Towards a circular construction industry

A study of strategies a contractor can implement to lead the transition to circular economy

Master's thesis in Industrial Ecology

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Abstract

The climate challenges the world is facing are a fact and sustainability is becoming more prioritized in companies' agenda. A large part of the global emissions is coming from the construction industry. The construction industry uses many resources at the same time as it produces a lot of waste. Hence, there is a need for a transition from the current linear economy to a circular economy.

The thesis aims to investigate which strategies contractors in construction can implement to lead the transition to a circular economy and recommend a potential circular business model. It is done by investigating the gap between the current status of where Skanska and the construction industry today and identifying what is needed to change in order to reach a sustainable future. Through the identified gaps strategies are formulated and an analysis of the value chain is conducted to be able to recommend a potential circular business model for the company.

The study was conducted using the backcasting methodology to be able to envision the future state and formulate strategies to reach that scenario. Interviews with persons within the company, internal seminars, and literature have been used as support during the backcasting process.

The main findings of the thesis were that there are currently several barriers but also opportunities and great potential for circularity at Skanska and in the construction industry. When the current status was assessed, five actions Skanska could take to lead the transition to a circular economy were identified; *Implement circular design*, *Develop competence within circularity*, *Ensure a circular value chain*, *Manage circular practices* and *Track the circular development*. From the actions identified, strategies were formulated with the potential to reach the actions and thereby connect the current situation with the future state. Lastly, a potential circular business model was recommended to the company.

Keywords: Circular business model, Circular economy, Construction industry, Backcasting, Circularity indicators

Mot en cirkulär byggbransch
En studie om strategier en byggentreprenör kan implementera för att leda omställningen till cirkulär ekonomi
EMMA STRIDH
ELINA WAHLSTRÖM
Intuitionen för Arkitektur och samhällsbyggnadsteknik
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Sammanfattning

Klimatutmaningarna världen står inför är ett faktum och ett område som står allt högre upp på företags agenda. En stor del av de globala utsläppen kommer från byggbranschen. Dessutom kräver byggindustrin stora mänger resurser samtidigt som den producerar mycket avfall. Det finns därför ett stort behov av att gå från den linjära ekonomi byggbranschen har idag till en mer cirkulär.

Masteruppsatsen syftar till att undersöka vilka strategier entreprenörer inom byggbranschen kan implementera för att leda omställningen mot en cirkulär ekonomi och rekommendera en potentiell cirkulär affärsmodell. Det görs genom att undersöka det gap som finns mellan vart Skanska och byggbranschen befinner sig idag och identifiera vad som måste ändras för att nå en hållbar framtid. Utifrån det identifierade gapen formuleras ett antal strategier och analys av värdekedjan för att komma fram till en lämplig potentiell cirkulär affärsmodell.

Studien har genomförts utifrån backcasting metodologin som används för att visualisera ett önskvärt framtida scenario för att sedan kunna formulera strategier för att nå dit. Intervjuer med personer på företaget, interna seminarium och literatur har använts som support under backcasting processen.

De viktigaste resultaten från rapporten är att det finns just nu flera barriärer men också möjligheter med stor potential för cirkularitet på Skanska och inom byggbranschen. Efter utvärdering av nuläget, identiferades fem åtgärder Skanska kan ta för att leda omställningen till cirkulär ekonomi; *Implementera cirkulär design*, *Utveckla kompetens inom circularitet*, *Säkerställa en cirkulär värdekedja*, *Hantera cirkulär ekonomi praxis* och *Följa upp den cirkulära utvecklingen*. Från de identifierade åtfärderna formulerades strategier med potentialen att uppfylla åtgärderna and därigenom uppnå det framtida scenariot. Slutligen, rekommenderades en potentiell cirkulär affärsmodell till företaget.

Nyckelord: Cirkulär affärsmodell, Cirkulär ekonomi, Byggbranschen, Backcasting, Cirkulära indikatorer

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First of all, we want to express our gratitude towards our supervisors Maud Lanau at Chalmers and Peter Samuelsson at Skanska for their guidance and support throughout the thesis. We also want to thank John Holmberg for guiding us in the backcasting process. Moreover, we want to show appreciation towards our examiner for the valuable feedback on our thesis during the project. We are deeply grateful to Emmie Wahlström for the illustration of the cover page. Thank you to all interviewees who contributed their time, valuable knowledge and thoughts to the study. Lastly, we want to thank Skanska for the opportunity to write the master's thesis at the company.

Emma Stridh & Elina Wahlström, Gothenburg, June 2023

Acronyms

BM Business Model. 3–6, 8, 15, 27, 43, 52, 56, 59
BMC Business Model Canvas. 4, 6, 15

CBM Circular Business Model. 4–8, 14, 15, 43, 52, 55, 56, 59, 60
CE Circular Economy. 1, 3–8, 14, 16, 17, 19–21, 23, 25–29, 31–36, 38, 39, 41–43, 45–49, 51, 52, 55–57, 59, 60

DfD Design for Deconstruction. 21, 39, 40, 45, 46, 57

EOF End-of-Life. 39

GHG Greenhouse Gases. 40

PBO Project-based organisation. 23

ROI Return on investment. 25, 32, 55

SEOL Sustainable End-of-Life. 28

WTP Willingness to pay. 25

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1
Introduction

1.1 The construction industry

The industrial revolution was a turning point in human history since it resulted in innovations and economic growth, but also the transition to capitalism (Pincetl et al., 2012). Even if it has been an important part in the development of the society it has come with downsides. The industrial revolution also meant the exploitation of resources, more consumption, and increased use of both energy and fossil fuels (Pincetl et al., 2012). McNeill (2000, p. 15) states that *"No other century—no millennium—in human history can compare with the twentieth for its growth in energy use. We have probably deployed more energy since 1900 than in all of human history before 1900"*.

During the Paris Agreement 2015, the world leaders decided to keep the global average temperature below a 2℃ increase from the pre-industrial levels, to limit it to 1.5℃ (United Nations, 2015). In line with the Paris Agreement, a net zero target has been set as a global effort to reduce CO_2 emissions. The net-zero target is a commitment to reduce the CO_2 emissions by 45% by 2030 and reach a net zero emission by 2050 (United Nations, n.d.). Despite the different agreements being made over the years to lower the environmental impact, the emissions are still increasing (United Nations Environment Programme, 2022). Remaining is the major challenge and ambitions gaps in reaching climate neutrality by 2050.

The construction industry is a large contributor to the emissions. Globally the sector stands for 37% of the world's energy and process-related CO_2 emissions, mainly coming from building operations and material use, whereas materials such as steel, alumina, glass, and bricks account for 10% (United Nations Environment Programme, 2022). The common practice in the industry is the extracting, using, and disposing of large amounts of resources linearly, without concerning the limitations of resources (Minunno et al., 2020). In short, it would imply that emissions would have to decrease by over 98% to be aligned with reaching climate neutrality by 2050. (United Nations Environment Programme, 2022). Hence, there is a need for a transition from the current linear economy to a Circular Economy (CE).

1.2 Skanska

In the list of the 30 largest construction companies in Sweden released by Byggföretagen (2022), Skanska is the second largest with 8630 employees and a revenue of 33 275 million Swedish kronor. Skanska has four business streams; Commercial Property Development, Investment Properties, Residential Development, and Construction (Skanska AB, 2022), which operates rather independently.

In Skanskas sustainability report from 2022, it is clearly stated that the goal is to achieve a net-zero carbon emission by 2045 at the latest, where the emissions from both their own business and their value chain are included (Skanska AB, 2022). Making it an even more ambitious goal than the net-zero target set to support the Paris Agreement. About 90% of Skanskas emissions come from the value chain (Skanska AB, 2022). It is therefore essential for them to collaborate with various actors to be able to reach their goal.

To reach climate neutrality Skanska has formulated an action plan called *ACT on climate* (Skanska AB, 2022), shown in Figure 1.1. It illustrates where the company intend to put the effort when it comes to climate actions and reaching the net zero carbon emission goal. Skanska has included circularity as one of the actions, but how it is going to be implemented is not clearly stated.

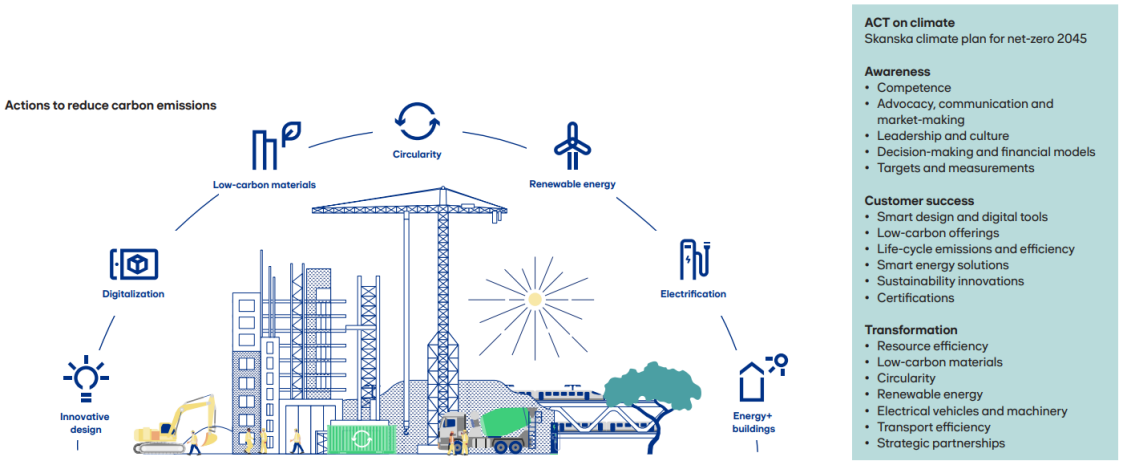

Figure 1.1: Actions to reduce carbon emission (Skanska AB, 2022).

1.3 Circular economy

Everything produced requires raw materials, which are traced back to physical resources. The common practice of extracting, using, and disposing of these resources has to a large extent contributed to major CO_2 emissions and resource scarcity. This linear system was made possible through cheap labour, rich natural resources, and free disposal to landfills or incineration. However, as the population grow and consumption levels increase in all parts of the world, the Earth's sustainability cannot be upheld by a linear model. In opposition to the linear economy, there is a

concept called CE, which term is becoming more known at an increasing number of businesses (Benton et al., 2014). Research has shown that CE practices have the potential to have remarkable environmental benefits, but also offer a business opportunity to meet their sustainability goals (Macarthur, 2021). The concept is built on the expression of the desire to extract more value from resources and keeps already used resources in productive use for as long as possible and thereby not allowing them to become waste. Mainly due to a growing range of pressures, resources face diverse risks including scarcity, negative reputation, and the impact of environmental and political decisions (Kirchherr et al., 2017). The framework of CE allows companies to evaluate their operational and supply chain practices to optimize resource usage to reduce the need for raw materials within their Business Model (BM) (Benton et al., 2014). Organizations can gain more knowledge and control over their supply chain, mitigate risks, avoid negative impacts, and reduce waste by following CE strategies. It can also serve as a distinguishing factor in the market, offering cost savings to businesses.

Research has shown that the interpretations of CE can diverge among individuals and organizations, resulting in multiple understandings of the concept (Kirchherr et al., 2017). However, the common denominator relates to sustainable development (United Nations, 1987) and economic benefits (Kirchherr et al., 2017). The literature distinguishes between two core principles on CE (Potting et al., 2017). The first core principle is the R framework which includes CE concepts on "how to", see Figure 1.2. The R Framework should be viewed as a priority list (the first R is prioritized over the second and so on) and corresponds to the waste hierarchy. The other core principle of CE is the systems perspective, including a fundamental shift instead of incremental twisting of the current system. Highlighted by several authors including (Kirchherr et al., 2017), is that the transition to CE needs to occur at three levels: macro-, meso- and micro-perspective. The macro-perspective considers the industrial structures, the meso-perspective considers the regional systems and the micro-perspective considers individual business structures and what needs to happen to increase circularity.

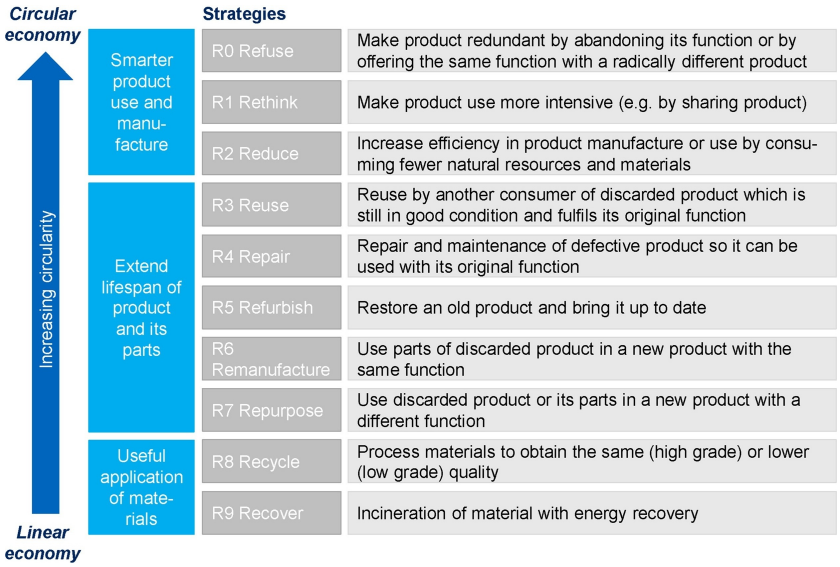

Figure 1.2: The 9R Framework (Potting et al., 2017).

Despite extensive research conducted on the barriers to implementing CE in the construction industry (Kumar et al., 2019), tangible actions from actors within the sector continue to be limited and slow. Also, considering the urgency of reaching sustainability goals and the forthcoming CE policies see e.g., EU (2020), it is crucial for construction companies to transition towards a Circular Business Model (CBM). However, companies often face challenges in understanding the practicalities of such a shift.

1.4 Circular Business Models

A BM serves as a blueprint for a company's operations, defining how it will create and deliver value to customers while generating revenue and profits (Verrue, 2014). It outlines the key components of a company's strategy, including its target market, product or service offerings, distribution channels, pricing strategy, cost structure, and revenue streams. The economical effectiveness of a BM depends on its ability to align with customer needs, capture value, and generate sustainable profits over the long term (Teece, 2010). Business Model Canvas (BMC) is a tool to analyse and visualise the BM of a company, as seen in Figure 1.3 (Osterwalder et al., 2009).

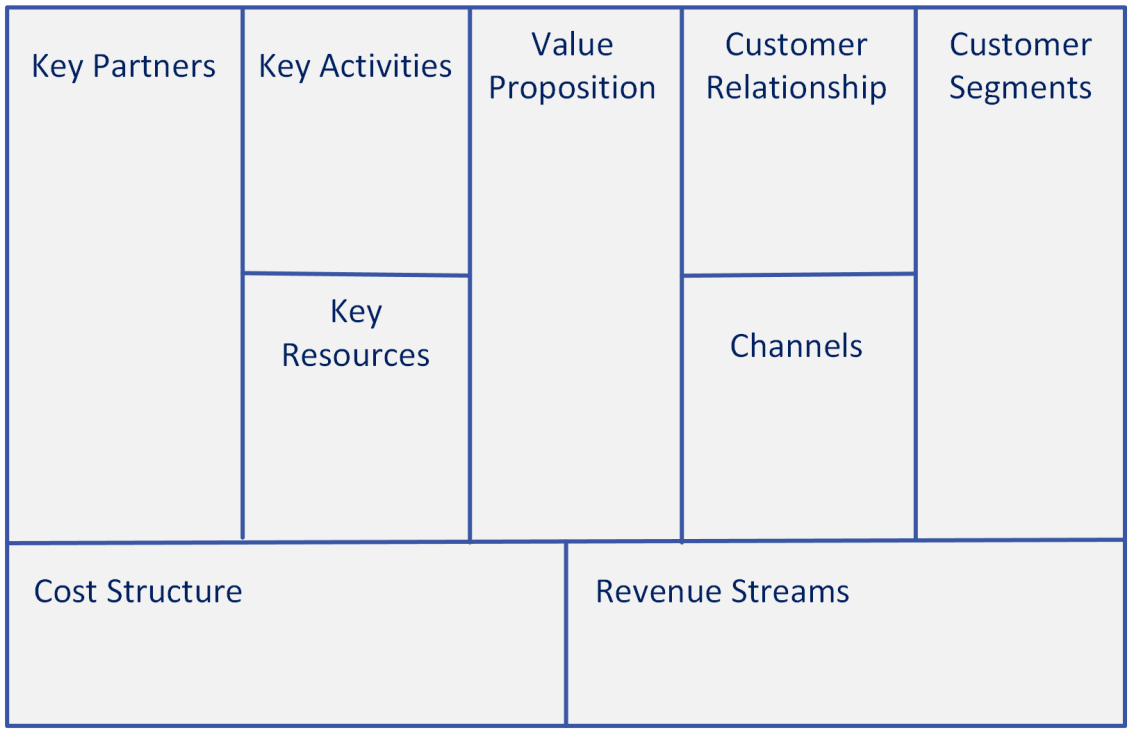

Figure 1.3: Business Model Canvas (BMC), Illustrated by the and based on the model found in Osterwalder et al. (2009)

The linear economy is dominating today's businesses by which resources are extracted and products are produced, sold, and then disposed of. The linear BM and its activities cause environmental problems to the extent that many companies today put sustainability issues at the top of the corporate agenda. For companies to cope with the sustainability challenges while at the same time not compromising on financial returns to shareholders, a shift to a Circular Business Model (CBM) is required. However, according to Frishammar and Parida (2019) companies fumble in the transformation from linear BM to CBM since their knowledge within the area is still low.

A CBM describes in which ways an organization creates, offers, and delivers value to the customers while achieving positive economic and environmental benefits (Pieroni et al., 2019). Rather than maximizing profit by cost-efficiency in the supply chain, the focus is on redesigning and restructuring the Product-Service-System to ensure future business activities and market competitiveness.

The CBM corresponds to the CE concepts of improving resource efficiency by allowing them to be in productive use longer while extracting as much value as possible in the process. It is defined by Frishammar and Parida (2019) as a model in which a company, together with stakeholders and actors within the industry uses innovation to create, capture and deliver value by applying CE concepts (see Figure 1.2). Furthermore, Kraaijenhagen et al. (2016) highlight the importance of BM innovation since they found that in most cases the organizations BM changed drastically in the way they operated as a result of the CE approach.

Argued by Geissdoerfer et al. (2020) to reach a CBM, the concepts of CE must be designed and implemented on the current BM. To visualize how to approach the BM with CE concepts a combined framework of Osterwalder et al. (2009) BMC (see Figure 1.3) and Bocken (2015) Sustainable BMC is presented by Kraaijenhagen et al. (2016), see Figure 1.4. The framework provides a deeper notion into the aspects of the value of a sustainable BM and allows for circular business in a BMC perspective.

To enable CBM, companies need to rethink the value proposition, value capture, value delivery (customer involvement), and value creation (supply chain management) in the BM, see Figure 1.4 (Geissdoerfer et al., 2020). The new type of thinking and doing business requires a fundamental change and consist of strategies that provide opportunities for implementing the idea of CE at a practical level. Companies can achieve significant improvements in natural resource productivity by utilizing either a single strategy or a combination of them.

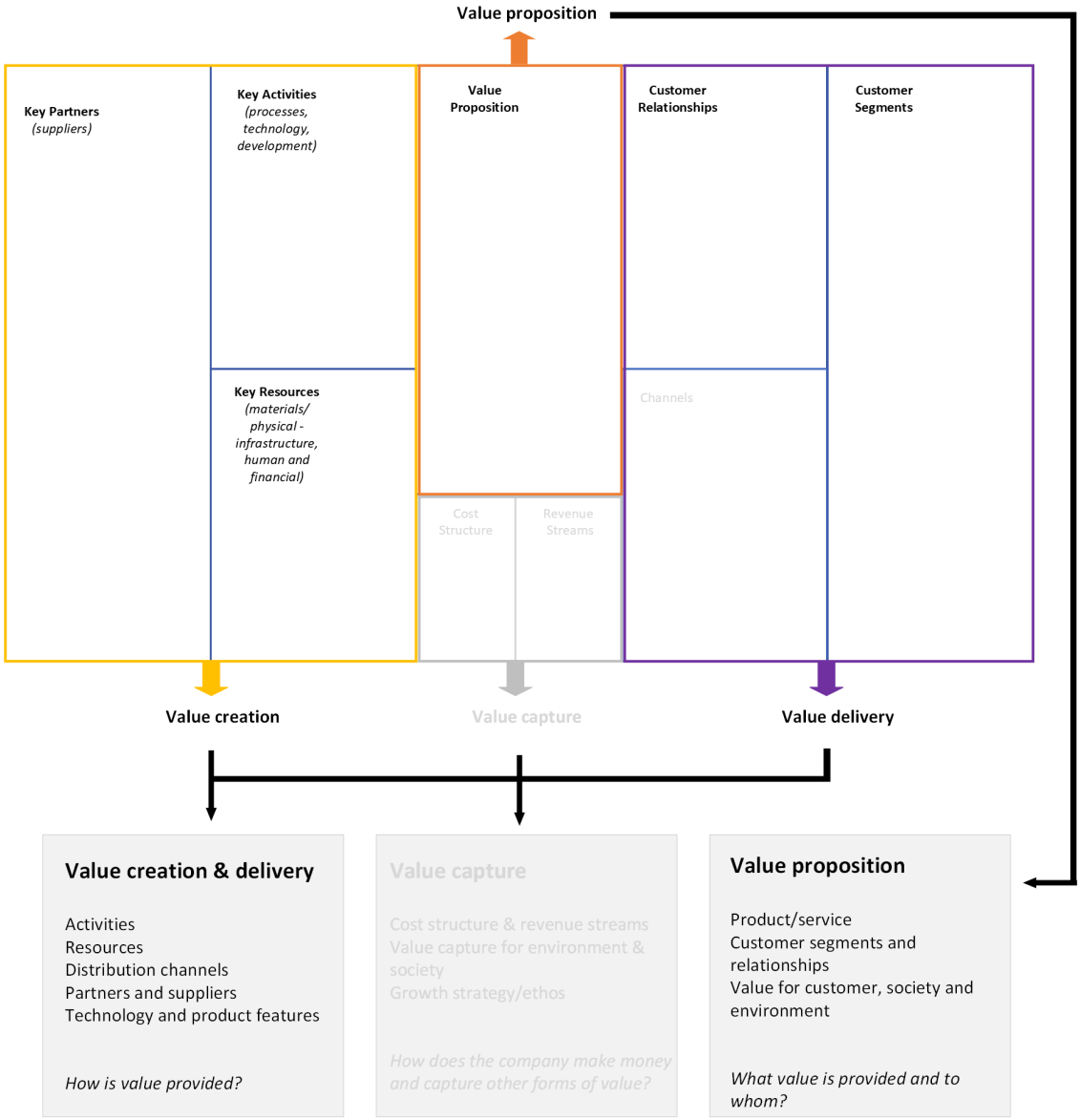

Figure 1.4: Circular business in a Business Model Canvas. Illustrated by the authors and based on the figure found in Kraaijenhagen et al. (2016)

1.5 Aim and objectives

The thesis aims to investigate which strategies contractors in the construction industry can implement to lead the transition to Circular Economy (CE) and recommend a potential Circular Business Model (CBM).

To fulfill the aim three objectives have been set. These objectives follow the main steps of the general methodological framework used in the thesis, i.e., backcasting (see section 2.1). The objectives are as follows:

(1) Assess the current status of Skanska regarding the transition to Circular Econ-

omy.

(2) Analyse results from (1) to identify actions for Skanska to take in the transition to Circular Economy.

(3) Based on (2) formulate relevant strategies related to the actions and recommend a potential Circular Business Model.

1.6 Delimitations

The study is primarily focused on the construction industry in Sweden. However, for the possibility to deliver comprehensive results, literature from outside the country will also be considered. Additionally, the study is limited to a contractor's perspective, specifically focusing on Skanska's operations in Sweden. Furthermore, the study specifically concentrates on the construction aspect within Skanska's business stream, without taking into account other parts such as infrastructure.

Moreover, it's important to mention that no economic evaluation has been conducted for the proposed actions, strategies and recommended potential CBM presented in the results. To assess the economic aspects of the BM, more time and knowledge about Skanska's operations and business structure would be necessary and crucial. Therefore, this thesis focuses on redesigning the value proposition, value delivery, and value creation specifically related to constructing a potential CBM (see Figure 1.4). Because of the lack of available information regarding specific details of Skanskas current BM, an estimated current BM was developed as a starting point for developing the CBM.

The study solely focuses on investigating and working on steps two-four of the Backcasting methodology. The conditions for step one in the methodology are based on Skanska's sustainability goals presented previously in this chapter.

2
Method

The following chapter will present the methods used in the thesis. This thesis is mainly based on the backcasting methodology. This methodology provides tools to envision a desirable future and the strategies to reach it (The natural step, 2022). Furthermore, the methodology allows for a system perspective which is relevant when looking at how a company could relate to a transition of the whole system. The backcasting methodology consists of four steps, each connected and built upon the previous step. Every step includes data collection gathered through different methods depending on the step, which can be seen in Figure 2.1.

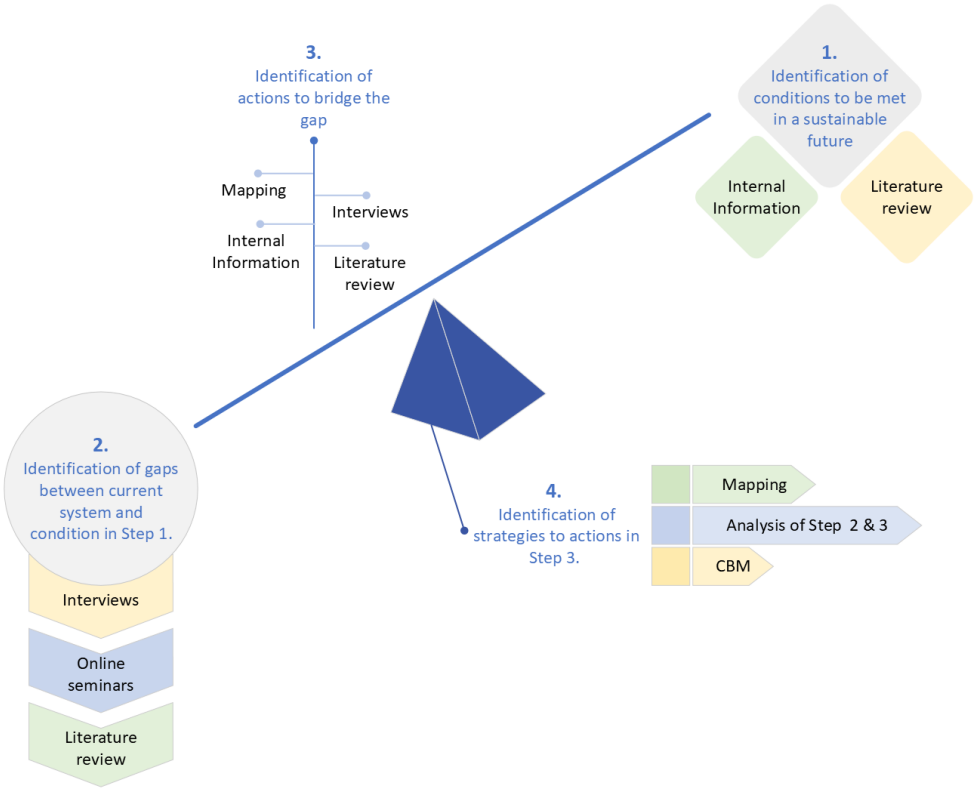

Figure 2.1: General methodological framework with data collection sources. Illustrated by the authors and based on the figure found in Holmberg and Holmén (2022)

2.1 Backcasting

Backcasting was chosen as the general framework of the thesis since it is a strategic planning method that involves envisioning a future state, working backwards to identify the actions and strategies needed to achieve the future state (The natural step, 2022). The methodology is particularly useful when the problem studied is complex and when there is a need for major change etcetera. The framework was developed by a network of scientists and business corporations called "The natural step" and is seen as a tool for sustainable development (The natural step, 2022).

The backcasting framework involves four steps, as seen in Figure 2.2;
(1) A description of conditions for sustainability
(2) Identification of the gap between the current system and the condition in (1)
(3) Identifying actions that can bridge the gap from (2)
(4) Finding strategies for those points from (3)

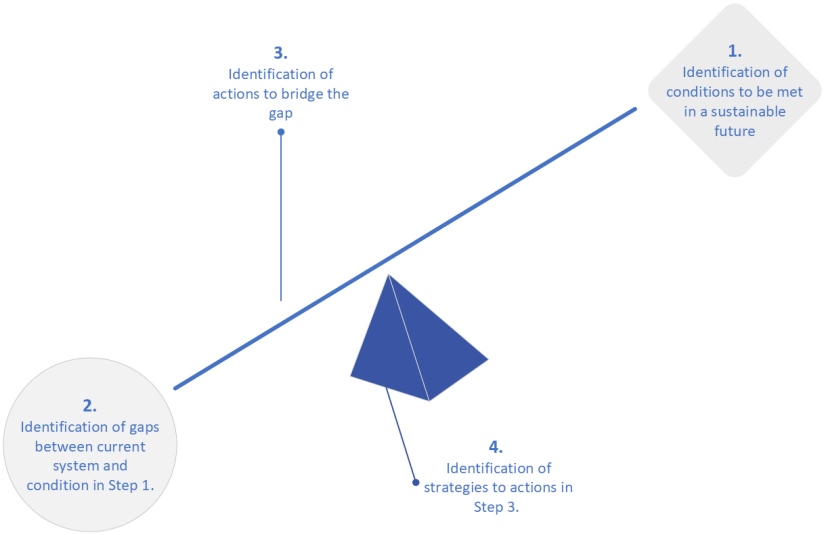

Figure 2.2: Backcasting methodology. Adopted by the authors from Holmberg and Holmén (2022)

By envisioning a future sustainable society, the framework helps identify what parameters will need to change to achieve that future. It can provide early warning signals of potential dead ends and help firms make long-term investments based on current structures and trends (Holmberg, 1998). It is not only a tool for sustainability, but also a tool for creativity. Liberating beliefs about today's trends can inspire new product designs and business ideas that are better aligned with a sustainable future. Overall, backcasting provides a structured approach to strategic planning that can help firms achieve their sustainability goals while also fostering creativity and innovation (Holmberg & Larsson, 2018). The framework has been proven to achieve change in organizations by allowing business leaders, together in workshop settings, to work with the methodology. Even though the study is lacking workshop settings, it was chosen for its potential for achieving change.

2.1.1 Step 1: Identification of conditions to be met in a sustainable future

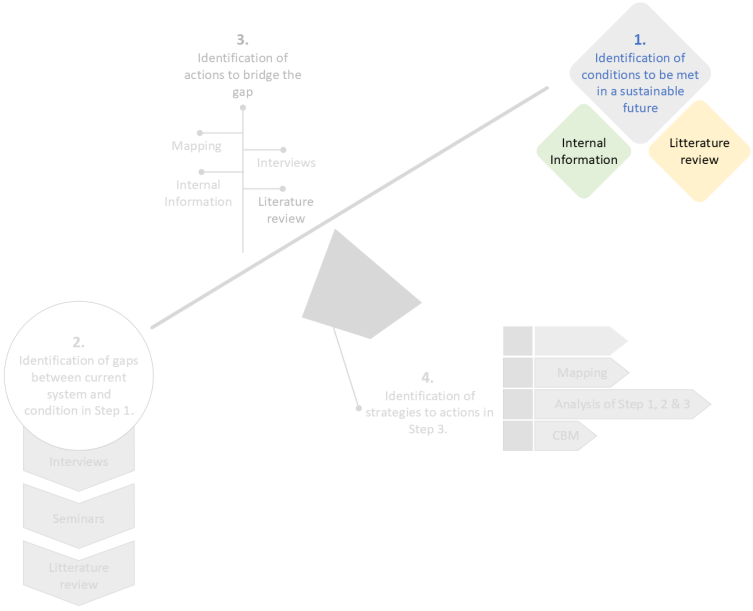

Figure 2.3: Backcasting Step 1: Identification of conditions to be met in a sustainable future. Illustrated by the authors and based on the figure found in Holmberg and Holmén (2022)

The first step of the backcasting method includes identifying the conditions to be met in a sustainable future, as illustrated in Figure 2.3. To be able to identify the conditions that Skanska wants to be met in a sustainable future, internal information, reports and other information published by Skanska were used. Furthermore, a literature review was performed to get a perspective of what the construction industry needs to be sustainable in the future. The conditions for a sustainable future (e.g., Step 1) were presented as a part of the introduction of the thesis, see Chapter 1.

2.1.2 Step 2: Identification of gaps between the current system and conditions in Step 1

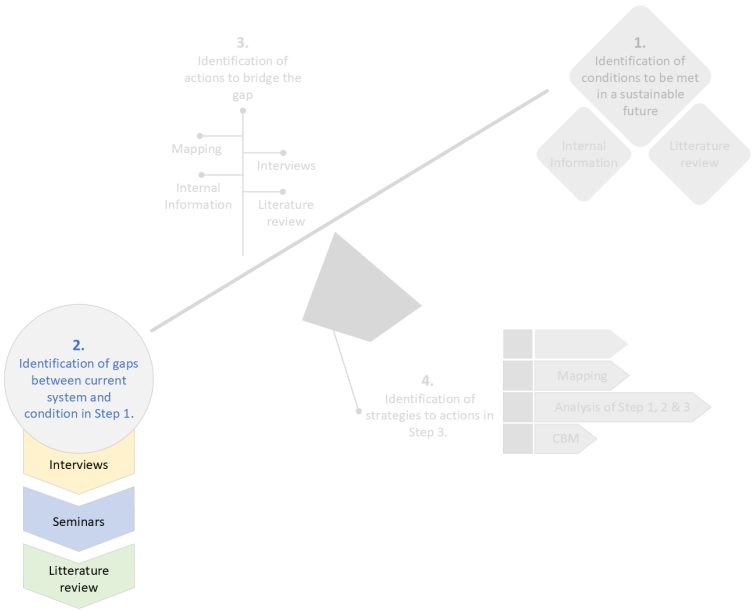

Figure 2.4: Backcasting Step 2: Identification of gaps between the current system and condition in Step 1. Illustrated by the authors and based on the figure found in Holmberg and Holmén (2022)

The second step of the backcasting method was to identify the gaps between the current system and the conditions in Step 1 which is illustrated in Figure 2.4. It was done by analysing the current activities and competencies of both Skanska and the construction industry. To collect the data needed to analyse the current situation interviews, online seminars and literature review was conducted.

To present the results, classifying the gathered information into subcategories allowed for a holistic approach to understanding and presenting the current status of the industry and Skanska. The classification provides a framework that facilitates analysis and discussion of specific characteristics, identification of commonalities, and development of targeted strategies. By organizing the objective into categories and subcategories, critical barriers and opportunities could be highlighted, offering a system perspective on the subject matter. The classification approach enhances the ability to comprehensively assess the various aspects of the objective and identify key areas for action and improvement. The categorization is based on relevant literature, primarily influenced by Huuhka and Hakanen (2015). The authors identified four categories of barriers: economic, social, ecological, and technological. Building upon this foundation, Rakhshan et al. (2020) expanded the categorization by introducing two additional categories: organizational and political. Consequently, for this study, a comprehensive framework comprising six main categories was adopted: economic, sociological, political, organizational, technological, and environmental. Subcategories related to specific stakeholders or phases were also incorporated as

needed within these main categories to enhance the granularity of the analysis. At the end of each subcategory are the barriers and opportunities summarized.

2.1.3 Step 3: Identification of actions to bridge the gap

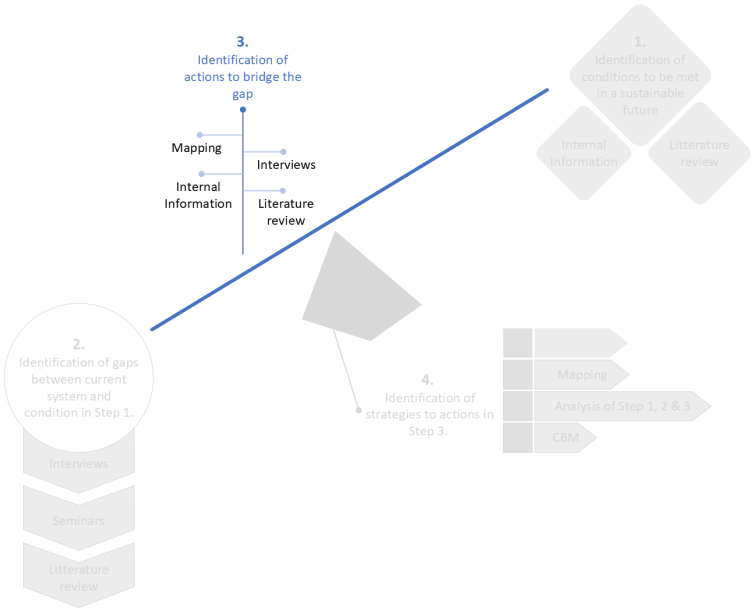

Figure 2.5: Backcasting Step 3: Identification of actions to bridge the gap. Illustrated by the authors and based on the figure found in Holmberg and Holmén (2022)

The third step of the backcasting method was to identify actions to bridge the gap between the current and future state, see Figure 2.5. To summarize the information from all data collection sources, a mapping was performed to get an overview of barriers and opportunities of the current status of the industry and Skanska, see the Appendix, Section A.3. Following, the information was analyzed and areas where the Skanska and construction industry may need to make changes to achieve a sustainable future were identified. Additionally, to identify potential actions on how the company's activities and competencies could be adapted to succeed in reaching the future scenario results from the interviews and literature study were used.

2.1.4 Step 4: Identification of strategies to actions in Step 3

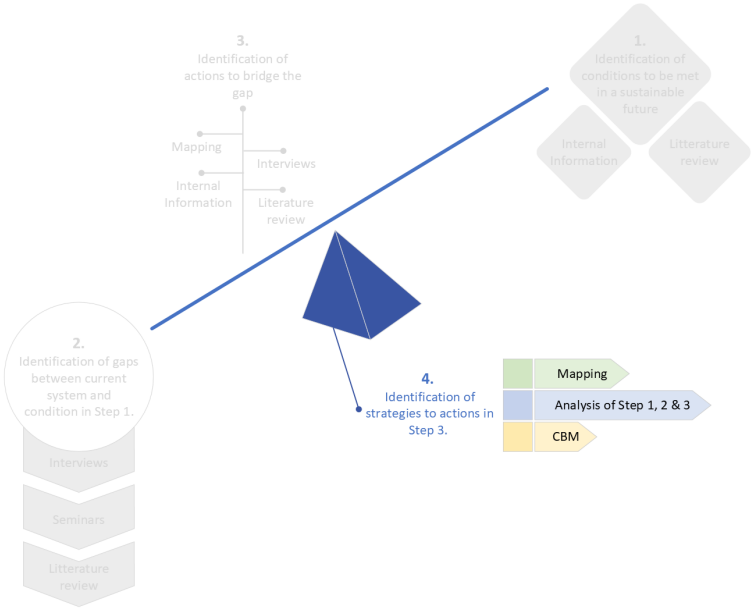

Figure 2.6: Backcasting Step 4: Identification of strategies to actions in Step 3. Illustrated by the authors and based on the figure found in Holmberg and Holmén (2022)

The fourth and last step of the backcasting method is to identify strategies for the actions in Step 3 as seen in Figure 2.6. The presented strategies were developed with the potential to reach the actions and thereby connect the present situation with the desirable future scenario. It was primarily done by an analysis of the second and third steps by using CBM. For the strategies to be adaptable to changing circumstances and to respond to unexpected challenges, the strategies were analyzed from a system perspective including micro, meso, and macro perspective from CE transitions.

When selecting guiding strategies the following points found in Holmberg (1998, p. 39), was considered:

- Will each measure bring us closer to sustainability?
- Is each measure a flexible platform for the next step towards sustainability?
- Will each measure pay off soon enough?
- Will the measures taken together help society to make changes at a sufficient speed and scale to achieve sustainability without too many losses for humans and other species during the transition?

Each point is designed to align with the goal of achieving sustainability. If they are not combined, organizations may face financial difficulties, experience a decline in their competitive position, or prioritize easily attainable goals in a less-than-optimal manner. These points have proven valuable in directing inquiries at a comprehensive

level, ensuring that detailed information is organized in a pertinent manner for decision-making purposes. They also provide guidance for analyses and research in situations where the necessary information may be lacking (Holmberg, 1998).

Lastly, to recommend a potential CBM the combined circular BMC framework presented by Kraaijenhagen et al. (2016), which can be seen in Figure 1.4 was used. The recommended potential CBM was formulated by creating additional posts from the identified strategies that were added to the current BM to make it circular.

2.2 Data collection

When doing the backcasting methodology several supporting methods were needed for the data collection, which is presented in the following section.

2.2.1 Interview methodology

The interviews were conducted as a part of the backcasting methodology. To find interviewees for the study the snowball sampling technique was used, which is based on referrals to find suitable persons to interview when doing research (Business Research Methodology, n.d.). According to Business Research Methodology (n.d.), snowball sampling is often used when gathering information from employees at a company. The first interviewees were selected from the persons working with sustainability in Gothenburg. The potential interviewees were asked to participate in the study through email, where the research was briefly described. Each of the interviews had a duration of about 60 minutes and was conducted in Swedish either remotely over Microsoft Teams or in person.

The semi-structured interview methodology was chosen for data collection since it is exploratory and thereby gives a good understanding of the field of research (DeJonckheere & Vaughn, 2019). Questions had been prepared beforehand and were mixed with follow-up questions during the interview. The prepared questions varied in character depending on the role that the interviewee had at the company, but also with the knowledge gained as more interviews were conducted. At the end of each interview, the person was asked to recommend other persons that might be of interest to the research, which were then contacted. The referrals that agreed upon being interviewed were interviewed and then also asked about relevant persons that might be interested in the study. The interviews were conducted until the same information was mentioned during the interviews. Then it was decided that enough information had been gathered.

In total 20 persons at Skanska were interviewed for the thesis. Most of them had different roles within the departments sustainable business development, purchase department, building department, and technical department. The full list of interviewees with their roles and department can be found in the Appendix, Section A.1. The interviews were transcribed, summarised and then mapped.

2.2.2 Internal Information

It is common practice in case studies and qualitative research to use internal information, such as organizational documents, to gather important background information about the organization being studied (Bell et al., 2022). Such documents can provide insights into the organization's culture, values, and history. In this case, internal information provided by Skanska was used to gain knowledge about circularity within both the company and the industry and consisted of recorded online seminars. Skanska has organised online seminars with the purpose of sharing the internal working methods within circularity but also inviting different stakeholders to present their ongoing work on circularity. The primary objective of these seminars was to spread knowledge and awareness within the company about CE practices. In total 17 online seminars were watched and are summarised in the appendix, section A.2.

Furthermore, Denscombe (2018) explains that by using internal information, the research can be made more adaptable, suitable, and useful for the team and the company in the future. Therefore, internal information can provide a more in-depth understanding of the organization's operations, challenges, and opportunities. Additionally, taking into account the ongoing development of circularity in the industry can ensure that the research is relevant and up-to-date, which can increase its impact and usefulness.

2.2.3 Literature Review

The literature review was conducted during the study to deepen the understanding of the subject and also to collect data for the research as a part of the backcasting methodology. A strategic literature search was used when collecting data for the study using the bibliographic resources Google Scholar and Scopus. The searches were conducted using snowballing strategy to find additional literature within the same area. Additionally, grey literature and books were also used for the data collection.

3
Result

In the following chapter, the results of the thesis will be presented. The purpose of the chapter is to present the findings for the research objectives obtained through the conducted research. Given the nature of the thesis and the subject of CE, it is crucial to present the result in a holistic approach to further facilitate the analysis and discussion later in the thesis. For that reason, the results will be presented in an analytical character. Hence, the first objective (e.g., the second step in backcasting methodology) will be sectioned to the perspective of the construction industry and the perspective of Skanska respectively. Thereafter, the second and third objectives (e.g., the third and fourth steps of backcasting) will be conducted from Skanskas's point of view.

3.1 Identification of gaps between the current system and the future

The identification of the gaps between the current system and the envisioned sustainable society is the second crucial step in the backcasting methodology 2.4. To effectively determine the gap, it is necessary to gain a comprehensive understanding of both the industry and Skanska's present status regarding CE. The section aims to provide a comprehensive overview of the current status of the industry and Skanska, highlighting the existing barriers and opportunities that will aid in facilitating the subsequent stages of the process. As mentioned previously, this section will present the current status of the industry and Skanska respectively.

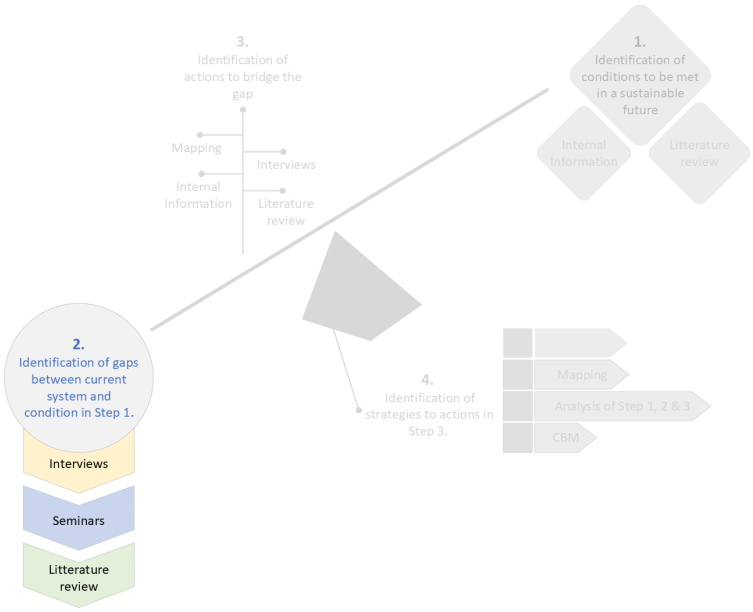

Figure 2.4: Backcasting Step 2: Identification of gaps between the current system and condition in Step 1. Illustrated by the authors and based on the figure found in Holmberg and Holmén (2022)

3.1.1 Overview of construction industry

To be able to understand the current situation, a description of how the construction industry operates is needed to be evaluated. It was identified from the online seminars by actors in the industry and their perception of it. How the industry operates will be presented below and will provide an overview of the construction industry.

Typical for the construction industry is a project-based organisation, which implies that every project is different from others. The project-based organization facilitates a barrier when talking about system change and implementing sustainable practices(Havinga et al., 2023). Each construction project follows a distinct process, which can vary based on the nature of the structure being constructed or the preferences of the client who initiated the project. However, when putting the information from stakeholders together, the general framework of the process can be described as follows:

The client, often a property owner, has an idea for a project. The idea is often generated years before the project starts to be built, which corresponds to the change rate being low in the industry. Since a project takes years from idea to finished product, improvements and implementation of new methods and approaches take a long time. The issue is well discussed in the literature and is one of the greatest barriers to circular development (Spence & Mulligant, 1995).

The client hires consultants to advise on the design, costs are calculated, materials are decided for the project, etc. The client must then get a permit from the

municipality to have the right to build. The municipal decides if the building fits according to the surrounding environment and that it follows any other regulation needed. The client will then hire the construction contractor with the best tender, this is evaluated by parameters that are seen as valuable to the client. From a contractor's view, it is in a tender that they can show why they are the best choice to complete the project. This may include similar projects, skills, different processes and on budget. When it comes to the topic of demand and requirement on sustainability from the client in this stage, most of the stakeholders agree that there is normally lacking. Many stakeholders, including the literature, argue that the client rarely is inclined to pay for it (Varnäs et al., 2009).

The construction contractor that is hired for the project then brings in subcontractors with expert skills in electrics, plumbing, foundation etc. These subcontractors are hired in the same way as the contractor, with a tender to showcase their skills and budget. The role of the contractor is to put all these experts together to build the building. A contractor also purchases materials and coordinates all parts needed to produce a building in time and in line with the budget. One issue discussed is the large number of stakeholders in the process and the various decision that is being made in different stages. Many argue that the issue prevents the multidisciplinary teamwork that is required for sustainable solutions.

Sometimes, before construction begins, demolition must be carried out. The contractor hires a demolition company in the same way, by tenders. The materials from a demolished building are sent to a landfill or recycling, which the demolition company pays for.

The common view on barriers in the context of stakeholders in the construction industry is often associated with the large number of parties involved in the process. Each stakeholder has major challenges contributing to the transition to CE. From the stakeholder's perception of the industry, some specific barriers for each key stakeholder have been identified which are described further below and summarised in Figure 3.1.

Architects
Architects play a critical role in influencing contractors, but the success of implementing CE practises requires acceptance and changes in the design and construction processes. One change that often leads to successful reuse, according to stakeholders, is when the architect, contractor and owners have a close collaboration early in a project. They also play a critical role in circular design which is rarely implemented.

Contractors
Contractors face barriers such as communication issues and a lack of skills or knowledge regarding sustainable construction practices. Since they are dependent on and coordinate stakeholders both up and down the chain of the industry.

Manufacturers
Manufacturers' limited involvement and lack of responsibility in minimizing and handling waste pose additional barriers. It has been mentioned that manufacturing companies should take more responsibility for the way operate and offer more circular products or services.

Owners
Owners' unwillingness to invest upfront, particularly when contractors are not yet appointed, presents a significant challenge.

Deconstruction companies
The lack of deconstruction practises acts as a barrier.

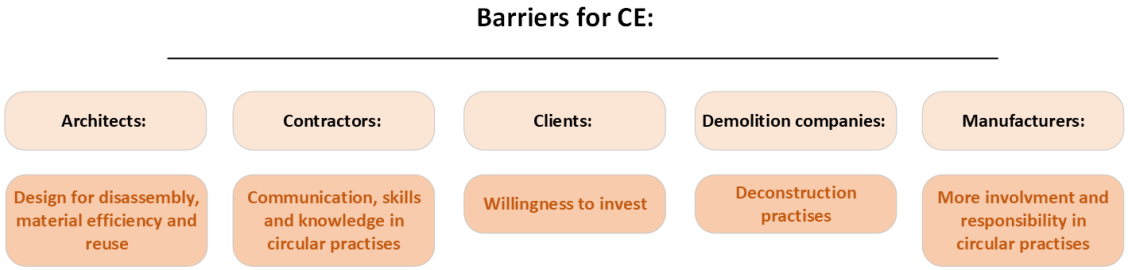

Figure 3.1: Barriers for CE for key stakeholders. Illustrated by the authors.

3.1.2 Organisational

The current situation when it comes to organisational barriers and opportunities within both the construction industry and Skanska is presented below. The main organisational barriers are centred around organisational structures, low competence within circularity and the overall goal of CE. Meanwhile, the opportunities found were mostly about collaboration, communication and the network.

3.1.2.1 Construction industry

The organisational barriers and opportunities found within the construction industry are described below and then the main points are summarised in Figure 3.2.

The literature describes, in the context of the construction industry, that organizational barriers encompass various challenges that impede the flow of information between stakeholders and across different phases of a construction project, consequently affecting its overall efficiency. Key stakeholders, presented above, contribute to the same conclusion and argue that these barriers harm the successful integration of sustainability and circularity considerations. Organizational barriers are frequently discussed and are recognized as significant, therefore a selection of key aspects is divided and includes:

Working methods and new approach
In the case of the reuse of materials and building components, not far from every

seminar by stakeholders mentioned issues correlated to the current linear approach of the industry. Supported by the literature, these barriers are primarily attributed to the fragmented nature of the construction sector and its inadequate organization, highlighting issues associated with the current linear approach. Also, it was found that insufficient support from management, coupled with a lack of maturity and inadequate investment in knowledge management, information systems and continuous planning, are contributing factors.

Key factors that have been found in the seminars are the absence of a holistic approach, limited innovation and ineffective methods. In the discussion on innovation, a waste- and recycling company (in the linear business) showed an example of how they, by innovation, transformed their business to a raw material supplier and a detoxify company in the CE. The person presenting at the seminar argued that companies in the construction industry need to rethink what part they should play in a society dominated by CE.

In terms of a holistic approach, everything is connected. Meaning that companies need to rethink their client, both up and down the value chain. To do so, one stakeholder argues that it requires increased innovation, collaboration and communication, something that is lacking in most companies in the construction industry today.

Multidisciplinary teamwork
As argued by both the literature and stakeholders systematic cooperation and a multidisciplinary approach are crucial for addressing the complexities of sustainable construction and deconstruction. The perspective is supported by authors who have studied decision-making frameworks in the steel industry and applied systems thinking in the construction industry (Rebs et al., 2019). To promote the circular strategies of building components and materials, it is necessary to challenge and change the established design and construction processes. It involves considering the potential for component reuse from the early stages of design, implementing standardized systems for component identification and documentation, and fostering a culture of resource conservation.

Education support for a skilled workforce
One of the obstacles related to competence improvement in the construction industry is the lack of lessons learned on Design for Deconstruction (DfD). Deconstruction involves carefully disassembling and salvaging materials from existing structures. It refers to the challenge of designing buildings and structures in a way that facilitates disassembling of the buildings and the recovery of materials for reuse or recycling. Without sufficient knowledge and experience in the area, stakeholders may struggle to implement effective design strategies for disassembly. Also, the industry will have the same issues regarding disassembly, deconstruction and reuse in the future.

Another obstacle is the lack of documentation to support competence improvement. It highlights the need for proper documentation and knowledge management prac-

tices to capture and share lessons learned from past projects. Insufficient documentation hinders the transfer of knowledge and best practices, making it difficult for stakeholders to improve their competencies in sustainable and circular construction.

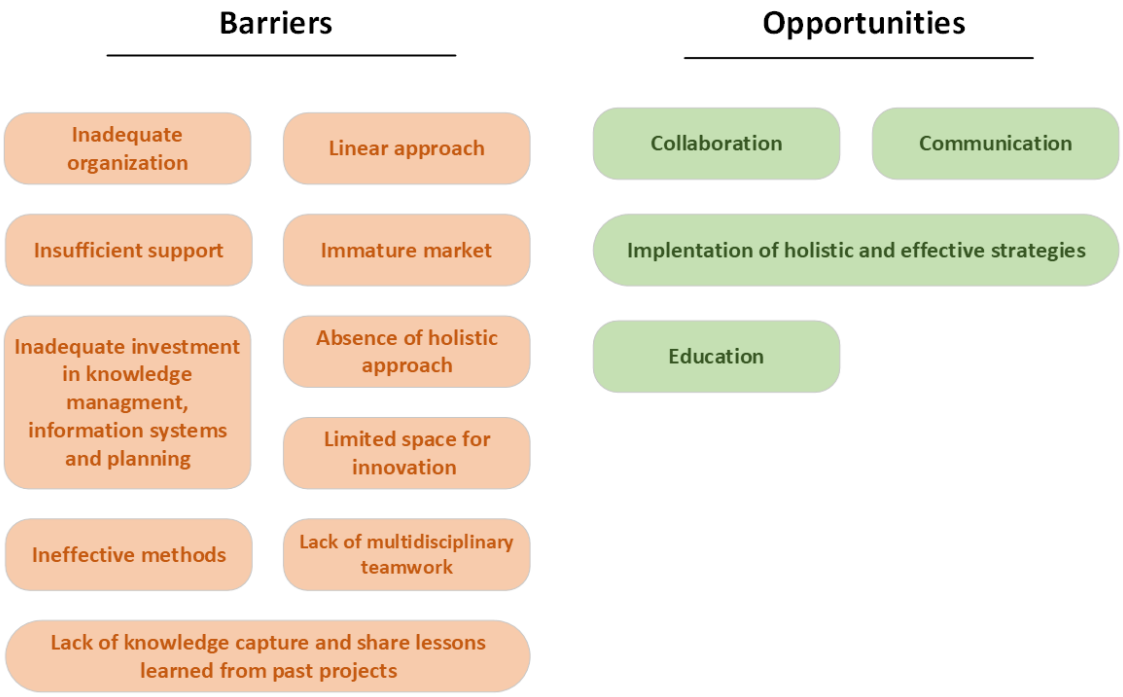

Figure 3.2: Organisational barriers and opportunities in the construction industry. Illustrated by the authors.

3.1.2.2 Skanska

The organisational barriers and opportunities at Skanska are described below and the main points are summarised in Figure 3.3.

Leadership

It is a common view among the interviewees that there is a need for a more clear path and focus when it comes to sustainability. Skanska has as an organisation set a distinct overall goal towards the net zero target by 2045, but the action plan to get there is not as clear. The majority of the interviewees hold the perception that the company is actively engaged in sustainability efforts without a clear strategic direction, resulting in an unclear focus.

Several of the interviewees mention the problem of not knowing which solutions to focus on when it comes to working with sustainability. There is a common view that projects are trying their best to find new sustainable solutions without knowing the direction. One interviewee points out that it is important to take into consideration if the solution will be scalable and not only focus on individual projects. In line with knowing where the focus should be, there is a need for a more clear action plan. According to one of the interviewees, there is a need to clarify the goal with

CE since it is not enough to only have it as an action to reach the net zero target. It is clearly stated in the overall action plan (see Figure 1.1 that Skanska should work with CE but is not stating how it should be worked with, how the circular development is going to be tracked or what the overall goal working with CE.

The consensus among the majority of interviewees indicated a perception of inadequate managerial competence concerning sustainability and that climate should be talked about with a similar degree of significance and consideration as financial matters. Since 2022 Skanska has had a new system for sustainability reporting that the CO_2 emissions from each project are followed up every quarter (Skanska AB, 2022), which means it is still quite new and the effects from demanding climate calculation at each project have not yet been evaluated. When working with CE there is also a need for additional measures to track the circular development at the company

Project-based organisation
Construction companies are a Project-based organisation (PBO) which means that at the end of a project they are handing over the final product to the customer has thereafter no control over the product. Hence, it is one of the largest barriers for construction companies in becoming circular. An interviewee, who possesses substantial expertise in sustainability within the company highlights the fact that since Skanska is a PBO which is characterised by continuous transition from one project to another the implementation of CE practice is limited.

Zhang et al. (2015) highlights several of barriers connected to PBO implementing sustainability. One of the barriers mentioned by the authors is the fact that the cost is affecting most of the decisions at projects, which makes it difficult to work with climate issues since they often come with a cost. Another barrier presented by Zhang et al. (2015) was when the client did not show any interest in working with sustainability, it became more difficult to work with the questions since the construction company did not have any incentives for taking the cost.

Moreover, the senior advisor with a focus on sustainability argues that since Skanska is a PBO it is important to design the buildings so they can be dismantled and reused in the future and thereby contribute to circular processes. According to the interviewee, there is too much focus on trying to use material from old buildings when that energy could be used in the design processes instead to make the buildings for the future better and more sustainable.

Collaborations
To reach the net zero target and for Skanska to become more circular, collaborations are essential. Most of Skanska's emissions come from the value chain (Skanska AB, 2022), which means that to tackle the environmental problems that the company is facing, collaboration will be a key factor in succeeding.

To be able to establish collaboration and close relationships with the material suppliers the purchasing department has a key role. Interviewees argue that the pur-

chasing department should start to work more proactive instead of reactively as they do today. One of the sustainability specialists at the company suggests that the purchasing department should not only focus on financial aspects and suppliers when establishing new relationships but also consider volumes. Furthermore, the sustainability specialist believes that the purchasing department should take greater responsibility for the products, rather than solely focusing on the suppliers, as is traditionally done in purchasing organisations. Therefore, it becomes crucial to enhance the department's knowledge and expertise in sustainability and circularity.

The projects also have a big responsibility when it comes to choosing the best suppliers. Even if the purchasing department does everything in its power to establish relationships with sustainable suppliers it is still up to each project to choose the supplier. Since the suppliers working with sustainable options often are more expensive, it is not always that projects want to pay for it. Several interviewees within the purchasing department express that it is difficult to know what to demand from the suppliers when the projects have not expressed what they want. Furthermore, if the purchasing department establishes a relationship with a supplier that prioritises sustainability there is often an associated cost. However, not all projects are willing to bear this additional expense.

One of the sustainability specialists also acknowledges the barrier of the organisation working on each project is exchanged to the next projects, which makes it difficult to establish relations and collaborations. Another interviewee, who is involved in the field of sustainability, challenges the current types of collaborations by asking if it is possible to work from a broader perspective rather than focusing on individual projects. The interviewee mentions partnering projects as a possibility to develop solutions together that can contribute to a more sustainable future.

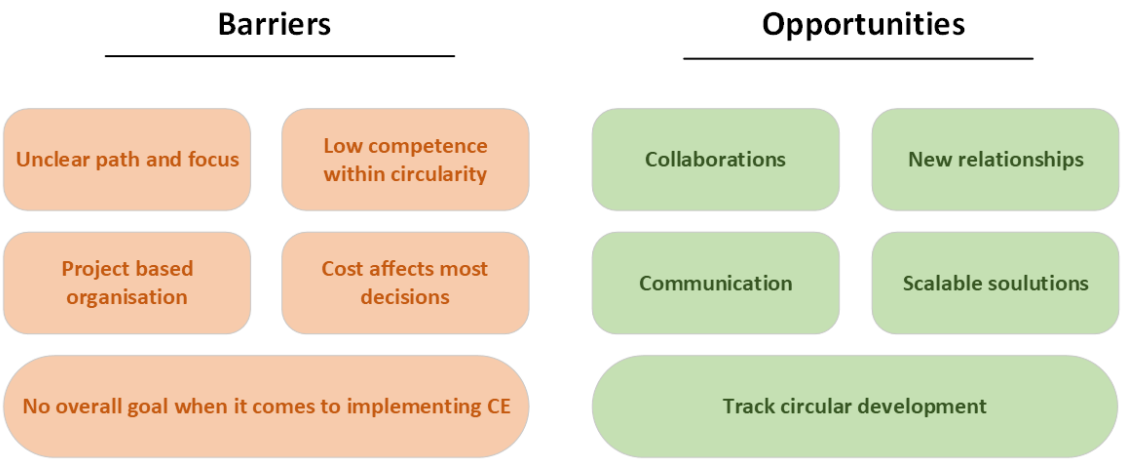

Figure 3.3: Organisational barriers and opportunities within Skanska. Illustrated by the authors.

3.1.3 Economical

The current situation when it comes to economic barriers and opportunities within both the construction industry and Skanska is presented below. The main economical barriers can be summarised into low demand and uncertainties when it comes to CE practices within the industry, while the opportunities were focused on the economic value of working more sustainably and creating a circular ecosystem in the construction industry.

3.1.3.1 Construktion industry

The economic barriers and opportunities found within the construction industry are described below and then the main points are summarised in Figure 3.4.

Economic profitability is a significant consideration in the implementation of sustainable and CE practices in the construction industry. As argued by stakeholders, they face the challenge of demonstrating the economic viability of such approaches compared to conventional methods. The perception of higher upfront costs or uncertainties regarding Return on investment (ROI) act as barriers to adopting sustainable and circular solutions.

Client requirements and their Willingness to pay (WTP) also play a crucial role in driving the adoption of CE practices. The willingness of clients to prioritize and invest in circularity in project objectives can create opportunities and incentives for stakeholders to incorporate these principles into their work. However, it rarely happens according to many stakeholders. In those cases when the client has made investments and prioritized CE practises, it has contributed to the finding of more solutions and continued development of the industry.

Deconstruction can be seen as both a barrier and a possibility. While the literature highlights the challenges associated with deconstruction, interviews with industry experts reveal the potential for deconstruction to offer economic and environmental benefits, such as reduced waste and lower material costs. From a seminar by a demolition expert, it was found that deconstruction practice indeed increases both time and cost. Despite that, economic benefits in avoiding sending materials to landfill were found, providing an opportunity for economic viability for circular management of old building materials and components.

Many authors argue that the availability of new products that are cheaper than old or reused ones can influence decision-making in construction projects. If sustainable and circular products are more expensive or perceived as less cost-effective, stakeholders may be hesitant to adopt them. However, the development of cost-competitive alternatives can encourage the use of reused materials and components. For example, one existing stakeholder for steel beams offers the same price on reused steel beams as newly produced ones. By offering the alternative it can influence the perception of cost-effectiveness and the hesitation to the adoption of circular products.

Designing for material efficiency is a circular aspect that many stakeholders are doing today. The purpose of designing a building component by using fewer materials is to save money. However, despite the cost-driven purpose, it is also a CE practice that shows economic viability.

Efficiency and cost considerations are crucial factors when choosing construction methods. The desire to complete projects fast and in the most economical way can sometimes conflict with the principles of sustainability and circularity. The additional time required for deconstruction or the implementation of CE practices may be perceived as an extra cost, posing a potential obstacle. Furthermore, the necessity of upfront planning and investment in the early stages of an asset's life cycle is another obstacle. Without the willingness of the client to allocate resources and prioritize sustainability from the outset, it can be challenging to integrate sustainable and circular approaches effectively.

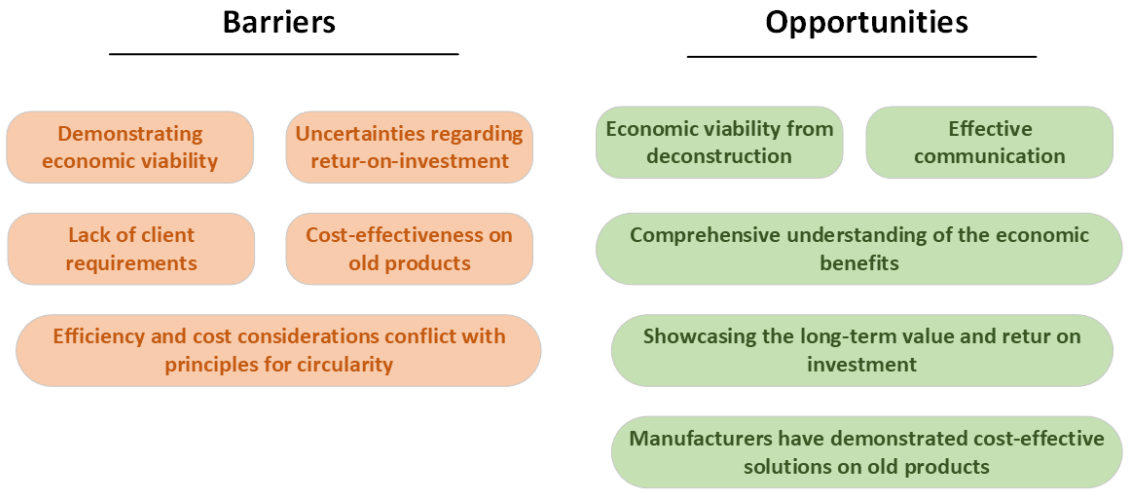

Figure 3.4: Economical barriers and opportunities in the construction industry. Illustrated by the authors.

3.1.3.2 Skanska

The economical barriers and opportunities at Skanska are described below and the main points are summarised in Figure 3.5.

Market

Based on the findings from the interviews conducted, it has become evident that despite the shared objective of achieving the net zero target by 2045 among many clients, there is a noticeable gap in the demand for climate actions and the willingness to invest in sustainable solutions within the construction industry. It raises a critical concern for Skanska and other actors within the construction industry, as the success of their CE initiative relies heavily on the alignment and active participation of clients and stakeholders.

One of the key insights shared by an interviewee with extensive experience in sustainability is that Skanska's commitment to driving change is not enough on its own. While the company may be eager to embrace CE practices, the same level of enthusiasm and dedication. Without collective commitment, the transition to a circular construction industry becomes challenging to accomplish.

The interviewee further suggests that the construction industry requires an entirely new system to effectively integrate CE principles. There is a need to go beyond isolated efforts or individual projects and instead have a holistic approach that induces all aspects of the industry's operations, from design and construction to maintenance and demolition. Achieving circularity requires a fundamental rethinking of processes, materials and BM to ensure a sustainable and regenerative approach throughout the entire life cycle of buildings.

However, the road to achieving such a comprehensive transformation is not without its challenges, It requires collective effort from Skanska, stakeholders and clients to drive significant change within the construction industry. It is important to commit to collaboration, knowledge sharing, and continuous improvement. By working together, the construction industry can overcome barriers and develop innovative solutions that not only meet sustainability goals but also deliver tangible benefits in terms of environmental impact, resource efficiency, and long-term economic viability.

Figure 3.5: Economical barriers and opportunities within Skanska. Illustrated by the authors.

3.1.4 Technological

The current situation when it comes to technological barriers and opportunities within both the construction industry and Skanska is presented below. The main barriers can be summarised in the lack of circular design and uncertainties in the quality of reused material. The opportunities found were innovations and systems support.

3.1.4.1 Construction industry

The technological barriers and opportunities found within the construction industry are described below and then the main points are summarised in Figure 3.6.

Building-related barriers
The design of buildings that were not originally made with a focus on Sustainable End-of-Life (SEOL) considerations can pose challenges in implementing CE practices. These buildings may not have been designed with disassembly or material recovery in mind, making it more difficult to effectively deconstruct and reuse or recycle building components.

During the use phase of a building's lifetime, different components may need to be updated or replaced at varying intervals. It introduces complexity in managing the life cycle of the building and its components. Coordinating the replacement or refurbishment of different components sustainably and efficiently requires careful planning and consideration of the CE principles.

Deconstruction, which involves carefully dismantling a building to recover materials for reuse or recycling, can encounter limitations due to space constraints. The process requires adequate space to manage the deconstruction activities and store salvaged materials. Limited space can pose logistical challenges and may impede the efficient execution of the deconstruction process.

Another barrier is the lack of recovery facilities and infrastructure for components. Without proper facilities and infrastructure in place, it can be challenging to effectively manage the recovery and processing of building components for reuse or recycling. The absence of specialized facilities and the associated logistics can hinder the implementation of CE practices.

Addressing these challenges requires a proactive approach that involves redesigning certain building components, integrating disassembly-friendly features, and developing strategies to optimize the deconstruction process within space limitations. Additionally, investment in recovery facilities and infrastructure is crucial to support the effective implementation of CE practices in the construction industry.

Material-related barriers
The low quality of materials can act as a barrier to implementing CE practices in the construction industry. Poor-quality materials may have limited potential for reuse or recycling, reducing their value in the CE. It can result from factors such as inadequate material specifications, improper handling or storage, or the use of low-quality construction techniques.

A lack of available data poses another challenge. Access to comprehensive and reliable data on materials, their properties, and life cycle characteristics is essential for making informed decisions regarding material recovery and reuse. Insufficient data availability hinders the ability to assess the feasibility and viability of CE practices. Weak data management practices regarding recovered materials can further hinder circular efforts. Inadequate systems for tracking and managing data on recovered materials, combined with limited collection points for these materials, create limitations in material availability. Improved data management and a more extensive

network of collection points are needed to enhance the availability and accessibility of recovered materials.

The recoverability of construction materials is also limited by several factors. First, the process of deconstruction itself can cause damage to materials, reducing their quality and potential for reuse. Second, contamination with hazardous materials poses challenges in safely and effectively recovering and re-purposing construction materials. Third, the deterioration rates of materials over time are often unknown, making it difficult to assess their viability for reuse or recycling. Lastly, the underestimation of the resources embedded in the building during the initial design and construction phases can lead to inefficient material recovery and hinder CE practices.

Technology-related barriers
Technological barriers in the construction industry often revolve around the absence of suitable tools and procedures such as a lack of common framework and automatic calculation procedures. Moreover, the lack of science-based, user-friendly tools acts as a barrier that otherwise would help assess the environmental performance, resource efficiency and cost-effectiveness of a building. Another mentioned barrier is the lack of specific tools for designers that would enable efficient deconstruction and help assess deconstruction waste generation. Without tools, it is difficult for designers to incorporate circular considerations into their design processes and make informed decisions regarding material choices. Finally, reusing reclaimed materials is a fundamental aspect of CE. However, the lack of techniques and processes specifically tailored for the reuse of reclaimed materials poses a significant barrier.

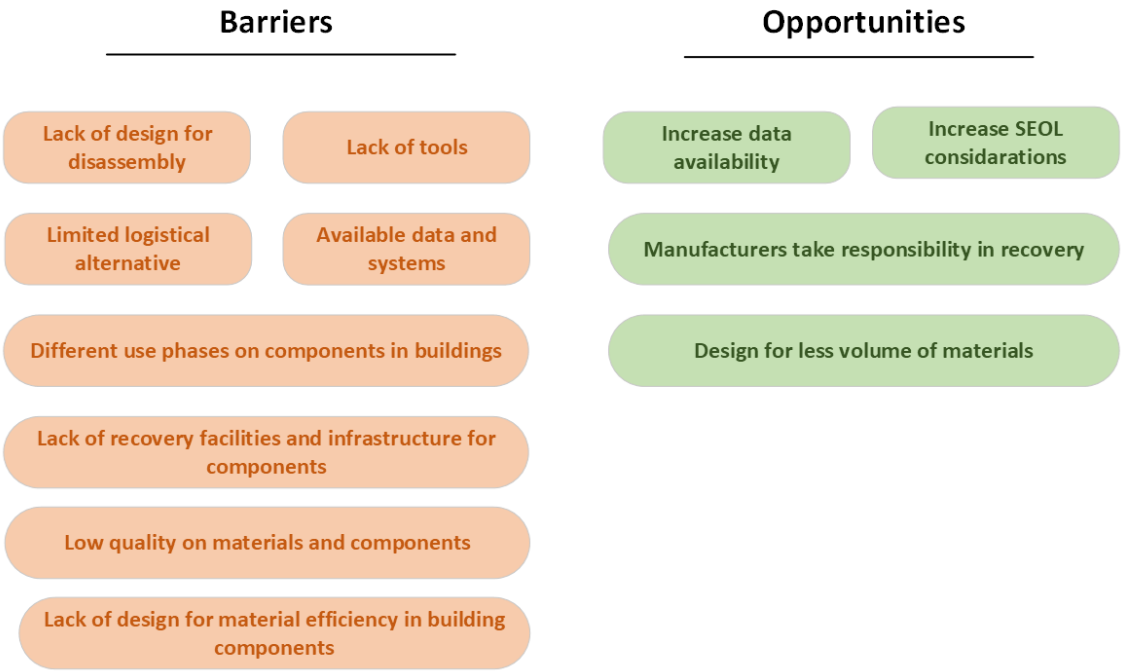

Figure 3.6: Technological barriers and opportunities in the construction industry. Illustrated by the authors.

3.1.4.2 Skanska

The technological barriers and opportunities at Skanska are described below and the main points are summarised in Figure 3.7.

Quality
When considering sustainable alternatives or the reuse of materials, the aspect of quality becomes a significant point of discussion. When incorporating new materials into projects, uncertainties regarding quality arise and any unforeseen issue can lead to significant costs for the projects. To ensure quality standards for new sustainable materials, Skanska has established an initiative that involves a dedicated quality group conducting evaluations upon request. In order for projects to access the expertise of the quality group, they are required to submit an application and contribute funding towards the research. The requirement primarily aims to ensure that the project is committed to using the material once it has been evaluated. However, it is worth mentioning that there is currently no equivalent group available to evaluate reused materials.

By establishing a quality group and evaluation process for new sustainable materials, Skanska aims to mitigate potential risks and ensure that the selected materials meet the necessary quality standards. This proactive approach helps minimise the risks of encountering quality-related issues that could have detrimental effects on the timeline and costs of the project. Nonetheless, it is crucial to explore alternatives for evaluating and ensuring the quality of reused materials as well, considering their increasing significance in sustainable construction practices.

Innovation
In addition to the aforementioned considerations, the importance of innovations emerges as another key factor in sustainable solutions. One of the interviewed experts in the field of sustainability highlights a recurring issue of redundant constructions that could have been integrated into a single, more efficient solution. To illustrate this point, the example of solar cell roofs is provided, where the conventional approach involves constructing the roof separately and then installing solar cells on top. However, by integrating these elements into a single product, it would yield several benefits, including improved material efficiency and reduced construction time.

The observations shed light on the potential for innovations to optimise sustainable solutions by eliminating unnecessary redundant constructions and finding more streamlined approaches. By reimagining traditional construction practices and seeking integrated solutions, it becomes possible to achieve greater material efficiency, reduce waste, and enhance overall project efficiency. Innovation is an important part of driving the progress of sustainable development, encouraging stakeholders to explore new ideas and alternative methods that can lead to improved outcomes in terms of both environmental impact and construction efficiency.

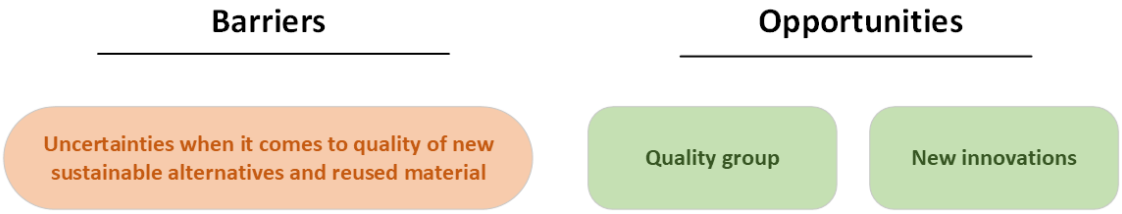

Figure 3.7: Technological barriers and opportunities within Skanska. Illustrated by the authors.

3.1.5 Social

The current situation when it comes to social barriers and opportunities within both the construction industry and Skanska is presented below. The main social barriers relate to social factors, including culture, knowledge, values and human behaviour. Meanwhile, the opportunities found were demonstrating, creating and fostering understanding, knowledge and incentives.

3.1.5.1 Construction industry

The organisational barriers and opportunities found within the construction industry are described below and then the main points are summarised in Figure 3.8.

In terms of cultural aspects, societal trends and cultural norms influence the acceptance and adoption of CE practices in the construction industry. Resistance to change arises due to ingrained cultural practices and established ways of doing

things. For example, a linear thinking mindset and ignorance of life cycle thinking hinder the transition to circular approaches. Supported by the literature, the construction industry is known to have resistance to change. However, as new people enter the industry, cultural practices are being challenged.

Human behaviour plays a crucial role in the adoption of new practices. The resistance to change is a commonly cited barrier in the literature, indicating a reluctance to embrace new ideas and approaches. Scepticism and a preference for traditional methods within the industry create resistance from manufacturers, builders, and owners. Consumer culture and attitudes towards the quality of salvaged and used items can also act as obstacles. However, the notion is strongly divided stakeholders. Some argue that the next generation of consumers' attitudes toward reuse products will generate different consumer preferences than today. Meanwhile, others argue that the preferences will remain the same.

Lack of knowledge and awareness of circularity and sustainability are well-discussed barriers in the literature and is supported by the stakeholder's perception of the current state of the industry. The lack of knowledge and awareness of stakeholders appears to be unawareness of various approaches, their benefits, and how to implement them effectively.

Some stakeholders also exhibit resistance to accepting reclaimed materials, which are essential for CE practices. Impatience to obtain a quick ROI can create an unfavourable business culture that hinders the acceptance and use of reused materials.

In the discussion of value, not far from all companies in the industry have ambitious public sustainability goals. However, it has been found that the underlying structure in the industry still holds the belief that the value of sustainability is not perceived as monetary value. In numerous projects where the decision between a slightly more expensive sustainable solution and a cheaper non-sustainable alternative was presented, the client adopted the cheaper option. In other words, the action or decision was not in line with the public sustainability goal for the company. Furthermore, it raises the importance of reflecting on the underlying motivations of sustainability in the industry. Accordingly, the industry seems to be driven by cost considerations, market advertising or enhancing its portfolio for competitive advantages rather than a desire to have a positive impact on the environment.

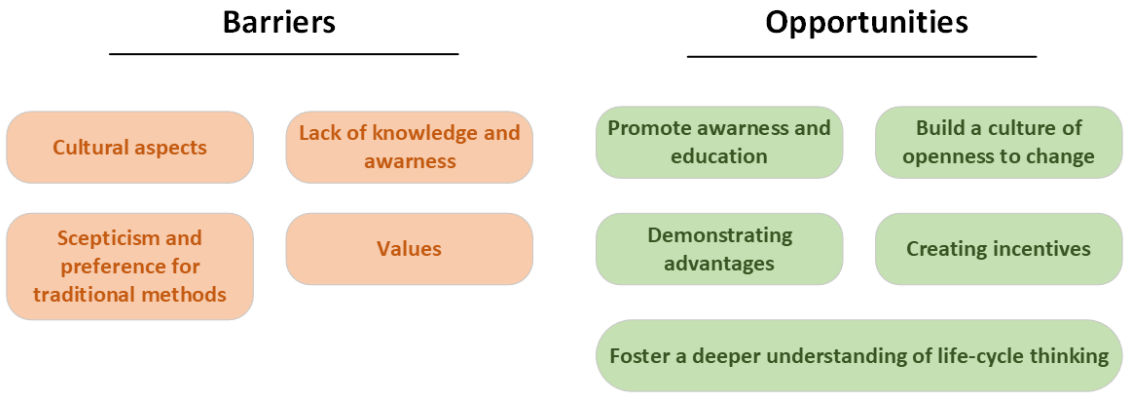

Figure 3.8: Social barriers and opportunities in the construction industry social. Illustrated by the authors.

3.1.5.2 Skanska

The social barriers and opportunities at Skanska are described below and the main points are summarised in Figure 3.9.

Mindset

The interviews have revealed a pressing need to shift the mindset regarding sustainability practices. A sustainability specialist at the company draws a parallel with questions regarding the working environment and points out that the profitability of addressing such issues is unquestionable and self-evident. However, the interviewee raises concerns about an excessive focus on immediate profitability in sustainable solutions. The interviewee continues by highlighting the fact that addressing the climate crisis will incur costs as it is an urgent reality that cannot be postponed. Skanska aims to have a leading role in the transition to CE, which will require financial investment, as no other company in the construction industry has achieved this transformation before.

Numerous interviewees have highlighted the importance of critically assessing the necessity of demolition, given that the most substantial gains in terms of economic viability, time efficiency and reduction of CO_2 emissions are achieved through rebuilding rather than demolishing. The interviewees have prompted a reconsideration of the prevailing tendency to prioritise new construction projects continuously, urging a paradigm shift towards the reuse of older buildings. By challenging the prevailing assumptions, the interviewees advocate for a more sustainable approach that recognises the untapped potential of existing structures instead of defaulting to new constructions as the primary solution.

One of the interviewees emphasizes the importance of fostering a culture in a project that embraces the willingness to try new things without the fear of things going wrong. The interviewee advocates for an open mindset that encourages projects to try new things, as even if the outcome does not align with the initial plans, there is still valuable knowledge to be gained. This approach recognises the inherent value

of learning through trial and error.

By trying new things, projects can uncover innovative solutions and unconventional approaches. Failure, in this context, should not be seen as a negative outcome, but rather as a valuable learning opportunity. Each new thing tried, regardless of the outcomes, contributes to the collective understanding and growth within the project organisation and Skanska.

To ensure that the experiences are not lost, it is crucial to document the process and outcomes of trying new things. This documentation becomes a valuable resource that can be shared among colleagues and future projects. By disseminating the knowledge gained from these experiences, the organisation can collectively benefit from the insights, discoveries and lessons learned along the way.

Competence
Several of the interviewees highlight the need to increase competence within the company when it comes to sustainability and working with CE. A manager at the purchasing department suggests a "competence ladder" and continues with the need for the knowledge about sustainability to be easy to learn.

Several of the interviewees point out the fact that management has a low competence when it comes to climate questions and therefore it is difficult for them to demand it.

Many of the interviewees discuss the fact that there is not enough to have a sustainability department working with the questions about the climate, but every employee should have sustainability integrated into the role. In projects, it is important for them to feel a personal investment in the question.

Knowledge sharing
When asking about how knowledge is shared amongst employees at the company it becomes clear that there is no systematic knowledge sharing at the company. According to one of the interviewees, Skanska is characterised as a relationship-oriented company, where individuals are generally helpful and willing to provide answers to inquiries. However, there is a need for employees to have a clear understanding of what information they seek and whom to approach.

Currently, Skanska has several pilot projects testing new sustainable materials and integrating reused materials in their construction processes. An interviewee involved in one of these pilot projects has had multiple site visits and seminars to share knowledge and experiences. These pilot projects serve as valuable learning opportunities, as they provide insights into the practical implementation of sustainable solutions. By learning from both successful and challenging experiences, Skanska can effectively apply these lessons to future projects, thereby driving the overall development of the company.

Ensuring systematic knowledge sharing is of utmost importance for Skanska to achieve its net-zero target. Some interviewees expressed the need for digital support or tools to facilitate the collection and organisation of data from various projects. Such digital platforms can serve as repositories for project-related information enabling efficient knowledge sharing and access to valuable insights.

By establishing a systematic approach for sharing experiences, best practices, and lessons learned, Skanska can enhance its collective knowledge base and accelerate progress towards its sustainability goals. Embracing digital solutions to facilitate data collection can further support the efficient sharing of information across the organisation, fostering a culture of continuous learning and improvement.

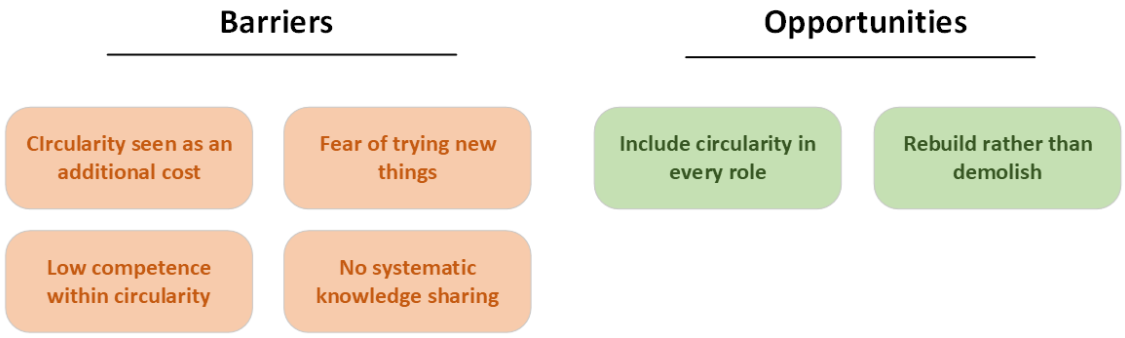

Figure 3.9: Social barriers and opportunities within Skanska. Illustrated by the authors.

3.1.6 Political

The current situation when it comes to political barriers and opportunities within both the construction industry and Skanska is presented below. The main barriers can be summarised as a lack of standards, policies and regulations. The opportunities found were certifications, incentives and the inventory law.

3.1.6.1 Construction industry

The political barriers and opportunities found within the construction industry are described below and then the main points are summarised in Figure 3.10.

Some stakeholders, especially contractors, argue that current regulations are overly strict and do not allow for innovation. In other words, they point out that building permits do not allow for flexibility in ecstatic and warranties when trying to use old materials or components. The strict regulation limits the flexibility and creativity required for implementing CE practises and impedes innovation. However, since the industry collectively has raised the major issue, the authorities are currently investigating how laws and regulations can be adapted to foster CE practises. Depending on the result of the investigation, they have stated that the regulations can be changed.

The absence of standardized processes, best practice sharing, and clear guidance further acts as barriers in the adoption of CE practises. It was found that companies lack clear information and guidance on the design and procurement procedures to follow when reusing components. The absence of re-certification, legal warranties, and residual performance analysis of recovered building materials also contribute to the barriers.

The common sense of the key stakeholders is the lack of fiscal incentives or support from governments. Incentives such as tax benefits or financial support for circular initiatives would encourage the adoption of these practices.

The absence of suitable assessment procedures, especially in architectural competitions, can hinder the integration of CE principles. Late assessment processes during the design phase and a lack of labelling or measurement standards contribute to the barriers in implementing CE practices effectively.

Some regional governments may be slow in applying construction and demolition waste management plans that have already been approved. Delays in implementing these plans can impede progress toward sustainable and CE practices in the construction industry. There is a new legal requirement to do an inventory before demolition on materials that have the potential for reuse. However, according to stakeholders, the inventory is only required to be done, not to be followed up. Resulting in materials not being reused due to the previously mentioned challenges it faces.

Several stakeholders agree that certifications in the building are a strong driver when it comes to sustainability practices. The certifications provide a guarantee that they follow the EU taxonomy meaning that there is no other measurement that would ensure that they operate to meet the environmental goals. Therefore, suggestions on their behalf are to integrate circular elements in the certifications. Accordingly, it would increase the drive for implementation of CE practises.

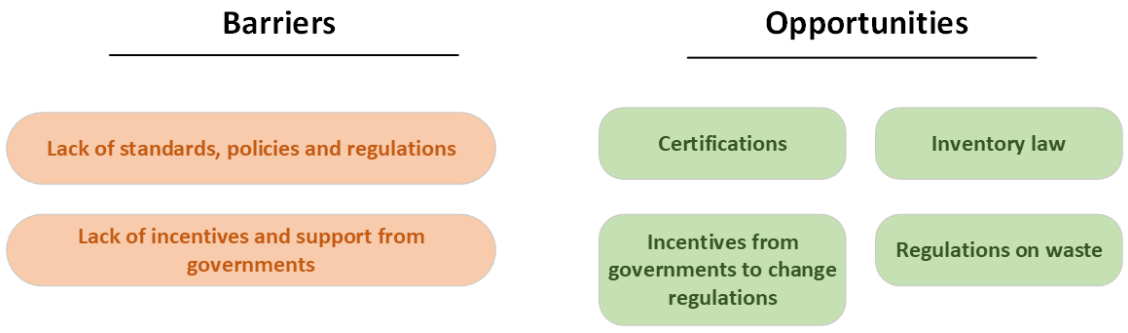

Figure 3.10: Political barriers and opportunities in the construction industry. Illustrated by the authors.

3.1.6.2 Skanska

The political barriers and opportunities at Skanska are described below and the main points are summarised in Figure 3.11.

Climate measurements
Uncertainties and concerns among employers arise when it comes to measuring sustainability within the company. Considering the unclear goals and where to put the focus there is also a need to clarify and have more measurements when it comes to the climate. All projects are doing a climate calculation where the CO_2 emissions for the project are calculated. Since January 2022 it is mandatory to do a climate declaration for new buildings (Boverket, 2021). However, despite the legal framework in place, uncertainties persist due to the relative novelty of the approach. The interviews reveal a lack of data from material suppliers, as well as uncertainties surrounding the calculation and interpretation of emission numbers. When the interviewee was questioned about determining an ideal emissions benchmark and whether the organisation is making progress towards the net-zero goal, a definitive answer could not be provided. The lack of clarity highlights the current absence of a standard for acceptable emissions levels and the challenges in assessing progress towards achieving net-zero CO_2 emissions.

Furthermore, multiple questionnaires highlight the importance of managers discussing CO_2 emissions with the same level of proficiency as they discuss financial aspects, a practice that is currently lacking. To facilitate informed inquiries about climate calculations, managers require appropriate education and training to enhance their confidence in addressing these complex matters. The active engagement of managers is important since when management demands attention to a specific aspect, it receives more focus in the projects. Conversely, when certain aspects are not requested, there is a lower chance of actions being taken. Therefore, providing managers with the necessary knowledge and empowering them to prioritise climate considerations creates a culture that fosters environmental awareness and encourages proactive measures.

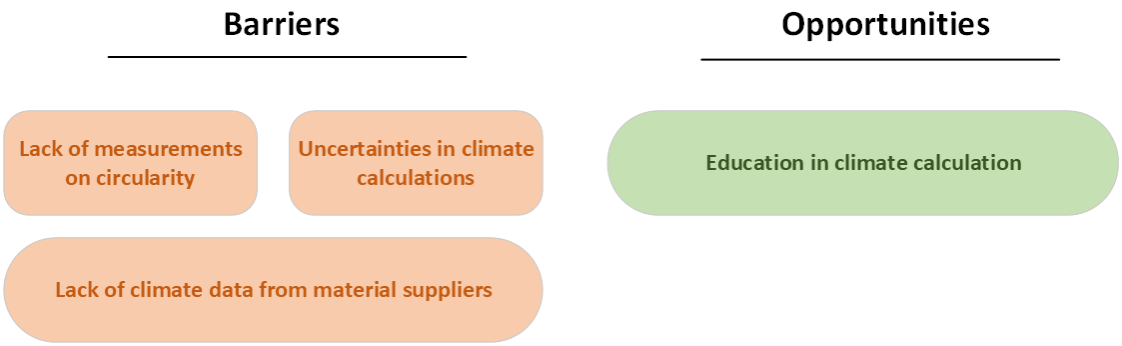

Figure 3.11: Political barriers and opportunities within Skanska. Illustrated by the authors.

3.1.7 Environmental

The current situation when it comes to environmental barriers and opportunities within both the construction industry and Skanska is presented below. The main barriers refer to a lack of awareness and understanding of benefits associated with CE practices. The main opportunities found were education and circular design.

3.1.7.1 Construction industry

The environmental barriers and opportunities found within the construction industry are described below and then the main points are summarised in Figure 3.12.

Some authors and stakeholders may not directly link pollution and environmental issues but rather view them as cost-related concerns. The lack of awareness about the environmental impact of construction processes can hinder the adoption of sustainable practices. It is important to raise awareness about the environmental consequences of traditional construction methods and highlight the benefits of sustainable alternatives.

Often environmental awareness, in the industry, is limited to the subject of toxic substances in materials or emissions. Stakeholders argue, that its lack of holistic environmental understanding prevents CE practises in the industry. Therefore, it is not surprising that the issue of toxic substances in old building materials is raised in discussions about reuse. Some stakeholders mention that it is a barrier despite a showcase of the company, Lendager Group from Denmark, that presents great examples of how to detoxify materials and use them again.

Many studies have identified a lack of strong evidence demonstrating the environmental and sustainability benefits of CE practises. The absence of comprehensive data and research can create uncertainty and scepticism among stakeholders.

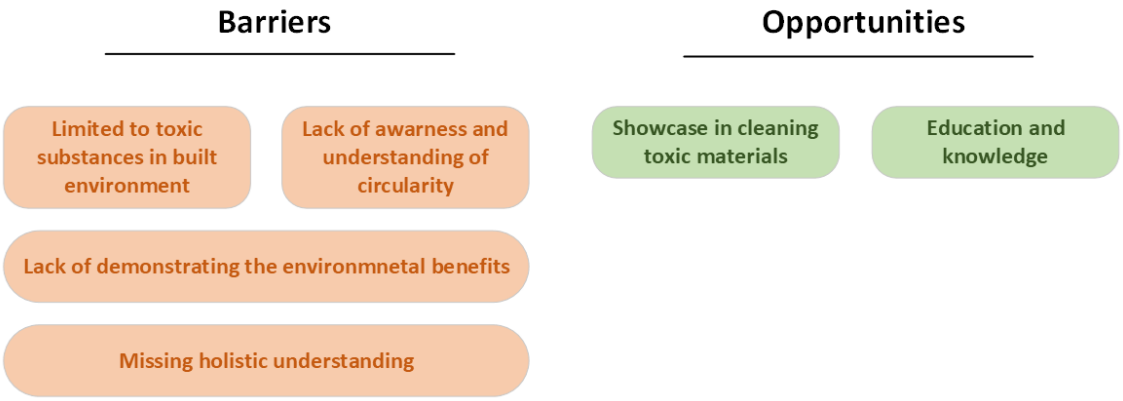

Figure 3.12: Environmental barriers and opportunities in the construction industry. Illustrated by the authors.

3.1.7.2 Skanska

The environmental barriers and opportunities at Skanska are described below and the main points are summarised in Figure 3.13.

Reuse
Currently, Skanska is engaged in limited-scale reuse initiatives, primarily implemented through pilot projects that possess a well-defined climate profile. However, such practices are still far from being ingrained as a fundamental component in projects across the organisation. In a specific region in Sweden, there exists an ambition to incorporate at least one instance of reuse in every project undertaken. It is worth noting that when discussing the concept of CE, the majority of the interviewees primarily associate it with the notion of reuse, despite its broader scope and implications.

A senior advisor at the company, possessing extensive experience in sustainability, highlights that while reuse is an important aspect of CE, it is just one component of a much broader concept that encompasses resource reduction. The interviewee points out that projects often excessively focus on the disposal part, attempting to utilize items produced several decades ago, which the interviewee believes is a time-consuming and energy-intensive approach. Instead, the interviewee suggests that projects should begin by analysing how they can enhance material efficiency during the design and construction process, as well as in the context of DfD. Additionally, the interviewee highlights the effectiveness of combining material efficiency with productivity, asserting that such an approach would serve as a highly efficient starting point for embracing the principles of CE.

The interviewee, possessing significant expertise in sustainability, further argues that scaling solutions within reuse poses considerable challenges. The primary reason behind this difficulty lies in the contrast between the number of new buildings being constructed and the relatively fewer buildings being demolished. Even if Skanska excels in material reuse, its climate impact would be limited in the larger context. A more comprehensive approach that integrates material efficiency, circular design and waste reduction is necessary to drive significant change in the construction industry.

Design for Deconstruction
There is a great potential in working proactively with sustainability measures during the design process one of them being DfD. One of the interviewees with great knowledge of sustainability argues that circularity should not solely focus on reusing material from decades-old demolished buildings. Instead, at least equal attention should be given to the design process, as it significantly impacts the future potential of reuse. Several interviewees advocate for a greater emphasis on disassembling and deconstruction as part of a forward-looking approach. It is also one of the solutions being mentioned by Hossain et al. (2020) when presenting potential solutions connected to challenges within design when implementing CE in the construction industry. Furthermore, Hossain et al. (2020) highlights the importance of taking materials durability and End-of-Life (EOF) into consideration during the design

process.

Implementing DfD facilitates future material reuse by enabling easier disassembly of buildings. However, it is important to note that DfD may not have an immediate impact on short-term CO_2 emissions reductions, making it challenging to prioritise among sustainability solutions. It is because many companies are actively striving to achieve net-zero targets. Currently, there are no existing measures that assess a building's potential for future deconstruction and its associated benefits.

Material efficiency
One of the interviewees, who possesses substantial knowledge in the field of sustainability, argues that material efficiency is not receiving the attention it deserves in terms of climate savings. Instead, the main focus has been on circularity and material reuse within the construction industry. The interviewee continues that if materials were used more effectively, there would be both environmental and economic benefits. The construction industry is a significant consumer of materials. According to a study by Ruuska and Häkkinen (2014), the building sector uses around 50% of the resources extracted in Europe. Even though most of the materials and key components used are not scarce resources, there might be a shortage of materials in the future. Ruuska and Häkkinen (2014) acknowledges that material efficiency is crucial when it comes to reducing GHG emissions since it has a large saving potential. Besides the environmental benefits of material efficiency, it has economic benefits as well, since it will not only save the cost of using more material but also labour hours due to the increased productivity (Ruuska & Häkkinen, 2014).

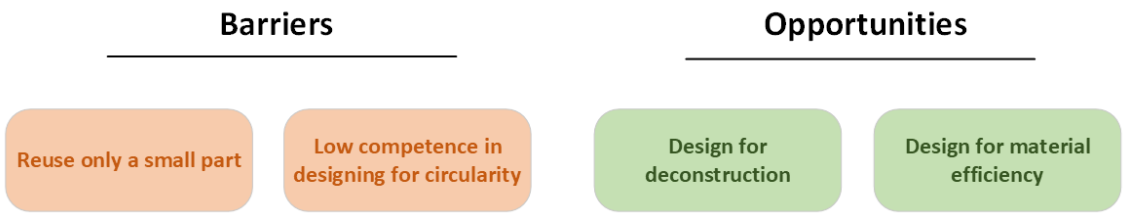

Figure 3.13: Environmental barriers and opportunities within Skanska. Illustrated by the authors.

3.2 Actions to bridge the gap

In the backcasting methodology the third step, shown in Figure 2.5, involves the identification of actions that can effectively bridge the gap between the current status and the envisioned future society. It is achieved by evaluating the parameters that require change. In the subsequent section, specific actions are formulated to bridge the gap between the present state and the desired future state for Skanska as an integral part of the industry. To identify and develop appropriate actions, the summary of barriers and opportunities from the previous step is utilized as a valuable resource.

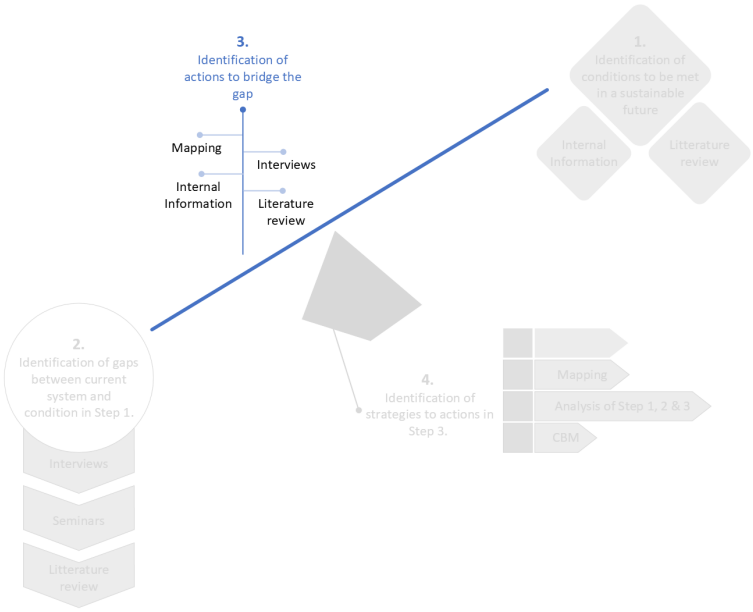

Figure 2.5: Backcasting Step 3: Identification of actions to bridge the gap to the future scenario. Illustrated by the authors and based on the figure found in Holmberg and Holmén (2022)

The actions identified for Skanska to implement to lead the transition to CE is; *Implement circular design*, *Develop competence within circularity*, *Ensure a circular value chain*,*Manage CE practices* and *Track the circular development*. An overview of the actions is presented in Figure 3.14 and briefly explained in the following section where a more detailed explanation of its meaning will be provided in sections under each strategy.

Figure 3.14: Actions to bridge the gap. Illustrated by the authors.

3.2.1 Implement circular design

Implementing circular design is identified as a key action for Skanska to take a leading role in the transition to CE. It has significant potential to reduce the overall resources consumed by the company. By adopting circular design principles, Skanska can optimise material efficiency, minimise waste generation, and enable the reuse of materials, thereby contributing to the sustainable and responsible use of resources.

3.2.2 Develop competence within circularity

The study has revealed a notable gap in the company's competence regarding circularity. As a result, developing competence within circularity has been identified as a crucial action for Skanskato take a leading role in the transition to CE. By enhancing the company's expertise in CE, Skanska will position itself at the forefront of sustainable construction practices, driving positive change within the construction industry. The strategic investment in competence development will enable Skanska to proactively address future challenges within CE.

3.2.3 Ensure a circular value chain

Given the role of a contractor and the multitude of stakeholders involved in each project, establishing a circular value chain becomes highly relevant in facilitating the potential transition to a CE within the industry. Additionally, considering that

Skanska cannot achieve full circularity without the active participation of stakeholders, ensuring a circular value chain becomes exceptionally important. The current status assessment reveals a lack of engagement and responsibility from material suppliers and manufacturers, as well as reluctance from clients to invest in circularity and sustainability. Therefore, to facilitate the transition to a CE, it is crucial to provide the necessary support to the value chain, addressing their needs as a top priority. Another aspect identified in the current state is the need to rethink clients, meaning that efforts should be made to attract clients who are inclined towards fostering a closed-loop system, thereby contributing to the circularity of the industry.

3.2.4 Manage Circular Economy practices

When it comes to managing CE practices, the significance of establishing an appropriate organizational structure becomes evident based on the identified barriers. This entails restructuring the organization to promote the advancement of CE practices. Additionally, enhancing leadership capabilities and creating a conducive working environment are crucial factors that contribute to the successful implementation of CE initiatives.

3.2.5 Track the circular development

It is important to be able to assess circularity to be able to track the progress of the work. Therefore, tracking the circular development is identified as an action for Skanska to lead the transition to CE. From January 2022 Boverket required climate declaration of all new buildings constructed (Boverket, 2021), which is one step in the right direction of getting more aware of how the emissions from projects. Since 2022 Skanska started to follow up the CO_2 emissions quarterly (Skanska AB, 2022), which probably is an effect of the stricter requirements from Boverket. In the report Boverket (2023) that was newly released Boverket states that limits in the climate declaration will be established on the first of July 2025 as soonest. To guide towards high energy efficiency and solutions supporting future reuse, flexibility etcetera other means of control probably will be necessary according to Boverket (2023).

3.3 Action strategies

The fourth step of the Backcasting methodology illustrated in Figure 2.6, involves the formulation of strategies for the actions identified in the previous section. In the subsequent section, these strategies will be presented. Moreover, the strategies will be tailored and adapted to Skanskas' current BM, ensuring they align seamlessly and facilitating the presentation of a recommended potential CBM.

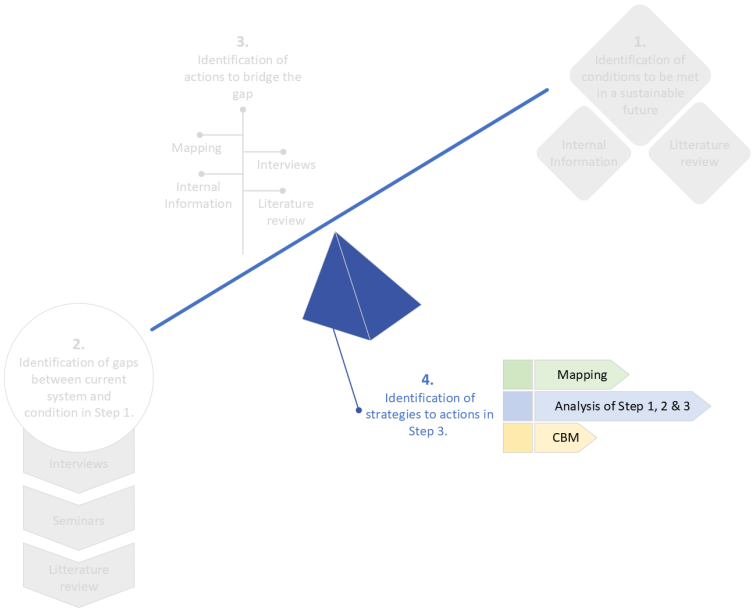

Figure 2.6: Backcasting Step 4: Identification of strategies to actions in Step 3. Illustrated by the authors and based on the figure found in Holmberg and Holmén (2022)

The strategies are developed based on a guiding set of principles presented in the method chapter, offering a structured approach to strategic planning that aids the company in achieving its sustainability objectives. An overview of the identified strategies for each action is presented in Figure 3.15 and is further explained in the section.

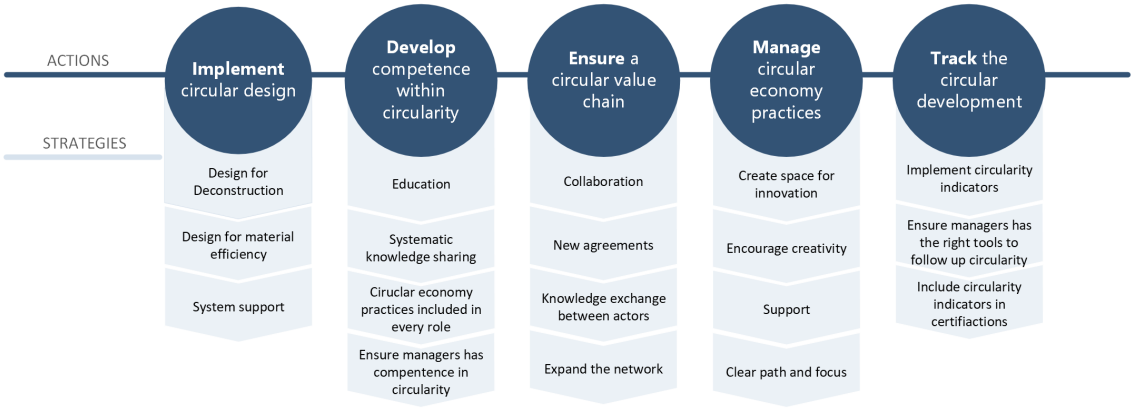

Figure 3.15: Strategies to the actions identified in step 3. Illustrated by the authors.

3.3.1 Implement circular design

The strategies are crucial in facilitating the reduction of material usage. It is important with forward-thinking design principles that enable future building deconstruction and material reuse. Additionally, these strategies aim to promote lower

resource consumption through material efficiencies. The strategies identified for the action *Implement circular design* are summarised in Figure 3.16.

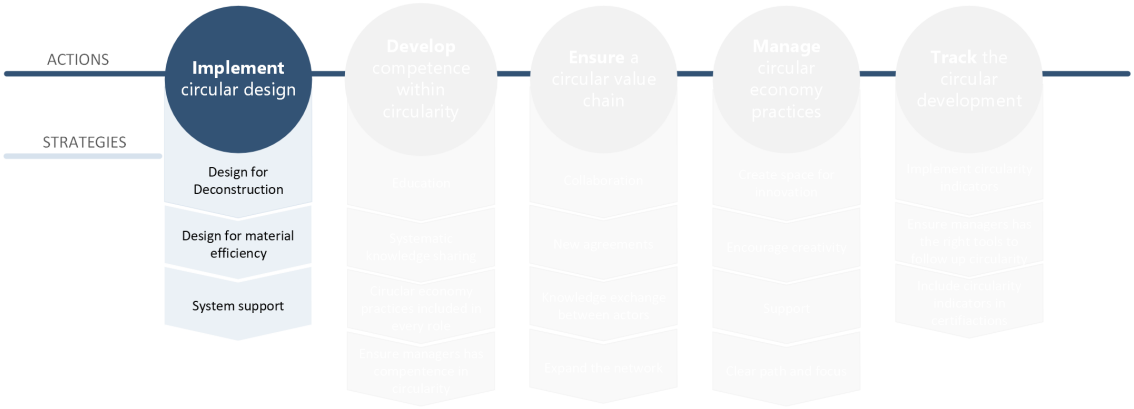

Figure 3.16: Strategies to implement circular design. Illustrated by the authors.

3.3.1.1 Design for Deconstruction

DfD is an important part of implementing circular design and therefore a key strategy connected to the transition to CE. Therefore, it is important to gain competence on how to DfD. Bertino et al. (2021) argues that deconstruction is important for the circularity of a building since it enables repurposing, recycling and reuse in the future. By offering buildings that could be disassembled it will therefore offer a greater potential to be circular in the future.

3.3.1.2 Design for material efficiency

Enhancing competence in designing for material efficiency is a crucial step towards achieving circularity, as it enables Skanska to optimise resource use. By developing a deeper understanding of material-efficient design practices, the company can effectively reduce resource consumption, resulting in significant climate savings. Additionally, designing with material efficiency in mind could lead to shorter construction time and cost savings.

3.3.1.3 System support

To facilitate the implementation of circular design, systems support is an important part. One key aspect is the utilization of a digital twin for the new building, which offers numerous advantages. It provides a centralised platform to track and manage the building's components, making it easier to identify when replacements or updates are required in the future. The digital twin also stores essential information about the building, enabling efficient material reuse and promoting flexibility. Furthermore, by optimising systems support, the relationship with the client can be developed further by simplifying building management processes and ensuring efficient maintenance and operation.

3.3.1.4 Practical suggestion for Skanska

To successfully implement circular design, it is recommended to initiate pilot projects that focus on either DfD strategy or material efficiency, depending on the specific demands and requirements of the clients. The approach allows practical exploration and evaluation of the implementation process, thereby enabling valuable insights and learnings for future development.

3.3.2 Develop competence within circularity

Even though the demand for circularity from clients is currently low there will probably be stricter requirements in the future. Therefore, it is of the highest importance to develop competence within circularity. The strategies identified from the action *Develop competence within circularity* are shown in Figure 3.17.

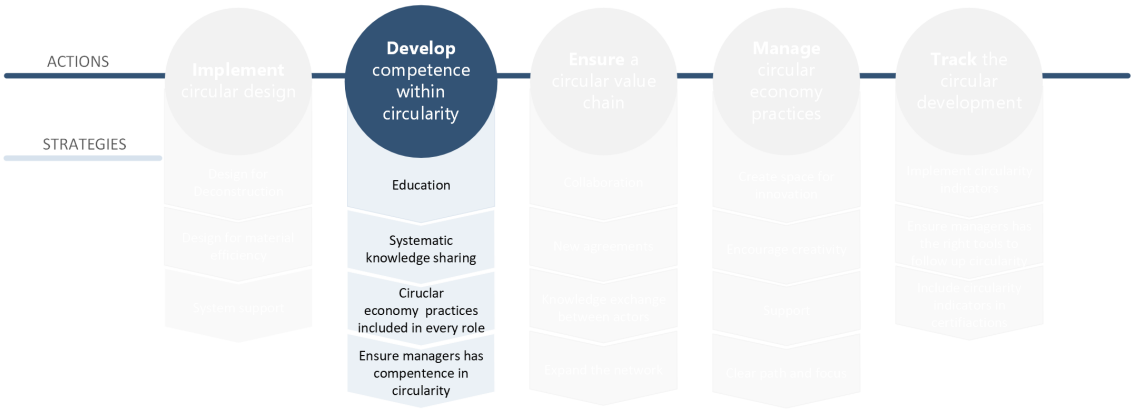

Figure 3.17: Strategies to develop competence within circularity. Illustrated by the authors.

3.3.2.1 Education

Lack of knowledge about CE practices has been identified as one large barrier at the company. Therefore Education has been identified as a strategy connected to the action of developing competence within circularity. The education should be adjusted for the specific roles at the company and explain how they can work with circularity in their daily work as well as how different choices affect the emissions.

3.3.2.2 Systematic knowledge sharing

To develop competence within circularity, it is crucial to establish systematic knowledge sharing to spread the experiences throughout the company. Skanska is currently having several pilot projects that are leading the way in implementing CE, exploring sustainable materials and pursuing net-zero certifications. The knowledge and insights gained from these pilot projects are valuable assets that need to be collected and shared among colleagues at Skanska. By prioritising knowledge sharing, the information and expertise are not confined to specific project organisations but made accessible to all employees across the company.

3.3.2.3 Circular Economy practices included in every role

In the interviews, it has been discussed the fact that having a sustainability department is not enough for Skanska to work with the CE questions. Instead, it should be included in every employee's role how they should work with climate issues and how different choices affect the climate.

3.3.2.4 Ensure managers have competence in circularity

Managers need to have competence within circularity to have the best prerequisites to guide their employees in the transition to CE. Therefore, they need education on what is affecting the circular development within the company and how they can guide and demand circular actions from their employees.

3.3.2.5 Practical suggestion for Skanska

To develop competence within circularity, it is recommended to begin by providing comprehensive education to all employees at Skanska about the principles and concepts of circularity. It will ensure that everyone has a shared understanding of what circularity means. Additionally, employees should get practical knowledge on how they can integrate CE practices into their respective roles. They need to be aware of the potential environmental impacts associated with their choices and understand how their decisions can contribute to reducing emissions throughout the project. By empowering employees with the necessary knowledge and tools, Skanska can foster a culture of circularity and enable everyone to actively contribute to the company's transition towards a more sustainable future.

3.3.3 Ensure a circular value chain

To effectively contribute to the transition to a CE, a contractor must also ensure the establishment of a circular value chain. It entails dedicating additional efforts to ensure that the entire value chain operates circularly. The action and the identified strategies are shown in Figure 3.18.

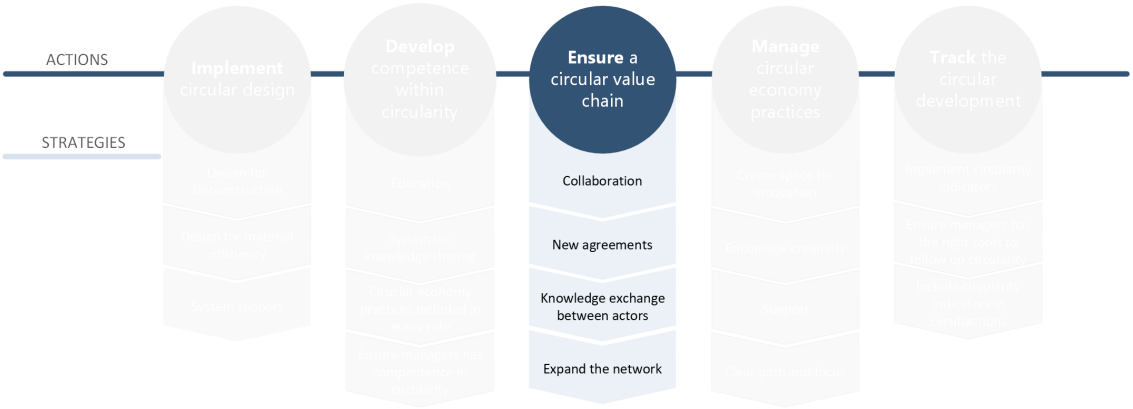

Figure 3.18: Strategies to ensure a circular value chain. Illustrated by the authors.

3.3.3.1 Collaboration

An effective strategy to ensure a circular value chain is to promote enhanced collaboration between stakeholders and employees within the company. This includes fostering multidisciplinary teamwork within the organization and cultivating closer collaboration with clients. By actively involving stakeholders and clients, the aim is to assess and incorporate circularity principles in the early stages of the project process. This approach would provide a greater potential for implementing and managing circularity and sustainability initiatives. Additionally, it would help reduce uncertainties associated with risks.

3.3.3.2 New agreements

A strategy to promote CE practices in manufacturing companies involves implementing new agreements within the value chain. Manufacturing companies require certainty that their investments will yield tangible benefits, such as competitive advantages or financial returns. A contractor must assure them that these outcomes are also valued. Additionally, there are opportunities in the current state to divert materials away from landfills and explore alternative disposal methods. By establishing innovative agreements specifying where materials and old building components should be directed, manufacturers can be supported in their ongoing efforts to develop and utilize reused materials.

3.3.3.3 Knowledge exchange between actors

Another correlated strategy associated with the action is to enhance knowledge exchange among the various actors involved. This strategy promotes the collaborative transformation of the system, enabling actors to learn from one another throughout the process. By facilitating knowledge exchange, a deeper understanding and advancement of circularity can be fostered collectively.

3.3.3.4 Expand the network

Skanska can contribute to the transition towards a circular economy by prioritizing alternative clients. In an enclosed industrial system, this entails finding customers for used materials and building components. To establish this, a recovery facility is required, as it is currently lacking. One suggested solution, which has been demonstrated in certain cases, involves manufacturing companies refurbishing and reselling old components.

3.3.3.5 Practical suggestion for Skanska

To facilitate the ongoing adoption of CE practices by these manufacturing companies, one potential action would be for Skanska to offer support. This strategy would involve giving priority to these companies as a contractor. The suggestion put forth is centred around creating new agreements, fostering closer collaboration, providing support, and expanding and prioritizing new segments of the value chain. A visual

representation of a new type of agreement with a material supplier, exemplified in 3.19, illustrates the concept of the suggestion.

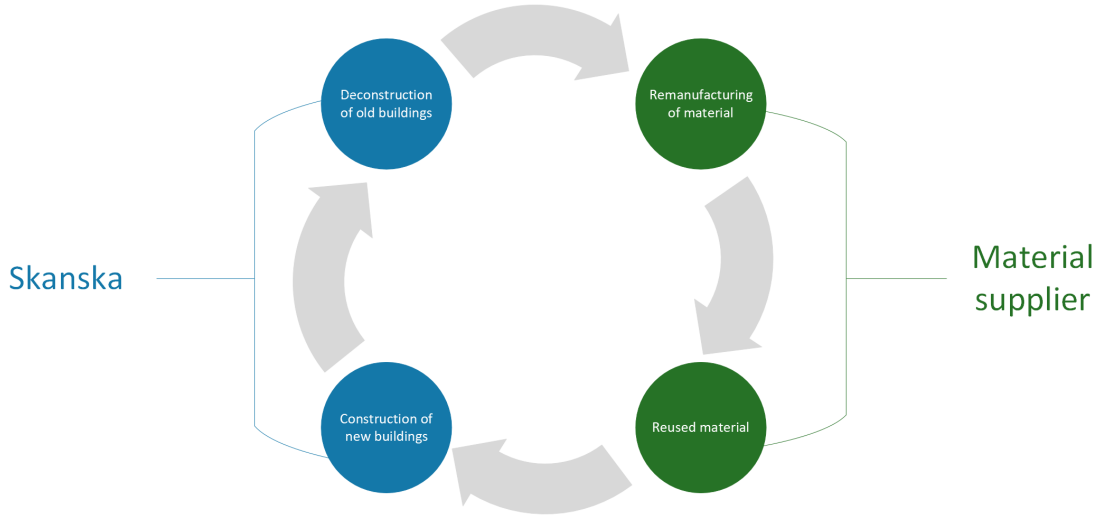

Figure 3.19: Suggestion on a potential new agreement. Illustrated by the authors.

The suggestion is based on a collaboration between Skanska and a material supplier, inspired by Stena Stål's approach to reusing steel beams. The supplier brings in steel beams, which are then reconditioned and quality stamped before being added to their regular range. These reused steel beams are sold at the same price as the regular ones. When ordering steel beams, customers have the option to select reused beams. The supplier then fulfils the order by providing as many reused beams as they have in stock, supplemented by newly produced ones to meet the ordered quantity. This approach ensures both quality assurance and mitigates uncertainties during delivery.

The proposal suggests collaborating with companies that adhere to the circular structure and extending similar partnerships with additional material suppliers within the industry. Moreover, it emphasizes the importance of seeking clients who value sustainability. By offering circular solutions, there is an opportunity to not only enhance customer relationships but also promote sustainable practices throughout the industry.

3.3.4 Manage circular economy practices

The significance of establishing an appropriate organizational structure is necessary, as emphasized by both the existing literature and stakeholders. Restructuring and developing the organization to promote the advancement of CE practices entails implementing strategies shown in Figure 3.20.

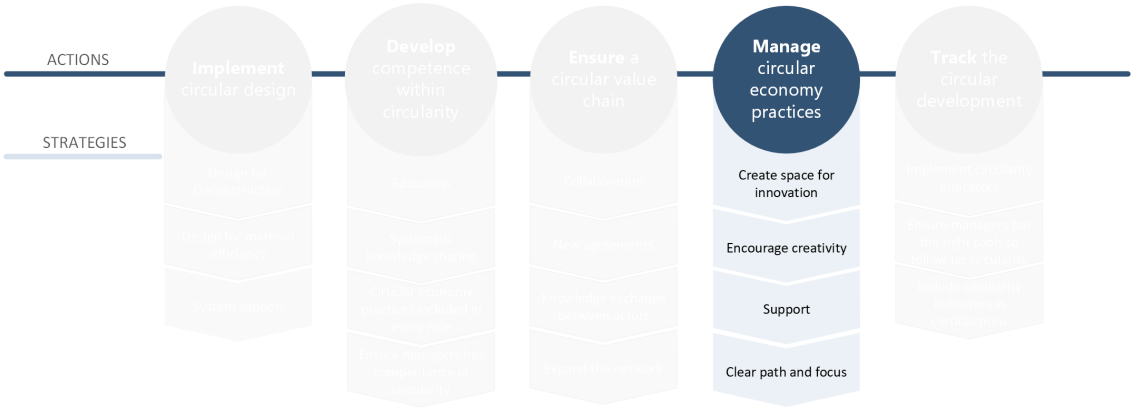

Figure 3.20: Strategies to manage circular economy practices. Illustrated by the authors.

3.3.4.1 Create space for innovations

While the goals may be apparent, the pathway to achieving them lacks clarity which is creating uncertainty within both the company and the industry. This uncertainty hinders the exploration of potential solutions. To address this challenge, a strategy is to seek out new approaches for creating space and fostering innovation within the company and the industry. The space could be in the form of financial resources, dedicated time, or favourable conditions that facilitate the promotion and development of circularity.

3.3.4.2 Encourage creativity

Shifting away from linear thinking and the entrenched culture associated with it requires strong leadership to foster a new perspective. By encouraging the necessary creativity to challenge the existing mindset and culture of the industry, leadership can inspire the development of innovative approaches. Creating favourable working environments that empower individuals and systems to embrace creativity holds great potential for driving the desired transformation.

3.3.4.3 Support

The presence of an inadequate organization becomes evident when personal responsibility takes precedence over systematic approaches. The barrier is frequently cited by employees and contributes to an organizational environment that lacks room for innovation and stifles creativity. The transition towards a more sustainable future involves embracing uncertainties and taking calculated risks. To foster an organization that effectively navigates these risks, support is crucial. The support encompasses both individual and organizational levels and may include assistance from regulations, incentives, or personal resources.

3.3.4.4 Clear path and focus

The need for a more clear and visible focus is frequently expressed. In situations where knowledge gaps exist and uncertainties are abundant, a visual leadership style becomes essential in providing guidance. The guidance encompasses aspects such as prioritization, method selection and development, and effective communication strategies. The focus and direction must be clearly visible and easily comprehensible, allowing employees to follow the established path with ease.

3.3.4.5 Practical suggestion for Skanska

Suggestions related to these strategies could involve establishing a cross-departmental group within the organization consisting of managers from each department. The group would work collaboratively to agree on a suitable path forward, taking into account the unique characteristics and requirements of each department concerning circularity. Skanska could conduct further investigations to determine the specific support needed by each department, as this may vary and encompass aspects such as time, financial resources, incentives, and more. Additionally, the group should engage in discussions on how to foster a culture of creativity and innovation, encouraging the sharing of creative approaches to address the challenges encountered along the journey towards circularity.

3.3.5 Track the circular development

It is of greatest importance to be able to track the circular development in the transition to CE to be able to assess the progress. The strategies identified related to the action are illustrated in Figure 3.21.

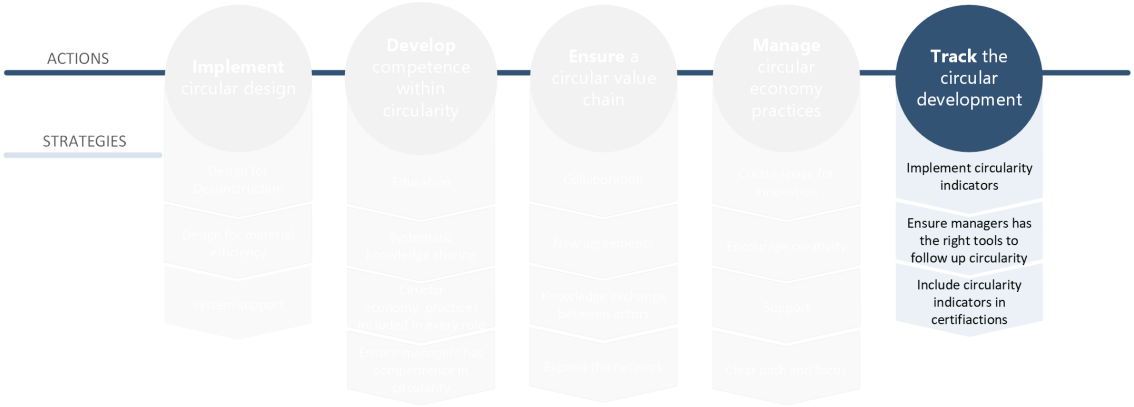

Figure 3.21: Strategies to track the circular development. Illustrated by the authors.

3.3.5.1 Implement circularity indicators

There is a need to measure the progress of the transition to CE. Therefore it is essential to implement circularity indicators to be able to assess the circularity. Nordic Networks for Circular Constructions is a project that aims to develop a framework

for implementing CE in the construction industry in the Nordics (Nordic Networks for Circular Construction, 2023). As a part of the framework for implementing CE voluntary goals and indicators for circularity is going to be developed (Nordic Networks for Circular Construction, 2023). Skanska is recommended to take part in the Nordic Networks for Circular Constructions to be guided in the implementation of circularity indicators.

3.3.5.2 Ensure managers have the right tools to follow up circularity

When tracking the circular development it is important to ensure that the managers at the company have the right tools to follow up circularity. The managers already know how to follow up on the economy at a project. They know what to look for and what questions to ask. When it comes to circularity it is not as obvious, since measures are lacking and the competence is low at the company.

3.3.5.3 Include circularity indicators in certifications

Including circularity indicators in certifications will be a driver and incentive for projects to implement CE practices in the projects since certification of buildings is valued highly when constructing new buildings. Including circularity indicators in certifications will also be a statement towards the whole construction sector that circularity is valued highly when it comes to new projects. Skanska and other large construction companies are often asked about their opinion when it comes to what should be included in certifications. Therefore they have a large responsibility in driving the matter of including circularity indicators in certifications.

3.3.5.4 Practical suggestion for Skanska

To track circular development, Skanska should initially focus on developing the necessary competence to accurately assess the CO_2 emissions from the projects. Thereafter Skanska should proceed to identify and evaluate additional measures for assessing circularity within the company. It is important to highlight that CO_2 quantifications alone are not sufficient to capture the full extent of circularity. Therefore, Skanska should consider incorporating circularity indicators. The choice of measures to assess circularity at the company ultimately rests with Skanska. It is important that they select indicators that align with their sustainability goals. By establishing a system for tracking circularity, Skanska can gain valuable insights into their progress and identify areas of improvement.

3.4 Recommended circular business model

In the section, some of the guiding strategies are adopted to the current BM of Skanska to generate a potential CBM. The strategies are placed as extended parts in the BM, seen in green in Figure 3.22. These newly identified entries could potentially generate a CBM.

Under key partners, new entries such as remanufacturers and circular material suppliers are added. Further, there is uncertainty regarding if a deconstruction company may be needed. It depends on how the new agreement would look like. There is also a possibility that the remanufacturers and circular material suppliers develop their proposal and business model. For key activities, a new waste flow, creativity and innovation are added. For key resources knowledge about circular processes and system support is added. These will act as extended parts and would enable and support all other parts in the model. Under the value proposition, sustainable buildings are added, meaning that Skanska is not limited to one solution but includes all aspects of both circular practises and other sustainable options. Skanska's new value proposition also includes a partner in reaching net zero targets, meaning that Skanska is a partner in achieving the transition together with the industry. Furthermore, in the customer relationship, early collaboration, new agreements and extended relationships are placed. These parts aim to expand the collaboration with clients and new clients. Lastly, under customer segments, customers that value sustainability is added. This implies that the new customers that value sustainability should be prioritised.

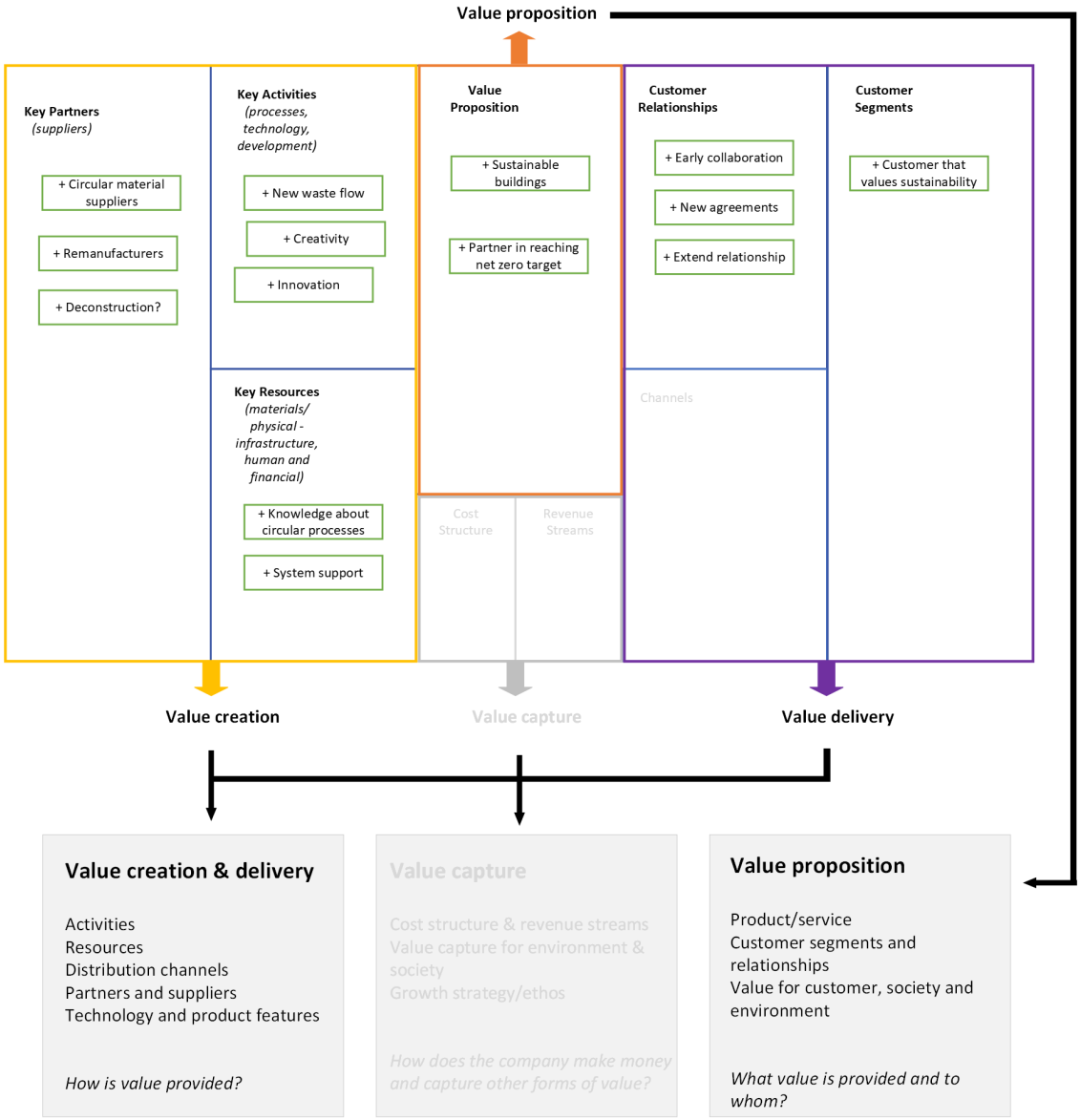

Figure 3.22: Potential circular business model. Illustrated by the authors and based on the figure found in Kraaijenhagen et al. (2016)

4
Discussion

The study has achieved a thorough comprehension and presentation of the current state of the transition to CE in the construction industry. However, due to the complexity of the construction industry and the limitation of time and resources, there are still some uncertainties regarding the findings. It is crucial to recognise that certain aspects of the system may not have been considered in the study and could potentially influence the overall result. In the following chapter, limitations, uncertainties and conflicts of the results are going to be discussed.

4.1 Limitations

Given that the thesis is solely centred on the business stream construction at Skanska and more specifically the buildings, it is important to recognise that the findings and recommendations may not capture the full picture of what Skanska needs to do in order to make the transition to CE. If other parts of the company such as infrastructure would be taken into consideration, it could have influenced the findings of the report. Furthermore, to truly achieve circularity Skanska needs to extend its efforts beyond the business stream construction. To fully embrace CE principles Skanska must integrate CE practices across all its business streams, fostering a company-wide commitment to circularity. By broadening the scope to include other business streams within Skanska, a more comprehensive understanding of the challenges and opportunities associated with the CE transition can be achieved. The expanded perspective will provide a more accurate assessment of Skanska's progress towards CE.

The study did not include an economic evaluation of the actions, strategies and recommended CBM. The limitation was made due to several factors, including the limited understanding of Skanska's internal operations and the complexities associated with analysing the company's business structure. Conducting a comprehensive economic evaluation would have required a deeper level of insight into Skanska's financial data and operations, which was beyond the scope and time constraints of the thesis. It is important to acknowledge that economic considerations play a significant role in the implementation of sustainable initiatives. Assessing the financial feasibility and potential ROI is crucial for Skanska to make informed decisions and ensure the long-term viability of their sustainability efforts. However, conducting a thorough economic evaluation necessitates a more extensive study of specific financial aspects of the company, its market and cost-benefit analyses. While the

economic dimension was not explored in the thesis, it is recommended that future research or initiatives consider integrating economic evaluation to provide a comprehensive understanding of the financial implications associated with the proposed actions and strategies.

The study is primarily based on Skanska, but the findings obtained from the research can potentially be applicable to other contractors in Sweden that share similar organisational structures. However, it is important to consider the unique characteristics of each organisation and project. Factors such as company size, project scope, regional variations and stakeholder dynamics can introduce variations in the implementation. Therefore, while the study's findings offer valuable insights, it is recommended that other contractors assess their individual circumstances and adapt the strategies and recommendations to align with their operations.

4.2 Uncertainties

The existing uncertainty surrounding the current situation has a significant influence on the identification of strategies. Given that the methodology is based on previous steps, the uncertainty means that the strategies formulated should be considered as suggestions rather than conclusive solutions. It is possible that there are additional strategies that could be included or strategies that have not been identified yet. The inherent uncertainty in the current context allows for flexibility and further exploration, enabling strategies to be refined and improved in the process.

There is a lack of information available regarding Skanska's current BM. In the results, an approximated current BM was created as a foundation when developing the CBM. By adding entities to the approximated BM, the potential CBM was created. However, it is essential to consider that the approximated BM entails uncertainties in the study.

Furthermore, the first step in the backcasting method is the identification of conditions to be met in a sustainable future, since both Skanska and the construction industry already have clear goals when it comes to CE it was only included in the introduction. The results are therefore limited to addressing step 2 to 4 of the backcasting methodology. Using the already stated visions for step 1 it entails uncertainties in the backcasting method when it comes to envisioning the future. If the study were to include an evaluation in the first step, the outcomes could potentially differ. It is because the criteria used in the study to define a sustainable future may not encompass all the ecological, social and economic aspects. Therefore, the results might vary if the study were to incorporate criteria for a sustainable future when considering step 1.

4.3 Conflicting results

There are several conflicting goals within the identified actions and strategies. Specifically, there is a conflict within the action *Implement circular design* between the strategies *Design for deconstruction* and *Design for material efficiency*. In the context of DfD, the primary focus is on optimising the building's ease of disassembly, which necessitates avoiding materials with combined functions. The aim is to facilitate the separation and reuse of components and materials. On the other hand, designing for material efficiency aims to minimise the use of materials, favouring those combined functions to achieve the objective of using as little material as possible. It arises a dilemma since it is not possible to achieve a building that can be easily disassembled while simultaneously ensuring the efficient use of materials. The requirements of these two strategies create a contradiction, as a building cannot simultaneously possess both characteristics. The conflict highlights the need for careful consideration and decision-making when choosing between DfD and designing for material efficiency. It becomes crucial to weigh the advantages and disadvantages of each approach and make informed decisions based on project-specific priorities and goals. Additionally, it underscores the complexity of achieving a perfect balance between circular design principles and material efficiency in the construction industry.

It is also necessary to review the optimal value for measures related to circularity. Striving for the highest or lowest value may not always be the best approach, as it could potentially lead to trade-offs or compromises in other areas. One consistent challenge encountered is the conflict between climate actions and profitability. Sustainable solutions often involve additional costs, making it difficult to have a balance between environmental goals and financial viability. Therefore, it is crucial to establish a goal that enables the business to be sustainable while also generating profits. Finding the right equilibrium between climate actions and profitability requires careful consideration and strategic decision-making. It involves identifying and implementing CE practices and solutions that align with the company's core values and long-term objectives, while also taking into account the economic feasibility of such measures. By setting realistic and attainable goals that integrate both sustainability and profitability, companies can navigate the challenges posed by these conflicting factors. The approach enables them to make meaningful progress towards circularity while ensuring the long-term success and resilience of their business operations.

5
Conclusion

To conclude, tackling the current status of CE in the construction industry and Skanska from a holistic perspective resulted in a wide understanding of the system. The construction industry has a long way to go before transforming to a CE. However, the presence of both opportunities and initiative exists. The derived actions were based on those insights and further aligned strategies were developed based on those actions, thereby connecting the present with the desirable future.

The following actions with corresponding strategies were identified and developed; *Implement circular design*, with strategies such as design for deconstruction, design for material efficiency, and system support; Develop competence within circularity, with strategies such as education, systematic knowledge sharing, CE practises included in every role and ensure managers have competence in circularity; *Ensure a circular value chain*, with strategies such as collaboration, new agreements, knowledge exchange between actors and expand the network; *Manage circular practices*, with strategies such as create space for innovations, encourage creativity, support and a clear path and focus and *Track the circular development*, with strategies such as implement circularity indicators, ensure managers have the right tools to follow up circularity and include circularity indicators in certifications.

The strategies were applied in the BM, resulting in a recommended potential CBM. By adopting a reflective and holistic approach to addressing the current status of CE in the construction industry, it generated valuable indications of the needs within Skanska and the industry to transition to a circular economy. It is important to note that this is not an exhaustive or definitive approach. However, the thesis provides an outside perspective that should be further developed and investigated by a skilled workforce.

5.1 Future research

The thesis focuses primarily on the perspective of contractors, their strategies, and their visions for the future. It would be intriguing to explore the strategies required for other stakeholders within the industry regarding the transition to a CE. This would provide valuable insights into the diverse perspectives and actions necessary for achieving circularity across various sectors within the industry.

As discussed in the study, the new agreements with manufacturers have been identi-

fied as a potential aspect to enhance circularity in the industry. Further investigation into how these agreements are established and supported would be of great interest. Understanding the most effective methods for creating and facilitating such agreements could foster increased circular initiatives from manufacturers, thereby advancing the overall circularity goals of the industry.

The study highlights the importance of implementing circular design, and it would be beneficial to further explore the optimal methods for integrating it into current working practices. This investigation could involve assessing how to educate and effectively incorporate circular design principles. Furthermore, it would be valuable to explore how circular design contributes to the potential for reuse and facilitates savings in materials and emissions. Understanding these aspects in greater detail can provide insights into maximizing the benefits of circular design within the industry.

An additional investigation focusing on the economic aspects of the recommended potential CBM would be intriguing to explore. Such an investigation could serve as a demonstration of the economic viability of the CE and act as an incentive for further transformation within the industry. Understanding the financial implications, potential cost savings, and revenue opportunities associated with the CE can provide valuable insights into its feasibility and encourage broader adoption across the industry.

Lastly, investigating stakeholders' perceptions of the required level of collaboration would make a significant contribution to the research field. Such an investigation would facilitate a better understanding of stakeholders' perspectives, promote increased collaboration, and foster support among stakeholders. By exploring and addressing the perceptions and expectations related to collaboration, it becomes possible to enhance cooperation and collective efforts towards achieving transformation to CE within the industry.

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A

Appendix

A.1 Interviewees

Interviews were conducted with 20 persons at Skanska with different roles and departments. The interviewees' roles and departments are listed in Table A.2.

Interviewee	**Role**	**Department**
Interviewee 1	Sustainability Specialist	Sustainable business development
Interviewee 2	Climate and sustainability manager	Sustainable business development
Interviewee 3	Purchasing Director	Purchase department
Interviewee 4	Category Manager	Purchase department
Interviewee 5	Project Leader	Purchase department
Interviewee 6	Development Responsible	Building department (central level)
Interviewee 7	Technical Mission Leader	Technical department
Interviewee 8	Sustainability Specialist	Sustainable business development
Interviewee 9	Team manager	Sustainable business development
Interviewee 10	Project Manager	Building department (South Region)
Interviewee 11	Technology Mission Coordinator	Technical department
Interviewee 12	Business Project Manager	Building department (Gothenburg Region)
Interviewee 13	Team Manager	Sustainable business development
Interviewee 14	Sustainability Specialist	Sustainable business development
Interviewee 15	Operational Manager	Building department (Stockholm South and North Region)
Interviewee 16	Regional Purchasing Manager	Building department (Stockholm South Region)
Interviewee 17	Production Manager	Building department (Gothenburg Region)
Interviewee 18	Design Manager	Building department (Gothenburg Region)
Interviewee 19	Senior Advisor	Skanska Sweden

Interviewee 20	Estimator Manager	Building department (Gothenburg Region)

Table A.1: List of interviewees

A.2 Internal online seminars

Internal online seminars were watched as a part of the data collection with different actors presenting. The internal online seminars are listed in Table A.2.

Name of seminar	**Actors presenting**	**Year of production**
Learn more about circular construction	Skanska	2022
Reuse inventory	Skanska	2022
Skanska ReSource	Skanska	2022
Hyllie Terrass - Our way to climate neutrality	Skanska	2022
Gångaren 13 - NollCO2	Skanska	2022
Environmental requirements in a construction project - Which ones do you need to know?	Skanska	2022
SKAVANK - glass that is too good to be thrown away	Material supplier	2022
Disassembly as an alternative to demolishing	Client, Demolishing company and Skanska	2022
Circular construction	Skanska	2022
Agenda 2030 in a tender	Skanska	2021
Customer survey on climate-smart houses	Skanska	2021
Reuse - winwin for the wallet and the climate	Consultants within reuse and circularity	2021
The value chains of the future needs to be circular - Circularity and material flows	Recycling company	2021
Circular construction in our surrounding world	Architects, Marketplace for reuse	2022
Webinar from Green Week 2018	Circular architects	2018
Lendager	Circular architects	2023
What does the recycling market look like today and where is it going?	Skanska, material supplier	2023

Table A.2: List of internal online seminars

A.3 Mapping

The interviews were mapped to be able to identify actions and strategies to overcome the barriers and opportunities. The mapping is shown in Figure A.1

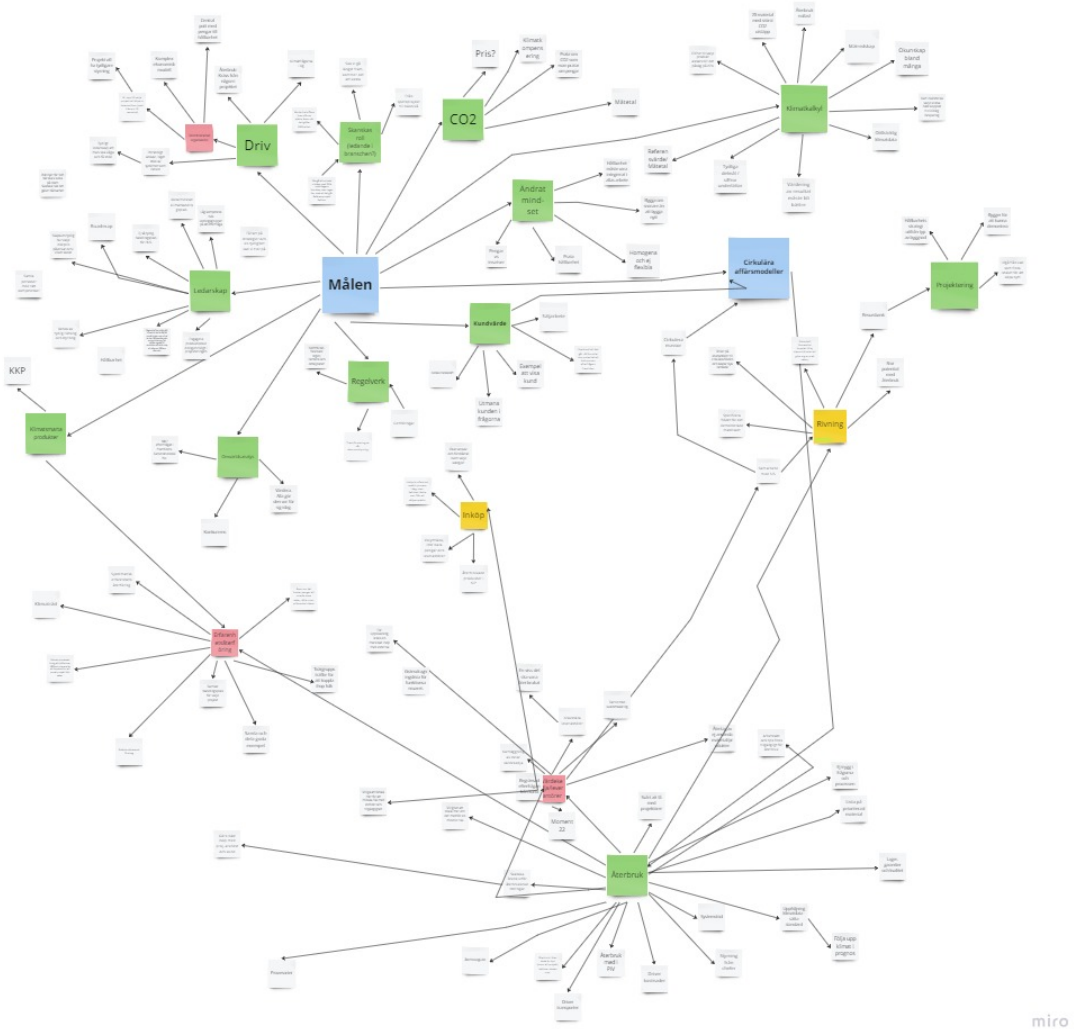

Figure A.1: Mapping. Illustrated by the authors

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