVISA KAPANEN, 2023.

Supervisor: Matilda Petersson, COWI

Supervisor: Gilliam Dokter, Department of Architecture and Civil Engineering

Examiner: Liane Thuvander, Department of Architecture and Civil Engineering

Master's thesis 2023

Department of Architecture and Civil Engineering

Chalmers University of Technology

SE-412 96 Gothenburg

Telephone + 46 (0)31-772 1000

Cover: Illustration of a house within a circle of arrows, symbolizing circular construction, but with no other relation to the studied objects in this thesis.

Gothenburg, Sweden 2023

Scaling Reuse in the Construction Sector

The Role of Technical Consultants in the Transition Toward a Circular Construction Sector

LOVISA KAPANEN

Department of Architecture and Civil Engineering

Chalmers University of Technology

# Abstract

This thesis discusses the transition from a linear economy to a circular economy in the construction sector, where waste generation is minimized, and economic growth is decoupled from resource consumption. The construction industry is a key focus in this transition due to its significant resource depletion, waste generation, and ecological footprint. The European Union and Sweden, including the city of Gothenburg, have implemented initiatives to support circular construction (CC). Reusing building components is highlighted as a strategy to eliminate waste and circulate materials. However, the construction sector is a complex sociotechnical system and the industry faces challenges in adopting reuse practices due to factors such as change resistance and complex product systems. The multi-level perspective is employed in this study to better understand this system and the barriers and enablers to advance reuse in the construction sector. The study is conducted in partnership with the consultancy COWI in Gothenburg, Sweden, to gain insight into the role of technical consultants and their experience with reuse.

The thesis aims to explore the circular economic transition of the construction sector in Sweden, with a focus on the role of technical consultants in facilitating this transition. The construction industry operates within a well-established infrastructure and follows a linear economic model, making it challenging to bring about change. However, there is a growing interest in reuse practices within organizations, and e.g., COWI experiences a rising demand for reuse practices from their clients. The research questions addressed in this thesis include identifying the barriers and enablers to scaling reuse in the construction sector, understanding the stakeholders that affect and are affected by technical consultants in advancing reuse, determining the regime categories in which technical consultants can influence the barriers and enablers, and exploring the roles of technical consultants in scaling reuse.

The transition towards reuse and a CC sector requires collaboration among multiple stakeholders. This study emphasizes the significance of technical consultants in scaling reuse practices and identifies potential roles they can adopt in a CC industry, including reuse coordinators, reuse inventory managers, reused-product assessors, reuse educators, and reuse visionaries. Quality assurance and warranty challenges, limited external market scalability, and complex logistics emerge as major barriers, while collaboration and cooperation, well-functioning reuse logistics, increased demand and attractiveness for reuse, and climate policy and legislation are seen as significant enablers. Technical consultants can more easily influence barriers and enablers associated with knowledge and technology, although their influence on laws & regulations is more challenging. Nonetheless, technical consultants can leverage climate policy and regulations to support clients in achieving climate targets and promote reuse strategies. By understanding these dynamics, technical consultants can effectively contribute to advancing reuse practices and facilitating the circular economic transition in the construction sector.

Keywords: circular economy, reuse, construction sector, barriers, enablers, technical consultants

# Acknowledgments

I am grateful to have received a considerable amount of input and support throughout the course of this thesis. I would like to express my sincere appreciation to all the individuals who have contributed to my work during this semester.

Firstly, I would like to extend my deepest gratitude to Matilda Petersson, a technical consultant at COWI, who has been my supervisor throughout this thesis. I am truly thankful for your invaluable support, guidance, and insights into the field of technical consulting. Your enthusiasm and positive attitude have been a great source of inspiration and motivation for me.

I would also like to express my thanks to my academic supervisor, Giliam Dokter, and my examiner, Liane Thuvander. Your support, provision of interesting literature, inspiration, and guidance in methods and report writing have been essential in my work. I am genuinely appreciative of the detailed and highly valuable feedback you have provided on all my written work this semester.

Furthermore, I would like to extend my gratitude to all the individuals who participated in the study. To all the interviewees who generously shared their knowledge and perspectives from various areas of the industry, thank you. I would also like to thank everyone at COWI who supported my work through workshops, seminars and interesting discussions. Moreover, I would like to thank Julia Gutke for providing valuable opposition and feedback to my work.

Lastly, I would like to express my heartfelt appreciation to my family, friends, and fellow students at Chalmers University of Technology for their constant support during the thesis work and throughout my time at Chalmers. Your encouragement has meant the world to me.

# List of Acronyms

ABK	General Conditions of Contract for Consulting Agreements for Architectural and Engineering Assignments
BIM	Building Information Modelling
CC	Circular Construction
CCBuild	Center for Circular Building
CE	Circular Economy
IoT	Internet of Things
IVL	The Swedish Environmental Research Institute
LCA	Life Cycle Assessment
MLP	Multi-Level Perspective
STS	Sociotechnical System

# Table of Contents

<i>Abstract</i> .....	<i>v</i>
<i>List of Acronyms</i> .....	<i>vii</i>
<i>List of Figures</i> .....	<i>x</i>
<i>List of Tables</i> .....	<i>xi</i>
<b>1. Introduction</b> .....	<b>1</b>
<b>1.1 Background</b> .....	<b>1</b>
<b>1.2 Aim and Research Questions</b> .....	<b>3</b>
<b>1.3 Scope and Delimitations</b> .....	<b>3</b>
<b>2. Theory</b> .....	<b>5</b>
<b>2.1 Circular Economy</b> .....	<b>5</b>
<b>2.2 Reuse</b> .....	<b>6</b>
<b>2.3 Multi-Level Perspective</b> .....	<b>8</b>
<b>2.4 Previous Research on Barriers and Enablers to Scaling CC and Reuse</b> .....	<b>11</b>
<b>2.5 Previous Research on the Role of Technical Consultants in Advancing Reuse</b> .....	<b>12</b>
<b>3. Method</b> .....	<b>15</b>
<b>3.1 COWI as Case Study</b> .....	<b>15</b>
<b>3.2 Literature Review</b> .....	<b>15</b>
3.2.1 Data Gathering.....	16
3.2.2 Data Analysis.....	17
<b>3.3 Stakeholder Mapping</b> .....	<b>18</b>
<b>3.4 Interview Study</b> .....	<b>19</b>
3.4.1 Data Gathering.....	20
3.4.2 Data Analysis.....	21
<b>3.5 Feedback Seminar</b> .....	<b>22</b>
<b>3.6 Method Reflection</b> .....	<b>22</b>
<b>4. Results</b> .....	<b>24</b>
<b>4.1 Barriers</b> .....	<b>24</b>
4.1.1 Laws & Regulations .....	25
4.1.2 Market.....	25
4.1.3 Infrastructure.....	27
4.1.4 Technology .....	27
4.1.5 Knowledge.....	28
4.1.6 Culture & Norms .....	29
<b>4.2 Enablers</b> .....	<b>31</b>
4.2.1 Laws & Regulations .....	32
4.2.2 Market.....	33
4.2.3 Infrastructure.....	35
4.2.4 Technology .....	35
4.2.5 Knowledge.....	36
4.2.6 Culture & Norms .....	38
<b>4.3 The Role of Technical Consultants in Scaling Reuse</b> .....	<b>40</b>

4.3.1	Various Roles of Technical Consultants According to the Interviewees .....	40
4.3.2	Leveraging Collaboration and the Expertise of Technical Consultants .....	42
4.3.3	Uncertainties About the Role of Technical Consultants.....	44
4.3.4	Categories of Barriers and Enablers and the Influence of Technical Consultants.....	44
4.4	<b>Summary of the Feedback Seminar .....</b>	<b>48</b>
5.	<b><i>Discussion</i>.....</b>	<b>50</b>
5.1	<b>Barriers to Scaling Reuse.....</b>	<b>50</b>
5.2	<b>Enablers to Scaling Reuse.....</b>	<b>51</b>
5.3	<b>Identified Roles for Technical Consultants in Scaling Reuse .....</b>	<b>52</b>
5.4	<b>Contributions of the Study.....</b>	<b>56</b>
5.5	<b>Development Areas and Future Research.....</b>	<b>56</b>
6.	<b><i>Conclusions</i>.....</b>	<b>58</b>
7.	<b><i>Bibliography</i>.....</b>	<b>59</b>
	<b><i>Appendices</i>.....</b>	<b>61</b>
A.	<b>Interview Questions .....</b>	<b>61</b>
B.	<b>Barriers and Enablers from Previous Studies Related to Laws &amp; Regulations .....</b>	<b>63</b>
C.	<b>Barriers and Enablers from Previous Studies Related to Market .....</b>	<b>64</b>
D.	<b>Barriers and Enablers from Previous Studies Related to Infrastructure .....</b>	<b>65</b>
E.	<b>Barriers and Enablers from Previous Studies Related to Technology .....</b>	<b>66</b>
F.	<b>Barriers and Enablers from Previous Studies Related to Knowledge .....</b>	<b>67</b>
G.	<b>Barriers and Enablers from Previous Studies Related to Culture and Norms.....</b>	<b>68</b>
H.	<b>Table of Barriers by Interviewees per Profession from Coding.....</b>	<b>69</b>
I.	<b>Table of Enablers by Interviewees per Profession from Coding.....</b>	<b>70</b>

# List of Figures

Figure 1: Butterfly diagram of the biological and technical material flows in a CE (Ellen MacArthur Foundation, n.d.-a). .....	6
Figure 2: Waste hierarchy adapted from (European Commission, n.d.). .....	7
Figure 3: Illustration of a dynamic MLP on system innovation [(Geels, 2005), p. 685].....	9
Figure 4: Different dimensions of the regime [(Geels, 2004), p. 912] .....	10
Figure 5: Regime categories applied in this study. ....	10
Figure 6: Actors involved in the construction process (adapted from (Kanters, 2020))......	12
Figure 7: Affinity diagram over barriers and enablers to scaling reuse in the construction sector found in the literature. ....	18
Figure 8: Stakeholder mapping diagram.....	19
Figure 9. Example of the coding in NVIVO, here showing the third grouping within the main group ‘Barriers’ .....	21
Figure 10: Third grouping of barriers to scale reuse derived from interviews. ....	24
Figure 11: Third grouping of enablers to scale reuse derived from interviews. ....	31
Figure 12: Regime categories in which technical consultants have a greater chance to influence the barriers and enablers. ....	45
Figure 13: Regime categories in which technical consultants have less chance to influence the barriers and enablers. ....	45
Figure 14: Roles of technical consultants in scaling reuse. ....	54

# List of Tables

Table 1: A literature overview. ....	17
Table 2: List of the interviewees.....	20
Table 3: The roles of technical consultants in scaling reuse.....	55

# 1. Introduction

This chapter serves as the introductory section of the thesis, offering an overview of the research. Firstly, it presents a background of the study's topic (1.1), introducing the context for the research. Secondly, the chapter states the aim of the study and presents the research questions that guide the investigation (1.2). Lastly, the chapter presents the study's scope and delimitations (1.3), outlining the boundaries within which the research is conducted.

## 1.1 Background

Our current economy is based on a linear process where we extract materials from the Earth, use them to make products, and then discard them as waste (Ellen MacArthur Foundation, n.d.-b). In a circular economy (CE), waste generation is avoided, and economic growth is decoupled from resource consumption. The CE acts as a framework of systems solutions for some of our greatest global challenges; pollution, waste, biodiversity loss, and climate change. Furthermore, CE contributes to reaching the Sustainable Development Goals (Dokter et al., 2020). According to the Ellen MacArthur Foundation (n.d.-b), there are three main principles of the CE; 'eliminate waste and pollution', 'circulate products and materials (at their highest value)', and 'regenerate nature'. CE has become significantly important in European policymaking and the construction sector is considered one of the highest priorities in the circular transition (Wuni, 2022; Giorgi et al., 2022). This is because of the sector's vast depletion of resources, waste generation, and ecological footprint. Meanwhile, the construction industry is notorious for lagging in digitization, strict change resistance, and complex products, leading to major challenges in adopting this transition (Wuni, 2022).

The member states of the European Union (EU) are starting to implement different programs and initiatives in line with the CE transition (Giorgi et al., 2022). Sweden, including Gothenburg, is not an exception. The city of Gothenburg started the initiative 'Circular Gothenburg' in 2016 with the ambition of developing and supporting the circular transition in the city (Göteborgs Stad, 2021). Furthermore, they have developed a metropolitan agreement for circular construction (CC), a collaboration between the delegation for CE, and the city of Malmö, Gothenburg, and Stockholm. The aim of the agreement is to stimulate the scaling of CC from niche to business-as-usual through a common strategy. It is an investment between the three largest Swedish cities in close collaboration with the industry. Around 200 people from different organizations within the industry participated in the preliminary study where six sub-strategies were developed. According to the participants, these strategies were considered holistic with the potential to achieve the aim (Göteborgs Stad, 2021).

Reusing building components is a strategy to eliminate waste and circulate products and materials. The concept of reuse in the construction sector involves utilizing existing construction materials, components, and even entire buildings instead of using new products made from virgin materials. There are several ways to reuse building components including, adaptive reuse, moving and reusing entire buildings, component reuse, and material reprocessing (further described in 2.2) (Bertino et al., 2021; Densley Tingley et al., 2017; Gorgolewski, 2008). This study does not only consider one specific mode of reuse related to buildings, but addresses reuse in a broader context, including different ways of reusing building components. However, to maximize the sustainability benefits, the reuse of entire buildings

should be prioritized, followed by reusing individual building parts and lastly reprocessing materials before considering material recycling (Bertino et al., 2021).

The construction industry in Sweden is a complex sociotechnical system (STS) deeply ingrained in society (Anund Vogel, 2020). It combines economic and cultural mechanisms with technical and institutional aspects, providing critical infrastructural services through numerous organizations and actors. Despite being recognized as path-dependent and resistant to change, recent innovations in environmental performance have emerged within the industry. However, these innovations face challenges in terms of regulation, infrastructure, culture, economy, and social factors, hindering their widespread adoption (Geels, 2005). To understand and address these challenges, the academic examination of sustainability has shifted from focusing on individual artifacts to encompassing entire STSs. The multi-level perspective (MLP) offers a comprehensive framework for studying these systems and their innovations. The MLP consists of three key levels: the meso-level, micro-level, and macro-level. These three levels interact and influence each other, leading to transitions and system innovations. In the context of the Swedish construction sector, adopting the MLP highlights reuse practices as potential niches for innovation. Environmental concerns and increased climate awareness have created a window of opportunity to establish reuse as a norm within the construction industry. By analyzing the existing regime by dividing it into categories such as laws & regulations, market, infrastructure, technology, knowledge, and culture & norms, hereafter referred to as regime categories, this study aims to understand the barriers and enablers for scaling reuse in construction and the role of technical consultants in supporting this effort.

The construction sector faces numerous barriers and enablers when it comes to scaling reuse practices and adopting CE principles (Frändberg & Nyqvist, 2021; Giorgi et al., 2022; Strand Nyhlin & Åfreds, 2022; Wuni, 2022). This study identifies barriers and enablers to scaling reuse in the Swedish construction sector and explores the role of various stakeholders in this effort. The reason for investigating barriers and enablers is to better understand what hinders and what could facilitate the Swedish construction sector to adopt reuse practices and transition toward a CC industry.

Technical consultants, who provide expertise in areas such as building physics, structure, energy, environment, and sustainability, play a vital role in the construction process (Harrigan, 2004). While the role of architects in the circular economic transition of the construction sector has been extensively studied, the role of technical consultants has received less attention (Anund Vogel, 2020). However, their collaboration with other stakeholders, including architects, contractors, and property developers, is crucial to fulfilling the CE vision in building projects. The emergence of new roles, such as reuse consultants and CC platforms, along with other digital reuse advancements, is shaping the industry landscape. Considering e.g., the evolving roles of architects and emerging reuse actors, the question arises: What will future development look like for technical consultants in the CC industry?

To gain insights into the role of technical consultants, this study has been conducted in partnership with the technical consulting company COWI in Gothenburg, Sweden (further explained in 3.1). COWI serves as a representative actor for technical consulting companies within the Swedish construction sector. The company is witnessing a growing interest in CC as the demand for reuse practices from their clients continues to rise. However, they also experience that there is a lack of knowledge on how to approach this issue both within their own organizations and among stakeholders. As part of their general sustainability strategy, COWI has initiated reuse efforts e.g., by providing reuse evaluations to their clients. In these

reuse evaluations, the products possessed by clients are examined to determine their potential for reuse. This evaluation also encompasses identifying products that may need to be purchased and assessing their suitability for reuse. Nevertheless, COWI and its employees aim to further develop and enhance their capabilities in this area.

## 1.2 Aim and Research Questions

The construction industry operates within an established infrastructure, following a linear economic model, and involves numerous stakeholders. Bringing about change in such a well-established system entrenched with long-standing traditional practices poses significant challenges. Transitioning towards reuse and CC requires collective efforts from multiple actors and organizations. Despite this complexity, there is a noticeable increase in interest regarding reuse and CC within various organizations and companies. Therefore, this thesis aims to (1) increase the understanding of how the circular economic transition of the construction sector in Sweden can be facilitated, (2) what role technical consultants play in this transition, and (3) how they might contribute to the scaling of reuse practices in the construction sector. To answer the thesis aim, the following research questions were developed and addressed during the project:

1. What are the barriers and enablers to scaling reuse in the construction sector?
2. Which stakeholders do technical consultants impact and engage with in the promotion of reuse?
3. Which regime categories do technical consultants have a greater versus lesser chance to influence the barriers and enablers within?
4. What are the roles of technical consultants in scaling reuse?

## 1.3 Scope and Delimitations

The geographical scope of this study is centred on the Swedish construction sector. The research is conducted in collaboration with the technical consulting company COWI and their operations in Gothenburg, Sweden. Consequently, the findings and conclusions of this study should be interpreted within the context of the Swedish construction sector. Furthermore, the interviews conducted for this study only involve stakeholders from Sweden and especially from Gothenburg and Stockholm, narrowing the geographic focus even further. It is important to note that while COWI is used as a representative actor for technical consulting companies in Sweden, it should be acknowledged that there are variations among different technical companies in the country.

This study focuses on the second circular economy principle, which aims to promote the circulation of materials and products at their highest value, with a particular emphasis on extending their lifespan through reuse strategies. While all circular economy principles are indirectly considered, the main focus lies on the circulation of products within the construction sector through reuse. Within the waste hierarchy (see Figure 2), this study specifically delves

into the reuse part, which encompasses practices such as adaptive reuse, moving and reusing entire buildings, component reuse, and material reprocessing. However, component reuse and material reprocessing are more extensively discussed due to the emphasis on these modes of reuse in the findings from the interview study.

The research specifically targets technical consultants who work with sustainability and environmental aspects of construction, commonly referred to as e.g., environmental consultants or green building consultants. According to Harrigan, 2004, while there may not be a single definition for green building consultants, they do bring valuable expertise in the realm of green buildings, encompassing environmental, economic, and social sustainability. For the sake of simplicity, they are further referred to as just technical consultants in this study. However, it is important to recognize that other types of technical consultants working with e.g., structural engineering or HVAC engineering, are not within the scope of this study, despite their possible significance in scaling reuse within the construction sector. The technical consultants involved in the study, both representatives from COWI and the ones interviewed, were mostly environmental consultants or green building consultants.

Finally, the primary objective of this study is to identify the barriers, enablers, and the role of technical consultants within the Swedish construction sector. This investigation specifically focuses on six regime categories: laws and regulations, market, infrastructure, technology, knowledge, and culture and norms. These categories have been chosen to provide a comprehensive framework for understanding the sector and its dynamics. It is important to note that while these regime categories serve as organizing principles for the study, there are other dimensions within the construction sector that may have an impact on the research findings. These additional dimensions, although beyond the scope of this study, should be acknowledged as potential factors that could influence the results. By delving into these six regime categories and examining the role of technical consultants, this research aims to shed light on the factors that either hinder or facilitate the scaling of reuse practices in the construction sector.

It should also be clarified that the frequency of a certain barrier or enabler mentioned by the interviewees, which is presented in the results chapter, does not necessarily correlate with the importance of the barrier or enabler. Moreover, some barriers and enablers are mirroring each other. For example, there are barriers that are simply the absence of a certain enabler. Furthermore, some enablers are more general about advancing reuse while others are solutions to certain barriers. In this study, both sorts of enablers are included, the more general enablers and the more specific ones suggesting solutions to certain barriers.

# 2. Theory

This chapter delves into the theoretical framework that supports the study. It begins by providing a brief overview of CE and its specific application within the construction sector (2.1). Afterward, the concept of reuse within the context of CE and the construction sector is explained (2.2). Further, an exploration of the MLP employed to analyze the transition of the construction sector toward CE is presented (2.3). Additionally, this chapter examines previous research on the barriers and enablers to scaling reuse (2.4), as well as the role of technical consultants in this process (2.5).

## 2.1 Circular Economy

In the current linear economic model, resources are extracted from the Earth, transformed into products, and ultimately discarded as waste. However, the CE offers a different approach by focusing on preventing the generation of waste altogether. The concept of the CE presents a systemic solution framework aimed at addressing critical global challenges such as climate change, biodiversity loss, waste, and pollution (Ellen MacArthur Foundation, n.d.-b). A key foundation of the CE is the transition to renewable sources of energy and materials. By decoupling economic activity from the consumption of finite resources, the CE promotes a resilient system that benefits businesses, individuals, and the environment simultaneously. At its core, the CE is guided by three fundamental design-driven principles:

- Elimination of pollution and waste by rethinking production and consumption patterns.
- Promote the circulation of materials and products at their highest value, extending their lifespan through reuse, recycling, and other strategies.
- Regenerate nature by actively restoring and replenishing ecosystems and resources.

The butterfly diagram (Figure 1), also referred to as the CE system diagram, visually represents the seamless movement of resources within a CE (Ellen MacArthur Foundation, n.d.-a). It highlights two primary cycles: the biological cycle and the technical cycle. The technical cycle focuses on maintaining the circulation of products and materials through practices like reusing, repairing, remanufacturing, and recycling. The biological cycle emphasizes the restoration of nutrients from biodegradable materials back to the Earth to rejuvenate the natural environment.

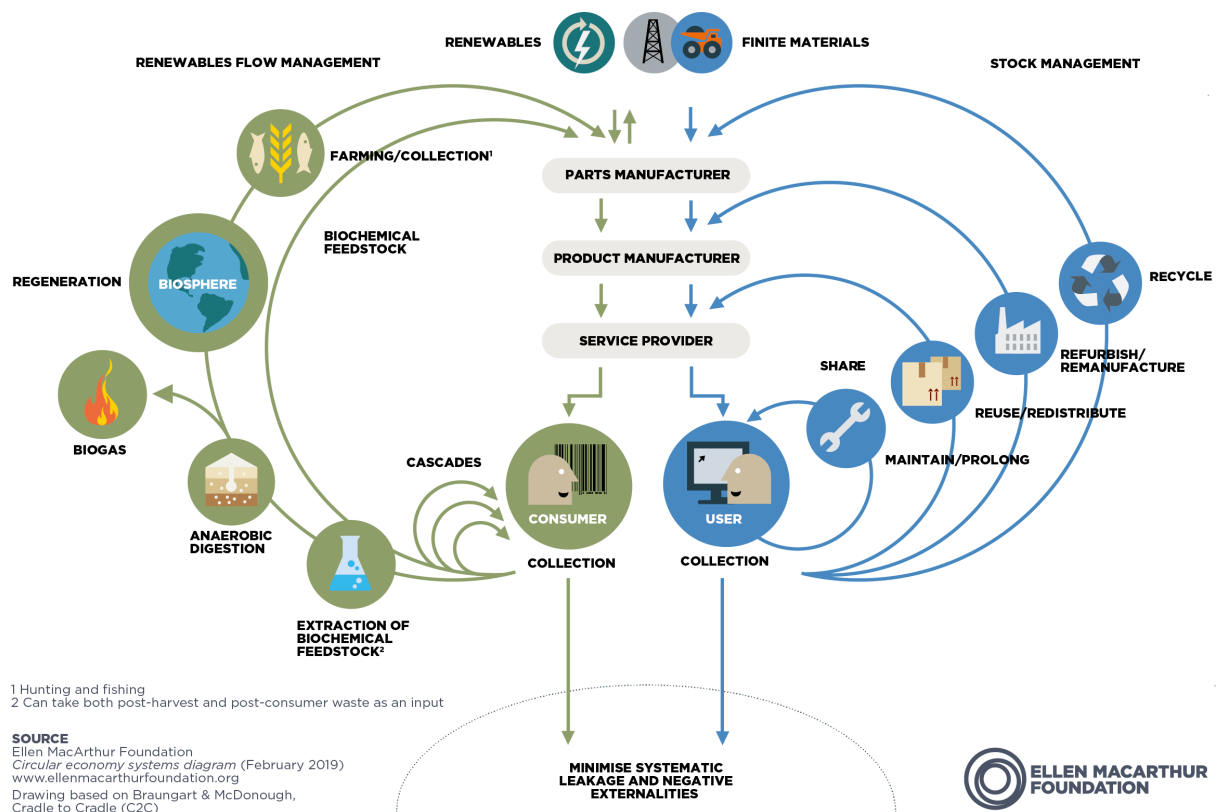


Figure 1: Butterfly diagram of the biological and technical material flows in a CE (Ellen MacArthur Foundation, n.d.-a).

Both the biological and the technical cycles of the CE system are important when considering the built environment. In this thesis, however, the focus is applied to the technical cycle where the principles of the CE are applied to maximize the lifespan and value of materials and products. This is achieved through strategies such as designing for deconstruction, promoting reuse and refurbishment, implementing efficient recycling systems, and utilizing renewable or recycled materials (Acharya et al., 2018). By adopting these practices, the construction sector aims to minimize waste generation, reduce resource consumption, and create a more sustainable and circular approach to building and infrastructure development.

## 2.2 Reuse

In the context of the construction industry, reuse is about reusing construction materials, components, and even entire buildings or structures, instead of using new products made of virgin materials. There are several ways to manage buildings at their end-of-life and concepts such as reuse and recycling are often confused and misunderstood (Rahla et al., 2021). Preparing for reuse is highest in the hierarchy considering waste (see Figure 2) (European Commission, n.d.). The overall top priority is the prevention of waste in the first place which can be done with e.g., maintenance and adaptive reuse (Gorgolewski, 2008), also called building reuse (Densley Tingley et al., 2017). Adaptive reuse implies that a substantial amount of the building or structure is reused on the site, possibly with some alterations and additions.

To be able to reuse building components, deconstruction must be considered as an alternative to demolition (Bertino et al., 2021). There are various possibilities for the use of dismantled

building components including reusing and relocating entire buildings, reusing components in other buildings, and reprocessing and recycling material. The reuse of entire buildings involves moving them from their original location to a new one, either through disassembly and reassembly or by using temporary rails or wheels for long distances. This method is expensive and challenging, and it is typically feasible only if the building has been designed for deconstruction. Furthermore, component reuse involves dismantling building parts during deconstruction and relocating them to be used in new contexts and lifecycles, either within the construction sector or elsewhere. These components, selected during the design phase, can be reused without requalification or reprocessing, although cleaning may be required. However, there are time limits to this process, and eventually, every component will need to be reprocessed or recycled when it is no longer suitable.

Material reprocessing refers to the reuse of building components after deconstruction, but only after reprocessing or refurbishment to adapt them for reuse (Bertino et al., 2021). This process requires additional energy and can result in upcycling (improved characteristics) or downcycling (reduced quality and functionality). Downcycling is more common and involves recycling materials into lower-performance products. Finally, material recycling is the next option in the hierarchy when reuse is not applicable. Material recycling allows building materials, products, and components to re-enter the supply chain and includes recovering useful materials from being disposed of at landfills. It prevents potentially useful materials from being wasted, decreases the use of virgin materials, and thereby energy use and associated greenhouse gas emissions. It also helps avoid environmental impacts caused by raw material extraction, such as water contamination and air pollution.

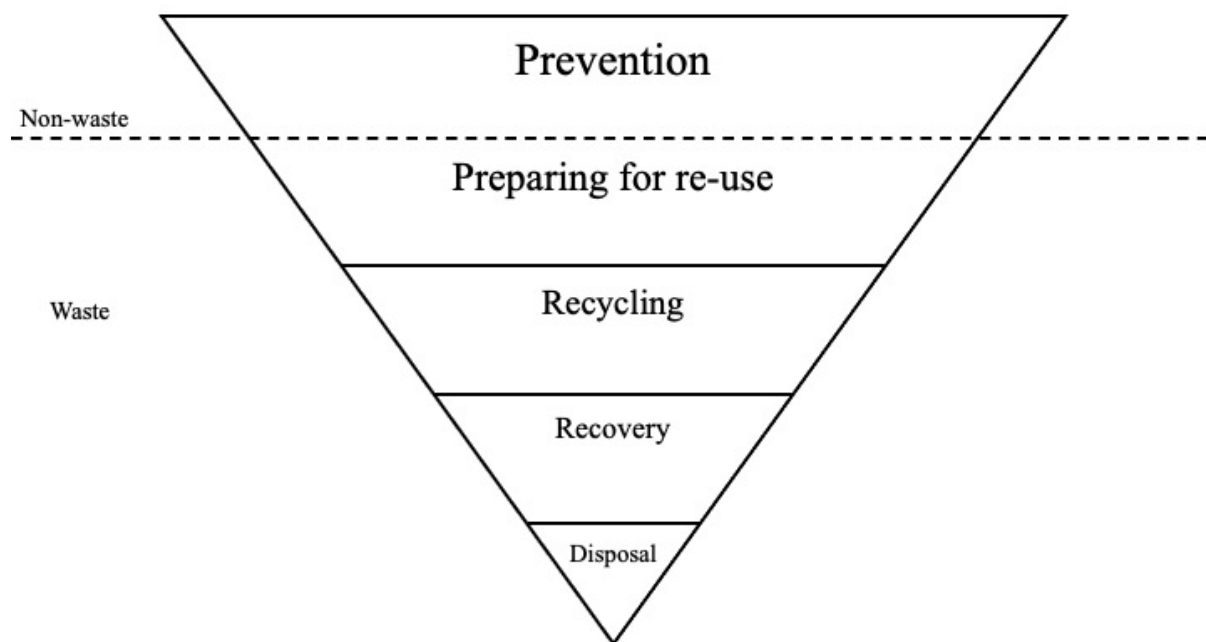


Figure 2: Waste hierarchy adapted from (European Commission, n.d.).

This thesis considers the various approaches to reusing building components, with a particular emphasis on component reuse and material reprocessing. The decision to focus extensively on component reuse and material reprocessing stems from its prominence in both the interviews conducted and the existing literature on scaling reuse. For simplification, the different ways of

reusing building components such as adaptive reuse, relocation of entire buildings, component reuse, and material reprocessing will hereafter all be referred to as reuse. However, it is important to clarify that there is a sustainability hierarchy for these different ways of reusing. To maximize the sustainability benefits, the reuse of entire buildings should be prioritized, followed by reusing individual parts and lastly reprocessing materials before considering material recycling (Bertino et al., 2021).

## 2.3 Multi-Level Perspective

The construction industry is a complex STS deeply established in Swedish society, combining economic and cultural mechanisms with technical and institutional mechanisms (Anund Vogel, 2020). It provides critical infrastructural services, is dependent on many institutional frameworks, and involves a multitude of organizations and actors. Furthermore, the industry is often recognized as path-dependent and change-resistant where existing trends are difficult to change. One reason for this is the long lifespan of buildings in relation to other technical systems. In comparison to many other STSs, this industry lacks centralized decision-making and system management. Different actors (e.g., occupants, contractors, consultants, developers, and municipalities) instead share responsibility for risk-taking and decision-making. This does not mean that there is a lack of regulation in the construction sector. On the contrary, the regulatory system is well-defined and widely used by actors in everything from small to large aspects.

There are promising new innovations in terms of environmental performance emerging in STSs e.g., in the housing, energy, and transport system (Geels, 2005). However, many of these innovations have not been established in a larger sense (yet) due to reasons such as regulative, infrastructural, cultural, economic, and social reasons. Existing systems are stable and difficult to change because they are locked in at multiple dimensions. Consequently, the academic examination of sustainability has shifted its analytical emphasis from individual artifacts to encompassing entire STSs. The MLP provides a comprehensive framework for understanding STSs and system innovations. Based on innovation studies, technology history, sociology of technology, and evolutionary economics, the MLP consists of three key levels: the meso-level, micro-level, and macro-level (see Figure 3).

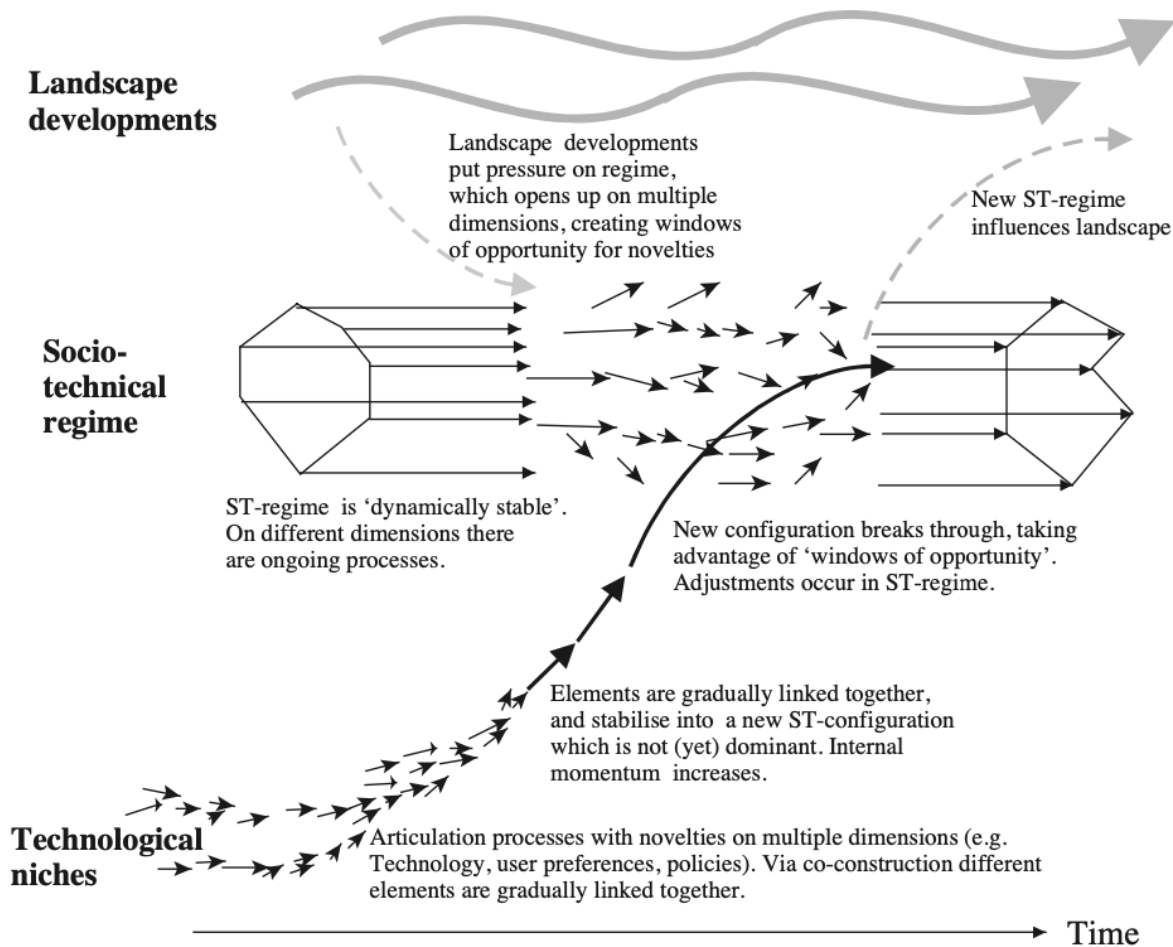


Figure 3: Illustration of a dynamic MLP on system innovation [(Geels, 2005), p. 685]

At the meso-level, ST regimes are examined. These regimes consist of rule sets embedded in e.g., product characteristics, production processes, engineering practices, skills, and procedures, which are all embedded in infrastructures and institutions. ST regimes are created and maintained by various interdependent social groups and account for the stability of STSs. The micro-level focuses on technological niches, which serve as incubation spaces for radical innovations. Niches provide protected environments where low-performance radical novelties can develop and learn. They facilitate learning processes related to production systems, infrastructure, regulation, user preferences, and technology. Niches also support the building of social networks necessary for innovation. Finally, the macro-level encompasses the ST landscape, which includes the broader external factors influencing ST development, such as cultural changes, environmental issues, and globalization. The landscape represents the material aspects of society, including physical infrastructure like cities, highways, and electricity grids. The three levels of regimes, niches, and landscapes interact and influence each other. Niches often address the problems of existing regimes, and actors hope that novelties emerging from niches will eventually be adopted by or replace the current regime. System innovations occur through the interplay of dynamics at multiple levels, leading to transitions. These transitions involve phases of novelty emergence in relation to the existing regime and developing landscape, niche development, breakthrough and diffusion, and eventually the adoption by or replacement of the old regime.

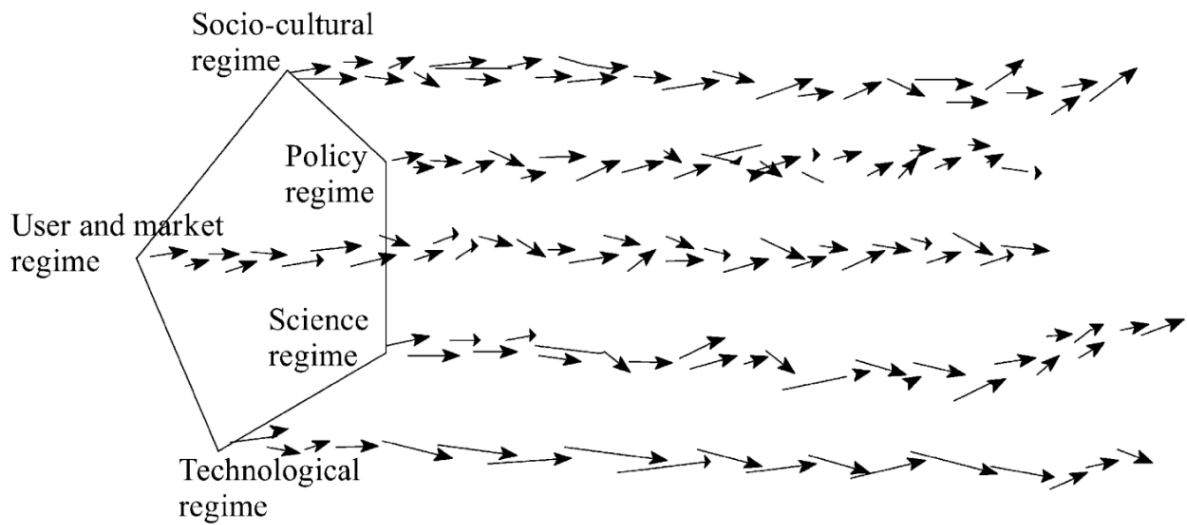


Figure 4: Different dimensions of the regime [(Geels, 2004), p. 912]

Adopting the MLP, CC and particularly reuse practices, could be interpreted as niches at the micro-level. Landscape developments such as environmental issues and increased climate awareness have put pressure on the existing linear economic regime and created a window of opportunity for reuse to be established as ‘business as usual’ in the construction sector. The regime can further be divided into different interdependent dimensions (see Figure 4). In this study, the dimensions ‘laws & regulations’, ‘market’, ‘infrastructure’, ‘technology’, ‘knowledge’, and ‘culture & norms’ are used to better understand the existing regime of the current Swedish construction sector (see Figure 5). These dimensions have been chosen to provide a comprehensive picture of the regime. They are mostly based on the dimensions shown in Figure 4 but have been slightly reformulated and the infrastructure dimension has been added as it is considered relevant for understanding the Swedish construction sector. These dimensions, hereafter referred to as regime categories in this study, are further used to categorize the barriers and enablers for scaling reuse in the construction sector identified in previous studies and from the findings of this study.

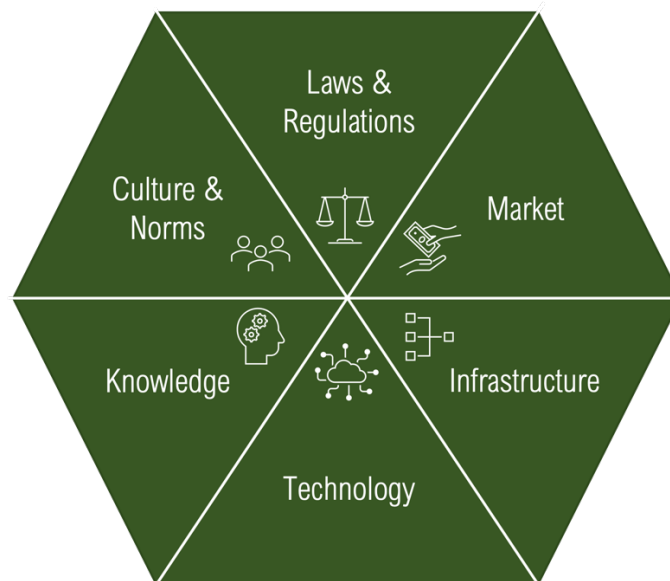


Figure 5: Regime categories applied in this study.

## 2.4 Previous Research on Barriers and Enablers to Scaling CC and Reuse

Previous research on barriers and enablers to scaling reuse in the construction sector and the role of technical consultants in advancing reuse was identified through the literature review described in 3.2. Several studies were identified on barriers and enablers, both to the adoption of CC in general, and to reuse in particular.

Regarding CC more generally, market and cultural issues are major barriers to achieving a circular built environment (Hart et al., 2019). Collaboration with the supply chain and demonstrating a strong business case for circular models are crucial. Additionally, Hart et al (2019) suggest that further research is needed to define the practical implementation of enablers and accelerate CE adoption in the built environment. The lack of a clear definition of circular building design which leads to diverse approaches in projects, was another barrier mentioned (Kanters, 2020). Kanters (2020) further mentions that choosing the right materials is essential, but there is a lack of standardized methods and tools for architects to make informed decisions. Furthermore, early feedback tools are needed to support environmentally conscious design decisions. According to Wuni (2022), higher upfront investment costs, lack of financial support, lack of expertise and knowledge, limited stakeholder awareness, and regulatory gaps, are the most cited barriers to CE adoption in the construction industry (Wuni, 2022). Furthermore, interactions between these barriers can lead to CE failure, emphasizing the need for an integrated strategy to overcome them including targeted interventions and countermeasures to mitigate the key barriers. Moreover, current legislation and policies are inadequate, and there is a need for more participatory decision-making processes (Giorgi et al., 2022). Strategies for the CE are diverse and fragmented among countries, and coordinated actions and policies are required. Improved resource and waste management strategies, design criteria for disassembly and reversibility, harmonization of enabling tools, and evaluation of environmental effects are necessary. Stakeholder involvement, co-creation, stable supply chain relationships, and the use of digital technologies are important for driving circular change in the construction sector.

Regarding reuse more specifically, previous studies highlight the importance of collaboration and involvement of all stakeholders in driving reuse, the need for standardization and necessary infrastructure, as well as support from authorities. Knoth et al (2022) explain how reuse in the Norwegian construction sector is still in its early stages and requires more standardized solutions. More pilot projects and coordinated large-scale reuse are needed to establish the necessary processes and infrastructure (Knoth et al., 2022). They conclude that authorities should support through regulations, R&D funding, and financial incentives. Anastasiades et al (2021) also emphasize standardization as crucial for scaling reuse (Anastasiades et al., 2021). On the one hand, they add that all construction stakeholders should be involved in developing structural standards and standard procedures for reuse. On the other hand, there is inertia in the construction sector, making companies hesitant to start working with reuse (Frändberg & Nyqvist, 2021). Companies need support, and to share information with each other and develop routines to overcome perceived risks and ensure profitability and competition. Furthermore, market-based, operational, and governance factors are key to developing a marketplace for construction and demolition waste (Caldera et al., 2020).

Advanced technologies, known as Industrial 4.0 technologies, can help achieve CE goals in the construction industry (Chen et al., 2022). These technologies provide analytical capabilities,

connectivity, and intelligence, which are useful for addressing the problem of fragmented data among different stakeholders. For example, data collected from Internet of Things (IoT) devices can be used to predict the status and behavior of materials throughout the lifetime of buildings. Blockchain technology has also emerged as a reliable and secure way to track reused materials. Building information modeling (BIM) has been used by demolition contractors and construction designers to accurately develop material passports and verify data. However, these examples are limited, and there is still a lack of knowledge on how to integrate them into a framework to achieve CE targets in construction.

## 2.5 Previous Research on the Role of Technical Consultants in Advancing Reuse

Expert consultants working with construction, referred to as technical consultants in this study, are one of many stakeholders involved in the construction process (Kanters, 2020). Figure 6 provides an overview of the order in which stakeholders are involved in the construction process. Kanters (2020) explains that technical consultants, as well as contractors, are important to collaborate with to ensure that the CE vision is fulfilled in building projects. Technical consultants offer expertise in different areas e.g., regarding building physics, structure, energy, environment, and sustainability to clients such as property developers and contractors.

In this thesis, technical consultants especially those focused on environmental and sustainability aspects of construction are considered. Harrigan (2004) discusses the concept of ‘green building consultants’ and highlights the absence of a single definition for this type of consultant (Harrigan, 2004). Harrigan emphasizes that consultants who possess expertise and skills in the field of green buildings and their sustainable advantages, encompassing social, economic, and environmental aspects can expect to encounter a wide range of opportunities. Technical consultants are in demand due to several factors shaping the business and industry landscape. These factors include e.g., the emergence of innovative technologies and initiatives, increased public and corporate consciousness about current issues, growing time constraints, insufficiently developed skill sets, and limitations in the availability of human resources.

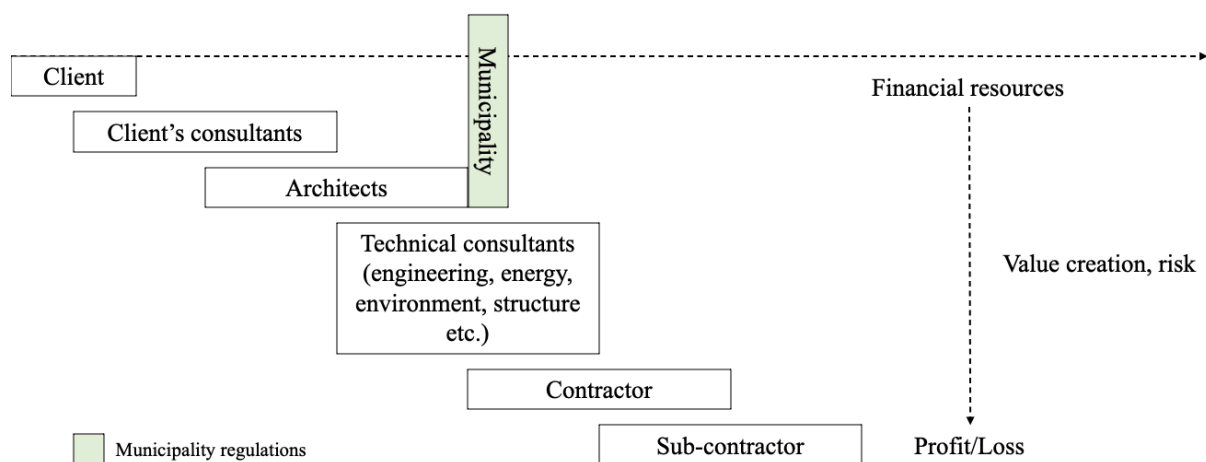


Figure 6: Actors involved in the construction process (adapted from (Kanters, 2020)).

A previous study suggests that the current general conditions of contracts for consulting agreements for architectural and engineering assignments in Sweden (ABK 09), may not provide adequate incentives for choices that align with the long-term goals of society (Anund Vogel et al., 2019). ABK 09 is a standard contract often used in agreements between developers and consultants. Anund Vogel (2020) highlights that Swedish consultants applying ABK 09 are incentivized to incorporate low-risk technologies that are thoroughly tested, and widely adopted to mitigate potential risks for their own benefit. This could hinder consultants from implementing reuse practices that are not as widely adopted as traditional practices. The author emphasizes the dilemma between risks and incentives and encouraging innovation and sustainability. Furthermore, he proposes several points to consider in future revisions of the terms in ABK 09 which aim to balance incentives and risks between consultants and developers such as promoting risk sharing between parties and incorporating building performance and sustainability goals into the contract objectives, and not just focusing on financial risks.

The role of architects in the circular economic transition is addressed in previous research. For example, Kanters (2020) discuss the new role of architects in the CC industry and explains how they e.g., can play a crucial role in offering innovative circular solutions and linking key stakeholders together. However, technical consultants have not been addressed as much in this context. As previously mentioned, Anund Vogel et al., (2019) address technical consultants in relation to contracts saying, *“This paper focuses on an actor that has received limited attention in this context: consultants”*, referring to the context of incentivizing innovation and sustainability to acquire smarter and more sustainable buildings that reach environmental and energy goals (Anund Vogel et al., 2019). Even though interviews with technical consultants have been included, the traditional technical consultant is not addressed as one of the different professions relevant to reuse in the book *Återbruk av byggmaterial* (English translation: Reuse of building materials) (Strand Nyhlin & Åfreds, 2022). Nevertheless, together with the architect, demolition contractor, property developer, and construction contractor, the reuse consultant is addressed, which is a relatively new and demanded profession (Strand Nyhlin & Åfreds, 2022).

With increased investments in CC, new roles have started to take shape such as the previously mentioned reuse consultant, CC arenas, and tech companies offering digital reuse solutions. A reuse consultant carries out reuse inventories which is a documented mapping of hidden assets in a property (Strand Nyhlin & Åfreds, 2022). The reuse consultant assesses the condition of the building components, how they are assembled, and whether they are possible to reuse again. Some reuse consultants focus on building materials, others on installations or interior design. Additionally, reuse consultants can also offer advice on how the customer may proceed with the reuse work and assist with broader consulting assignments. Furthermore, they can help in purchasing reused materials, offer e.g., online training, and mark products that are to be reused. Moreover, the reuse consultant can also be the one in charge of contact with important stakeholders such as the dismantling company throughout the project. Finally, climate calculations and comparing the climate impact of reused material in relation to new material is also included in the role.

The Center for Circular Building (CCBuild) is one example of a common arena for CC. CCBuild was founded in 2017 within the framework of Vinnova’s challenge-driven innovation program and is today operating as a non-profit subsidiary of IVL, the Swedish environmental research institute (CCBuild, n.d., 2020). CCBuild offers services such as an online marketplace of reusable products, digital services such as a product bank and application for reuse inventories, as well as reference projects their partners can be inspired and learn from. Continuing with new actors in the reuse context, Palats is an example of a Swedish property

technology (proptech) company offering digital solutions for inventorying building materials and products to enable efficient reuse and management via smartphones or the web (Palats, n.d.). Considering the studied emerging role of architects and the emerging new reuse actors, the question can be asked what the development will look like for technical consultants. What will their role be in the CC industry?

## 3. Method

In this chapter, the method applied in this thesis is described. The method mainly consisted of an interview study which is described in section 3.4. First, the case study is presented in 3.1 where the company COWI is introduced. The literature review and stakeholder mapping are described in sections 3.2 and 3.3 respectively and provided the foundation for the interview study (3.4). The results from the interview study were evaluated and discussed in a feedback seminar with COWI which is described in section 3.5. Finally, a critical method reflection is provided in section 3.6.

### 3.1 COWI as Case Study

To gain insight into the work of technical consultants, this study has been done in collaboration with COWI in Gothenburg, Sweden. COWI acts as a representative actor for technical consultants in the Swedish construction sector. The company has contributed with supervision, contacts and professional network, organizational insights, and industry understanding. Technical consultants from the group ‘Sustainable Building’ within the section ‘Environmental Modelling and Sustainability Analysis’ have supported the thesis mainly during the stakeholder mapping workshop (described in 3.3) and the feedback seminar where the interview study results were discussed (described in 3.5).

COWI is originally a Danish technical consulting company of roughly 6900 employees, primarily operating in Scandinavia, the UK, North America, and India, offering services within energy, environment, architecture, and engineering (COWI, n.d.-b, n.d.-a). COWI's strategy FUTURE-NOW is focusing on shaping a sustainable and liveable world while meeting customer demands and seizing market opportunities (COWI, n.d.-c). With a strong focus on sustainability, COWI aims to allocate all resources to projects that drive sustainability and exit fossil fuel activities. They prioritize key customers, and long-term perspectives and offer a range of services in water, climate adaptation, environment, transportation, buildings, industry, energy, and urban development. By concentrating on sustainable energy, large infrastructure, large buildings, and climate adaptation and water, COWI aims to be a leader in these market segments. They prioritize their people as a key differentiator, investing in deep technical expertise, a diverse workforce, and training and development. Additionally, COWI actively seeks partnerships and invests in new green technologies and digital solutions to support the green transition. Their workplace culture emphasizes collaboration, well-being, and personal and professional growth, guided by their vision of shaping a sustainable and liveable world.

### 3.2 Literature Review

The purpose of the literature review was to partially address the first research question: "What are the barriers and enablers to scaling reuse in the construction sector?". The literature review aimed to establish a broad understanding of the transition to CC and reuse practices specific to construction. To investigate the barriers and enablers related to scaling reuse in the construction sector, existing studies on the topic were identified and analyzed. Additionally, previous research focusing on the role of technical consultants in promoting reuse and CE in

construction was reviewed. The findings from the literature review served as a foundation for the following interview study.

Given the time constraints of this master's thesis, a scoping review methodology was chosen instead of a full systematic literature review. While systematic reviews require a comprehensive and rigorous approach involving extensive search strategies, selection criteria, and in-depth analysis of selected studies, a scoping review allows for a broader exploration of the literature without the same level of detail and synthesis (Arksey & O'Malley, 2005; Jönköping University, n.d.). This approach was better suited to the timeframe of the thesis. Conducting a scoping review provided a valuable overview of the existing literature and a comprehensive understanding of the topic within the time limitations. The scoping review process followed the steps outlined by (Arksey & O'Malley, 2005) which included defining research questions, identifying relevant studies, selecting appropriate studies, organizing the collected data, and summarizing and presenting the results.

### 3.2.1 Data Gathering

Chalmers Library and Google Scholar were used to access scientific literature. First, studies with a more general focus on barriers and enablers toward CC were identified. Secondly, literature more specifically focused on barriers and enablers toward reuse in the construction sector was gathered. The keywords used were 'barriers', 'challenges', 'enablers', 'drivers', 'circular economy', 'circular construction', 'circular buildings', 'reuse', 'built environment', 'construction', 'construction industry', and 'construction material' in different combinations. Furthermore, the snowballing technique was also implemented to derive more sources from a selected one. The study selection was made based on the year of publication, the place of the study, and how the study was carried out. Only publications from 2019 at the earliest were included to limit the search range and only include up-to-date studies. Mainly studies from Europe and especially Scandinavia were demanded, and literature reviews and interview studies of several different stakeholders were valued. The chosen literature consisted mainly of scientific literature reviews and interview studies on barriers and enablers toward CC and reuse in the construction sector. Furthermore, one master's thesis on barriers to reuse was included. All gathered literature was in English except for the Swedish e-book 'Återbruk av byggmaterial' (English translation: 'Reuse of building materials'). The selected literature on barriers and enablers is presented in Table 1.

Table 1: A literature overview.

Source	Study object	Study region
Circular construction		
Giorgi et al (2022)	Drivers and barriers towards circular economy in the building sector: Stakeholder interviews and analysis of five European countries policies and practices	Europe
Hart et al (2019)	Barriers and drivers in a circular economy: the case of the built environment	Global
Kanters (2020)	Circular Building Design: An Analysis of Barriers and Drivers for a Circular Building Sector	Sweden
Wuni (2022)	Mapping the barriers to circular economy adoption in the construction industry: A systematic review, Pareto analysis, and mitigation strategy map	Global
Reuse		
Anastasiades et al (2021)	Standardisation: An essential enabler for the circular reuse of construction components? A trajectory for a cleaner European construction industry	Europe
Caldera et al (2020)	Enablers and Barriers for Creating a Marketplace for Construction and Demolition Waste: A Systematic Literature Review	Global
Frändberg and Nyqvist (2021)	Challenges for implementing reuse in the construction sector	Sweden
Knoth et al (2022)	Barriers, success factors, and perspectives for the reuse of construction products in Norway	Norway
Strand Nyhlin and Åfreds (2022)	Återbruk av byggmaterial	Scandinavia

### 3.2.2 Data Analysis

To analyze the barriers and enablers found in the literature, an affinity diagram was created in the visual collaboration software Miro (see Figure 7). The barriers and enablers were written down on sticky notes and categorized after the six regime categories (see Appendices B-G). The barriers were placed on the top half of the circles while enablers were placed on the bottom half of the circles. The size of the sticky notes indicates how often the barrier or enabler is mentioned in the literature or how detailed they are. Larger sticky notes represent more generic or frequently mentioned barriers and enablers whereas smaller sticky notes represent more detailed or less mentioned barriers and enablers. This method provided a clear overview of the crucial barriers and enablers related to the different regime categories. The affinity diagram was used during the last part of the interviews as a basis for discussion and to get input regarding the role of technical consultant in relation to the regime categories, further explained in 3.4.



relationships involving mutually interdependent stakeholders and daily operational aspects. While ad-hoc relationships refer to relationships that are targeting more specific matters or means. Finally, indirect relationships refer to relationships that are unspoken or latent and often connected to regulations or laws.

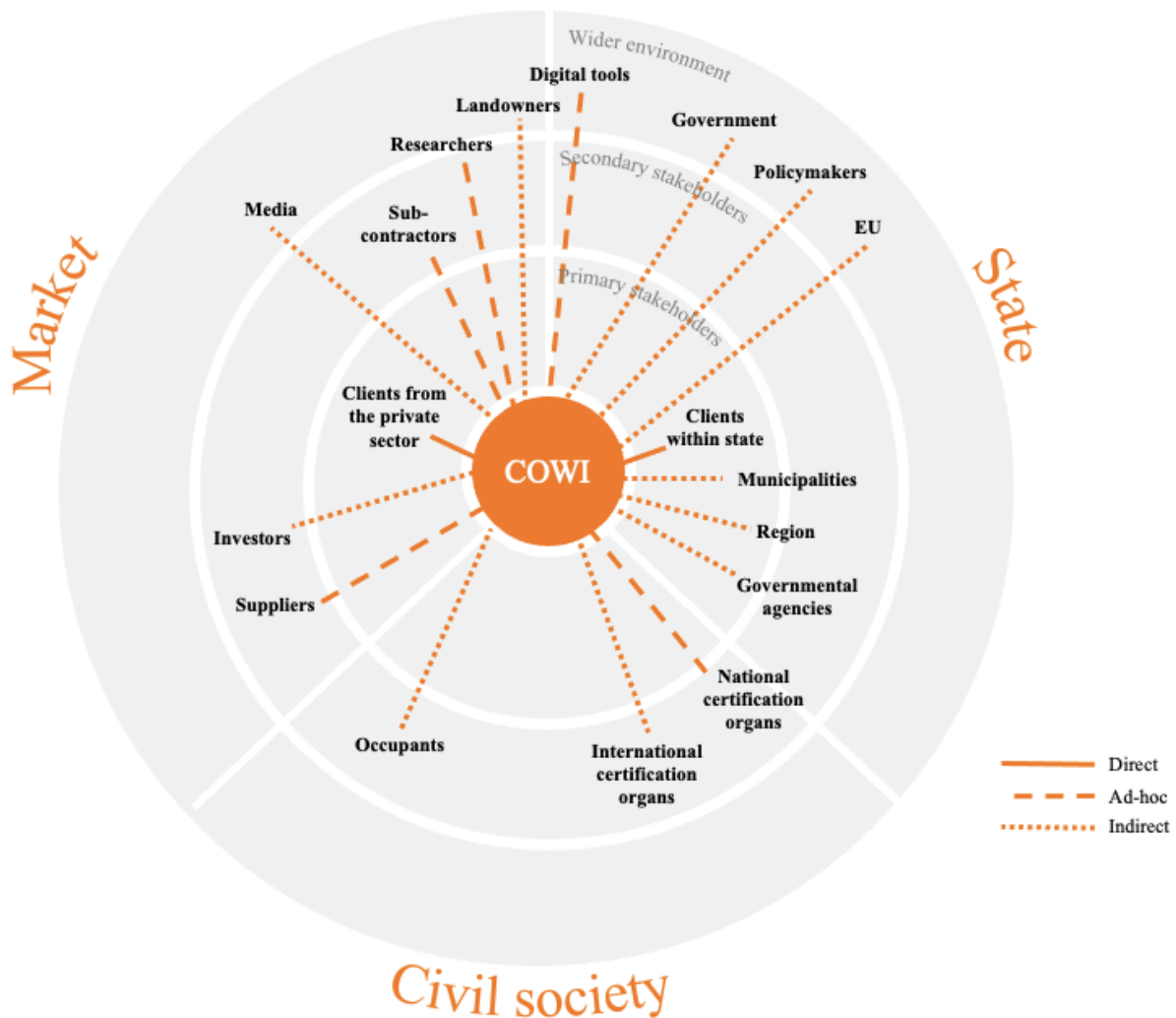


Figure 8: Stakeholder mapping diagram.

### 3.4 Interview Study

An interview study was conducted with the purpose of gathering more perspectives on the barriers and enablers to scaling reuse in the Swedish construction industry, covering the first research question, and the role of technical consultants in this transition, covering the third research question. Various actors from the industry were interviewed and the following subsections describe how the interview data was gathered (3.4.1) and analyzed (3.4.2).

### 3.4.1 Data Gathering

To get a comprehensive picture of the barriers, enablers, and role of technical consultants in scaling reuse, different types of actors from the construction industry were interviewed. The stakeholder mapping with COWI helped with identifying actors who are influenced by and influence technical consultants. The study consisted of 13 interviews and the selected interviewees were representatives from technical consulting companies, real estate companies, an environmental research institute, a proptech company, an architectural firm, and a construction company (see Table 2). Additionally, two industry reporters and authors of a book about reuse in the construction sector were interviewed together (I13). The snowball method was applied where interviewees were asked if they could suggest other suitable interviewees for the studied topic.

The interviews were semi-structured and lasted around 60 minutes. They were held virtually in Swedish and were recorded and transcribed. The interviews were divided into two parts which were dedicated 30 minutes each. The first part consisted of an open discussion about barriers, enablers, and the role of technical consultants in scaling reuse with some guiding questions (found in Appendix A) and the purpose of gathering new perspectives. The second part was more steered where the affinity diagram (see Figure 7) was shown to the interviewees with the purpose of getting input on the barriers and enablers gathered from the literature. During the second part, the interviewees were asked about which of the regime categories of barriers and enablers technical consultants have a greater vs. less chance to influence, and more specifically how they might contribute to the scaling of reuse. Two of the interviewees (I10 and I13) did only participate in the first part of the interview.

*Table 2: List of the interviewees.*

<b>Interviewee</b>	<b>Organization type</b>	<b>Role</b>	<b>Location</b>	<b>Organization size</b>
I1	Environmental research institute	Project leader	Gothenburg	200-500
I2	Technical consulting company	Project manager	Umeå	15000-20000
I3	Technical consulting company	Environmental consultant	Gothenburg	15000-20000
I4	Technical consulting company	Project manager	Stockholm	15000-20000
I5	Technical consulting company	Environmental consultant	Gothenburg	15000-20000
I6	Real estate company	Project manager	Stockholm	200-500
I7	Architectural firm	Sustainability officer	Gothenburg	500-1000
I8	Technical consulting company	Innovation manager	Gothenburg	500-1000
I9	Proptech company	CEO	Gothenburg	<15
I10	Real estate company	Sustainability officer	Gothenburg	200-500
I11	Real estate company	Project leader	Gothenburg	200-500
I12	Construction company	Project manager	Gothenburg	20000-40000
I13	Industry magazines	Industry reporters	Stockholm	<15

### 3.4.2 Data Analysis

The interview data were analyzed with qualitative coding analysis using the software NVIVO. All interview transcripts were imported into the software and given demographic attributes to clarify which perspectives were provided by which actors and types of organizations. An initial review was made of all transcripts where relevant data were coded and broadly grouped into the main groups of 'Barriers', 'Enablers', and 'Role of technical consultants'. Then, a second review was made of the data coded to the main groups, where the data was coded more specifically within the different main groups. This resulted in many unique codes in each of the three main groups. The next step was then a second grouping within the main groups, followed by a third grouping (See example in Figure 9). Within the main group 'Role of technical consultants', the codes were grouped according to data related to which regime categories technical consultants have easier vs. more difficult to influence and more general data regarding the role of technical consultants.

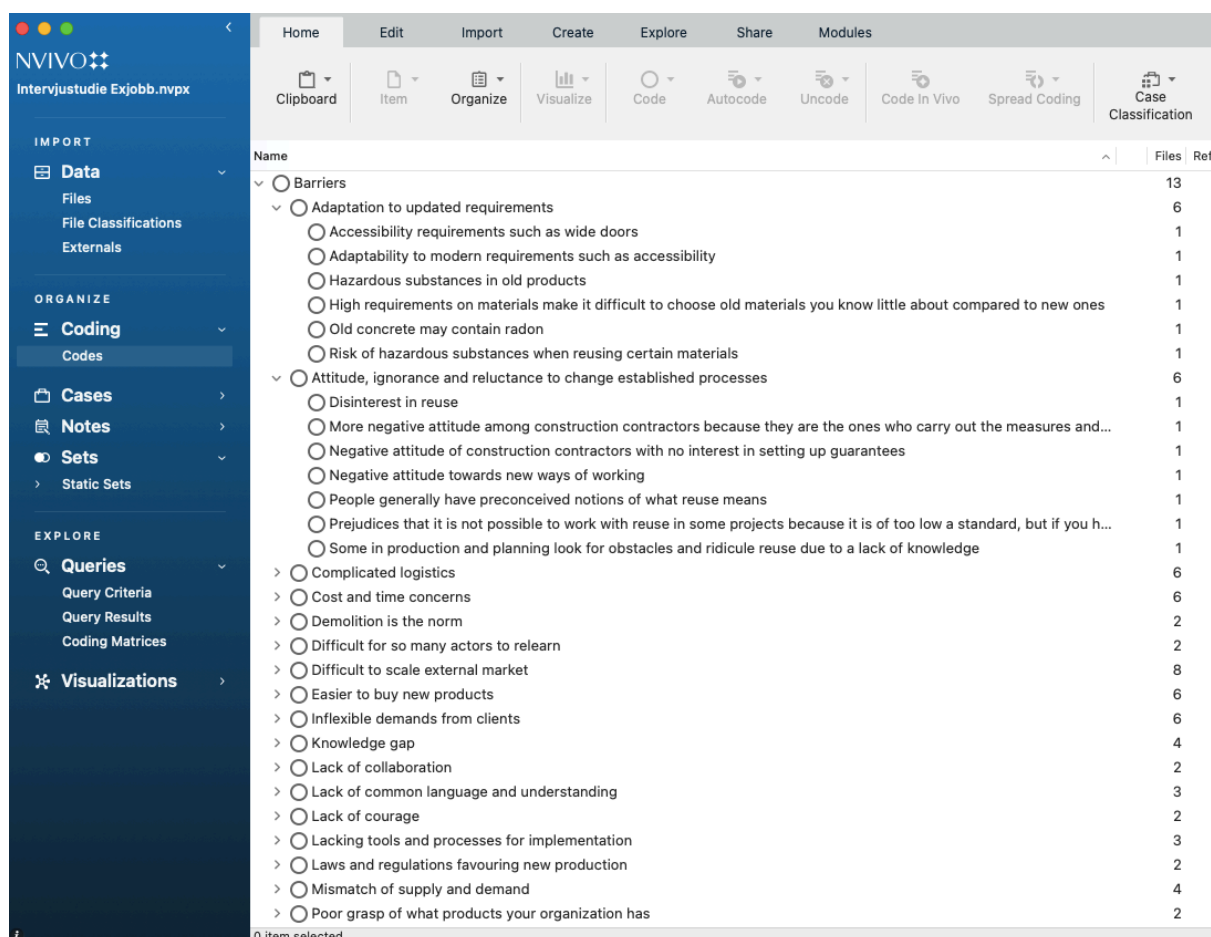


Figure 9: Example of the coding in NVIVO, here showing the third grouping within the main group 'Barriers'.

When all coding and grouping were done, crosstab matrices were created to demonstrate the correlation between the codes, actors, and the type of organizations they represented (see Appendices H and I). The matrices were then exported to Microsoft Excel where they were processed for visual purposes resulting in the diagrams presented in Chapter 4 (see Figures 10-13). Furthermore, quotes from the interviewees emphasizing key points were continuously

marked and saved during the process. Since the interviews were held in Swedish, the quotes used in this thesis have been translated from Swedish to English.

Regarding the grouping of barriers and enablers both in the literature review and the interview study, it is important to emphasize the interconnectedness of the categories of barriers and enablers. This makes it challenging to select the most suitable category for some of the barriers and enablers which could fit in several of the regime categories. For example, the enabler of 'Circular design' could be placed both under 'Technology' and 'Knowledge' because it involves the use of design strategies and technologies to create circular products and systems while it also involves a deep understanding of the principles and concept of circularity. Hence, the grouping of barriers and enablers would look different depending on the individuals organizing them. Still, the reason for grouping barriers and enablers is to break down and simplify a complex STS to grasp and understand it better.

## 3.5 Feedback Seminar

After the interview results were compiled, a seminar was held with COWI. The purpose of the seminar was to present an overview of the interview study results and get input from technical consultants at the company. Eight technical consultants from the group sustainable buildings participated in the seminar. The time dedicated to the seminar was 45 minutes, 15 minutes for the presentation, and 30 minutes for the discussion. After the presentation, the consultants provided input to the results and discussed how some of the challenges to scaling reuse can be handled and how technical consultants can contribute to this purpose. Notes were taken during the discussion and a summary of the seminar discussion can be found in section 4.4.

## 3.6 Method Reflection

Regarding the use of COWI as a case study, the collaboration with COWI provided valuable industry insights and support throughout the thesis. However, it is important to acknowledge the risk of potential biases or limitations that might arise from working closely with one specific company. The thesis strived to maintain objectivity and considered multiple perspectives within the construction sector during the interview study. Still, it is important to remember that COWI has been given more prominence than other consulting firms in this study due to their involvement throughout the entire process.

The decision to use a scoping review methodology instead of a full systematic literature review was made given the time constraints of the thesis. However, it is worth considering the potential impact on the comprehensiveness and rigor of the review. A scoping review may not provide the same level of detail and synthesis as a systematic review and important studies could have been missed. It is important to acknowledge the limitations associated with the chosen methodology.

The interview study provided a valuable opportunity to gather insights from various actors in the Swedish construction sector. The selection of interviewees from different types of organizations helped to capture a diverse range of perspectives. The use of qualitative coding analysis and the NVivo software for data analysis seemed appropriate for the nature of the research. However, it should be noted that only the author of the thesis performed the qualitative coding analysis. To ensure transparency and reliability in the coding process, it is

recommended that multiple researchers independently review and validate the codes. Unfortunately, this was not possible due to time constraints. Nonetheless, a feedback seminar was conducted to enable COWI to validate the findings obtained from the interview study.

The inclusion of the feedback seminar with technical consultants from COWI was a valuable step in the research process. It allowed for a presentation of the interview study results and encouraged discussion and input from industry experts. However, it is important to note that only one company (COWI) participated in the seminar. Although the discussion remained open and impartial, including perspectives from additional companies would have provided a broader range of perspectives and potentially yielded different results.

Another important aspect to highlight is the fact that interviewees representing technical consulting companies were over-represented in this study. The reason for this is the study's emphasis on the role of technical consultants in scaling reuse in the construction sector but it was also important to include other actors in the study as well to gather more perspectives and get a more comprehensive understanding of the system. However, because of the larger share of interviewees from technical consulting companies, their perspectives are over-represented, and it is not possible to draw any conclusions on what the other types of organizations stand for because of the few representatives interviewed from these organizations.

The stakeholder mapping workshop helped identify and categorize stakeholders with whom COWI interacts. The diagram used for mapping relationships between COWI and the stakeholders provided a structured framework. However, it is essential to critically assess the completeness of the identified stakeholders and ensure representation from a wide range of actors, including those with different interests and perspectives. The stakeholder mapping was conducted with two technical consultants from COWI. If more consultants or even more companies had participated in the mapping, a more diverse range of perspectives would have been considered, and better representation could have been ensured.

# 4. Results

In this chapter, the findings of the interview study are presented including the results on barriers (4.1), enablers (4.2), and the role of technical consultants in scaling reuse (4.3). Additionally, a summary of the feedback seminar with COWI is presented (4.4) where the interview study results were discussed and related to their work as technical consultants at COWI.

## 4.1 Barriers

The interviewees highlighted several barriers to scale reuse in the construction sector. These were sorted into more general groups seen in the following diagram (see Figure 10). Furthermore, the groups of barriers were categorized after the six regime categories. First, an overview of the result is presented in the diagram (see Figure 10). Secondly, the barriers are described more deeply based on the regime categories.

### Unique mentions of barriers to scaling reuse



Figure 10: Third grouping of barriers to scale reuse derived from interviews.

## 4.1.1 Laws & Regulations

### **Compliance with Evolving Regulations and Standards**

According to I3, accessibility requirements such as wide doors may limit the availability of reusable materials. I2, I8, and I12 all noted that there is a risk with old products containing hazardous substances, such as radon in old concrete for example. Additionally, I13 pointed out that the high requirements for products in modern construction make it difficult to choose old materials with unknown properties over new ones. Finally, I4 also emphasized the need for adaptability to modern requirements, such as accessibility, which old materials may not meet.

### **Legislation Favoring New Production**

Both I1 and I8 mentioned the barrier of laws and regulations favoring new production. *“Our system is designed with newly produced products in mind, so you must have guarantees, you must have quality assurance in a certain way, and we basically have laws and regulations that are built on the fact that we are supposed to have newly produced products, so it is very difficult to implement reuse”* (I1). Furthermore, I8 added that it has not been obvious how the legislation works in relation to reuse. The waste directive partially addresses reuse, but it has not yet been clearly addressed by Boverket, the Swedish administrative authority for community planning, urban development, construction, and housing.

## 4.1.2 Market

### **Cost and Time Concerns**

The reuse of products can be hindered by uncertainties and risks related to the costs involved and time constraints. According to I2, clients may choose not to reuse certain products due to uncertainty about costs, and new products may be cheaper and more profitable for contractors who receive kickback discounts when buying from the same suppliers. There are also uncertainties about how costs for reuse actions are to be shared between actors and worries about additional time-consuming administrative work (I2). Furthermore, time constraints and financial pressures can discourage reuse, and the linear model used in project finance and planning does not account for reuse (I4 and I8). I4 stated, *“...is there time and financial pressure, then you try to get out of this in the simplest way possible”*.

I1 also brought up the barrier of reuse being time-consuming, requiring creative problem-solving, and increasing costs. *“It is also the reason why I have shifted to talk circular economy and not reuse because I think reuse is too time-consuming and we do not have that time”* (I1). Additionally, storage and maintenance costs for products can be high, and there may be concerns that contractors charge more for working with reused products (I2). However, I9 noted that prejudices against reuse being expensive are not always accurate and that there are cases where significant savings have been achieved.

### **Limited External Market Scalability**

The interviewees representing real estate companies expressed that they primarily reuse products internally within their own organizations. *“Unfortunately, it is very internal (reuse), but we also have many examples when we have done it externally”* (I11). *“It is a bit difficult, and we have to find that*

*balance between what we should keep ourselves and for how long, and when we should sell, to still get the market going” (I10). Meanwhile, several interviewees explained that external reuse between companies is complex and currently limited. A disadvantage with this, I10 added, is that the technical quality of reused products can degrade over time when they are kept in-house. While some interviewees emphasized the need for an increased supply of reusable products on the external market, they also acknowledged the difficulty in getting products sold externally. Moreover, property owners tend to decide which products to reuse internally, and the rest are either recycled or discarded (15).*

I1 mentioned that not many actors post reusable products on digital marketplaces. While all the real estate company interviewees said that they do post products on digital marketplaces, such as Blocket and CCBuild. However, they rarely purchase reused products externally due to difficulties with quality assurance, trust, and logistics issues. I9 suggested that the complexity of logistics and the effort required to connect with sellers may discourage buyers from using digital marketplaces.

### **Supply-Demand Mismatch**

I5, I10, I11, and I13 identified challenges in the availability and accessibility of reusable products. They noted that buyers and sellers often struggle to find each other, despite the potential supply of products. Additionally, there are uncertainties about future supply, and the desired amount and type of product may not exist when needed. *“...it's the fact that we cannot know that the exact product we want, and the quantity of the product, is available when we need it” (I10).* I5 also emphasized that the reuse market is slow, and it is difficult to get things sold. In summary, there seems to be a serious mismatch between the supply and demand.

### **Easier Buying New Products**

Several interviewees mentioned the relatively simple purchases of new products as a barrier to scaling reuse. I1 highlighted the established system that is based on new materials, which can make it challenging to shift towards buying reusable products. I2 emphasized that different company forms can also pose challenges in trading products with each other, making it more suitable to purchase new products. Furthermore, I3 pointed out a lack of information about the quality and quantity of products on digital platforms, which can further hinder the exchange of products. Additionally, I6 explained that having standards for product requirements could reduce uncertainties when buying reusable products. However, it could also make the reuse process more complex which could become another barrier. Finally, I8 noted that greater availability and predictability regarding delivery times and prices for new products make it difficult to switch to reuse.

### **Inflexible Client Demands**

Another market barrier mentioned is inflexible client demands. I2, I3, I6, and I8 identified customer requirements as a significant barrier to scaling reuse in the construction sector. I2 noted that brokers are often more interested in rental fees and therefore agree to everything the client wants to replace. I3 further stated that customer requirements pose a more significant challenge to scaling reuse than legal requirements. I6 and I11 added that some tenants are not interested in reusing products and prioritize new products, which hinders the adoption of circular practices. However, I8 explained that there is an issue with assuming that the customers always want new products because some may be interested and see the value in reuse. Finally,

I11 discussed the lack of knowledge among tenants and explained that some tenants have strange environmental priorities and are very focused on e.g., the availability of waste sorting in their offices while not giving a thought to reusing products.

### 4.1.3 Infrastructure

#### **Complex Logistics**

Several interviewees including I1, I6, I7, I12, and I13, highlighted logistics and storage as significant barriers to scaling reuse in the construction sector. They noted that it can be challenging to coordinate the transportation of materials from one location to another, and a lack of intermediate storage space limits the amount of reuse that can take place. I4 pointed out that transport to and from intermediate storage can be costly, and I9 noted that there is a lack of actors providing surrounding services, such as dismantling, intermediate storage, and reconditioning. Furthermore, while reuse is already happening on a large scale on the furnishing side, I9 emphasized that there is still a lack of surrounding services for building materials.

#### **Quality Assurance and Warranty Challenges**

Several interviewees highlighted concerns around quality assurance and warranties as significant barriers to scaling reuse in the construction sector. Specifically, I4 and I5 expressed conflict and reluctance to provide guarantees when selling products for reuse. I2 also expressed concerns about contractors who do not provide guarantees on work done with reused products, saying, *“Then you arrive at the start of construction, and you have a building document where it says that this and that must be reused and then you have a contractor who says yes, we can do that, but then we will cost this much per hour when we work with reused materials, and we will not provide any guarantees on work done with reused materials.”* Additionally, I8 highlighted the difficulty of guarantees and similar issues when exchanging products between different actors. I13 noted that the quality and guarantees of reused products cannot simply be looked up in a catalog as for new products. Furthermore, I1 pointed out that warranties are often adapted for new goods. On the other hand, I9 suggested that the warranty issue is a matter of attitude and that it is only important for limited product categories. Nonetheless, several interviewees identified warranties as a significant issue, suggesting that it is a barrier that must be addressed if the construction sector is to successfully scale reuse.

### 4.1.4 Technology

#### **Insufficient Tools and Processes for Implementation**

I1 noted a lack of process tools for reuse, which could hinder the efficient implementation of reuse practices. I7 emphasized the importance of considering many details and processes in reusing materials, e.g., how to dismantle a windowsill without breaking it. Additionally, I4 pointed out that although there are digital tools and marketplaces for reuse, their use is currently scattered. These barriers could be addressed through the development of standardized process tools and the creation of more comprehensive and user-friendly digital marketplaces, ultimately facilitating the adoption and scaling of reuse practices in the construction sector.

## **Complex Products**

Some actors mentioned the complexity of certain construction products as a barrier to scaling reuse. I2 and I9 expressed concerns about difficulties regarding wrong dimensions, quality uncertainties, and in reusing certain products such as steel beams, frame material, and plaster. Additionally, I6 noted that frames and concrete, especially cast-in-place, are very difficult to reuse. I3 and I7 highlighted the limited reuse potential of products such as reinforcement, insulation, and ventilation units, as well as the need for careful consideration of processes and calculations when dismantling elements. Moreover, I8 pointed out that some products are more sensitive to reuse even though they are in good condition, e.g., toilet seats. Finally, I7 mentioned that they failed to reuse a certain bicycle rack in a project because it was of the wrong model.

### 4.1.5 Knowledge

#### **Knowledge Gap**

The knowledge gap was another barrier several interviewees highlighted. Although larger companies are aspiring to adopt more circular practices, I2 noted that it can be difficult to reach out to smaller property owners across the country and communicate the importance of reuse. Similarly, I2 also mentioned a lack of time and knowledge in the early stages of the construction process as a challenge. I8 explained that there is a general lack of knowledge on how to work with reuse in the industry. I13 agreed that there is a general lack of knowledge and more specifically they pointed out the lack of knowledge in the municipal permit process. Furthermore, they explained that the influence of traditions within the sector is another barrier. These barriers highlight the need for increased education and outreach efforts, particularly in terms of engaging smaller property owners and municipal stakeholders in the reuse process.

#### **Late Consideration of Reuse in the Construction Process**

I2 emphasized the need for early reuse actions, stressing that once a construction deed is complete, it becomes challenging to do changes such as implementing reuse practices. Similarly, I3 experiences that reuse actions are often considered too late in the construction process when all the products have already been procured. These barriers indicate the importance of early planning and a shift towards prioritizing reusable products in the procurement process.

#### **Lack of Inventory Management, Common Language, and Understanding**

I3 underlined the barrier of not knowing what products your organization has, explaining that a lot of the reuse work depends on individuals knowing what products are available for reuse in their organization. Furthermore, I4 noted that a lack of long-term thinking can limit reuse efforts, with organizations often satisfied with a single reuse instance. Similarly, I5 highlighted the risk of greenwashing, with companies promoting minimal reuse efforts as significant. I8 identified two additional barriers, including a narrow focus on reuse without considering trade-offs, such as meeting modern energy requirements, and a lack of understanding of reuse concepts and the language used to discuss them.

## **Learning Challenges for Multiple Actors**

I8 pointed out that many manufacturers are willing to be part of the circular transition but lack knowledge of how to achieve this and have logistics chains that are not adapted to reuse. Moreover, the industry's fragmentation poses a challenge, and simply writing on a drawing that something should be reused does not guarantee that it will be reused after all handovers to contractors (I8). Additionally, I11 and I8 both noted that relearning is a major challenge, as it is difficult for many actors to adopt new practices and change their mindset regarding reuse.

### **4.1.6 Culture & Norms**

#### **Poor Implementation of Reuse Visions**

As noted by the interviewees, the success of scaling reuse in the construction sector is hindered by several organizational and communication barriers. Specifically, I2 highlighted the lack of communication within companies between decision-makers and those who work practically with reuse. I2 also noted that people with power and money in organizations often make decisions without understanding of the available products. I9 echoed these concerns, emphasizing the need to anchor reuse visions with someone who can carry them out practically. Additionally, I9 noted that decisions made by people with a limited understanding of how to work with reuse can lead to impractical visions. Moreover, I2 highlighted the risk of greenwashing on the developer's side, while I8 acknowledged the possibility of some actors claiming to work with reuse while doing minimal efforts.

#### **Hesitant Attitude and Change-Resistance**

According to I13, attitude is a key factor, as a lack of interest in reuse by actors can hinder progress. I5 and I8 noted a negative attitude toward reuse among construction contractors, who are often held accountable if something goes wrong, which could make them reluctant to embrace reuse. I10 also pointed out a negative attitude towards new ways of working, which could slow down the adoption of reuse practices. Preconceived notions about reuse can also be a barrier, as highlighted by I9, who noted that people may not fully understand what reuse entails. I9 also mentioned prejudices about the quality of reused products, which could be reduced and overcome by conducting reuse inventories. Finally, I4 highlighted individuals in planning and production who are just looking for obstacles and ridiculing reuse, probably due to a lack of knowledge.

#### **Demolition-Centric Norms**

Some interviewees highlighted the demolition norm and a lack of experience in deconstruction as barriers to scaling reuse. Both I1 and I3 noted that demolition is the norm, which implies that buildings are often not designed with reuse in mind, and products are not carefully selected for their reuse potential. Furthermore, I3 noted that contractors are accustomed to demolishing constructions quickly, which could limit their willingness and ability to explore alternatives such as dismantling.

### **Limited Collaboration**

Lack of collaboration is another barrier identified by the interviewees. I5 and I9 both noted the need for greater collaboration among stakeholders to facilitate the transition to reuse practices. However, I9 highlighted that consultants may be reluctant to share their knowledge about reuse because they view it as a competitive advantage. This reluctance could hinder the flow of information necessary for effective collaboration. I5 also noted that there may be a mismatch between the skills required for reuse work and those typically expected of sustainability or environmental consultants, which could contribute to a lack of collaboration and hinder progress toward circularity.

### **Risk Aversion**

According to I1 and I13, actors' lack of courage to explore new methods and take risks is a significant obstacle. Moreover, I13 emphasized that profitability is the primary concern in construction projects, and not everyone is willing to take chances with new approaches to reuse saying, "*Profitability is crucial in construction projects, so not everyone dares to take a chance*" (I13). These barriers may pose a significant challenge to scaling the adoption of reuse in the construction sector.

### **Valuing New Products Over Reused Ones**

According to I4 and I13, one significant barrier is the traditional view that new materials are more valuable than old ones. I4 further emphasized that in the past, reusing products were the norm until old became synonymous with bad. Another barrier to the adoption of reuse identified by I13 is the lock-in of the industry in the linear economy, which is not questioned and thereby inhibits the exploration of new circular approaches. "*We are stuck in a linear economy, which we rarely question*" (I13). These barriers may hinder the widespread adoption of reuse in the construction sector, underscoring the need for strategies to address these challenges.

## 4.2 Enablers

To scale reuse in the construction sector, the interviewees suggested several enablers. These were sorted into more general groups seen in the following diagram (see Figure 11). Furthermore, the groups of enablers were categorized after the six regime categories. First, an overview of the result is provided in the diagram (see Figure 11). Secondly, the enablers are described more deeply based on the regime categories.

### Unique mentions of enablers to scaling reuse

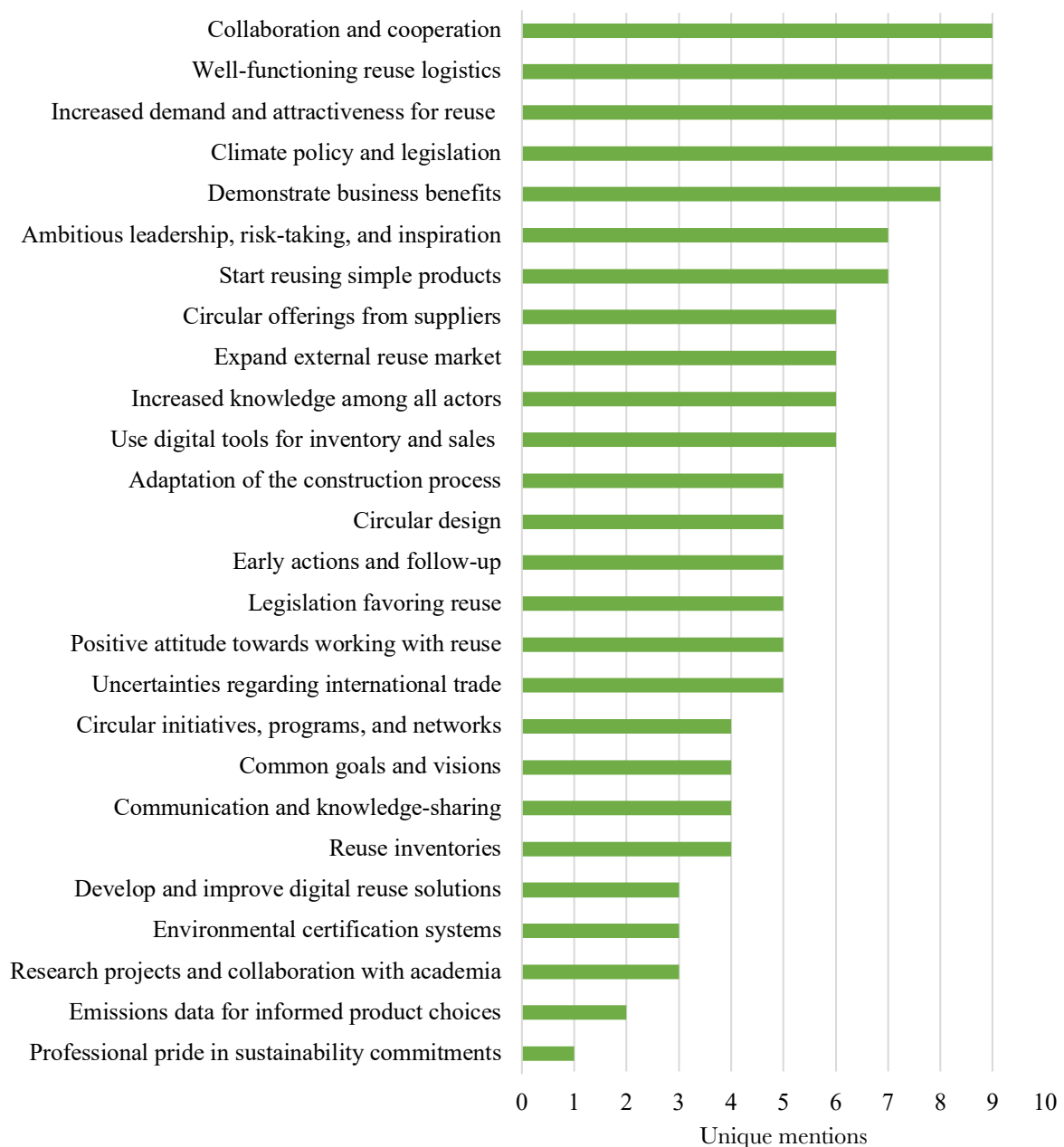


Figure 11: Third grouping of enablers to scale reuse derived from interviews.

## 4.2.1 Laws & Regulations

### **Climate Policy and Legislation**

Several interviewees identified legal requirements and incentives as key enablers for achieving more reuse. I1, I4, and I6 emphasized the importance of legal requirements, such as sustainability reporting and top-down incentives, which can drive companies towards sustainability including reuse actions. *“Everything that comes from the EU is kick ass... ...It does not help from the bottom up, it is not enough. Top-down, forced incentives, that is simply what must be required for this to happen. I am completely convinced of that”* (I1). I3 and I12 noted that climate declarations and meeting EU requirements were significant motivators for reuse, while I5 emphasized that the EU taxonomy is pushing companies towards more sustainable practices including reuse. Meanwhile, I10 highlighted demands from external actors to reduce companies’ climate impacts as another enabler to scale reuse. Finally, I13 emphasized the importance of tightened climate requirements, such as the EU's climate declaration, taxonomy, and green financing.

Financial incentives and policy instruments can be important enablers for scaling reuse in the construction sector. According to I11, companies can introduce financial incentives such as bonuses in their contracts to encourage reuse. Additionally, there is increasing demand from European investors for sustainability requirements in green buildings, which can drive reuse efforts. I6 emphasized the need for policy instruments to push the industry in the right direction, while I5 noted that the EU taxonomy can act as a financial incentive for reuse actions.

### **Environmental Certification Systems**

Standards and environmental certification systems for buildings can play an important role in promoting reuse in the construction sector, according to several interviewees. I5 emphasized the need for more focus on reuse within existing environmental certification systems, while also noting that the EU taxonomy includes requirements for design and preparation for reuse that some certification systems have already integrated. I6 also highlighted the potential of environmental certification systems in promoting reuse. Finally, I4 discussed the EU's assessment system for buildings, which considers how little buildings are rebuilt.

### **Legislation Favoring Reuse**

Legislation favoring reuse was identified as a potential enabler for scaling reuse, according to several interviewees. I7 emphasized the importance of always working with laws and influencing legislation to promote reuse. I2 noted that cultural-historically classified properties can force reuse, while I13 suggested introducing similar legislation for reuse as for the cultural environment, as well as legislation and requirements that make demolition more difficult and require special reasons to demolish buildings. Meanwhile, I3 highlighted the need for more flexible product requirements, as well as standards or minimum requirements for information provided when selling products, to enable reuse. I8 also emphasized the importance of support from legislation and adaptation of standard agreements such as the ABK in favor of reuse. Finally, I13 noted the potential of new waste directives requiring preparation for reuse.

## 4.2.2 Market

### **Demonstrate Business Benefits**

Demonstrating the business benefits of reuse and highlighting the added value it can bring were identified as important enablers for scaling reuse, according to several interviewees. I1 emphasized the need to demonstrate the business benefits of reuse and its relevance in a future market, while I10 and I4 both suggested showing how reuse can lead to reduced costs and delivery times. “...*So that several actors start to see how this benefits them in their own way, and that is what you have to find to motivate everyone, what it is that triggers them to work towards reuse*” (I10). I9 emphasized that reuse done right can bring large environmental and financial savings. I3 also highlighted the potential for smarter renovations that minimize demolition and environmental impact to be cheaper financially for real estate companies. Meanwhile, I13 and I8 both emphasized the value that storytelling and the history of a project can bring as another way to promote reuse.

Some interviews emphasized the benefits of time and cost savings associated with reuse practices. I6, I3, and I4 highlighted the advantages of reusing existing products within a property. I6 noted that reusing products already present in the property can lead to time savings and a faster schedule compared to ordering new products. I3 emphasized that although planning and implementing reuse may require additional time, the time and money saved from not having to purchase new products offset these costs. I4 further emphasized that by reusing products already in place and knowing their cost, both time and money can be saved within the same project. These are crucial benefits as noted by I10 who pointed out that project managers, real estate managers, and tenants have a shared interest in shortening delivery times and move-in times. In summary, the interviews highlighted that time and cost savings are key enablers for scaling reuse in the construction sector. The reuse of existing products can lead to faster project schedules, reduced expenses, and shorter delivery times, aligning with the interests of project managers, real estate managers, and tenants.

### **Increased Demand and Attractiveness for Reuse**

I8 emphasized the importance of increasing demand for reuse, while I11 suggested that growing reuse interest from companies renting their premises is important. Additionally, I5 stressed the need to improve the market reputation of reuse and demonstrate its value and modernity. Similarly, I7 proposed influencing the market to look positively at reuse. Society's increased sustainability awareness and requirements, as noted by I6, and tenants who demand sustainable premises, according to I5 and I10, are further enablers. To make reuse more aesthetically attractive, I11 suggested using appropriate product selection, repair, and communication. Similarly, I6 suggested that achieving the same aesthetical finish with reused products as with new ones is critical in raising the attractiveness of reused products. On the contrary, I13 explained that many people already appreciate older products for their quality. Finally, I5 emphasized that the industry has started to recognize the value of reuse and I2 believes that the current reuse trend is gaining momentum, making reuse even more interesting.

Promoting and showcasing successful examples of reuse can serve as an effective enabler according to the interviewees. I5, I9, I10, and I13 emphasized the importance of highlighting and demonstrating successful reuse practices. I5 suggested the need to highlight good reuse examples, while I9 expressed that working with reuse often brings positive results. I10 further emphasized the importance of showcasing good and stylish examples of reuse to encourage more actors to invest in reuse. Lastly, I13 emphasized the significance of demonstrating

successful parts of test projects involving reuse. In summary, the interviews emphasized that promoting and showcasing successful examples of reuse can inspire and encourage broader adoption of reuse practices within the construction sector.

### **Expand External Reuse Market**

Several interviewees mentioned enablers related to expanding the external reuse market between companies. For instance, I4 highlighted the importance of being able to share and see what is available from other companies. Similarly, I10 suggested buying products from other property owners to contribute to a functioning reuse market. I3 also emphasized the need to match projects between companies to scale the external market. Additionally, I3 suggested selling products to other actors instead of keeping them in-house. I11 had the same opinion and added that there must be a match between the supply and demand of reused products and that keeping products in-house should be avoided. Several interviewees, such as I6, suggested that more actors should post products on digital marketplaces to increase the supply of reused products. Moreover, I10 highlighted that there must be the right amount of reused products available on the market for it to be as easy to reuse as it is to buy new products. Finally, I7 stressed the need for functioning product banks to be available.

### **Circular Offerings from Manufacturers and Wholesalers**

Several interviewees have emphasized the importance of manufacturers and suppliers in promoting reuse in the construction sector. For instance, I7 suggested that suppliers should take back materials to refresh and quality-assure them for reuse. I8 noted that there are manufacturers who update older products to meet new energy requirements and who recall and repair products, such as lighting and suspended ceiling tiles. I12 also noted this trend and highlighted the importance of manufacturers recalling and repairing products. Furthermore, I7 noted that more suppliers need to take back products for reuse. I2 highlighted one example of this with some window manufacturers updating double-glass windows and adding insulating glass to them so they can be reused instead of discarded. I4 added that some lighting manufacturers recall lighting fixtures and refurbish them for reuse. Moreover, I7 stressed that manufacturers must provide documentation for the emissions their products generate, suggesting that this could increase reuse. Finally, I8 noted that as manufacturers are starting to review their circular offerings, it is not impossible for wholesalers to follow in this direction. In this regard, I11 noted that wholesalers have started to recall certain products, such as pallets, which they can resell.

### **Uncertainties Regarding International Trade**

The low cost and predictable availability of new products were identified as barriers to reuse by some interviewees. However, some interviewees viewed these factors the opposite way, identifying increasing costs and unpredictable availability of new products as enablers to scaling reuse. Interviewees highlighted that rising prices and delivery times for new products and limited availability of some exclusive materials make it more profitable and sustainable to reuse existing materials. As I8 pointed out, these factors are likely to increase in the future, further emphasizing the importance of reuse. The uncertainties in the world situation, such as the Covid-19 pandemic and vulnerable international logistics chains, material shortages, changes in the world economy, and rising material prices, were seen as drivers for increasing the adoption of reuse. *“With the pandemic, people became aware of how vulnerable these logistics chains are and how we have become dependent on a constant influx of material from countries that are far away... ..Several*

*things have happened in the world economy since we wrote the book, which I think is an enabler for more use of local materials”* (I13). As I2 noted, the fact that the manufacturing industry has moved abroad adds to the unpredictability and urgency to develop a more sustainable and resilient approach to material supply and use.

### 4.2.3 Infrastructure

#### **Well-Functioning Reuse Logistics**

Enablers regarding effective logistics were mentioned by most of the interviewees. According to I7, finding functional logistics, access to sufficient storage space, and ensuring quality control are required to scale reuse. I2, I4, and I6 also emphasized the importance of access to storage space. I4 further stressed the need for innovative solutions regarding logistics, storage, transport, and sales. I9 highlighted the emergence of ancillary services linked to reuse and suggested that new actors acting as intermediaries must be supported and grow larger to offer a large-scale reuse function that can compete with the experience of buying new products. Similarly, I8 highlighted the necessity of intermediaries to manage storage and logistics, as well as to support tax legislation between projects. I5 and I12 also underscored the value of intermediaries for inventorying, storing, and transporting reused products. Furthermore, I7 agreed that an external party taking responsibility for repair, storage, and quality assurance would be ideal. On the contrary, I3 emphasized the importance of matching demolition projects with new production projects rather than involving intermediary actors to avoid complicated logistics. I9 admitted that it is required to match demolition projects with new construction when frames are to be inventoried and reused. However, intermediaries that are pure logistics firms should still be involved when frames are to be inventoried and reused (I9).

#### **Adaptation of the Construction Process**

Enabling the scaling of reuse in the construction sector requires a less tight schedule and more flexibility in the construction process, according to I3. Architects and designers should produce drawings with the understanding that changes may occur depending on available products during production. Creative problem-solving is also crucial for scaling reuse, as emphasized by I1, I2, and I3. I2 and I3 suggested finding creative ways to reuse materials instead of throwing them away. I3 especially emphasized the importance of thinking outside the box and coming up with creative reuse solutions. Additionally, I13 suggested that many people are curious about reuse, so adapting the construction process to reuse could encourage more people to start reusing. Collaborative projects where risks are spread among the stakeholders and there is more openness are also recommended by I5 saying, *“...and this is a partnering project or a collaboration project, and then it works. Then you spread the risks in a different way. You do it together, you are a little more open, everyone takes the same amount of risk, and it works better...”* when referring to a reuse project she is working with.

### 4.2.4 Technology

#### **Develop and Improve Digital Reuse Solutions**

The development of digital solutions and tools is required to scale reuse in the construction sector according to I6, I9, and I12. I9 highlighted the importance of digital services that show the time required for reuse work and the potential earnings, as well as the development of digital

products that speed up manual processes such as reuse inventory. I12 suggested digital solutions that facilitate the inventory and documentation of all necessary information about products to reuse. Finally, I6 emphasized the need for increased user-friendliness of digital inventory tools and marketplaces to reduce learning time.

### **Use Digital Tools for Inventory and Sales Management**

Several interviewees highlighted the importance of using digital tools and platforms. Specifically, I2 suggested that apps for sharing and exchanging products could be useful, and I3 and I5 spoke about the value of digital inventory tools and marketplaces for raising awareness and making products visible to more actors. I5 also noted that digital marketplaces can make products more visible, while I6 and I11 highlighted the need for more people to post products on these platforms to increase the supply. Finally, I10 suggested that CCBuild's marketplace is used by their organization when they are not buying or selling internally between projects, indicating the potential value of these platforms for external transactions. Overall, the use of digital platforms and marketplaces appears to be a key enabler for the scaling of reuse in the construction sector, according to these interviewees.

### **Circular Design**

The importance of designing buildings and structures for disassembly and flexibility was highlighted by several interviewees. Specifically, I3 emphasized the need for avoiding materials that hinder disassembly and designing buildings in modular systems to facilitate adaptation to different purposes without demolition. Similarly, I4 highlighted the importance of designing buildings and especially frames for disassembly. I6 suggested the use of hollow-core slabs instead of cast-in-place concrete as a means of enabling disassembly. Furthermore, I8 stressed the need to be able to design installations with reused products as well as with new ones. Finally, I10 suggested that flexible product choices, where the function is prioritized over the manufacturer, can facilitate reuse.

### **Reuse Inventories**

According to several interviewees, it is important to conduct thorough inventories to identify products that are available for reuse to scale reuse in the construction sector. I2 and I6 emphasized the importance of conducting inventories before demolition to identify potential reuse opportunities. I2 also suggested offering reuse inventories as an additional service to maintenance inventory. I9 stressed the need to identify the types of products available to have a starting point for reuse efforts. Additionally, I7 noted the importance of conducting environmental inventories to identify hazardous substances that need to be properly managed.

## **4.2.5 Knowledge**

### **Increased Knowledge Among All Actors**

Several interviewees pointed out the importance of increased knowledge among all actors. I8 emphasized the importance of collective knowledge building and providing guides for reusing product categories such as installations to increase reuse knowledge. Similarly, I1 highlighted the positive relationship between increased knowledge and greater reuse motivation. I3 pointed out the need to find actors with the expertise to dismantle buildings, while I7 suggested

increasing knowledge about dismantling processes to promote reuse. I2 highlighted the importance of brokers also having knowledge and a desire to promote reuse. Furthermore, I8 suggested an example of providing reports outlining the state of the art and how to approach the reuse challenge for municipalities and regions. Lastly, I13 emphasized the importance of understanding that reusing components such as foundations and frames, although not the most creative reuse example, can have significant benefits from a climate perspective.

### **Communication and Knowledge-Sharing**

Communication and knowledge-sharing were other important enablers according to some interviewees. I13 highlighted the importance of making use of competence in building maintenance to promote reuse. I5 emphasized the passion and willingness of those working with sustainability to share their knowledge, suggesting that knowledge sharing can be a valuable enabler. Similarly, I2 suggested reaching out to property owners through trade press articles to increase awareness of reuse. I4 suggested spreading knowledge about the greater purpose of reuse and demonstrating the link from planning and design to the annual sustainability report. Finally, I5 emphasized the importance of sharing knowledge with others instead of holding onto it as a market advantage.

### **Research Projects and Collaboration with Academia**

Insights from the interviews revealed that collaboration between academia, research, and industry is a crucial enabler. I7 and I1 both emphasized the importance of seeking research and development grants and collaborating with academia to develop new approaches for scaling reuse. Additionally, I9 suggested applying for funded research projects dealing with reuse as a potential enabler.

### **Circular Initiatives, Programs, and Networks**

I11, I8, I9, and I7 suggested that connecting to various networks and initiatives can effectively promote reuse in the construction sector. I11 specifically mentioned the effectiveness of circular initiatives such as Handslaget, which has been signed by many developers in Gothenburg. I8 stressed the importance of networks and projects such as Återbruk Väst, CCBuild, and Recirculate to encourage the industry to take small but simultaneous steps in the right direction. I9 suggested networks that connect real estate companies with actors who offer reuse services such as intermediate storage. Furthermore, I7 proposed participation in reuse competitions between companies.

### **Emissions for Informed Product Choices**

I6 and I7 suggested that increasing customer awareness about the climate impact of different product alternatives and comparing products monetarily and in terms of emissions are enablers to scaling reuse in the construction sector. By showing the environmental benefits of reusing products, customers can become more conscious of their choices and contribute to creating demand for sustainable construction practices. This aligns with the larger goal of reducing carbon emissions and mitigating climate change. Thus, increased awareness and consideration of environmental impacts can be key enablers in driving the adoption of reuse practices in the construction sector to encourage reuse.

## 4.2.6 Culture & Norms

### **Ambitious Leadership, Risk-Taking, and Inspiration**

Other enablers discussed were ambitious leadership and inspiration for reuse, increased ambition from developers for reuse, risk-taking, and learning by doing. I9 highlighted that companies must have the courage to test and work with reuse. Additionally, I11 noted that actors must act and learn by doing, not only focusing on research. Furthermore, companies that use science-based targets and other ambitious climate targets can drive progress toward reuse according to I8.

According to I7, property developers must decide how to handle reuse challenges internally when starting a project. Furthermore, I5 suggested that reuse requirements must come from the developer who must be willing to pay for them. Additionally, developers must have goals for reuse and environmental requirements (I2) and have the courage to ask for reuse and manage temporal and financial risks (I8). Finally, many real estate companies have set goals to become climate neutral earlier than the national goals (I3), and there are tone-setting actors who are leading the way and whom others will have to catch up with sooner or later according to I8.

### **Collaboration and Cooperation**

The success of scaling reuse requires cooperation and collaboration among various stakeholders, as suggested by several interviewees. According to I3, a lot of coordination and cooperation are needed, and actors should collaborate and communicate to share products. I7 and I11 emphasized the importance of collaboration during the design phase, with all disciplines working together to find new ways to collaborate on warranties and contracts. Collaboration through the entire value chain, including with suppliers, was suggested by I10 and I11. I2 also stressed the importance of cooperation among all actors. Furthermore, I1 and I13 highlighted the importance of interaction between different professions and intensive cross-border collaboration. It was also suggested that the reuse work cannot be assigned to a single reuse coordinator, as all actors can contribute and have valuable skills (I11). Finally, I4 suggested that there must be an interaction between technical consultants and developers to promote reuse. In summary, working collaboratively across the entire value chain and avoiding working in silos are essential enablers for scaling up reuse in the construction sector, and cooperation among all actors is crucial for success.

### **Common Goals and Visions**

Several interviewees highlighted the importance of setting clear goals and ambitions for reuse within organizations. I11 suggested anchoring common reuse goals and ambitions within the organization is essential. Similarly, I2 emphasized the need to bring reuse into company visions and annual reports. It was also noted by I12 that clear goals are important for scaling up reuse in the construction sector. Internal support from the organization in changing the way of working was also deemed crucial by I4. Finally, I2 pointed out that the corporate norm must be to reuse a certain percentage because new products are often cheaper than the costs of reuse. In summary, setting clear goals and integrating reuse into organizational visions and reports, along with internal support and a shift in corporate norms, are essential enablers for scaling up reuse in the construction sector.

## **Early Actions and Follow-Up**

According to several interviewees, early collaboration and planning among the actors involved are crucial to scaling reuse in the construction sector. I2 emphasized that actors must meet early in the process to conduct risk assessments, environmental and reuse inventories, and ensure that reuse is implemented throughout the project. I3 suggested that early meetings should focus on determining which product groups can be replaced by reused products. I11 added that addressing reuse in the design stage is important to avoid difficulties during production.

Architects and developers can also play a key role in enabling reuse in construction projects. I2 highlighted the importance of involving architects early in the process and for them to ensure that reuse is considered throughout the project. I5 suggested that construction contractors also should be involved early in the process to better understand what will happen and ensure that reuse is addressed. Furthermore, I9 noted that many actors are already experimenting with reuse in the early stages of projects, indicating a growing interest in sustainable and circular practices in the construction sector. Finally, I3 emphasized that a focus on reuse earlier in the process can lead to more effective and efficient reuse of products. In summary, addressing reuse early in construction projects is crucial to achieving sustainable and circular practices in the sector.

## **Positive Attitude Towards Working with Reuse**

Enabling reuse in the construction sector requires a shift in perspective and a positive attitude toward new ways of working. The interviewees highlighted the importance of committed individuals in companies and the need to influence culture and norms to promote reuse. I8 and I10 emphasized that a positive attitude from construction contractors towards warranties and new ways of working can greatly facilitate the implementation of reuse practices. I13 suggested that changing perspectives and reframing difficulties as opportunities are important for promoting reuse. Finally, I8 emphasized the need to stop seeing barriers and instead start working with reuse and continue learning more along the way. In summary, promoting reuse in the construction sector requires a shift in perspective and culture, as well as committed individuals who have a positive attitude towards new ways of working.

## **Professional Pride in Sustainability Commitments**

According to I13, promoting reuse in the construction sector can have positive impacts on employee motivation and professional pride. I13 suggested that the excitement and sense of pride that comes from working together on reuse as a sustainability effort can make the employer more attractive and contribute to a positive work environment. This highlights the potential for reuse to contribute not only to environmental sustainability but also to social sustainability in the workplace.

## **Start Reusing Simple Products**

According to several interviewees, some products are easier to reuse than others including bricks, suspended ceiling tiles, windows, doors, glass sections, toilet seats, and sinks. I5 and I8 suggested starting with the 'low-hanging fruit' and the products that are easy to understand, such as cable ladders, when implementing reuse practices. I7 suggested reusing products that can be left outside and do not require a room for storage. I11 highlighted the abundance of practically easy products to reuse. In summary, the interviews suggest that there are many

products that are relatively easy to reuse, e.g., bricks and interior doors, and they advise starting to reuse simple products and those that can be left outside without the need for storage space.

## 4.3 The Role of Technical Consultants in Scaling Reuse

This section presents the interview study's results regarding the role of technical consultants in scaling reuse. First, the interviewees' general perspectives are summarized in the sub-sections about the various roles of technical consultants according to the interviewees (4.3.1), leveraging collaboration and the expertise of technical consultants to scale reuse (4.3.2), and the uncertainties about the role of technical consultants (4.3.3). The data for this result was gathered during the first part of the interviews. Secondly, the interviewee's perspectives on the role of technical consultants linked to the regime categories are summarized (4.3.4). This data was gathered during the second part of the interviews.

### 4.3.1 Various Roles of Technical Consultants According to the Interviewees

Most of the interviewees agreed that technical consultants can play various essential roles in the scaling of reuse. One environmental consultant (I5) said that technical consultants working with environmental coordination may take on a larger role regarding reuse in the future. Furthermore, I10 explained that technical consultants play a vital role, at least for them as a real estate company since they are a large organization and do not have time to handle all the reuse work themselves. Another point was that if the interest in reuse continues to increase, there will be room for both large and small reuse consultancies, according to the industry reporters (I13). They further explained that larger consulting companies can benefit from different types of in-house competence. Finally, another technical consultant, I3, believed that technical consultants have quite a few roles to play in this transition.

I9 highlights the essential educative role of technical consultants in the transition toward a CC sector. Technical consultants can act as advisors and educators, guiding individuals with limited knowledge during the changeover process and implementation. They can support other actors by teaching clients how to work in the processes and effectively utilize their expertise to perform reuse inventories. The educative role of technical consultants is crucial for promoting reuse practices in the sector. In conclusion, their expertise is vital in educating, advising, and supporting the implementation of reuse practices in the construction sector.

According to several interviewees, technical consultants can provide support, share knowledge, and offer guidance to various actors such as real estate companies, demolition contractors, and municipalities. I6 from one of the real estate companies explained that technical consultants can provide support to real estate companies and help spread knowledge to their project teams. Furthermore, they can also offer support to other actors by lecturing, sharing knowledge, and providing information on reuse. According to I7 from the architectural firm, technical consultants can assist demolition contractors by offering knowledge about environmental inventories and other areas. In addition, they can provide knowledge on working methods and structures to support the implementation of reuse practices. Technical consultants can also contribute to the knowledge base by producing guides and reports on reuse practices according

to I8. Finally, their competence and special knowledge of reuse can be crucial in getting the job done, and they could play a huge role in supporting other actors with knowledge of the reuse process.

Many of the interviewees expressed that technical consultants could support their efforts to scale reuse, although their role in promoting reuse may vary depending on the project and context. I12 noted that both in-house and external technical consultants can support their work as a construction company toward reuse. However, I6 from one of the real estate companies, explained that they do not hire consultants as frequently in projects regarding existing properties as they do in projects concerning the production of new buildings.

One significant advantage of working with consultants, according to the industry reporters (I13) and I7 from the architectural firm, is their ability to learn from different projects, gain broad insights, and stay updated on the market's latest developments. According to them, consultants' experience from working on numerous projects is highly valuable, and it enables them to bring that knowledge to the next project, continually improving the reuse practices. The more projects they work on, the more experience they accumulate, creating a vast source of knowledge and examples that can be applied to future projects.

Another important role of consultants is to recommend new reusable products and suppliers with specific solutions to support reuse practices, according to I6 from one of the real estate companies. This was also brought up by I8 from one of the technical consulting companies saying, *"We can support by finding the appropriate products and the appropriate materials"*. In addition, I8 explains that wholesalers are interesting actors because contractors often buy their materials from them, and it will be interesting to see how they keep up with the reuse trend. Some suppliers are starting to offer more circular solutions but as long wholesalers do not have reused products on their shelves, I8 believes that technical consultants have a role in providing essential support in finding suitable reused products for construction projects.

The interviewees highlighted the importance of consultants' knowledge and expertise in assessing product quality, suitability for reuse, and identifying critical properties, as well as providing support on reducing climate impact and prioritizing materials and products. According to I7, technical consultants can provide knowledge and expertise on product quality. For example, consultants in the HVAC industry and structural engineers possess knowledge of products and whether they can be reused, which can be of great help to architectural firms. I6 agrees that HVAC consultants might possess the necessary expertise to judge the quality of products, which is crucial in determining whether a product can be reused. I11 also highlights the need for consultants working with structural engineering when e.g., reusing a frame. Meanwhile, I4 emphasizes the role of technical consultants in helping to work around the warranty barrier, which is often used as an excuse not to reuse products.

I10 states that technical consultants can provide technical expertise in assessing the aesthetic condition and technical performance of products, determining whether they are suitable for reuse. Furthermore, I6 emphasizes the importance of consultants' knowledge regarding the reuse process, particularly which products have an adverse climate impact and are most critical to reuse. I2 suggests that technical consultants can contribute their expertise in building physics and technology to identify which materials are worth reusing. I3 explains that consultants play a vital role in assessing a product's specifications, requirements, and critical properties to determine whether it is suitable for reuse. Finally, I5 stresses that consultants can support other actors by providing knowledge on how to reduce climate impact and prioritize products.

Some interviewees suggest that technical consultants have an essential role to play in advancing reuse in the construction sector, both by providing expertise and guidance and by ensuring that reuse is incorporated into project goals and practices. I13 emphasizes consultants' ability to highlight reuse as a means of achieving sustainability goals and to demonstrate how it can fulfill their clients' climate goals. I10 highlights their role in setting project goals, while I7 emphasizes the importance of including environmental consultants or someone with environmental expertise in every project. I4 speaks to the practical role of consultants in working with checklists of questions to ask suppliers about reuse and ensuring that quality and environmental systems are in place to enable reuse.

Most of the interviewees mentioned the importance of technical consultants advocating for and promoting reuse among their clients which are often the property developers. For example, I13 notes the increased awareness among consultants and their ability to proactively steer clients toward reuse. I4 stresses the importance of persistence and dialogue with clients to find solutions. I11 emphasizes the value of consultants in understanding their business models as a real estate company and prioritizing reuse. Furthermore, I1 suggests building strong relationships with clients to become advisors on reuse saying, *"You must create good relationships with the client so that the customer comes to you with a challenge, not a solution. Because usually the client comes and says: Now we want you to do this. And then you are usually a bit too late on the ball, but you want to become a consultant in an advisory sense as well"*. I6 highlights the importance of incorporating reuse questions into project processes and following up to ensure they are carried out. Moreover, I8 highlights the essential role consultants can play in raising awareness and promoting reuse among clients. Finally, I5 notes the need to advocate for reuse and come up with proposals, while I9 suggests consultants can lead the way in implementing reuse and setting an example for property owners.

### 4.3.2 Leveraging Collaboration and the Expertise of Technical Consultants

According to some of the interviewees from technical consulting companies, technical consultants can be important partners in promoting reuse in the construction sector, especially when involved early in the construction process and working collaboratively with other actors. I2 emphasizes the need for consultants to come in early, work closely with architects, and identify opportunities for reuse from planning to maintenance. I3 highlights that consultants may not have the same chance as architects to come up with innovative ideas and emphasizes the importance of getting involved as early as possible to ensure that reuse is integrated into the project from the beginning *"The architects are the ones who have a vision. They are the ones who draw something up from the beginning and they get the chance to think outside the box in a way that the technical consultants don't really have the same opportunities for"* (I3). I13 echoes this suggesting that a combination of architects and consultants is required to access the creative potential and be able to determine if the reuse practices are technically possible. Collaboration between consultants, architects, developers, and other stakeholders is crucial to prioritize reuse throughout the construction process.

I1 and I5 highlight the importance of collaboration between consultants and academia in promoting reuse in the construction industry. According to I1, consultants can get involved in research and development, collaborate with academia and investigate reuse opportunities within their own business area *"All consulting companies can get involved in research and development,*

where you can get grants to explore something that you otherwise can't afford to explore" (I1). Additionally, I1 notes that the environmental research institute collaborates with most actors in various projects, including consultants. Moreover, I5 suggests that strengthening collaboration between academia and industry through reference projects, surveys, and research studies can promote more sustainable construction practices. Together, these perspectives suggest that partnerships between consultancies and academia can be a valuable tool for promoting reuse in the construction industry.

According to several interviewees, technical consultants could play a crucial role in carrying out reuse inventories and ensuring the quality of products. I13 pointed out that technical consultants could carry out reuse work that architects often undertake, such as reuse inventories. I10, a representative from a real estate company, emphasized the need for technical consultants to assist in surrounding services like reuse inventories, assessments, storage, and transports. I9 mentioned that technical consultants could help ensure the quality of complex products such as frames, HVAC products, and electronics during reuse inventories. I12 also highlighted the significance of technical consultants in supporting reuse projects by contributing to quality assurance. Technical consultants could assist in informing customers about reuse and carrying out inventories, as stated by I6 and I8. Finally, I10 mentioned that property owners may require technical consultants to find suitable reused products and help with inventory management.

According to some of the interviewees, technical consultants could have a critical role as reuse coordinators and mediators, by facilitating the reuse process and supporting companies in adopting reuse practices. I7 noted that a reuse coordinator should help and inspire others to start thinking about reuse and question certain practices. I9 explained that reuse coordinator is a new role that did not exist when he started working with reuse only a few years ago and added that technical consultants are probably best suited to take on this role and bridge the current gap in reuse implementation. I10 agreed that technical consultants could take on the role of reuse coordinator by assessing what can be preserved, sold, and finding actors who can dismantle, transport, and store materials. In addition, technical consultants could act as mediators between companies, advising them on available materials, as suggested by I3. Additionally, I8 suggested that there could be new roles for technical consultants, such as reuse consultants or coordinators, who could ensure that materials are transported and stored appropriately. Technical consultants could also use their experience from previous projects to support construction contractors who have not worked with reuse before and act as the spider in the web, according to I8. *"That's the typical role for consultants really, you could say. Being in different places, picking up new solutions, and taking them with you to the next (project and client). That's sort of what the whole strength of a consultant really is"* (I8).

Two of the interviewees from different real estate companies mentioned that technical consultants can support them with reuse logistics. I11 noted that technical consultants could contribute to achieving functional, sustainable, and profitable reuse logistics. A similar response was also provided by I10, who added that consultants could assist with the assessment, storage, and transportation of materials for reuse. These perspectives indicate that technical consultants could play a role in scaling reuse by supporting real estate companies with their expertise in the sustainable reuse of products and solutions for efficient reuse logistics.

According to several interviewees, it is evident that all actors, including technical consultants, have an important role to play in scaling reuse in the construction sector. I1 emphasizes the need for increased communication among actors to achieve this goal. I11, representing a real

estate company, believes that support from all actors is essential for success including support from consultants regarding sustainability and reuse logistics. Finally, I13 acknowledges the crucial role of technical consultants in achieving sustainable construction practices, which have not received much attention in the past. Therefore, it is imperative for all actors to collaborate and involve technical consultants to ensure that reuse in the construction sector is scaled up effectively.

### 4.3.3 Uncertainties About the Role of Technical Consultants

Most interviewees believe that consultants play a critical role in scaling reuse, but there are challenges that need to be addressed to ensure effective knowledge sharing, experience building, and active engagement in the reuse process. According to I9, consultants can act as a barrier regarding knowledge dissemination because some are not willing to share their knowledge, which they see as a competitive advantage. Meanwhile, I13 pointed out that consultants can sometimes be passive and only do what the client asks for. However, it is also difficult to imagine which actor will do what when it comes to reuse as it will look different in different companies. The practical knowledge gained through projects can help in understanding the needs. I2 mentioned that consultants might lack experience when it comes to the cost of reusing certain materials, but this can be overcome with time and experience. Finally, I7 adds that environmental consultants do not have all the knowledge and that collaboration with other actors is essential.

### 4.3.4 Categories of Barriers and Enablers and the Influence of Technical Consultants

The categories of barriers and enablers in which technical consultants have a greater versus a less chance to influence differ among the participants. Regarding the categories that technical consultants have a greater chance of influencing (see Figure 12), knowledge was the one mentioned the most (by ten out of eleven interviewees) followed by technology (eight out of eleven) and culture & norms (six out of eleven). On the contrary, regarding the categories that technical consultants have less chance of influencing (see Figure 13), laws & regulations were mentioned the most (by eight out of eleven interviewees) followed by infrastructure and market (four out of eleven each). The results indicate that most of the interviewees see that there are more categories where technical consultants have a greater chance of influencing the barriers and enablers than where they have less chance.

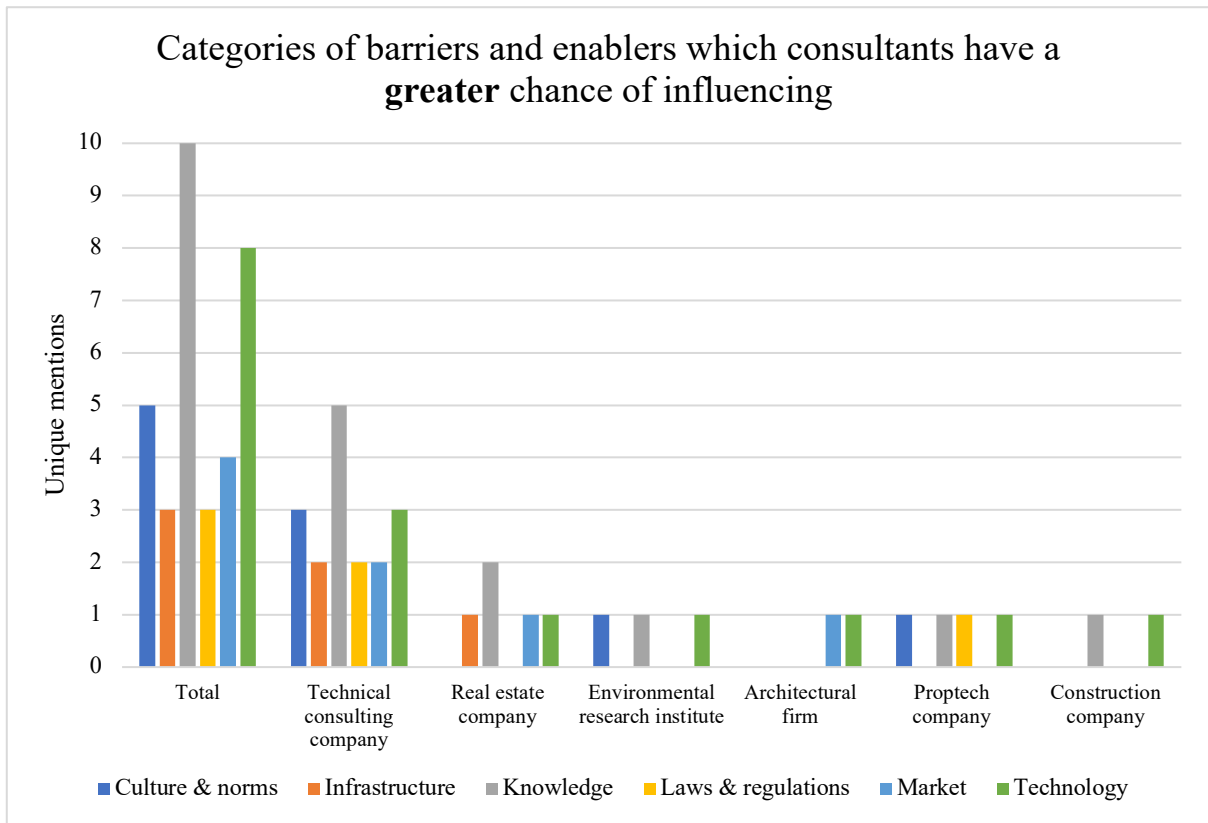


Figure 12: Regime categories in which technical consultants have a greater chance to influence the barriers and enablers.

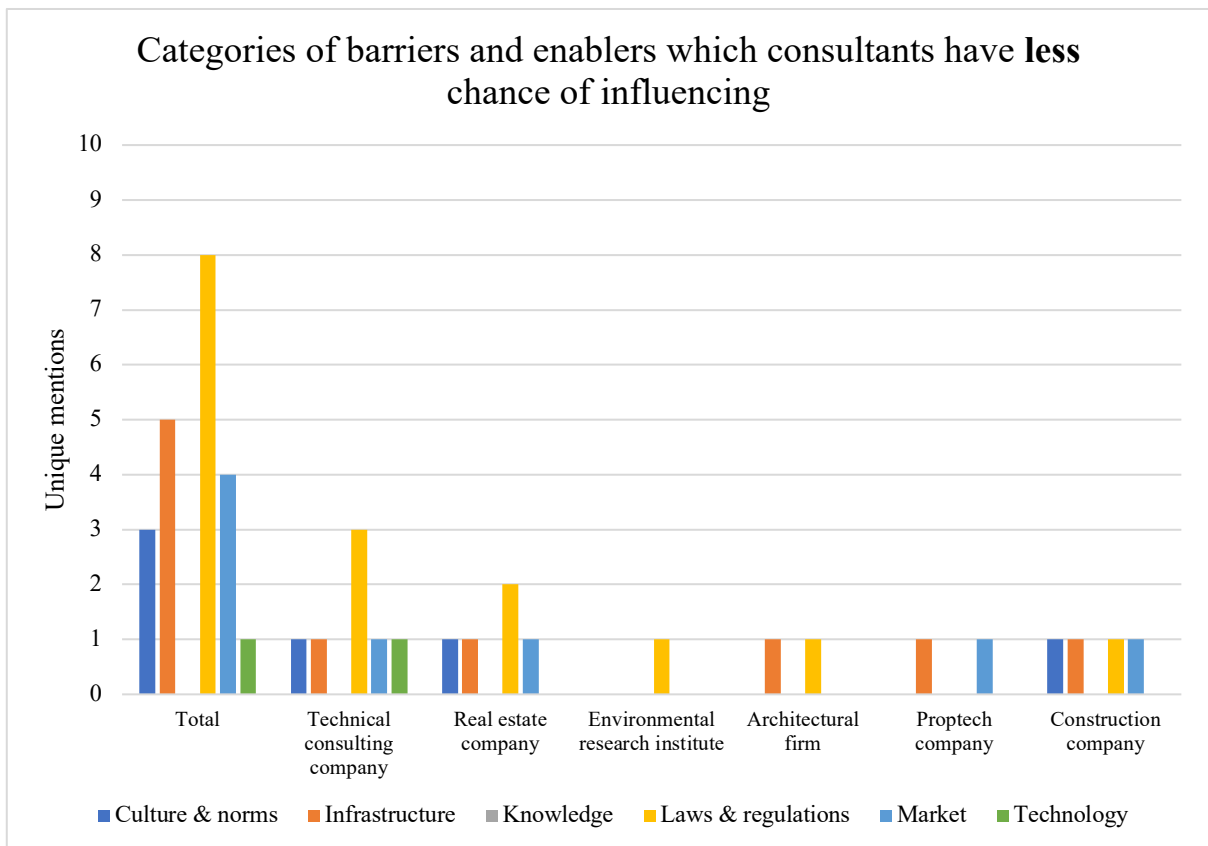


Figure 13: Regime categories in which technical consultants have less chance to influence the barriers and enablers.

## **Laws & Regulations**

Most of the interviewees mentioned laws & regulations as a category that is more difficult for technical consultants to influence. On the other hand, a few mentioned this category as one that technical consultants can and should influence by supporting the enablers and mitigating the barriers in different ways. One interviewee said that this category can even be seen as a business opportunity for the consultants. Several of the interviewees who mentioned laws and regulations as difficult to influence claim that they can be influenced but not as directly as other categories. The representative from the architectural firm, I7, expressed the challenges they face with legislation, but that they are trying to influence laws and regulations through different projects and development tracks. An example of how they do this is by participating in various research and development projects financed by e.g., Mistra and Vinnova.

Another way technical consultants can work with influencing laws and regulations is to act as a referral body, according to I8 and I4 who work in technical consulting companies. I8 explained that this is something they have acted for e.g., the new version of the environmental certification system Miljöbyggnad. I4 further explains that if a law or regulation is to be rewritten, referrals are sent out to actors in the industry to be reviewed where the actors get a chance to have their say and make sure that e.g., reuse is considered. *“There, we have a chance to agree on the content of laws and regulations... ..so I don't see that we stand outside of this in any way”* (I4). However, I4 further explains that he is not sure that referrals are sent out specifically for reuse. On the other hand, he explained that if he were to receive a referral, he would make sure that reuse is included. Finally, the CEO of the proptech company believes that technical consultants have a great opportunity to implement laws and regulations and make a business out of it. He explains that he thinks it is a great business opportunity for them to stay up to date in this area and offer support to other actors in achieving different requirements such as e.g., the EU taxonomy.

## **Market**

Regarding the market category, the answers vary relatively much. Four interviewees believed it is a category in which technical consultants have a greater chance to influence whereas four other interviewees believe it is a more difficult category to influence. The ones believing it is more difficult, explain e.g., that it is difficult for consultants to affect the whole market even though they can work with value communication, branding, and marketing of reuse. The project manager from the construction company, I12, said it might be difficult for technical consultants to overcome the barrier of low material costs of new material because it is money that rules in these situations. Furthermore, the CEO of the proptech company, I9, explained that technical consultants can help steer actors in the right direction, but they cannot directly make any kind of impact *“...they will find it quite difficult to influence the market as well because they are somehow never the owners of the products that will create the market”* (I9).

One of the representatives from a real estate company, I6, explained that technical consultants can influence the market by having direct contact with construction product suppliers and affecting them in terms of reuse. I6 also believed that consultants can help scale the market by ensuring that more products are visible to other actors on marketplaces. They could also act as reuse coordinators, contacting contractors and requesting reused products. Furthermore, I7 suggested that technical consultants can contribute to helping reused products compete with new products on the market by showing the climate impact of different product choices. This can be done with e.g., climate calculations such as life cycle assessments (LCAs). This way

reused and new products can be compared in terms of cost not only monetarily but also in terms of climate impact. One of the technical consultants, I4, also explained that technical consultants can perform LCAs on products to counteract the barrier of low costs for new materials.

## **Infrastructure**

Infrastructure was another category where there was some division among the interviewees. Three interviewees see that technical consultants have a greater chance of influencing this category while five interviewees think they have less chance. One of the project leaders from a real estate company, I11, said that if we define infrastructure as the contact between companies and suppliers, technical consultants can contribute with knowledge and help develop this infrastructure, keep track of material flows, and be in contact with environmental coordinators from other projects. Furthermore, I4 explained that technical consultants can help develop the working method regarding infrastructure which he also mentioned is linked to the market and laws & regulations categories.

One of the interviewees who believe technical consultants have less chance to influence this category said that it is more up to the developers and suppliers to influence the infrastructure. Several interviewees agreed that it can be difficult to influence the infrastructure as technical consultants and that there are other actors who have a greater opportunity to do so. For example, I6 explained that the actors involved in this area are more waste- or demolition contractors. Furthermore, I5, a technical consultant, said, “...it is very difficult for me to influence, I can recommend those that I know exist, but it is not like I can start a new one” in the context of storage and process facilities. Finally, the CEO of the proptech company explained that he does not believe that technical consultants will, want, or should take care of logistics, intermediate storage, etc. He further explained that the skills of consultants are not required here but rather an executor from the recycling or logistics industry.

## **Technology**

Technology was a category most interviewees mentioned as one which technical consultants have a greater chance of influencing. Eight interviewees thought so and only one thought that this category might be more difficult for technical consultants to influence. The innovation manager at one of the technical consulting companies, I8, thought that the technology category is more relevant for manufacturers and therefore explained that this is more difficult for technical consultants to influence. However, he further explained that technical consultants can contribute with knowledge of what is in demand regarding reuse and in that way influence the manufacturers. Among the ones seeing more potential in technical consultants influencing this category, they mentioned e.g., that they can make sure that products can be reused and built-in in a safe way without containing hazardous substances. Furthermore, they can help assess the quality of products, provide alternative solutions for materials, and make demands on the technology to ensure that products such as lighting fixtures are adapted for reuse.

## **Knowledge**

The knowledge category was the one mentioned the most by the interviewees when asked about which category they thought technical consultants have a greater chance of influencing. The only interviewee not mentioning this category as one which technical consultants have a greater

chance of influencing was the sustainability officer from the architectural firm, I7. On the other hand, I7 did not mention it as a category in which they have less chance to influence either. I8 explained that technical consultants can provide knowledge to their clients and help them understand what they need depending on the stage in the construction process. Several interviewees emphasized that technical consultants should work with knowledge dissemination both within their own organizations but also externally with other companies and actors. For example, they can spread knowledge about reuse in the projects they are involved in to raise awareness about reuse and eventually put it on the agenda. Furthermore, I1 stressed the importance of educating yourself, acquiring expertise, spreading knowledge, and helping other actors to be able to influence the knowledge barriers.

Another aspect raised was that technical consultants are in a great position to influence the knowledge category since they have lots of experience from many different projects. When asked if technical consultants can influence the knowledge category, one of the project managers from a real estate company answered, *“Yes, absolutely, because they usually have a lot of knowledge and can contribute to removing the gap around the process itself and maybe they have experience on how to handle and use products from other projects where things have gone well. How to recondition those products so that they are like new products again”* (I6).

### **Culture & Norms**

The opinions on how easily technical consultants can influence culture and norms varied a little among the interviewees. Five of them believed that technical consultants have a greater chance of influencing this category but there were three interviewees who thought it might be more difficult for consultants. Among the ones seeing it as more difficult, I11 explained that it is difficult for anyone to influence culture and norms. Furthermore, I4 said that out of all categories, this might be the most difficult for technical consultants to influence because it is easy to want to adapt to what the group thinks and if arguments against reuse come up, it can be difficult to resist. However, he further explains that it is important to try and break the current reuse-resistant norm and find alternatives.

On the other hand, other interviewees believed that culture and norms can be influenced by technical consultants e.g., by knowledge-sharing with property owners. I6 suggests that technical consultants can influence culture and norms by actively promoting reuse efforts on digital professional networks and showing successful examples. Furthermore, I8 explains that technical consultants can contribute to changing the attitude and culture within their own culture but also help construction contractors and other actors who have not worked with reuse before.

## **4.4 Summary of the Feedback Seminar**

During the seminar with COWI, the results from the interview study were presented and the partitioners provided input and discussed how some of the challenges to scaling reuse can be faced and how technical consultants can contribute. Several aspects were discussed in this regard, including the combination of material and reuse inventory during demolition, the importance of flexible and circular design, implementation of reuse plans, demonstrating the benefits of reuse, formulation of reuse requirements, and the use of digital platforms for product data.

One of the key aspects discussed was the importance of combining material and reuse inventory during demolition. By doing this, it becomes easier to identify and separate materials that can be reused from those that cannot. Technical consultants can play a crucial role in this process by helping to identify reusable materials and ensuring that they are properly stored and transported. Another important aspect that was discussed is the need for flexible and circular design. Technical consultants can work with architects to incorporate ranges for dimensions in plan documents, which can help to adapt to the products available in production. However, this approach may be more expensive, and there may be legal considerations that need to be considered. Additionally, just as circular design is applied to other products, it should also be applied to building materials, making them easier to disassemble and remanufacture.

Implementation of reuse plans is another critical aspect that technical consultants can contribute to. While architects may be involved early in the construction process, their reuse plans are not always implemented. Technical consultants can act as reuse coordinators and work with architects to ensure that their reuse plans are carried out throughout the construction process. Furthermore, demonstrating the benefits of reuse is also crucial. Technical consultants can help to clearly show the emission-related benefits of reuse for customers, and how it can contribute to their sustainability goals, climate declaration, EU taxonomy, green loans, and other initiatives. This can help to create a greater awareness of the importance of reuse and encourage more actors to adopt it.

Formulation of reuse requirements is another important aspect. Technical consultants can help developers formulate requirements for reuse. For example, in one project, at least one product category must be reused, and in the next project, it may be two, and so on. This can help to encourage more reuse in the construction sector and create a more sustainable industry. Finally, digital platforms for product data can be used to evaluate construction products according to their potential for reuse or recycling. Technical consultants can use this data to assess the overall climate impact and circularity of a construction project. This can help to identify how many products can be reused in the future and how well-adapted a project is for future reuse.

In summary, technical consultants can play a vital role in advancing reuse in the construction sector by combining material and reuse inventory, promoting flexible and circular design, implementing reuse plans, demonstrating the benefits of reuse, formulating reuse requirements, and using digital platforms for product data. These are some examples of practices discussed during the seminar that could be adopted to advance reuse and thereby reduce the construction industry's environmental impact and make it more sustainable.

# 5. Discussion

In this chapter, the results of the study are discussed as well as the applied method and suggestions for future research. First, barriers to scaling reuse are discussed (5.1) followed by a discussion about the enablers (5.2). Thereafter, identified roles of technical consultants in scaling reuse are discussed (5.3) and the contributions of the study (5.4). Finally, development areas and suggestions for future research are presented (5.5).

## 5.1 Barriers to Scaling Reuse

The interviewees highlighted a narrower range of barriers in comparison to the broader range of enablers they mentioned. It seemed easier to agree on and define the challenges rather than what can be done to overcome them, which might be why the enablers are relatively scattered or simply that there are many enabling factors to scaling reuse. Nonetheless, the construction sector faces several barriers that need to be addressed to scale reuse.

Considering the perspectives regarding compliance with evolving regulations and standards, careful consideration of the risks and benefits of reusing products in construction is necessary. However, adaptation to modern requirements poses a barrier to scaling reuse. Furthermore, the findings regarding cost and time concerns indicate that financial and time-related considerations, as well as uncertainties about cost-sharing and administrative work, are significant barriers to scale reuse in the construction sector. Given the barrier of limited external market scalability, there appears to be a preference for internal reuse, a mismatch between supply and demand on the external market, and a need for increased trust and simpler logistics to encourage more external reuse. Additionally, to successfully scale reuse in the construction sector, addressing logistical and storage challenges and providing necessary surrounding services seem to be crucial.

Addressing knowledge gaps and developing better outreach and education efforts are important to overcome the knowledge barriers. Further insights from the interview study suggest that addressing knowledge gaps regarding inventory management and promoting a more holistic understanding of reuse within the industry are essential to overcoming barriers to scaling reuse in the construction sector. Additionally, because of the learning challenges for multiple actors, there is a need for further collaboration and education across the industry to enable a successful transition to a more CC sector. The barrier of hesitant attitudes and change resistance in the industry further underscores the importance of education and awareness-raising. It is crucial to address misconceptions and negative attitudes toward reuse through educational efforts. Additionally, fostering collaboration and knowledge-sharing among all actors in the construction sector as well as re-evaluating the skills required for reuse in construction is vital for facilitating a successful transition towards a more circular industry.

The barrier of late consideration of reuse in the construction process indicates the importance of early planning and a shift towards prioritizing reusable products in the procurement process. Regarding the poor implementation of reuse visions, organizational and communication barriers must be addressed to successfully scale reuse in the construction sector. Furthermore, the barrier of demolition-centric norms suggests the need for a shift in mindset towards circularity, with greater consideration given to the potential for reuse and a focus on developing expertise in dismantling techniques that enable more materials to be recovered and repurposed.

Finally, strategies are required to address the challenges of new products being valued over reused ones which could hinder the widespread adoption of reuse in the construction sector.

Most barriers identified in the interviews relate to the ones identified in the literature e.g., quality assurance and warranty challenges, limited external market scalability, and complex logistics. The barrier of lack of common language and understanding of the reuse concept was not only mentioned by the interviewees but also experienced during the interviews. For example, one interviewee mentioned how they had reused concrete in a project. When the interviewee was asked how it was reused, the interviewee explained that it had been crushed to be used as a replacement for aggregate in the production of new concrete. This action would be referred to as material recycling rather than reuse according to the literature about reuse presented in Chapter 2. This example indicates that there are misconceptions about the reuse concept in the industry.

Previous studies have highlighted that both cultural and market challenges pose significant barriers to achieving CC. The findings of this study further reinforce these notions by highlighting specific market and cultural barriers. Market barriers encompass concerns related to costs and time, limited scalability in external markets, imbalances between supply and demand, the ease of purchasing new products rather than reusing existing ones, and inflexible client demands. On the other hand, cultural barriers encompass the inadequate implementation of reuse strategies, a hesitant attitude towards change, resistance to adopting new practices, norms that prioritize demolition-centric approaches, limited collaboration among stakeholders, risk aversion, and a tendency to value new products more highly than reused alternatives. These barriers are recognized in previous studies e.g., in the study by Frändberg & Nyqvist (2021) which e.g., also is emphasizing the inertia in the construction sector which makes companies hesitant to start working with reuse.

## 5.2 Enablers to Scaling Reuse

Compared to the relatively narrow range of barriers, the enablers mentioned by the interviewees were more scattered. There seem to be a lot of things that can be done to advance reuse and there are different opinions on how to meet certain barriers including e.g., the logistics challenges. On the other hand, there are some areas in which everyone agrees e.g., that more collaboration and cooperation is needed and implement reuse actions early in the construction process. Just with the barriers, many of the enablers mentioned during the interviews were recognized in the literature, e.g., collaboration and cooperation, demonstrating the business benefits of reuse, knowledge-sharing, and risk-taking. Collaboration between all actors, demonstrating a strong business case for reuse, knowledge-sharing between companies, and developing routines to overcome risks and ensure profitability is crucial for scaling reuse according to previous studies. This was also emphasized during the interviews.

The findings from the interview study suggest that a combination of policy instruments, incentives, legal requirements, and external pressures can enable the scaling of reuse. Climate policy and legislation can help create a more supportive environment for the implementation of reuse practices. Furthermore, the findings suggest that certification systems can be an important enabler for scaling reuse in the construction sector, both by setting requirements for design and preparation for reuse and by providing a framework for assessing and recognizing sustainable practices including reuse. Considering the enabler of legislation favoring reuse, a combination of legislation, cultural heritage considerations, and standards can enable the

scaling of reuse in the construction sector by creating a legal and cultural framework that favors reuse and makes it a more attractive option.

The results suggest that showcasing the business benefits and added value of reuse, both in terms of environmental sustainability, time savings, and financial savings, can be a key enabler. Furthermore, raising awareness about the environmental benefits of reusing products can empower customers, e.g., property developers, to make more conscious choices and generate demand for sustainable construction practices. This aligns with the broader objective of reducing carbon emissions and addressing climate change. Therefore, fostering increased awareness and emphasizing the environmental impacts can play a crucial role in promoting the adoption of reuse practices within the construction sector.

The insights regarding research projects and collaboration with academia indicate that fostering cooperation between different stakeholders and seeking funding for research and development can facilitate the scaling of reuse in the construction sector. Such initiatives can help to develop innovative solutions, promote knowledge sharing, and accelerate the transition towards a more sustainable construction industry. Additionally, the enabler of circular initiatives, programs, and networks indicates that collaborations, networks, and partnerships can foster a culture of reuse in the construction sector.

The enabler of expanding the external reuse market could facilitate the availability and accessibility of reused materials, thereby promoting the widespread adoption of reuse in the construction sector. Furthermore, ensuring that manufacturers, wholesalers, and other suppliers prioritize circular offerings and take back products for refurbishment and preparation for reuse could facilitate the adoption of reuse in the construction sector. Finally, regarding the enabler of developing and improving digital reuse solutions, the insights underscore the role of technology in scaling reuse. Digital tools and solutions can help streamline manual processes, improve inventory management, and enhance market accessibility.

In relation to previous research on the topic, advanced technologies as enablers to scale reuse were not mentioned much during the interviews. The need for increased use and development of digital solutions and tools for reuse was mentioned by the interviewees, especially regarding reuse inventory and marketplaces. However, this was discussed quite broadly, and no specific enabling technologies were mentioned, such as e.g., IoT devices, BIM, and blockchain technology which were mentioned in the literature. The reason for this can be a lack of awareness and knowledge of these advanced technologies and their potential as enabling factors to CC. Once again, this emphasizes the knowledge barrier and requirement for enhanced knowledge dissemination among stakeholders.

## 5.3 Identified Roles for Technical Consultants in Scaling Reuse

The role of technical consultants in scaling reuse has not been given much attention in previous studies. The findings of this study confirm and align with the claim that technical consultants have not been adequately addressed or considered in previous research on this topic. During the interview study, the industry reporters acknowledged the importance of exploring the role of technical consultants, which they admitted had received less attention from them compared

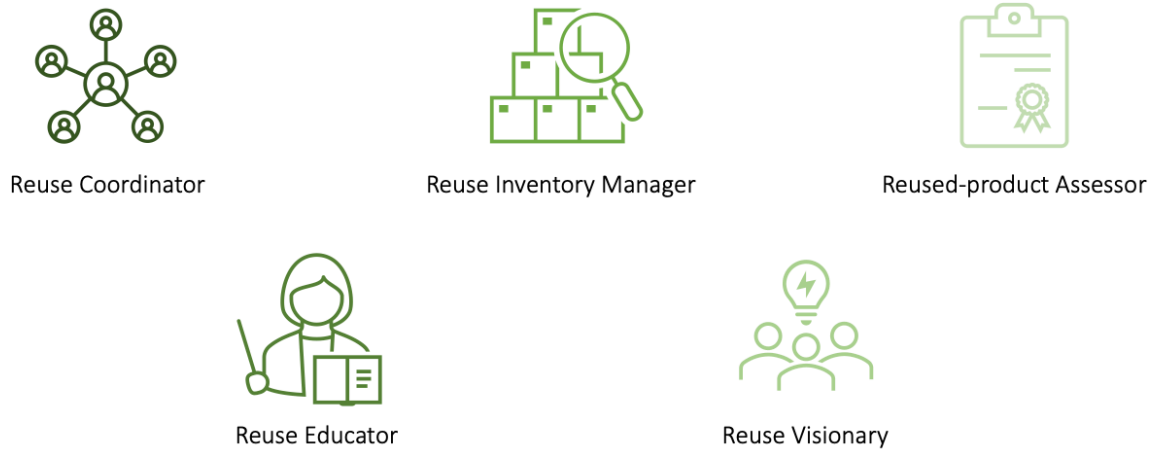
to other actors, making it an intriguing area of study. However, the results from this study indicate that technical consultants play essential roles in scaling reuse and can have a significant impact on promoting reuse in the construction sector. The interviewees suggested many ways in which technical consultants can contribute to the scaling of reuse. On the other hand, some interviewees also mentioned risks with technical consultants and uncertainties about their role.

There are several uncertainties and challenges about the role of technical consultants that must be addressed for effective knowledge sharing, experience building, and active engagement in the reuse process. Briefly repeated, the uncertainty about the role of technical consultants concerns reluctance to share knowledge, passive approach and only doing what the client asks for, different companies handling the reuse issue differently, and lack of reuse experience. These aspects pose challenges to knowledge dissemination and inhibit the potential benefits of collaboration. Furthermore, they suggest the need for technical consultants to take a more proactive role in guiding and advising clients on effective reuse strategies. They also emphasize the importance of gaining practical knowledge through projects to better understand the unique needs of each organization.

The potential barrier of consultants being passive and only doing the bare minimum asked by the clients is in line with the literature on contracts between developers and consultants (ABK09) presented in section 2.5. According to the literature, contracts such as ABK09 encourage consultants to adopt low-risk technologies that have undergone comprehensive testing and are widely accepted, to minimize potential risks for their own benefit. However, this approach may discourage consultants from implementing less commonly adopted reuse practices in comparison to traditional methods. This was also something I5 mentioned as an enabler, recommending that the risks are spread among the stakeholders in construction through collaborative or partnering projects. Furthermore, I8 also emphasized that adaptation of standard agreements such as ABK 09 is required to scale reuse.

The role of consultants in influencing logistics was a topic that resulted in divided opinions among the interviewees. While some see significant potential for technical consultants to contribute and support reuse logistics, others believe that their impact is more limited, with responsibility falling on different actors and industries. For example, one representative from a real estate company emphasized that technical consultants could assist real estate companies in managing reuse logistics, including assessing, storing, and transporting materials, contributing to functional, sustainable, and profitable reuse practices. On the other hand, the interviewee from the proptech company expressed that technical consultants should not be involved in aspects like logistics or intermediate storage. According to the interviewee, these areas require specific skills from specified recycling or logistics companies rather than technical consultants. These varying perspectives highlight the complexity and varied nature of logistics development and underscore the need for collaboration among several stakeholders to address these challenges effectively.

Based on the findings from the interview study, five different roles technical consultants can undertake to support the scaling of reuse and the transition toward a CC industry have been identified. These include the roles of reuse coordinators, reuse inventory managers, reused-product assessors, reuse educators, and reuse visionaries (see Figure 14). Short descriptions of the different roles are described in Table 3.



*Figure 14: Roles of technical consultants in scaling reuse.*

Technical consultants can act as reuse coordinators and mediators, inspiring actors to consider reuse and bridging the gap in implementation. They assess what products can be preserved and sold, and connect the various actors involved in dismantling, transporting, and storing these products. Technical consultants already working with environmental coordination can include reuse coordination, recommending new reusable products, and suppliers with tailored solutions. However, as I5 mentioned, it is important that everyone collaborates and that not one person is expected to know everything about sustainability issues including reuse. Furthermore, reuse coordinators assist in finding appropriate products and materials for construction projects and are important partners in the CC sector. By collaborating with architects, developers, and other stakeholders, technical consultants prioritize reuse throughout the construction process and ensure architects' reuse plans are implemented.

Reuse inventory managers carry out reuse inventories which are comprehensive records of the assets in a property where the state of the building components, their assembly, and their potential for future reuse are evaluated (further explained in section 2.5). They are responsible for making reuse inventories when a house is to be demolished or renovated to see what can be reused in-house or sold to other actors who want to reuse. Reuse inventories could become a natural part of the more comprehensive environmental inventories of buildings that are already carried out today. This is a natural role for technical consultants to take as they already carry out built environmental inventories of buildings.

Furthermore, technical consultants could act as product assessors. They could play a crucial role in assessing product quality and technical performance, particularly in identifying key properties and determining if they are suitable for reuse. They can help overcome obstacles such as warranty limitations and contribute to ensuring the quality of reused products like frames, HVAC systems, and electronics. This, however, would require expertise from a variety of technical consultants. Additionally, they can offer expertise in evaluating the suitability and condition of reused materials and assist in prioritizing materials for reuse, considering their climate impact. This can be aligned to previous research where e.g., Giorgi et al., (2022) highlights that evaluation of environmental impact is necessary to scale CC. By promoting the use of reused products and providing advice on eco-friendly practices, they contribute to reducing environmental impact. Moreover, technical consultants can use digital platforms to evaluate construction products, considering their potential for reuse or recycling, and assessing

the project's climate impact and circularity to determine the feasibility and extent of future product reuse.

Technical consultants in the context of reuse can act as advisors and educators, supporting various actors such as real estate companies, demolition contractors, and municipalities with reuse implementation. By sharing their knowledge and providing guidance, technical consultants can educate different actors in the construction sector about reuse practices. They can offer lectures and educational sessions to promote reuse awareness among stakeholders. Furthermore, technical consultants help communicate the environmental benefits of reuse to customers and stakeholders, emphasizing how it aligns with sustainability goals, climate declarations, EU taxonomy, green loans, and other initiatives. Their efforts as reuse educators could raise awareness and foster wider adoption of reuse practices. Additionally, technical consultants can play a vital role as reuse visionaries by incorporating reuse into project goals, advocating for its adoption, collaborating with academia, formulating reuse requirements, and engaging with reuse networks to foster a more CC industry.

*Table 3: The roles of technical consultants in scaling reuse.*

<b>Role</b>	<b>Description</b>
Reuse coordinators	Coordinating the reuse efforts in a construction project, bridging the gap in implementation, ensuring implementation of architects' reuse plans, connecting relevant actors, recommending products and suppliers, etc.
Reuse inventory managers	Carrying out reuse inventories, documenting properties' assets, and evaluating the state of the building products, their assembly, and their potential for future reuse.
Reused-product assessors	Assessing technical quality and properties of building products, helping prioritize products, and reducing environmental and climate impact.
Reuse educators	Educating and advising stakeholders about reuse practices, sharing knowledge, providing guidance, offering lectures to promote reuse awareness, and demonstrating the benefits of reuse.
Reuse visionaries	Incorporating reuse into project goals, formulating reuse requirements, advocating for its adoption, collaborating with academia, and engaging with reuse networks.

Some parts of the roles can be related to the role of the reuse consultant described in the literature presented in section 2.5. For example, conducting reuse inventories, assessing the condition and environmental impact of building components, providing advice and guidance related to reuse, assisting with broader consulting assignments related to reuse, facilitating purchasing of reused materials, offering training and education, and coordinating stakeholders and acting as a mediator are some roles relating to the role of the reuse consultant found in the literature.

Considering the feasibility of the different roles, the role of reuse inventory managers is likely to have a higher level of feasibility. This can be recognized by the existing practices that are already in place to some extent, as well as the emergence of digital solutions aimed at managing reuse inventory. In contrast, the role of a reused-product assessor may have lower feasibility due to several factors. One such factor is the inherent complexity associated with construction products, which requires a deep understanding and knowledge base. Additionally, the role of a

reused-product assessor might necessitate collaboration with multiple disciplines to effectively evaluate and assess the viability of reused products. However, the currently most crucial of these roles might be the role of the reuse coordinator. The findings from this study and from previous studies highlight the implementation gap regarding reuse in construction. The findings indicate that the lack of reuse goals is not always the issue, on the contrary, many organizations have ambitious reuse goals, however, there is a lack of knowledge on where and how to start working with reuse and this is where reuse coordinators come in. Furthermore, during the feedback seminar, the consultants from COWI discussed the importance of ensuring the implementation of the architect's reuse visions which is something a reuse coordinator could be responsible for.

## 5.4 Contributions of the Study

This study has contributed to enhancing the understanding of barriers, enablers, and the influence of technical consultants in scaling reuse within the construction sector. While previous studies have explored barriers and enablers to scaling CC and reuse in the construction sector, the findings of this study do not contradict prior research. Instead, they complement earlier studies by providing up-to-date perspectives from the Swedish construction sector.

One notable contribution of this study relates to the varying opinions of the interviewees on how to address certain barriers to scaling reuse. For instance, there were divergent ideas on how to overcome the challenge of complex logistics. Some interviewees believed that construction and demolition projects should be matched, and intermediary actors should be eliminated. Conversely, other stakeholders expressed the view that this approach may not be practical in real-life scenarios, highlighting the necessity of intermediary actors to resolve logistics barriers and facilitate the scaling of reuse.

The most significant contribution of this study lies in its findings concerning the role of technical consultants, which has been underrepresented in previous research on transitioning to a CC industry and scaling reuse. The findings indicate some confusion surrounding the specific role that consultants should assume in the context of reuse. However, this study demonstrates that there is significant potential for technical consultants to contribute and support reuse efforts in many ways. The findings indicate that technical consultants can play a crucial role in promoting reuse, but there remains a question of whether smaller reuse consultancies or larger traditional consultancies will take on these responsibilities. One interviewee expressed the belief that there will be room for both types of consultancies, indicating that collaboration and a diverse range of actors may be necessary to effectively address the challenges of scaling reuse in the construction sector.

The study reveals that technical consultants have greater influence over certain dimensions of the regime, specifically knowledge, and technology, while they may encounter more challenges in influencing laws and regulations. Furthermore, the study proposes five roles that technical consultants can undertake to support the scaling of reuse in the construction sector and facilitate the transition towards a CC industry presented in Figure 14.

## 5.5 Development Areas and Future Research

In this study, a scoping review was conducted instead of a full systematic literature review due to the time constraints of the study. In addition, there are already many previous studies that

have performed literature reviews on barriers and enablers to CE and reuse in the construction sector. However, a recommendation for future research is to conduct a more thorough systematic literature review on the matter, especially focusing on the role of technical consultants in the circular economic transition of the construction sector.

The results about the influence of technical consultants in relation to the regime categories (see Figures 12 and 13) indicate quite a large variation between the interviewees' answers. Some reasons for this might be because of different interpretations of the categories and the strong interconnectedness between them. For example, technical knowledge could be interpreted as a contribution to either the technology category or the knowledge category. Furthermore, it may be due to different levels of understanding about the reuse transition and the work of technical consultants among the different actors. Because of the free interpretation of the regime categories and where certain barriers and enablers fit best, the results may vary depending on the individual performing the study and the individuals interviewed. The purpose of this study was partly to gather unaffected viewpoints from the interviewees. In the second part of the interviews, I provided my own understanding of the regime categories, as well as the barriers and enablers collected from existing literature. However, for future research, it would be beneficial to establish clearer definitions of the regime categories. One approach could involve presenting a survey to the participants, where they can review the author's interpretations of the regime categories and afterward indicate their opinions on which categories they believe technical consultants can influence to a greater or lesser extent.

Future research should focus on including more perspectives. In this study, the technical consulting company COWI was used as an example company, supporting the study in different ways (described in 3.1), although other technical consulting companies were interviewed. It is important to remember that COWI is not representative of all technical consultancies and different companies may have varying competence and working methods. Therefore, future research could focus on comparing different technical consultancies and how they approach the reuse issue. Furthermore, the technical consultants involved in this study were mostly environmental consultants or green building consultants working with sustainable construction including CC. There are many other types of technical consultants that are vital in the transition toward a CC industry, e.g., structural and HVAC engineers. To enhance future research, it is recommended to incorporate perspectives from a broader range of technical consultants. This would allow for a comprehensive mapping of the responsibilities and collaborations among different disciplines, aiming to optimize the scalability of reuse efforts.

Finally, it is imperative for future research to encompass a broader range of perspectives, including stakeholders such as demolition contractors, manufacturers, suppliers, and governmental agencies. Although these stakeholders were not part of the current interview study, their significance in the context of the reuse transition was emphasized by the interviewees. Therefore, it is crucial for future studies to prioritize the inclusion of these stakeholders' perspectives to attain a more comprehensive understanding of the overall system.

## 6. Conclusions

This thesis has contributed to an enhanced understanding of the barriers, enablers, and influence of technical consultants in scaling reuse within the construction sector. Building upon previous studies, this research provides up-to-date perspectives from the Swedish construction sector, complementing existing knowledge in the field. The most notable contribution of this research lies in its exploration of the underrepresented role of technical consultants in transitioning to a CC sector and scaling reuse. The study identifies significant potential for technical consultants to contribute and support reuse efforts in various ways.

This thesis highlights the importance of collaboration among multiple stakeholders to induce transitions of STSs. For scaling reuse in the construction sector, and in relation to technical consultants, various relevant stakeholders were identified. This study gathered perspectives from different actors including technical consulting companies, real estate companies, industry reporters, an architectural firm, an environmental research institute, a construction company, and a proptech company. Additionally, the interviews highlighted the importance of including suppliers and manufacturers of construction products, demolition contractors, and governmental agencies in future research.

Several barriers and enablers connected to the regime categories ‘laws & regulations’, ‘market’, ‘infrastructure’, ‘technology’, ‘knowledge’, and ‘culture & norms’ were identified in the interviews. The most mentioned barriers were quality assurance and warranty challenges, limited external market scalability, and complex logistics. The most mentioned enablers were collaboration and cooperation, well-functioning reuse logistics, increased demand and attractiveness for reuse, and climate policy and legislation. These barriers and enablers do not contradict previous research but complement this research with updated perspectives from the Swedish construction sector.

According to the interviewees, technical consultants have a greater chance to influence the barriers and enablers related to knowledge and technology. On the other hand, the category of laws & regulations might be more difficult for technical consultants to influence according to most of the interviewees. However, the opinions were divided, and some interviewees believed that technical consultants can and should influence laws and regulations. Moreover, they could leverage climate policy and regulations as a market advantage by supporting clients in their reach for climate targets, e.g., by promoting reuse strategies. Technical consultants play essential roles in scaling reuse and can have a significant impact on promoting reuse in the construction sector. There are several ways in which technical consultants can contribute to advancing reuse and their roles will shift depending on the project and organizations they are involved in. This study identified five roles of technical consultants in the CC sector: reuse coordinators, reuse inventory managers, reused-product assessors, reuse educators, and reuse visionaries.

In summary, this thesis underscores the importance of collaboration among multiple stakeholders in implementing transitions of STSs, particularly in scaling reuse practices in the construction sector. Technical consultants play essential roles in advancing reuse practices and facilitating the circular economic transition of the construction industry. By understanding the barriers, enablers, and their areas of influence, technical consultants can effectively contribute to the advancement of reuse practices and facilitate the circular economic transition of the construction sector.

# 7. Bibliography

- Acharya, D., Boyd, R., & Finch, O. (2018). *First Steps Towards a Circular Built Environment*.
- Anastasiades, K., Goffin, J., Rinke, M., Buyle, M., Audenaert, A., & Blom, J. (2021). Standardisation: An essential enabler for the circular reuse of construction components? A trajectory for a cleaner European construction industry. In *Journal of Cleaner Production* (Vol. 298). Elsevier Ltd. <https://doi.org/10.1016/j.jclepro.2021.126864>
- Anund Vogel, J. (2020). *Incentivising Innovation in the Swedish Construction Industry*. KTH Royal Institute of Technology.
- Anund Vogel, J., Lind, H., & Holm, C. (2019). Incentivising innovation in the construction sector: The role of consulting contracts. *Construction Economics and Building*, 19(2), 181–196. <https://doi.org/10.5130/AJCEB.v19i2.6613>
- Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology: Theory and Practice*, 8(1), 19–32. <https://doi.org/10.1080/1364557032000119616>
- Bertino, G., Kisser, J., Zeilinger, J., Langergraber, G., Fischer, T., & Österreicher, D. (2021). Fundamentals of building deconstruction as a circular economy strategy for the reuse of construction materials. *Applied Sciences (Switzerland)*, 11(3), 1–31. <https://doi.org/10.3390/app11030939>
- Caldera, S., Ryley, T., & Zatyko, N. (2020). Enablers and barriers for creating a marketplace for construction and demolition waste: A systematic literature review. In *Sustainability (Switzerland)* (Vol. 12, Issue 23, pp. 1–19). MDPI. <https://doi.org/10.3390/su12239931>
- CCBuild. (n.d.). *Om oss*. Retrieved May 12, 2023, from <https://ccbuild.se/om-oss/>
- CCBuild. (2020). *Klartecken för CCBuild att fortsätta utveckla det cirkulära byggandet*. <https://ccbuild.se/nyheter/klartecken-for-ccbuild-att-fortsatta-utveckla-det-cirkulara-byggandet/>
- Chen, Q., Feng, H., & Garcia de Soto, B. (2022). Revamping construction supply chain processes with circular economy strategies: A systematic literature review. In *Journal of Cleaner Production* (Vol. 335). Elsevier Ltd. <https://doi.org/10.1016/j.jclepro.2021.130240>
- COWI. (n.d.-a). *About COWI*. Retrieved May 11, 2023, from <https://www.cowi.com/about>
- COWI. (n.d.-b). *Meet our employees*. Retrieved May 11, 2023, from <https://www.cowi.com/careers/meet-our-employees>
- COWI. (n.d.-c). *Our strategy*. Retrieved May 12, 2023, from <https://www.cowi.com/about/our-strategy>
- Czischke, D. (2018). Collaborative housing and housing providers: towards an analytical framework of multi-stakeholder collaboration in housing co-production. *International Journal of Housing Policy*, 18(1), 55–81. <https://doi.org/10.1080/19491247.2017.1331593>
- Densley Tingley, D., Cooper, S., & Cullen, J. (2017). Understanding and overcoming the barriers to structural steel reuse, a UK perspective. *Journal of Cleaner Production*, 148, 642–652. <https://doi.org/10.1016/j.jclepro.2017.02.006>
- Dokter, G., van Stijn, A., Thuvander, L., & Rahe, U. (2020). Cards for circularity: Towards circular design in practice. *IOP Conference Series: Earth and Environmental Science*, 588(4). <https://doi.org/10.1088/1755-1315/588/4/042043>
- Ellen MacArthur Foundation. (n.d.-a). *The Butterfly Diagram: Visualising the Circular Economy*. Retrieved February 2, 2023, from <https://ellenmacarthurfoundation.org/circular-economy-diagram>

- Ellen MacArthur Foundation. (n.d.-b). *What is a circular economy?* | *Ellen MacArthur Foundation*. Retrieved February 2, 2023, from <https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview>
- European Commission. (n.d.). *Waste prevention and management - Environment*. Retrieved May 9, 2023, from [https://ec.europa.eu/environment/green-growth/waste-prevention-and-management/index\\_en.htm](https://ec.europa.eu/environment/green-growth/waste-prevention-and-management/index_en.htm)
- Frändberg, F., & Nyqvist, E. (2021). *Challenges for implementing reuse in the construction sector*.
- Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, 33(6–7), 897–920. <https://doi.org/10.1016/j.respol.2004.01.015>
- Geels, F. W. (2005). Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. *Technological Forecasting and Social Change*, 72(6 SPEC. ISS.), 681–696. <https://doi.org/10.1016/j.techfore.2004.08.014>
- Giorgi, S., Lavagna, M., Wang, K., Osmani, M., Liu, G., & Campioli, A. (2022). Drivers and barriers towards circular economy in the building sector: Stakeholder interviews and analysis of five european countries policies and practices. *Journal of Cleaner Production*, 336. <https://doi.org/10.1016/j.jclepro.2022.130395>
- Gorgolewski, M. (2008). Designing with reused building components: Some challenges. *Building Research and Information*, 36(2), 175–188. <https://doi.org/10.1080/09613210701559499>
- Göteborgs Stad. (2021). *Storstadsöverenskommelse för cirkulärt byggande 2030*. [www.goteborg.se/cirkularagoteborg](http://www.goteborg.se/cirkularagoteborg)
- Harrigan, M. (2004). *Defining the Role of a Green Building Consultant*.
- Hart, J., Adams, K., Giesekam, J., Tingley, D. D., & Pomponi, F. (2019). Barriers and drivers in a circular economy: The case of the built environment. *Procedia CIRP*, 80, 619–624. <https://doi.org/10.1016/j.procir.2018.12.015>
- Jönköping University. (n.d.). *University Library Guides*. Retrieved May 16, 2023, from <https://guides.library.ju.se/c.php?g=690269&p=4943634>
- Kanters, J. (2020). Circular building design: An analysis of barriers and drivers for a circular building sector. *Buildings*, 10(4). <https://doi.org/10.3390/BUILDINGS10040077>
- Knoth, K., Fufa, S. M., & Seilskjær, E. (2022). Barriers, success factors, and perspectives for the reuse of construction products in Norway. *Journal of Cleaner Production*, 337. <https://doi.org/10.1016/j.jclepro.2022.130494>
- Palats. (n.d.). *Palats*. Retrieved May 12, 2023, from <https://www.palats.io/>
- Rahla, K. M., Mateus, R., & Bragança, L. (2021). Implementing circular economy strategies in buildings—from theory to practice. *Applied System Innovation*, 4(2). <https://doi.org/10.3390/asi4020026>
- Strand Nyhlin, M., & Åfreds, J. (2022). *ÅTERBRUK AV BYGGMATERIAL*. [www.bygggtjanst.se](http://www.bygggtjanst.se)
- Wuni, I. Y. (2022). Mapping the barriers to circular economy adoption in the construction industry: A systematic review, Pareto analysis, and mitigation strategy map. In *Building and Environment* (Vol. 223). Elsevier Ltd. <https://doi.org/10.1016/j.buildenv.2022.109453>

# Appendices

## A. Interview Questions

[In Swedish]

### Intervjustudie

Cirkulär ekonomi och återbruk i byggbranschen

Tid: 60 minuter

### Introduktion

Jag skriver mitt examensarbete om cirkulär ekonomi och uppskalningen av återbruk i byggbranschen. Syftet med intervjun är att få en bättre förståelse för det som möjliggör (s.k. möjliggörare) och det som bromsar (s.k. barriärer) utvecklingen mot mer återbruk samt vilken roll olika aktörer spelar i denna omställning, med fokus på teknikkonsulter som arbetar med hållbart- och/eller cirkulärt byggande.

### GDPR

Resultatet från denna intervjustudie kommer publiceras som en del av mitt examensarbete. Inga personuppgifter som går att koppla till specifika individer eller företag kommer publiceras. Personuppgifter som kan komma att publiceras är:

- Demografiska uppgifter som exempelvis nationalitet, erfarenhet och utbildning.
- Åsikter och tankar kring cirkulär ekonomi och återbruk i byggbranschen.

Är det okej att jag använder materialet från detta samtal och de tidigare nämnda personuppgifterna i min rapport?

Är det okej att jag spelar in och transkriberar samtalet?

### Del 1 – öppen diskussion om barriärer, möjliggörare och roller

Syfte: samla in nya perspektiv

Skulle du vilja presentera dig själv, din roll och ditt arbete?

Vad har du för erfarenheter av återbruk, har du exempelvis jobbat med något återbruksprojekt?

Vilka hinder ser du när det kommer till uppskalningen av återbruk?

Vilka möjliggörare eller drivkrafter ser du när det kommer till uppskalningen av återbruk?

Vilken roll ser du att ni som ... har i uppskalningen av återbruk?

Vilken roll tänker du att teknikkonsulter inom hållbart- eller cirkulärt byggande har när det kommer till uppskalningen av återbruk?

Vilket stöd behöver ni som ... på ... och av vem/vilka, för att på bästa sätt kunna bidra till uppskalningen av återbruk?

Tror du att teknikkonsulter inom hållbart- eller cirkulärt byggande kan stötta ert arbete när det kommer till att skala upp återbruk, och i sådana fall, hur?

Hur tror du att uppskalningen av återbruk kan bidra till en cirkulär ekonomi?

## Del 2 – Diskutera utifrån diagram

Syfte: få input kring de barriärer och möjliggörare jag identifierat i litteratur

*Jag visar diagram där jag sammanställt barriärer och möjliggörare från litteratur som vi diskuterar kring.*

Vilka av dessa kategorier ser du att teknikkonsulter inom hållbart- eller cirkulärt byggande har större chans att kunna påverka?

Vilka av dessa kategorier ser du att teknikkonsulter inom hållbart- eller cirkulärt byggande har mindre chans att kunna påverka?

## B. Barriers and Enablers from Previous Studies Related to Laws & Regulations



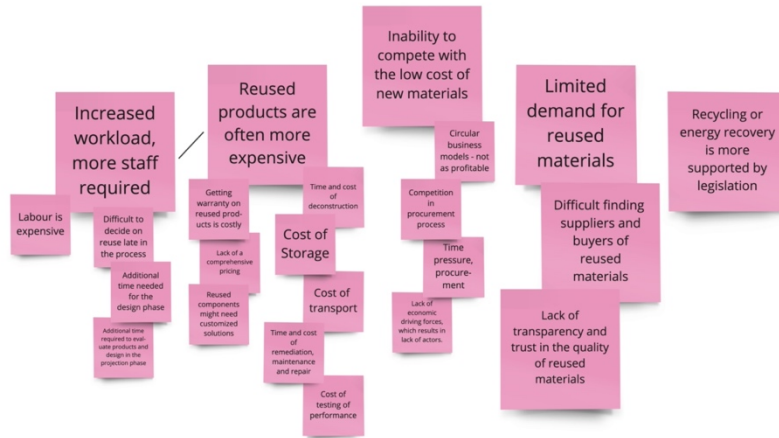
Barriers

Enablers

### ----- Laws & regulations -----



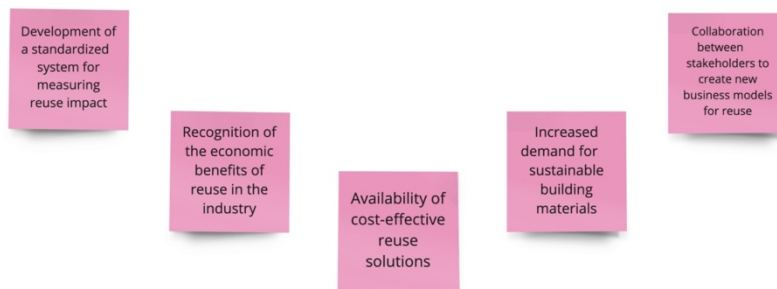
# C. Barriers and Enablers from Previous Studies Related to Market



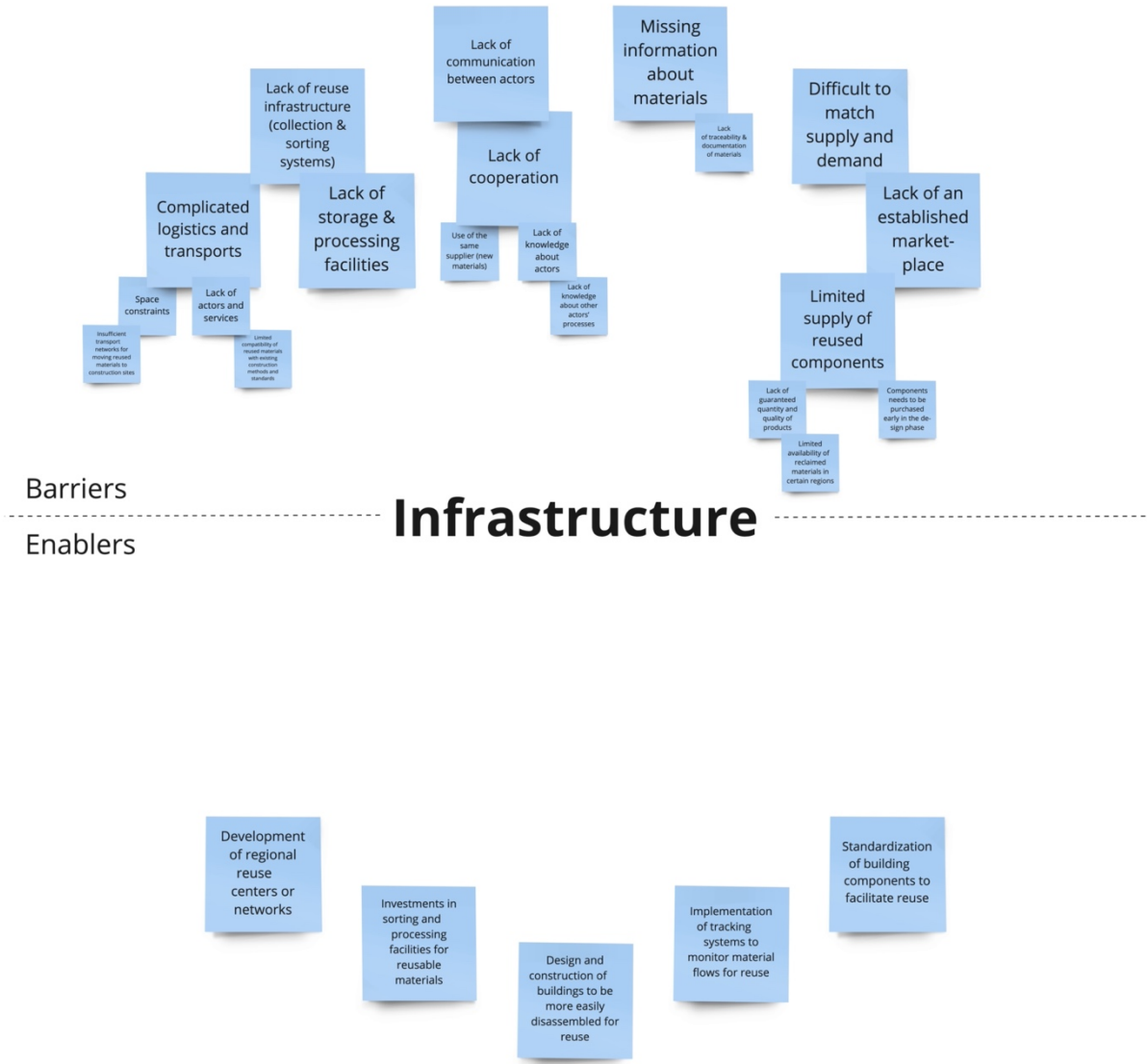
Barriers

Enablers

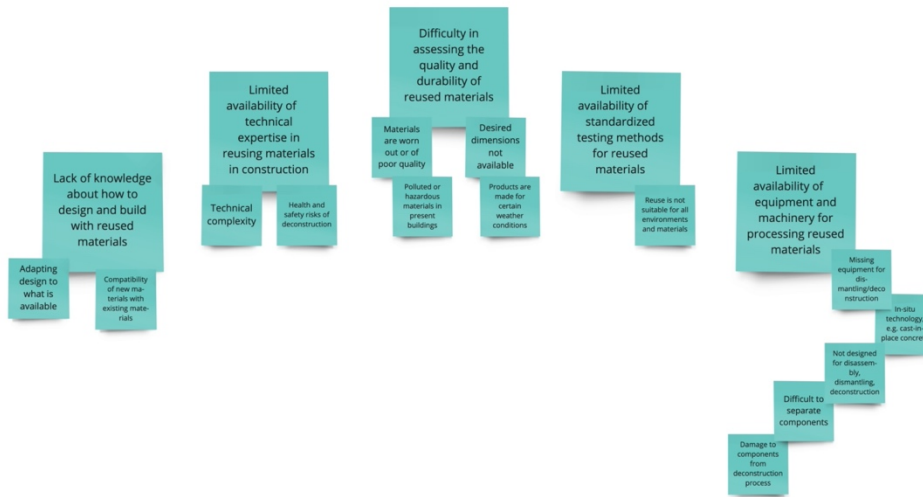
## Market



# D. Barriers and Enablers from Previous Studies Related to Infrastructure

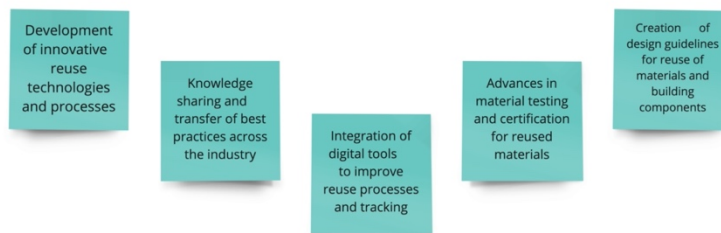


# E. Barriers and Enablers from Previous Studies Related to Technology



Barriers  
-----  
Enablers

**Technology**



# F. Barriers and Enablers from Previous Studies Related to Knowledge



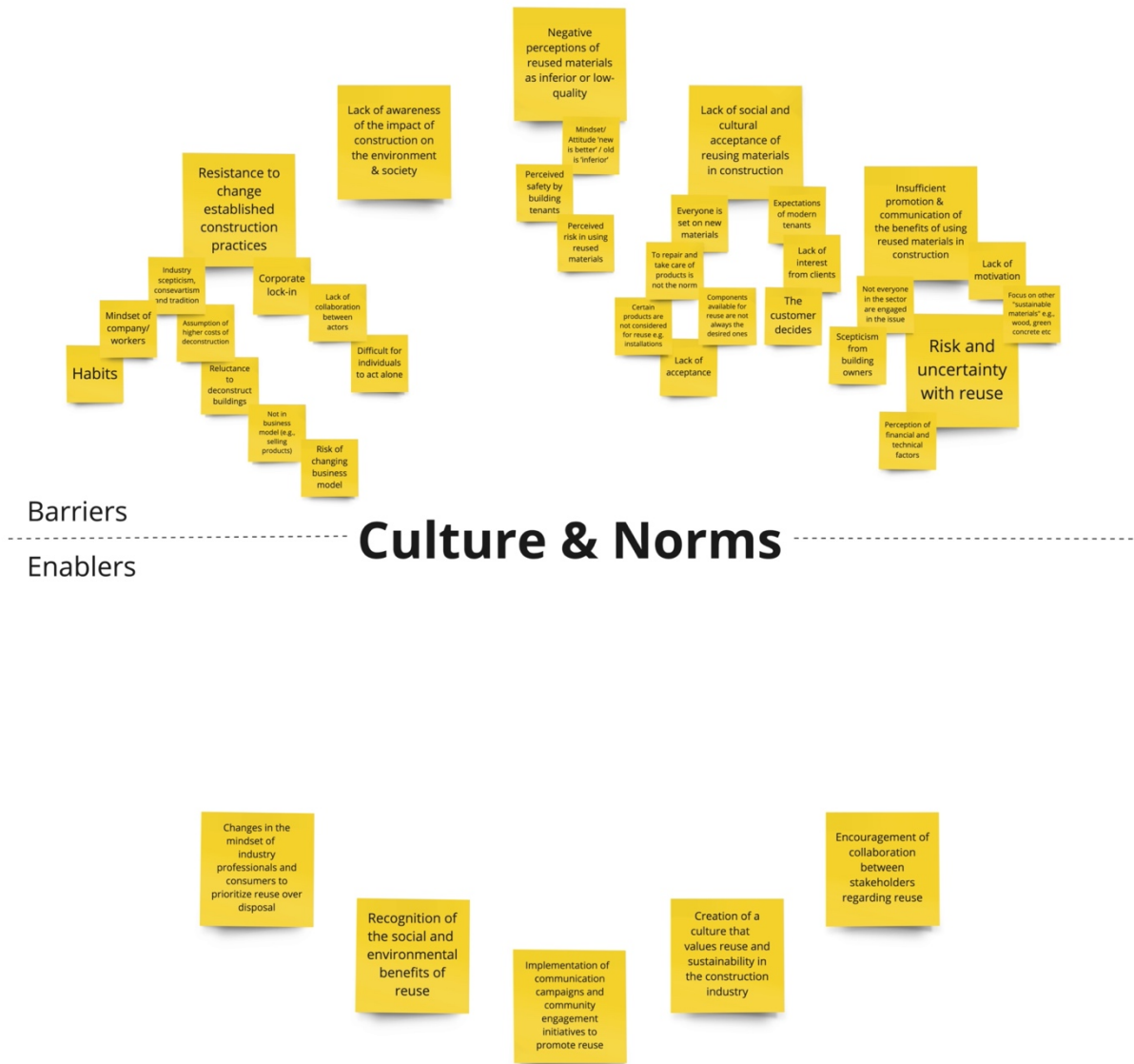
Barriers

Enablers

## Knowledge



# G. Barriers and Enablers from Previous Studies Related to Culture and Norms



## H. Table of Barriers by Interviewees per Profession from Coding

Barriers									
Codes	Total	Technical consulting company	Real estate company	Environmental research institute	Architectural firm	Proptech company	Construction company	Industry reporters and authors	
Compliance with evolving regulations and standards	6	4	0	0	0	0	1	1	
Hesitant attitude and change-resistance	6	3	1	0	0	1	0	1	
Complex logistics	7	1	1	1	1	1	1	1	
Cost and time concerns	6	4	0	1	0	1	0	0	
Demolition-centric norms	2	1	0	1	0	0	0	0	
Learning challenges for multiple actors	2	1	1	0	0	0	0	0	
Limited external market scalability	8	2	3	1	1	1	0	0	
Easier buying new products	6	3	2	1	0	0	0	0	
Inflexible client demands	6	3	3	0	0	0	0	0	
Knowledge gap	4	2	0	1	0	0	0	1	
Limited collaboration	2	1	0	0	0	1	0	0	
Lack of common language and understanding	3	3	0	0	0	0	0	0	
Risk aversion	2	0	0	1	0	0	0	1	
Insufficient tools and processes for implementation	3	1	0	1	1	0	0	0	
Legislation favoring new production	2	1	0	1	0	0	0	0	
Supply-demand mismatch	4	1	2	0	0	0	0	1	
Poor product inventory management	2	1	0	0	0	1	0	0	
Poor implementation of reuse visions	3	2	0	0	0	1	0	0	
Quality assurance and warranty challenges	9	4	0	1	1	1	1	1	
Complex products	6	3	1	0	1	1	0	0	
New materials valued over reused ones	2	1	0	0	0	0	0	1	
Late consideration of reuse in the construction process	2	2	0	0	0	0	0	0	
<b>Total (Unique)</b>	<b>13</b>	<b>5</b>	<b>3</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	

# I. Table of Enablers by Interviewees per Profession from Coding

Codes	Enablers									
	Total	Technical consulting company	Real estate company	Environmental research institute	Architectural firm	Proptech company	Construction company	Industry reporters and authors		
Ambitious leadership, risk-taking, and inspiration	7	4	1	0	1	1	1	0		
Adaptation of the construction process	5	3	0	1	0	0	0	1		
Circular design	5	3	2	0	0	0	0	0		
Circular initiatives, programs, and networks	4	1	1	0	1	1	0	0		
Circular offerings from suppliers	6	3	1	0	1	0	1	0		
Collaboration and cooperation	9	4	2	1	1	0	0	1		
Common goals and visions	4	2	1	0	0	0	0	0		
Communication and knowledge-sharing	4	3	0	0	0	0	0	1		
Demonstrate business benefits	8	3	2	1	0	1	0	1		
Emissions data for informed product choices	2	0	1	0	1	0	0	0		
Develop and improve digital reuse solutions	3	0	1	0	0	1	1	0		
Early actions and follow-up	5	3	1	0	0	1	0	0		
Environmental certification systems	3	2	1	0	0	0	0	0		
Expand external reuse market	6	2	3	0	1	0	0	0		
Well-functioning reuse logistics	9	5	1	0	1	1	1	0		
Increased demand and attractiveness for reuse	9	3	3	0	1	1	0	1		
Increased knowledge among all actors	6	3	0	1	1	0	0	1		
Climate policy and legislation	9	3	3	1	0	0	1	1		
Legislation favoring reuse	5	3	0	0	1	0	0	1		
Positive attitude towards working with reuse	5	3	1	0	0	0	0	1		
Professional pride in sustainability commitments	1	0	0	0	0	0	0	1		
Research projects and collaboration with academia	3	0	0	1	1	1	0	0		
Reuse inventories	4	1	1	0	1	1	0	0		
Start reusing simple products	7	4	1	0	1	1	0	0		
Uncertainties regarding international trade	5	2	1	0	1	0	0	1		
Use digital tools for inventory and sales	6	3	3	0	0	0	0	0		
Total (Unique)	13	5	3	1	1	1	1	1		

