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Executive Summary

The construction industry is a significant contributor to global waste and resource depletion. Transitioning to a circular economy model, where materials are kept in the loop for as long as possible, is crucial for reducing the industry's environmental impact. This study examines how the industry's value creation system could be altered to facilitate increased reuse of materials, a core principle of the circular economy.

The study identifies several key actors within the construction industry: clients, architects, consulting engineers, contractors, and policy makers. Each actor group has its unique challenges in transitioning to a circular model, requiring tailored approaches to foster circular practices. Three primary barriers and challenges to material reuse were identified: 1) documentation and regulations, 2) costs, and 3) competence and culture. A lack of standard documentation and regulations makes reusing materials complex and risky. Economic hurdles also exist due to the current cost structures that favor new materials. Moreover, the industry is hampered by a gap in knowledge and a culture resistant to change, which inhibits the shift towards a circular model. The study proposes three crucial activities to overcome these barriers and drive circular practices: 1) changing regulations and incentives, 2) creating a robust marketplace for reuse, and 3) developing effective take-back systems. By addressing these activities, they can navigate the challenges and enhance material reuse which can then lead to a more sustainable construction industry.

Overall, the study provides theoretical advancements and practical insights into the transformation needed within the construction industry to enhance material reuse. This can equip industry actors with the knowledge and understanding required to shape the industry's move towards more circular practices. The study has explored what's needed for this transition, suggesting promising avenues for future research within a circular construction industry, such as design of buildings for future reuse and life-cycle analyses.

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1.0 Introduction

This study seeks to pinpoint the areas in the current value creation system within the construction industry that need transformation to boost material reuse. The research topic holds significant academic interest and practical relevance as it delves into the evolving arena of reuse within the construction sector. From a theoretical standpoint, the research topic is interesting because it touches on business ecosystems, going from linear to circular economy, circular business model innovation, and value networks. It aims to determine how changes within the value creation process can foster more effective resource utilization. On a practical level, this investigation is crucial. Like many other industries, the construction industry is under increasing pressure to reduce its environmental impact, particularly with regards to climate change (Bygballe et al., 2021). As the construction industry is a major user of raw materials and a significant generator of waste, enhancing material reuse can drastically reduce its environmental impact and help achieve sustainability targets (Hossain et al., 2020). Moreover, understanding what needs to change within the current value creation system can equip actors such as policymakers, clients, and contractors with the insights required to formulate effective strategies and policies that encourage circular practices. With these concerns in mind, we developed the following research question:

Which areas of the current value creation system in the construction industry must be altered to facilitate increased reuse of materials?

A significant amount of research has highlighted the importance of transitioning towards a circular economy, where resources are used and reused for as long as possible. This principle has been applied across several industries, but its application in the construction industry is relatively limited and unexplored (Bigliardi & Filippelli, 2021). The shift from a linear to a circular economy is a complex process that involves systemic changes in the redesign of building components, transformation of supply chains, and innovative methods of service provision (Weetman, 2021). The construction industry faces hurdles in developing and adopting technologies for reusing, recycling, and repurposing building materials. Economic and regulatory obstacles often exist, as the current frameworks mainly support linear practices. Moreover, a significant cultural shift is required, where both construction professionals and clients prioritize the principles of

material reuse (Guerra & Leite, 2021).

Reuse plays an integral role in the implementation of a circular economy, and in the context of the waste hierarchy, reuse holds a higher position as it is prioritized over recycling, recovery, and disposal (Allwood, 2014). This is because reuse involves using items in their original form without additional energy expenditure for processing, as is needed for recycling or recovery. It not only reduces waste but also saves resources that would otherwise be expended in creating new products. For resource-intensive industries like construction, promoting reuse can significantly enhance resource efficiency, reduce environmental impacts, minimize waste, and bring economic benefits (Gharfalkar et al., 2015).

Moreover, value creation has traditionally been viewed from a profit-driven perspective in the construction industry (Kaartemo et al., 2017). A shift towards considering environmental and social value alongside economic value is a relatively new and evolving concept. While we understand that value creation and the reuse of materials are critical to promoting sustainability in the construction industry (Treptow et al., 2022), the interplay between these two aspects is somewhat underexplored. Addressing this knowledge gap is critical for the future construction industry. With increasing pressure to mitigate the environmental impacts of the construction industry, understanding how to alter current value creation systems to promote material reuse can be a game-changer.

Our study shed light on an underexplored area within the construction industry, offering both theoretical advancements and practical applications. It seeks to fill a crucial knowledge gap, and its findings can shape the industry's move towards sustainable practices. On the theoretical front, the research can redefine our understanding of value creation in the construction industry, and it can provide insights into how the principles of circular economy can be integrated within the value creation systems. It offers the potential to shift the narrative from a linear, single-use perspective to a circular, reuse-oriented perspective. On a practical level, the study can provide industry practitioners with actionable insights on how to modify their current value creation systems to facilitate material reuse. To comprehensively address our main research question, we have proposed three distinct research sub-questions. These sub-questions have been instrumental in

framing our approach to the study as they have provided a structured pathway for our literature review, enabling a targeted exploration of relevant theoretical perspectives and empirical findings. Moreover, these sub-questions have been central in guiding our discussion, helping us delve into various aspects of the research topic in a systematic and coherent manner.

(1) Who are the main actors ensuring the reuse of materials in the construction industry?
(2) What are the main barriers and challenges related to the reuse of building materials in the construction industry?
(3) What are the critical activities in the circular value creation system in the construction industry?

The rest of the study is structured as follows: First, a literature review that sets the theoretical context, exploring concepts related to business ecosystems, barriers and challenges to the circular economy, and the role of critical activities in circular value creation. This is followed by a description of the methodological approach. The next section presents the findings from our analysis, detailing the state of the construction industry and its main actors, the identified barriers and challenges, and the critical activities for transitioning to a circular economy. The findings are followed by a comprehensive discussion where we critically engage with our findings considering the reviewed literature. Finally, we offer a conclusion that summarizes the key insights from our research, their implications for both theory and practice, and the overall contribution of our study to the understanding of value creation systems in the construction industry to enhance material reuse.

2.0 Literature Review

This section offers a comprehensive review of the literature to identify relevant theory, methods, and gaps that help us in answering the research question. First, we'll describe business ecosystems, the interdependence of actors, and different mechanisms in such ecosystems. Next, we identify various barriers and challenges in the literature that arise while moving from a linear to a circular economy. Finally, we examine the literature on innovation in circular business models and value networks, and what it has to say about crucial activities in the transition to more circular practices.

2.1 Actors and Mechanisms in Business Ecosystems

2.1.1 Business Ecosystems

Moore (1993) was one of the first to conceptualize business ecosystems. He views them as structured communities where actors cooperate and compete to develop capabilities and bring about new rounds of innovation. A recent and concise definition of the concept comes from Adner (2017, p. 42), stating that "The ecosystem is defined by the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize". Adner (2017) posits that actors have defined positions and activities in an ecosystem, the alignment of which have to be satisfactory for each actor, which also raises the question of their consistent perception of configuration of these activities. This is linked with how the actors in an ecosystem have a joint value creation logic as their goal, but that the value proposition between actors may differ, which could cause conflict since these are individual to the firm. Further, Adner (2017) views ecosystems-as-structure, of which there are four elements – activities, actors, positions, and links. As the definition entails, the alignment of these four elements is crucial for the actors' value propositions to come true.

Other researchers, like Jacobides et al. (2018, p. 2264) define an ecosystem as "a set of actors with varying degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled." It is the nongeneric complementarities that are interesting here, and what sets ecosystems apart from either market- or hierarchically based arrangements or networks. According to Jacobides et al. (2018, p. 2261), these complementarities are "webs of standardized formal or informal alliances between participants" and where "[…] complementors can choose from a set menu of options and are treated similarly." However, they are specific and not generic, and entail some level of customization.

The concept of value creation is also quite prevalent in the business ecosystem literature, and one of the first to discuss it was Kandiah and Gossain (1998). In their time, the economy was becoming more information-oriented, which made customers more informed about firms' products and services and their differentiation, giving customers more power. In this new business ecosystem, companies had to compete on price, value, and service, and reinvent value creation by creating new value-added activities. More so, firms in the ecosystem must rely

on sharing information and creating shared value to get a better picture of the customers and what they can ultimately provide them. Another perspective comes in Adner (2017), who discusses how we can think about value creation in ecosystems as being interdependent between actors and channeled through cooperation and coordination. He also posits that although value creation and value capture usually happens within a focal firm's business model (Osterwalder & Pigneur, 2010; Zott et al., 2011), we can extend the level of analysis to ecosystem strategy by considering all the firms' business model that are present in the ecosystem as being 'under one roof'.

Hannah and Eisenhardt (2018) make a further contribution by creating a framework to aid in thinking about how ecosystems behave in terms of cooperation vs. competition and how this relates to value creation. The three ecosystem strategies that make up the framework are bottleneck strategies, component strategies, and system strategies. Bottleneck strategies focus on enhancing a specific aspect of a product or service that is limiting its overall value, thereby unlocking significant value for customers and companies to gain competitive advantage. This strategy is most optimal when combining cooperation and competition, i.e., combining value creation and value capture. Component strategies emphasize ecosystem cooperation by adding value to a product or service by improving on or innovating its constituent components. This strategy works especially well in fields where products are made of a variety of parts and an opportunity to innovate in each area, such as the manufacturing of smartphones. Lastly, system strategies focus on adding value through reinventing the entire system or business model of a product or service. This strategy requires a more comprehensive and holistic view of the industry, and it may involve significant changes to how products or services are produced, marketed, or delivered. For instance, a company might create a new disruptive business model, thereby creating more value for customers and gaining more market power. Overall, the various strategies can be used to create and capture value for customers and differentiate a product or service from competitors.

In recent years there has been an increase in the interest of circular business models (CBMs) in the business ecosystems literature. Kanda et al. (2021) attempt to bridge the gap between circular business models and so-called "circular business ecosystems" (CBEs), focusing on the shift from linear to circular business models

and ecosystems, offering another interesting perspective. The authors argue that establishment of these CBEs – which require cooperation and coordination among multiple actors, including firms, governments, and consumers – is the only way to realize the circular economy. It is further argued how circular business ecosystems are just one component of a larger circular ecosystem, and that a systemic approach is needed to achieve the full potential of the circular economy. Therefore, a conceptual framework with three levels – the micro-level (individual firms and their business models), the meso-level (industry or sector ecosystems), and the macro-level (societal and institutional ecosystems) - is proposed for comprehending circular business ecosystems. Kanda et al. (2021) look at how different types of actors can contribute to the development of circular business ecosystems at each of these levels. Furthermore, the authors argue that firms seeking to transition to circular business models and participate in circular ecosystems need to adopt a systemic approach that involves collaboration with other actors (customers, suppliers, competitors), while also emphasizing the importance of innovation and exploration.

2.1.2 Discussion

From the literature we see that the different actors in a business ecosystem should have their own specified role or set of activities which must align in order to reach the common goal of value creation (Adner, 2017). Later, Jacobides et al. (2018) add to this by characterizing actors in an ecosystem inhabiting 'multilateral and nongeneric complementarities' (like 'alignment structure of multilateral set of partners' in Adner (2017)). Where they seem to differ however is regarding hierarchy, where Jacobides et al. (2018) believe that an ecosystem is inherently 'not fully hierarchically controlled', but where Adner (2017) discusses firms in an ecosystem as either taking a leader or more of a follower role. It could be interesting to explore the spectrum of hierarchy in ecosystems, to see whether ecosystems are partially or fully hierarchically controlled, and if this depends on the ecosystem, industry, actors, or other factors.

Moreover, we found that value creation as a concept is quite prevalent in business ecosystem literature, which is interesting. The literature shows that times of change can spark firms to create ecosystems because they might have to enter collaborations with others to create value-added activities (Kandiah & Gossain,

1998). Adner (2017) adds to this by saying that value creation in an ecosystem is directed through firms' coordination and cooperation, and that this value creation is then aggregated to the ecosystem level. Which could mean that the whole ecosystem benefits from this, and not only individual firms and their business model. Furthermore, Hannah and Eisenhardt (2018) propose that cooperation and competition in an ecosystem is dependent on which type of ecosystem strategy a firm chooses, based on their situation and the development of their product or service. Further, the concepts of circular business models and circular business ecosystems are also found in the literature. Kanda et al. (2021) for example, highlight that cooperation and coordination among actors in a circular business ecosystem is crucial to make the transition to a circular economy. However, we suggest that more research is needed in linking the ideas of value creation and cooperation in ecosystems more together.

Having reviewed literature on business ecosystems, one can see a benefit to understanding how actors behave and mechanisms in an ecosystem could aid in answering the research question. However, we also need to look at what the literature says about the main barriers and challenges to a circular economy, therefore this is reviewed in the following chapter.

2.2 Barriers and Challenges to the Circular Economy

2.2.1 From Linear to Circular Economy

Before investigating the main barriers and challenges to the circular economy (CE), we first look at various definitions of CE and how this differs from the traditional linear economy (LE). The unsustainable LE is recognized by both Stahel (2019) and Weetman (2021) as being sparked by the industrial revolution in the 1700s and the most prevalent type of economy in the world today. This is an economy where resources are excessively extracted from the earth to produce products sold for a profit, without thinking about how these valuable manufactured objects would be regained at their end-of-life. Especially in recent decades this 'take, make, discard' mentality has become prevalent in most developed countries, but is not sustainable, neither financially, socially, nor ecologically. The CE on the other hand is according to Stahel (2019), the most sustainable post-industrial economy business model. Perhaps the most clear and concise definition of CE comes in Geissdoerfer et al. (2020, p. 3), who define it as "an economic system in which resource input and

waste, emission, and energy leakages are minimised by cycling, extending, intensifying, and dematerialising material and energy loops. This can be achieved through digitalisation, servitisation, sharing solutions, long-lasting product design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (see Appendix A).

Instead of the linear approach that we see today, Weetman (2021, p. 4) states that "the circular economy focuses on circulating resources instead of using them up, and designs waste out of the system. We aim to get more from less, getting more 'use' and value from every product, component and material, and ensuring all 'waste' becomes food – for another industrial process, or for nature – so regenerating future resources and the living systems we depend on." Stahel (2019, p. 6) has a somewhat different distinguishment between CE and LE by stating that "the circular industrial economy manages stocks of manufactured assets, such as infrastructure, buildings, vehicles, equipment and consumer goods, to maintain their value and utility as high as possible for as long as possible; and stocks of resources at their highest purity and value. This model contrasts with the linear industrial economy in that its objectives are to maintain value (not to create value added), to optimise stock management (not flows) and to increase the efficiency of using goods (not of producing goods)". Despite all having slightly different definitions, Stahel (2019), Weetman (2021) and Geissdoerfer et al. (2020) describe the CE as having a special focus on longevity in products, reuse and keeping resources in the loop for as long as possible.

2.2.2 Main Barriers and Challenges

Socio-cultural barriers and challenges are some of the most prevalent issues related to transitioning to a CE. Kircherr et al. (2018) believe cultural barriers among customers and companies to be the main barriers to CE. Among customers it has to do with a lacking knowledge of or interest for the circular economy, as well as the costliness and scepsis towards reused products and the safety and convenience of new products. Tan et al. (2022) propose a phenomenon called "intention-action gap", where customers have an awareness, interest, and intention of choosing more circular products but often do not follow through with said intention. They would rather go with the safe, cheap and convenience of buying new. Further, they talk about business leaders as being risk-averse to circular economy principles and

making changes, which are rooted in people's resistance to change, fear of uncertainty and a preference to maintain the status quo. Kircherr et al. (2018) finds companies' reluctance towards the circular economy, like with customers, largely attributed to a lack of awareness and understanding of the potential benefits with circular business models. Linked to this is the challenge of disrupting one's own supply chain, business model and production processes to shift towards more circular practices, which may be further challenged by having to collaborate with other companies. Similar issues are mentioned in Suzanne et al. (2020), such as having a more circular mindset, lack of understanding and awareness of circular economy principles, and reluctance towards collaboration and coordination among key stakeholders.

Economic/market barriers and challenges towards a CE are also well-documented in the literature. Hopkinson et al. (2018) mention the challenge of branding remanufactured and reused products, and how they must compete against new products. Branding remanufactured or reused products as creating value in the CE, more environmentally friendly and cheaper is possible, but marketing and influences from other customers reinforce the inherent view that new is always best, attitudes which are not changed overnight. Grafström and Aasma (2021) on the other hand mention that high up-front investment costs of CBM with poor access to finance, coupled with low virgin material costs and a lack of markets for recycled goods are the most concerning economic/market barriers to the development of a CE. This is similar to Geissdoerfer et al. (2022), who identified certain financial barriers like uncertainty, high initial investments, and short-term orientation of shareholders as large barriers to CE. Other studies like Tan et al. (2022), discuss the cost of mass-producing products through a linear production system as frequently less expensive than a circular production system, as the negative externalities on society, the environment, and the economy are not internalized. This cost disparity may hinder efforts to promote circularity and deter customers from switching to more environmentally friendly products. Current pricing structure is also emphasized as a barrier, claiming that it offers customers less financial motivation to choose environmentally friendly options and may impede the shift to a circular economy.

Further, there are significant policy/regulatory challenges and barriers to the shift

to a CE. According to Suzanne et al. (2020), policies that, for instance, support extended producer responsibility, product design for circularity, and circular procurement can help create a more favorable environment for circular economy initiatives. The lack of support from public organizations, on the other hand, is detrimental to CE implementation (Ormazabal et al., 2018), and the CE needs a supportive policy and regulatory environment to overcome barriers like a lack of awareness and understanding. This is also backed by de Jesus and Mendonça (2018) and Geissdoerfer et al. (2022), who identified regulatory and institutional factors such as lacking support of policies and legislations that make it difficult to implement circular economy principles. Highlighting other areas of regulatory barriers to CE, Tan et al. (2022) draw attention to the lack of pricing externalities in a linear production system, which enables the manufacturing of mass-market goods at a low price. Due to resource shortages, scarcity, intrinsic production inefficiencies, and operational inefficiencies, circular products may have a difficult time competing in the market. They argue that introducing extended producer responsibility (EPR) could assist in resolving these issues, as EPR programs encourage designing products with circularity in mind and assume responsibility for their disposal or recycling over to the producers rather than the customer.

Lastly, knowledge/technological barriers are discussed extensively in the literature. When there are high rates of innovation and short usage cycles, Hopkinson et al. (2018) emphasize the need for firms to adapt to the problems of maintaining profitable remanufacturing systems. This could suggest that acquiring and applying knowledge on new technologies and materials within the framework of circular economy activities may provide challenges. This is also backed by Kircherr et al. (2018) who mention several technological barriers to the circular economy, including the inability to deliver high-quality remanufactured products, the lack of circular design, and the lack of technological knowledge. Further, Tan et al. (2022) discuss the absence of expertise (deep domain knowledge, technological know-how etc.) as one of the salient barriers to the shift from linear to circular product life cycles. Few businesses truly possess the expertise and knowledge required to successfully alter their operations to participate in the circular economy. Suzanne et al. (2020) on the other hand contend that there isn’t enough research on non-deterministic or heterogeneous data formats. They emphasize the importance of extracting knowledge from data that is already available to support decision-making

in the circular economy, whether it is in deterministic-based, probabilistic, or fuzzy formats. The article implies that improvements in communicating technologies and high-performance computing technologies can help bridge this knowledge gap. Additionally, the article indicates the need for better material collection, material description, and material analysis understanding in the context of circular economy practices.

2.2.3 Discussion

From the literature, we see that there is a large discrepancy between the linear economy and the circular economy (Stahel, 2019; Weetman, 2021; Geissdoerfer et al., 2020). While the traditional linear economy deals with extracting and depleting virgin materials to create (often) cheap and low-quality products which end up in landfills at the end of their short life-span, the circular economy on the other hand is interested in keeping materials in the resource loop for as long as possible by for example ensuring product-life extension such as reuse and remanufacturing. It is a whole different mindset and requires quite different setups with regards to supply chains, business models, product processes etc., and there are large barriers and challenges linked to this.

The literature widely acknowledges the socio-cultural barriers to transitioning to a CE as one of the largest barriers. This includes things like customers' lack of knowledge and interest, and large skepticism towards reused products, as well as their preference for new products due to perceived safety and convenience (Kirchherr et al., 2018; Tan et al., 2022). We also found companies to be resistant to adopting circular economy principles due to a lack of awareness, understanding, and risk aversion (Kirchherr et al., 2018; Suzanne et al., 2020). However, as far as we could find, these barriers do not so much talk about other actors such as suppliers, policymakers, retailers etc. This could prove problematic, as we believe they could also be key actors in the shift towards CE, since they are important to things like the supply chain, regulatory support, and influence towards more demand of circular products. Therefore, we need more research into these actors and their role in the transition to CE and think that it could be interesting to look at them going forward.

The literature also extensively discusses the knowledge/technological barriers and

challenges to the circular economy. Among them are the need for businesses to adapt to new technologies and materials for profitable remanufacturing systems, the inability to deliver high-quality remanufactured products, the absence of circular design, and a lack of technological know-how. However, the literature does not agree on the perceived importance of technological barriers. While some studies emphasize their importance, other studies contend that technological barriers are not the most pressing issues (Kirchherr et al., 2018). We think that some companies might overemphasize the dependence of new technologies to create and implement more circular practices and is therefore interesting to look further into in our study. Furthermore, there is limited discussion on topics like better material collection and analysis in the context of the circular economy, knowledge extraction from available data, non-deterministic data formats etc. in the literature.

Finally, the literature acknowledges market/economic and policy/regulatory barriers to the CE. Market/economic barriers have to do with things like high upfront costs for circular business models, cost difference between linear and circular production systems, and a dearth of markets for recycled goods. Additional barriers are highlighted such as the cost structure and the financial incentive for customers to select environmentally friendly options. Policy/regulatory challenges have mostly to do with supportive regulations and policies for circular economy initiatives, such as policies for extended producer responsibility, product design for circularity, and circular procurement. Barriers also include the absence of support from government organizations and the existence of regulations that conflict with circular economy principles. Although we think research on things like cost issues, policies, and regulations is important and promising, we also contend that barriers and challenges companies face in the transition to a CE, are much more intertwined than the literature lets on. For example, it could be imagined that companies are skeptical (cultural barrier) towards circular economy practices because circular products are more expensive than new (economic/market barrier) due to non-supportive policies of reused products (policy/regulatory barrier) or due to not having the adequate knowledge (knowledge/technology barrier). How these barriers and challenges (and others) are linked could be an interesting avenue for further research and could be important to understand how businesses can overcome the barriers and implement more circular practices.

From the literature we see that there are large barriers and challenges to transitioning to a CE which requires a great deal of changes to existing regulations, business models, and socio-cultural issues. In the following, we try to identify which critical activities are needed to make the transition easier and how to alter the value creation system effectively to more circular practices.

2.3 Critical Activities in Circular Value Creation

2.3.1 Business Model Innovation

According to Osterwalder & Pigneur (2010, p. 14), the business model (BM) is defined as "the rationale of how an organization creates, delivers, and captures value", which says something about how organizations develop and give value to consumers. Osterwalder and Pigneur also attempt to describe, organize, and visualize the business model through what is known as the Business Model Canvas (BMC), consisting of elements such as key resources, value propositions, revenue streams and so on (see Appendix B). When it comes to describing business model innovation (BMI), Chesbrough (2007a, 2010) reports that BMI is an organizational change that happens within the firm. Teece (2010) concurs that a significant innovation barrier lies between current technology and business models, and the new model's efficiency needed to harness potentially disruptive technology for value creation. Massa and Tucci (2013) further argue that BMI, whether through design or reconfiguration, can itself be a source of innovation and competitive advantage if it's sufficiently unique and hard to replicate.

2.3.2 Circular Business Model Innovation

First, we look at literature on sustainable business models as this in many ways the antecedents of circular business model (innovation) and therefore important. Bocken et al. (2013, p. 484) define sustainable business models (SBMs) as "business models that create competitive advantage through superior customer value while contributing to sustainable development of the company and society." SBMs typically build on sustainable development and the 'triple bottom line' approach, a concept which posits that firms should in addition to financial performance, measure their environmental and social impact (Miller, 2020). Therefore, SBMs must have great consideration for economic, social, and environmental issues. Bocken et al. (2013) propose a value mapping tool (see Appendix C) based on case studies from companies in different industries and

countries, to help further research and practice of sustainable business model innovation (SBMI). The tool aims to describe the value network of stakeholders and identification of conflicting values and opportunities of business model redesign. Aspects of the value mapping tool include four value dimensions (value opportunities, value missed, value destroyed, and value captured), stakeholder segments (academia, investors, environment etc.) as an extension of the traditional business modelling focus on customer value proposition, and a network-centric rather than firm-centric perspective to optimize value.

Bocken et al. (2014) define sustainable business model innovation as innovations that significantly impact the environment and/or society through changes in how an organization and its value network operate. They propose sustainable business models archetypes like 'maximise material and energy efficiency' and 'create value from waste', which align with circular economy concepts. These archetypes not only mitigate environmental impacts but also offer potential for value creation, delivery, and capture. This is in contrasts to traditional linear business models (LBMs), which are described as open-loop, often disregarding product lifecycles, and where value creation is mostly about extracting virgin materials to produce products for the highest profit possible (Salvador et al., 2020). These business models and value chains are unfortunately so embedded in business and society, making the shift to circular models challenging. Bocken et al. (2014) propose a framework to facilitate the transition to a CE through product design and BM strategies (see Appendix D). The framework emphasizes the need for a circular vision, which inspires innovation to alleviate sustainability pressures. It suggests slowing resource loops through product-life extension and designing for technological and biological cycles, and closing loops through access and performance models, extending product and resource value, and promoting industrial symbiosis.

There are several researchers who point out that rethinking and redesigning business models in a radical manner is crucial for a successful transition to the CE (Pieroni et al., 2018; Geissdoerfer et al., 2020; Bocken et al., 2016; Stahel, 2019; Lewandowski, 2016). Circular business models and circular business model innovation (CBMI) are particularly important for sustainable development, and many highlight the typical economic, environmental, and social dimensions of

sustainability in this regard. CBM integrates elements from the CE definition and includes recycling (cycling), use phase extensions (extending), intensification of use phase (intensifying), and product substitution with services and software solutions (dematerializing) Geissdoerfer et al. (2020). Further, CBMI involves the creation, diversification, acquisition, or transformation of BMs into circular ones. Importantly, this can affect the whole model or parts of it, the element relations, and the value network, and understanding this is crucial. The four CBMIs are circular startups, CBM diversification, transformation, and acquisition (see Appendix E). Geissdoerfer et al. present a CBM framework covering value proposition, creation & delivery, and capture in the four CBMIs (see Appendix F). Geissdoerfer et al. (2022) explore CBMI drivers and barriers. Primarily, financial factors drive CBMI, linked to business growth and cost reduction. Main drivers for CBM transformation, startups, and diversification relate to the growing demand for sustainable products. Start-ups and diversification focus on growth and cost reduction, while transformation emphasizes strategic renewal and resilience.

Lewandowski (2016) acknowledges that extensive knowledge of CBMs must be developed on a firm-level to implement them successfully in companies and foster the move to a CE. To help companies in designing well-functioning CBMs, Lewandowski (2016) uses the BMC of Osterwalder & Pigneur (2010) and adds two new elements to the framework to move towards a circular business model canvas (CBMC), these being ‘adoption factors’ and ‘take-back system’ (see Appendix G). Take-back systems is about retrieving products and resources from customers to be recycled, reused, remanufactured, thereby given new life, and kept in the loop for longer. This incentivized reverse logistics is complex and requires different types of partnerships, channels, and customer relations, but the inclusion of it in the canvas could aid in an easier transition. Adoption factors meanwhile, are the ways a company responds to external and internal factors which determine a successful adoption to a CBM. The internal factors are concerned with things like developing human resources and team building, while external factors handle things like developing necessary technologies, understanding economic forces at play, and sociocultural issues such as customer habits. Both take-back systems and adoption factors are crucial for the 'triple fit challenge' of transitioning to CBMs, requiring alignment between take-back systems, value proposition, customer segments, and potential adoption factors which are blocking the way.

Pieroni et al. (2018) elaborate on Bocken et al. (2013, 2016) work, emphasizing the need for a network-centric approach to the circular economy, with sustainability as a key foundation for firms. They propose sustainable criteria for designing circular business models, divided into five categories: value proposition, creation, delivery, capture, and transformation. Notably, value creation can be tied to a value chain or network. Such networks can promote sustainability and circularity by managing environmental resources, minimizing waste, repairing environmental damage, and advocating network-centric approaches to the circular economy.

2.3.3 Value Networks

While the value chain model has been successful in driving economic growth and development in modern times, it is not necessarily sustainable nor circular (Eisenreich et al., 2022). Also, the value chain typically focuses on the production and delivery of a product, without considering its entire lifecycle. Further, as not all sectors have value chain creation, Stabell and Fjeldstad (1998) suggests that many businesses should be viewed and evaluated more as value networks. A value network is a concept that connects clients and customers that are or want to be dependent on one another. In this model, value is generated through interactions between the different stakeholders in the network. These interactions can take many forms, such as collaboration, information sharing, or co-creation of products and services. By working together, stakeholders can create new value that would not be possible if they were working in isolation. The most important elements are scale and capacity utilization since they have an impact on both value and cost. Due to the substantial infrastructure needs, scale is essential for costs - as when having many participants, one can cover these costs (Stabell & Fjeldstad, 1998). With such outcomes, the advantage of the service to the customer grows as the customer base does.

As technology continues to evolve at a rapid pace, its role in shaping and enhancing value networks is becoming increasingly significant. Mediating technology can be instrumental in optimizing value network functionality. The primary function of mediating technologies is to facilitate and streamline communication and interactions between different stakeholders within a network. This not only simplifies the sharing of information, resources, and ideas, but also fosters a

collaborative environment, encouraging co-creation of products and services (Eisenreich et al., 2022).

Overall, the value network model is considered a more sustainable and circular business model than the traditional value chain model because it encourages collaboration and take more of a lifecycle approach to value creation (Spraul & Stumpf, 2022). In the value network model, actors work together to create value, which can lead to more efficient use of resources and reduced waste. By working together, stakeholders can also identify opportunities for innovation and create new solutions that are more sustainable and circular (Spraul & Stumpf, 2022). As a result, a firm's BM can add value if it is approached in a more open manner. Also, by employing a company's key asset in both its own operations and the operations of other companies, more value can be captured. According to this approach, the move towards a circular economy shifts the focus from independently running businesses driven by individual profit maximization to sustainability-focused value chains powered by collaborative value creation (Chesbrough, 2007b). Also, the value network model could provide a more lifecycle approach to value creation, considering the environmental and social impacts of a product or service throughout its entire lifecycle, from sourcing to disposal. This approach helps to minimize waste and pollution and encourages the adoption of circular business practices, such as reuse and recycling (Spraul & Stumpf, 2022).

2.3.4 Discussion

The presented literature looks at exploring value creation through a lens that expands beyond the traditional economic-focused view. According to Bocken et al. (2013), sustainable business models create superior customer value while contributing to the sustainable development of both the company and society. Such models should consider economic, social, and environmental issues. From a more granular perspective, the literature outlines specific activities that can enable circular value creation. Bocken et al. (2014) mention 'maximise material and energy efficiency' and 'create value from waste' archetypes, which describe many concepts that are central to the circular economy literature. Activities such as closed loop and cradle-2-cradle can therefore be crucial for value creation in the circular business model context. Furthermore, Lewandowski (2016) introduces the concept of 'adoption factors' and 'take-back system' as necessary additions to the Business

Model Canvas when moving towards a CBM. In other words, the adoption of CBMs involves both responsive strategy to external and internal influences and the integration of take-back systems that allow for better circulation of materials.

Also, the concept of value networks, as presented by Stabell and Fjeldstad (1998) and developed upon by Eisenreich et al. (2022) and Spraul & Stumpf (2022), offers a beneficial framework for evaluating and enhancing the circular economy practices within the construction industry. Especially looking at activities can enhance interactions and dependencies among actors, potentially stimulating innovative collaborations and co-creations that drive circularity and sustainability.

Therefore, understanding these critical activities is crucial to answering the main research question as it can help uncover activities that need transformation to boost material reuse and maximize value creation. In the following we look at the methodological approach we used, what we found, and provide a discussion of the key findings.

3.0 Research Methodology

3.1 Research Design

In the context of our research question and study, we have chosen to employ a qualitative approach. This is because we wanted to understand the actors' experience of reuse of materials within the construction industry and explore the transformation of the current value creation system to a more sustainable one. A qualitative approach is determined to be the most suitable since our chosen case company (Sirkulær Ressurssentral) and its ecosystem partners are included in our sample, especially at the decision-making level, as an embedded highly complex unit of analysis (Straits & Singleton, 2018).

In order to conduct a thorough investigation of the phenomena and determine which aspects are critical for how value is created in a circular economy, this research uses a single case study method (Yin, 2017). Adopting a single case study approach for this research is beneficial due to several reasons, because it allows for an in-depth understanding of the dynamics of the current value creation system within the construction industry. It also offers the opportunity to analyze specifics that facilitate or obstruct the reuse of materials through our case company.

Understanding the unique environmental influences on a company's practices related to material reuse can offer rich, context-specific findings. The single case study approach permits a detailed exploration of the real-world implications of our research problem. The findings can provide practical and actionable recommendations for firms within the construction industry that wants to implement more reuse in building projects through our case company. Additionally, using single case study method enables us to develop new theoretical propositions in an area where existing theories may fall short (Siggelkow, 2007). The complex interrelation between the value creation system, circular economy principles, and material reuse can be effectively handled using this method. Finally, considering the uniqueness of the case in question, a single case study can uncover significant insights that would likely remain hidden with other research methods. The findings can potentially be generalizable and expand the literature, and also offer valuable knowledge for other firms in similar sectors or circumstances (Yin, 2017).

3.2 Empirical Setting

In our study, we seek to examine an organization within the construction industry to understand its value creation system and its methods for facilitating material reuse. For this purpose, we have chosen Sirkulær Ressurssentral, based on our interest in their innovative approach to material reuse and their willingness to facilitate our study. Sirkulær Ressurssentral is a business striving to increase the reuse of building materials in the construction industry. Through various initiatives, such as the establishment of one of Europe's largest reuse centers, the organization significantly contributes to reducing the carbon footprint of the construction industry in a socially and economically sustainable way (FutureBuilt, n.d.). As our research question centers around identifying areas within the construction industry's value creation system that need transformation for increased material reuse, Sirkulær Ressurssentral provides an ideal context. It operates in an environment where these transformations are underway, offering rich empirical insights into this complex process.

As we needed an empirical setting that clearly illustrates the phenomenon of transformation in value creation systems to facilitate increased material reuse (Eisenhardt & Graebner, 2007), we selected Sirkulær Ressurssentral as our case company. We identified this organization as one that could provide us with rich

empirical descriptions of material reuse practices within the construction sector. After engaging in discussions with Sirkulær Ressurssentral, we also understood that our research topic is of considerable importance to the organization and the industry. This relevance further underscored our decision to use Sirkulær Ressurssentral as the case company.

3.3 Data Collection

To comprehend the transformation needed within the current value creation system in the construction industry to promote increased reuse of materials, it's necessary to acknowledge the actors involved in and around Sirkulær Ressurssentral and their network within the industry. Therefore, employing a variety of evidence sources is crucial as they can shed light on the diverse perspectives and practices. This will improve the robustness and the overall quality of our research (Yin, 2017).

It is generally inadvisable to conduct a case study using only one information source. Yin recommends triangulation, which justifies the use of multiple sources of evidence. Accordingly, we gathered evidence through interviews, review of archival materials, and observations - all converging on the same research question. Each of these sources offered unique insights into the areas within the construction industry's value creation system that require change for enhanced material reuse.

3.3.1 Interviews

In our study, we employed theoretical sampling to guide our data collection. We started with Sirkulær Ressurssentral as our main case company to its role in promoting material reuse in the construction industry. As our understanding deepened through data analysis, theoretical sampling guided the selection of other participants. These included key actors within the industry whose experiences and perspectives could provide insights into the areas requiring transformation to enhance material reuse. This approach enabled us to capture a comprehensive and critical understanding of the value creation system within the construction industry. In addition to interviewing the representative from Sirkulær Ressurssentral, we therefore conducted interviews with 10 other individuals who play significant roles in promoting sustainability in the construction industry (see Table 1). These participants, although all having some connection with Sirkulær Ressurssentral, were chosen not only for their organizational affiliation but also for their broader

contributions and expertise in the sustainability field of the construction industry. Their perspectives were particularly valuable because they not only represent their respective companies, but also provide insights into the larger sustainability movement within the industry. They play crucial roles in influencing, implementing, and promoting sustainable practices and strategies within their respective organizations and the construction industry at large.

Table 1: Overview of conducted interviews

Informants	Actor	Area of responsibility	Length and type
A1	Resource center	CEO	1 hour - Teams
B1	Consulting engineer	Partner	1 hour - Teams
C1	Insurance	Industry Manager	1 hour - Teams
D1	Client	Consultant Engineer	30 min - Teams
D2	Client	Director of Sustainability	1 hour - Teams
D3	Client	Environmental Consultant	1 hour - Teams
D4	Client	Head of Department for Sustainability	30 min - Teams
D5	Client	Director of Sustainability	30 min - Teams
E1	Contractor	Director of Sustainability	30 min - Teams
E2	Contractor	Chief Adviser Climate and Environment	45 min - Teams
E3	Contractor	Head of Environment	45 min - Teams

We used semi-structured interviews as our primary source of data to gain an in-depth understanding of the actors, barriers and challenges with reuse, and critical activities in the circular value creation system. All interviews were conducted with the consent of the informants. To prevent bias and ensure that the data is sufficient and consistent in quality, both authors attended all interviews. To simplify the coding of the data, we transcribed the interviews after they were conducted, providing a wide range of data material (Straits & Singleton, 2018). We used the online platform Microsoft Teams to conduct all our interviews remotely while interacting visually with the informant.

To narrow the focus of the conversation, a general interview guide was developed before each interview. A semi-structured interview is used to examine the informants' unrestricted discussion of the subjects and to delve deeply into any knowledge gaps. Another rationale for this was to maintain consistency in the research done; as a result, we were required to ask comparable questions to guarantee accurate data. Additionally, the value of asking open-ended questions

cannot be overstated to avoid steering the informant in a particular direction (Straits & Singleton, 2018). As a result, we were able to conduct a variety of interviews and talks with various informants while still adhering to the research's essential subjects. We sent all informants an email outlining the purpose of the research before scheduled interviews, to enable informants to prepare and familiarize themselves with the conversation topics in the interviews. Additionally, we made sure the informants were comfortable with the audio recording of the interview being used to support our data and conclusions. By recording the interviews, the informants' verbal responses are fully obtained (Meyer, 2001).

3.3.2 Archival Records

We used archival data, such as minutes from conferences, internal and external reports, public files, service records, and survey data generated by others, to add to our data collection. These data sources, often underutilized, offer rich contextual information that can significantly contribute to understanding the research phenomena. The strength of archival records lies in their non-reactive nature, implying that they are not influenced by the research process, which enhances the validity and reliability of the results (Straits & Singleton, 2018). Furthermore, these sources can provide longitudinal perspectives, enabling researchers to analyze trends and changes over time (Yin, 2017).

3.3.3 Observations

We used observational data from participation in several workshops and meetings that Sirkulær Ressurssentral, Pådriv, and other partners facilitated during our study. Observations serve as a crucial data source in qualitative research because they provide a firsthand account of the behaviors, interactions, and practices within the context being studied (Straits & Singleton, 2018). We have gained a greater understanding of the dynamics of the actors in the circular economy ecosystem and how value creation networks are created and evolved within the network by attending these. To collect data on these observations, we took notes throughout the meetings and workshops.

3.4 Data Analysis

In order to answer the research question, data is categorized, reviewed, and combined during the analysis process (Yin, 2017). For our data analysis we

employed the Gioia Methodology, a systematic qualitative data analysis approach devised by Gioia et al. (2013). This methodology allowed us to discern the critical areas within the value creation system of the construction industry that require transformation to facilitate increased material reuse.

The first step involved the open coding of the data collected from our case study of Sirkulær Ressurssentral. Here, we read through our interview transcript looking for phrases, concepts, or ideas that were repeatedly mentioned or emphasized by participants. These recurring elements were then labeled as first-order concepts, maintaining the native terms used by our informants. Next, we proceeded to axial coding, where we grouped these first-order concepts based on their thematic commonalities, thus creating second-order themes. This step involved constant comparison and reflection to ensure that these themes accurately represented and synthesized the original first-order concepts. Lastly, we developed aggregate dimensions by combining related second-order themes. These dimensions provided an overarching categorization that captured the essence of the grouped themes. This data structuring process allowed us to distill complex and diverse data into a manageable and comprehensible format (Gioia et al., 2013).

Throughout the analysis, we consistently returned to our data to validate our interpretations and ensure that our final model accurately represented the participants' perspectives and experiences. This iterative and reflexive process led us to understand the specific areas within the value creation system of the construction industry that require change to foster greater material reuse. As a result, using the Gioia Methodology allowed us to gain detailed, nuanced, and grounded insights into our research question, facilitating a rich understanding of the current state and potential transformations within the value creation system of the construction industry.

3.5 Quality of Research

When conducting a qualitative study, quality criteria such as reliability and validity need to be considered to ensure the study's robustness and credibility. These quality criteria guide the researcher in maintaining rigorous methodological approaches and provide a framework for the assessment and interpretation of the study's findings. Additionally, addressing reliability and validity contributes to the

transparency of the research process, aiding in the establishment of trustworthiness and increasing the study's potential for impact and contribution to the existing body of knowledge (Straits & Singleton, 2018).

3.5.1 Reliability

Reliability, which is concerned with the reproducibility of a study's findings, can be divided into external and internal reliability, where the degree of research replication is referred to as external reliability (Straits & Singleton, 2018). Due to the distinctive characteristics of Sirkulær Ressurssentral and the circumstances of the construction sector throughout our study, replicability may offer difficulties in the context of our qualitative research. However, we make sure to provide a thorough description of our procedures and approaches to enable prospective replication in contexts that are similar to strengthen external reliability. Regarding internal reliability, it has to do with the degree of consistency among different researchers' observations and interpretations within the same study (Straits & Singleton, 2018). Internal reliability was preserved in our study by methodically recording every step of the investigation, especially while employing the Gioia Method for analyzing data. We thoroughly documented how we came to our coding choices, read the data, and processed it. If different conclusions were reached, we went back to our original data—interview transcripts and archive materials—to settle the differences. Given the difficulties and complexities of qualitative research, we have made substantial efforts to guarantee that our study is reliable in this regard.

3.5.2 Validity

Validity refers to the extent to which a study accurately reflects or assesses the specific concept or process that the researcher is attempting to measure, ensuring the research findings truly represent the phenomenon being studied (Straits & Singleton, 2018). It is an essential element of qualitative research and is divided into internal and external validity. Internal validity refers to the consistency of the theories the researchers establish with their observations. In our case, triangulation allowed us to cross-check data and assure internal correctness. We carefully reviewed notes from our meeting observations, analyzed archival records, and compared these findings with our interview data. This process made sure that the evidence supporting our claims came from a variety of sources (Yin, 2017).

External validity determines if the research findings may be generalized or applied to other settings, populations, or situations outside of the original research context (Straits & Singleton, 2018). Since our study is a case study that specifically examines Sirkulær Ressurssentral and has a limited sample size, our primary focus is not on achieving high levels of external validity. Instead, our goal is to give readers a thorough grasp of the precise value creation activities that take place within the context of the circular economy and material reuse.

3.5.3 Ethical Considerations

In all research, ethical issues are crucial. The protection of human objects, data collecting and analysis, and social responsibility are the three main themes of research ethics (Straits & Singleton, 2018). We follow guidelines set by BI Norwegian Business School to prevent endangering people while doing research to satisfy ethical issues. Careful assessment and referencing are used to prevent the informant's identity from being revealed to safeguard their anonymity. All informants have been told of the study and of what it intends to find, as well as their motivation for being invited to the study.

4.0 Findings

This section presents the findings of our interviews and other archival data. We will first provide an overview of the construction industry and the main actors that ensure the circulation of building materials. Then, we investigate the barriers and challenges of reuse for the main actors in the construction industry. Finally, we explore critical activities that can ensure material reuse.

4.1 The State of the Construction Industry and Main Actors

It is essential to examine the current actors in the construction industry, and its state, to identify the roles that are needed to accomplish a circular construction industry. Understanding these actors' existing business models is also crucial, and we utilize relevant elements from the Business Model Canvas (Osterwalder & Pigneur, 2010) to describe the current state of each actor based on our interviews and the report *Fremtidens forretningsmodeller i byggebransjen* developed by Æra (n.d.). We determine that the most significant actors in the construction industry are Clients, Architects, Consulting Engineers, Contractors, and Policy Makers.

4.1.1 Clients

Clients commission and fund construction projects. This can range from private individuals looking to build or renovate homes, to corporations building offices, commercial housing, or factories, to governments commissioning public infrastructure and building projects. Their primary concern is typically to get the best value for their investment, which often means minimizing cost while maximizing quality and functionality. Traditionally, property owners or clients prioritize lower upfront costs, faster completion times, and high quality. The construction process is often seen as a one-time expense, rather than a long-term investment. Clients' demands for low-cost, rapidly completed projects can discourage contractors from considering more sustainable, but potentially more time-consuming or costly, circular practices. The value that clients look for in the construction industry revolves around meeting their specific needs for buildings or structures, whether they are residential, commercial, or industrial. This value may be found in the quality of construction, cost-effectiveness, speed of project completion, sustainability credentials, aesthetic appeal, or post-construction services like maintenance and repair. When it comes to customer relationships, clients expect construction companies to provide personalized service, dedicated project management, post-construction support, or even self-service platforms for smaller projects. The nature of this relationship depends largely on the size and complexity of the project.

4.1.2 Architects

To guarantee that plans are accurately executed, architects design buildings and other structures, define the materials to be utilized, and supervise the construction process. Typically, their designs are influenced by customer needs, aesthetics, functionality, regional building codes, and cost. These professionals are typically focused on creating structures that meet client specifications, often without considering the life-cycle impact of their material choices or the potential for disassembly and reuse. The traditional fee-for-service model doesn't incentivize them to design for the long-term or consider the circularity of materials. The key activities of architects go beyond just creating building designs. They also include understanding the client's needs and vision, preparing detailed drawings and specifications, applying for necessary permits, and overseeing the construction

process to ensure that it adheres to the original design. The key resources for architects are their design skills, their knowledge of architectural principles and building codes, their proficiency in architectural software, and their professional reputation. These resources are the pillars upon which they build their practice.

4.1.3 Consultant Engineers

Consulting engineers in the construction industry serve a variety of clients, including real estate developers, construction companies, architectural firms, and government entities. Occasionally, they also cater to individual clients who require specialized expertise for their construction projects. The value proposition of consultants is centered around their expertise in material reuse, their ability to navigate regulations and standards related to reclaimed materials, and their capacity to manage the logistical complexities of material recovery and reuse. They might operate on a consulting fee basis, where they are paid for their expertise and advice. Alternatively, they might operate on a service contract basis, where they are paid to manage the reuse process, which could include sourcing reclaimed materials, managing deconstruction processes, or liaising with other construction professionals to integrate reused materials into new projects. Perhaps the most valuable resources that the consulting engineer possesses is technical knowledge and expertise in engineering, their understanding of building regulations, and proficiency in using specialized software and tools.

4.1.4 Contractors

Construction companies or contractors translate architects' designs into physical structures. They source the necessary materials, hire and manage the workforce or other sub-contractors and coordinate all aspects of the construction process. Conventionally, contractors operate on a project-by-project basis, focusing on delivering a quality product set in their contracts on time and within budget. Their main revenue comes from the completion of individual projects, with little consideration for the materials' lifecycle or the waste produced. Contractors tend to go for the least risky and most cost-effective methods, which often means using new, virgin materials instead of reused or recycled materials. The traditional contracting model also encourages a 'take, make, waste' mindset rather than a 'build, deconstruct and reuse' one. The key activities of contractors include not just the physical construction, but also project planning, sourcing, and managing resources

such as labor, materials, and machinery, ensuring safety compliance, and quality control. Coordinating with other stakeholders, like suppliers, subcontractors, and government bodies, is also a critical activity. Contractors often work closely with various partners, which include suppliers for materials, subcontractors for specialized tasks, architects and engineers for project planning and execution, and legal advisors for contract and regulation matters.

4.1.5 Policy Makers

These entities create and enforce laws and regulations and develop policy. Policymakers, while they do not have traditional "customers", serve a broad array of stakeholders. In the context of the construction industry, these stakeholders are typically construction companies, contractors, real estate developers, consulting engineers, and ultimately, the general public. The decisions policymakers make affect all these groups in various ways. The main offering, or value proposition, of policymakers is the creation and implementation of policies that aim to ensure a safe, sustainable, and equitable construction industry. Policymakers strive to balance the diverse interests and needs of their many stakeholders. They do this through setting effective regulations and standards that govern construction practices, from building safety and environmental impact to labor laws. The key activities of policymakers encompass a wide range of tasks, such as researching industry trends, consulting with stakeholders, drafting policies, guiding policy approval through legislative processes, and implementing the approved policies. Moreover, they periodically review and update policies to reflect changing circumstances or new information.

The transition to a circular construction industry presents significant challenges for all stakeholders involved. Nevertheless, identifying these challenges and critical activities can offer a structured approach to understanding and tackling the issues strategically, paving the way for a more sustainable and resilient construction industry.

4.2 Barriers and Challenges in the Construction Industry

The construction industry is one of the most pollutant and wasteful industries globally, due to the several barriers and challenges that stand in the way of effective reuse of building materials. This, alongside being increasingly visible in

the debate regarding circular business models in the industry, makes them important to address. Based on our findings we have created a data structure (Figure 1), which shows the two aggregate dimensions (Barriers/Challenges and Critical Activities) and their accompanying second-order themes: Documentation and Verification, Costs, Competence and Culture, Regulations and Incentives, Marketplace, and Take-Back Systems. Table 2 illustrates representative quotes underlying these second-order themes, which is explored in detail in the following sub-chapters.

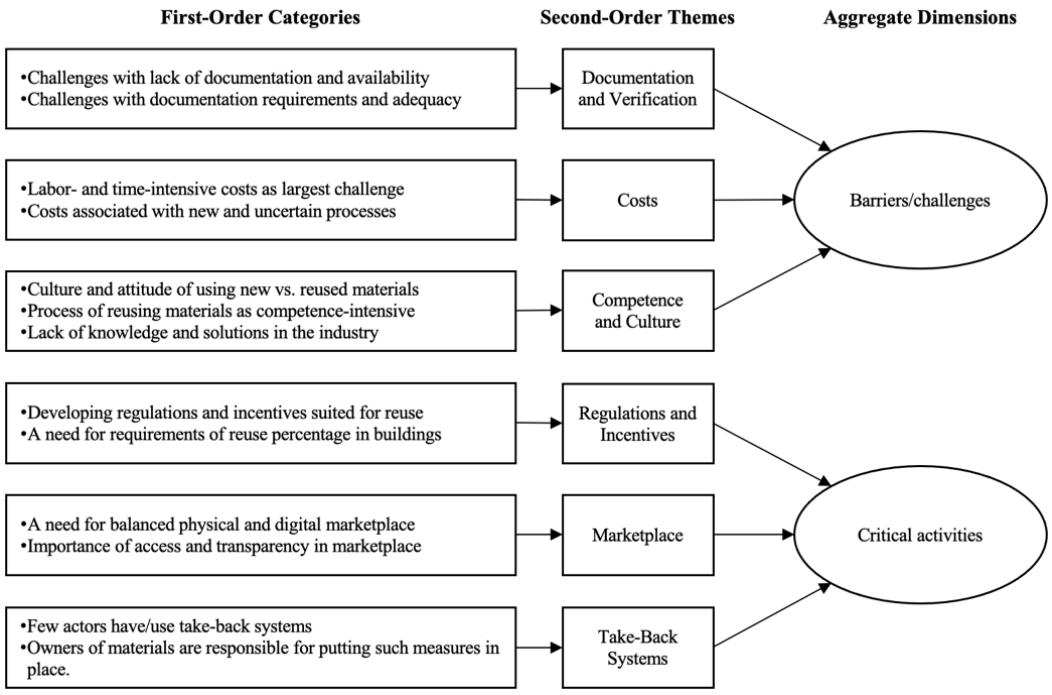

Figure 1: Data structure

Table 2: Representative quotes underlying second-order themes

First-Order Categories	Second-Order Themes	Aggregate Dimension
	Documentation and Verification	
Challenges with lack of documentation and availability	Yeah, because it's like these guarantee schemes for building materials. Like if the product is quite new, then it's fine. Then you know what the expected lifetime from the factory is, while is it's reuse or the reused building material... First of all, you might not have the original documentation, so then you have little to go on when it comes to the quality in the product. *Partner, B1*	Barriers/ challenges
	That' the largest challenge with regards to reused building materials today, the lack of documentation, and availability. That is, that you can plan to extract this amount of materials... that's where Sirkulær Ressurssentral can help increase volume, but their challenge is that they often receive material that does not have original documentation or that does not have a product warranty, so that... If there is some fault with the product that they are redistributing, then the contractor has nothing to go on. Then the contractor is standing there with the cost coverage of the deficiency that… or whatever damage may occur. *Industry Manager, C1*	
	And then we also see that it is difficult to find good enough documentation for what we want to reuse, so it creates consequential errors and cost effects. Then you must also be able to document that what is to be reused is good enough then. *Director of Sustainability, D5*	
	Broadly speaking, if a building changes hands three times, all the documentation is gone. Yeah, then you have almost nothing left. So to sort of get good… solutions that are applicable, to document… what's in the buildings... And in such a way that you're sure that, "yes, but this is responsible" right? *Industry Manager, C1*	
Challenges with documentation requirements and adequacy	[...] and they are 50 year old hollow core element floors. After all, there wasn't a standard for how to manufacture those element floors when they were even manufactured, so they kind of don't have any documentation that it's safe to put in (the building). And then comes.. Because after all, it's .. In 'Byggteknisk forskrift', there are a lot of requirements for it to be safe to build. And if you don't have documentation that it satisfies this and that, well, then it's very difficult to put it into your building. *Industry Manager, C1*	
	It's kind of what goes on documentation. (It) is still a challenge to get it at the right level at the right price, so you don't lose the financial sustainability because the documentation requirements are too high... Where it's not necessary, but that they're at a high enough level that it's still safe and secure and able to find the balance there. It's a challenge that needs to be worked on a lot, and we need to be many, many in that process. *CEO, A1*	
	Costs	
Labor- and time-intensive costs as largest challenge	[...] like with bricks, right, that it just takes more time, and time costs a lot. People's worktime, and to sit and wash by hand versus getting it on a pallet, done and everything, and you have warranty on it. It's very clear that it's much easier to buy new. Yeah, you have warranties and demands with regards to delivery time and, right? Clearly, it's… easier and therefore goes quicker and, yeah… it's probably the work hours and that additional cost that it (reuse) creates… *Director of Sustainability, D2*	Barriers/ challenges
	And a used building product is between 20 to 80% cheaper than a new building material. Depending on what kind of components it is and how long its residual lifetime will have then. So there are, in a way, significant financial opportunities to make savings on projects. But if there is too much process and too much consulting hours and too much reengineering, then it costs a lot of money. *CEO, A1*	
	[...] it's both like… actually time spent, that you have to find both the tailormade solution for where the material shall come to agreed delivery, and then plan all that and so it… it's kind of… it takes time and then again, it's logistics and… testing possibly also costs, which also takes a lot of time. So yeah, it's that. It's kind of that… that picture, very large differences between using new and reusing. *Head of Environment, E3*	
	Yeah, I mean, disassembly even though the material itself is perhaps cheaper than new material. It may need to be was hed. It may need to be treated/reprocessed. It's to be transported from one place to another. And then if it's going in… if it needs documentation on its properties. So I guess a lot of people say that they're sort of on the same level as new (materials) then, for now. *Environmental Consultant, D3*	
	But then there are some barriers, of course with regards to rehabilitation. Because you get a document fee, buy a building and are going to rehabilitate. But if it's demolished then the fee is dropped. I don't think I'm rendering it quite correctly, but it's a huge barrier. Just specifically against rehabilitation, because it just pays off to demolish and build completely new. Because then you avoid that big document fee, so there are some barriers like that. *Chief Adviser Climate and Environment, E2.*	

	Because to disassemble a building rather than demolish, to think of what we're demolishing as waste, to think that what we're disassembling is something that we're going to reuse, those are two totally different processes… it's more time-consuming. It's more resource-demanding, competence-intensive, and you need people who really understand this stuff, and you have to do it with 'silk gloves' on. *Director of Sustainability, D2.*	
Costs associated with new and uncertain processes	It cost a lot of money with Kristian August gate.. Because it's just a pilot project. You hadn't done it before, because you didn't have a value chain. You had very expensive advisers who sat on Finn.no and had to find used building materials, so if you spend 1400 kroner or more an hour for someone to sit on Finn.no, then it becomes expensive. *CEO, A1*	
	[...] we need experience in the field for the value chain to be as smooth as possible. Because if you look at Kristian August gate 13 and the cost estimates made there. They had to do things for the first time, and it was very expensive. But now that if you are clever in a way and share experiences and people become good at handling reuse or the value chain and how it works, then it will be cheaper and more efficient. *Partner, B1*	
	So the re-use of steel, for example, we see that there can be very good profitability in it, while there are other things such as the re-use of hole covers, concrete hole covers, have so far not been shown to have any good economics, but we must develop new knowledge and techniques that have looked at when it may be suitable and when it is not suitable. *Chief Adviser Climate and Environment, E2*	
	Competence and Culture	
Culture and attitude of using new vs. reused materials	We're very spoiled in Norway since we have for too many years been able to just demolish, because it's so cumbersome to take care of… and rehabilitate and reuse, disassemble and reuse. So yeah, we have too much money in a way. I mean, back in the day we used to reuse stuff because we had to, due to resource scarcity. And we didn't have economic opportunities to buy new materials, so then we didn't think of that… or then, the labor (for reuse) was cheaper, so there was no way that… but now the labor costs more, and we have more money to buy new materials. *Partner, B1*	Barriers/ challenges
	[...] I mean, it's very easy to say 'No, that's too difficult' or like 'I don't think it will be possible', without really checking, so that's perhaps a large challenge that we're working with… it's just human nature, that when you're used to ripping out and throwing away stuff and buying new, and that's comfortable and nice, then it's weird to have to disassemble and reassemble something which you used to just throw away. *Consultant Engineer, D1*	
	The culture within (our organization) you see that… people are on the same team when it comes to reuse and everything, but other than that we have a long way to go when it comes to like the human and psychological… We're actually positive when we put it on the board and say 'this is what we want, we must become better at it', but once you start talking about your project and how to finance it, right… then you become more difficult to deal with and yeah, a bit more insecure. The project leader doesn't dare take so much risk, yeah. *Head of Department for Sustainability, D4*	
Process of reusing materials as competence-intensive	Because to disassemble a building rather than demolish, to think of what we're demolishing as waste, to think that what we're disassembling is something that we're going to reuse, those are two totally different processes… it's more time-consuming. It's more resource-demanding, competence-intensive, and you need people who really understand this stuff, and you have to do it with 'silk gloves' on. *Director of Sustainability, D2*	
	[...] it's not just anyone who can carry out a good reuse project today. It's a special competence and not everyone thinks it's worth the effort. So it's very important that we choose actors with… both right competence, attitude, and understanding when it comes to reuse projects today. *Director of Sustainability, D2*	
	There are always challenges when you do something new. There will be other ways of planning. Yeah, right, because we have to think holistically, for example in my project (unnamed), it's not just that we think that 'yeah, here we're going to have other hub solutions for hollow-core element floors which can be disassembled and reused'. We have to think about the buildings stability and if it's to be an effective dismount, we have to have smaller special solutions so that it goes quick and efficiently to disassemble. *Chief Adviser Climate and Environment, E2*	
Lack of knowledge and solutions in the industry	There's little overview in the industry. We have little knowledge about that yet. In a project of mine (unnamed), where we follow several building projects all the way from element floors are disassembled till they are reused in a new project… and to learn from that. Where are the cost drivers, where are the barriers? A cost driver can also be uncertainty because we don't have enough knowledge. And this applies for most of what is suitable for reuse from demolition waste today. We have a long way to go, and then it's about the whole value chain from you have disassembled it to you have reused it. Because it has to be transported somewhere, and then it has to be tested and then stored. *Chief Adviser Climate and Environment, E2*	
	And then another element is about knowledge and solutions, simply. As a whole, the industry probably lacks knowledge to make it happen, and lacks the big solutions which makes it possible to compete with today's practice. *Director of Sustainability, D5*	

	Regulations and Incentives	
Developing regulations and incentives suited for reuse	No, it is. . . to be able to.. It's twofold then. To have.. requirements from, i.e. regulatory requirements, that can be fulfilled by reuse, right? And the second involves documenting that you have satisfied those requirements with the word usage material. [...] It's not so easy to know what it was that was in this building, right? *Industry Manager, C1*	Critical Activities
	[...] if there is an accident, you can still take the parts that are undamaged. And either keep them, that's the very best thing in that building as it stands, but if that's not an option, that you can take them out and put them in a new building and still be confident that this is good enough. [...] That then.. Then we have come a long way. I think that's the hardest bit.. to get.. Yeah, regulations such as... It must be strict, but not so strict that it stands in the way of being able to reuse. And therein lies probably a little bit of the challenge, that it is. The documentation requirements are aimed at the manufacturing industry, those who sit and produce new goods. Um. And that makes it difficult to build a new building with old goods. *Industry Manager, C1*	
A need requirements for reuse percentage in buildings	And then there's come a legal requirement that if you're going to do a resource mapping... that is.. It is a step along the way, but there is no requirement that you do anything with the information you collect then. But of course it is an awareness that you have some material that can be used and not thrown away. Obviously, and that's important, but... but.. It kind of has minimal effect really. [...] But obviously, if you could get a little more incentive that actually makes a difference when it comes to reusing material, that would be great. I think so. *Director of Sustainability, D2*	
	But in projects where a lower reuse rate of 10, 20, 30% is used and you work with components that are easier to reuse than load-bearing components and so on, there is a financial incentive… but there are of course many things that cost money because you have to pilot, figure out stuff and solve new problems, but.. some components are easier to reuse, and then you can also save some money. *CEO, A1*	
	Marketplace	
A need for balanced physical and digital marketplace	Our reason for wanting to contribute to this here is that we see that there is a shortage in the market today, meaning there is a lack of a marketplace, a physical marketplace. There are some digital ones, but they also have to put something physical in place. So we want the market to have that opportunity both here in Oslo, but we want similar things to happen across the rest of the country as well. And then we want to use it in our projects as well. To the extent that we need it, we are now working on an agreement with the Circular Resource Center to establish the extent to which we will use it in the future. *Director of Sustainability, D5*	Critical Activities
Importance of access and transparency in marketplace	What I think is a very weak point of (another existing marketplace), is that you have to be a member and pay for it to be able to... it's not like Finn.no where everything is open. I think it is an unnecessary threshold to speed up the re-use because then we can choose permission to see what we have posted to customers of ours or actors we have a relationship with then. But it would have been much better if it was open then. *Director of Sustainability, D2*	
	We probably need to get the industry together about a tool that everyone can access and share. So, yes, we need a Finn.no like that for building materials or something like that. That would have been nice. *Head of Department for Sustainability, D4*	
	Take-Back Systems	
Few actors have/use take-back systems	So, we do not have such a system. Hopefully we try to keep the materials in the loop for as long as possible, but we look at this, for example, with... we follow projects... for example with... We started using shipwrecks for another project… *Consultant Engineer, D1*	Critical Activities
	Yes, we are working on working with that type of solution. But traditionally we haven't had that. *Director of Sustainability, D5*	
Owners of materials are responsible for putting such measures in place.	We have done some pilots, but this is more for building and property owners. They are the ones who sit on large building lots and have the potential to acquire a lot of material. *Director of Sustainability, E1*	

4.2.1 Documentation and Regulations

One of the largest challenges and barriers to effectively reuse building materials in the construction industry today has to do with the lack of adequate documentation, or in many instances, any documentation at all. Primarily, this is lack of documentation of building materials regarding its properties, meaning that they often don't meet the requirements of either 'Regulations on technical requirements for construction works' (TEK) or 'Regulations on documentation of construction products (DOK). This is especially the case if the products are old and non-standardized, which means it is difficult to say anything concrete about their properties and potential faults.

First, we are talking about the first-order concept 'challenges with lack of documentation and availability', and from Table 2 we see informant B1 talking about how buying new materials is much easier to deal with than reused materials. With new materials you have all the documentation in place and guarantee schemes which protect the buyer from faults and damage related to the material. This is most often not the case with reused materials, as they can be quite old (50+ years old), meaning that they were produced at a time with less standardization and documentation. This, along with being sat in a building for many years means that its quality may have been exposed and almost rendered useless. Another informant (C1) talks about the negative ramifications lack of documentation has on contractors who buy reused materials today, since the missing documentation means they must bear all the risks and costs associated with potential faults of the product. This is also highlighted by informant D5.

Other challenges with documentation have to do with 'documentation requirements and adequacy', with informant C1 talking about how meeting documentation requirements and safety issues is key when using reused materials. He talks about a project that used 50-year-old element floors which lacked original documentation, which was difficult with regards to meeting the safety requirements from 'Byggteknisk forskrift' (TEK). Informant A1 discusses how balancing documentation requirements could help in the previous types of problems, that requirements must be strict enough so that they maintain the safety of inserting old materials into an existing/new building, but also not too strict that they hinder the financial incentive of building with reused materials. A1 highlights this is an

ongoing challenge that several actors must continually be part of and influence.

4.2.2 Costs

Costs is another large barrier and challenge related to ensuring more reuse of materials in the construction industry. Because many of the reuse projects are pilots and novel in nature, the actors often lack the necessary knowledge to make them efficient and the processes therefore quickly become uncertain and costly. This is what we call the first-order concept 'costs associated with new and uncertain processes'. One example of this is the well-known Kristian Augusts gate 13 project which sought to reuse around 80 % of the materials in the rehabilitation of the building. As informant A1 and B1 highlight, due to the novelty of this project, there wasn't enough knowledge to create a proper value chain in place for effective reuse of materials, which caused it to be very expensive in the end. However, it was highlighted by informants that this is perhaps to be expected from pilots because someone must pioneer, experiment, and take the costs associated with that. Informant E2 highlights that to overcome these types of challenges we must continue developing new and adequate knowledge and techniques. Also, rethinking how we reuse materials is necessary, for example that an element floor is not just an element floor and that it can have other purposes.

'Labor- and time-intensive costs as largest challenge' is another large cost-challenge with reused materials. According to informant A1, a used building material is around 20-80 % less expensive than a new one at first glance, but if there is a lot of process around testing, recertification, many consultant hours etc. it quickly becomes expensive. An example is the hollow-core element floor that were reused in Kristian Augusts gate, which were reportedly around eight times as expensive as buying new. This was mainly due to the high costs of the time-intensive process of testing and getting the element floors recertified for use and so on. Other informants like D2 point out the labor-intensive costs of building with reused materials, such as the inspecting, washing, and prepping of each brick for reuse in a project they had recently done. They also mention how the process of carefully disassembling a building with the goal of reusing its materials rather than just demolishing it, is more time-consuming and costly. Another factor with regards to demolition vs. disassembly is highlighted by E3, who says that you must pay a document fee when the intention is to rehabilitate, but that it is dropped when you

demolish. In other words, it is often cheaper to demolish and build new than to rehabilitate and perhaps reuse materials, which then of course is a large barrier to reuse. E3 also highlights their largest costs related to reusing materials, having to create a tailormade solution for the client, having to test and recertify the reused materials, transportation, storage and so on. The process quickly becomes timely, cumbersome, and therefore costly.

4.2.3 Competence and Culture

Lastly, having the appropriate competence about how to effectively reuse materials and the inherent culture and attitudes against building with reused, are also large barriers and challenges in the construction industry. From the first-order concept 'culture and attitudes of using new vs reused' we see that culture and attitudes have mostly to do with how actors in the industry get comfortable doing a thing because it is easy and less costly, for example demolishing buildings instead of rehabilitating and always buying new materials instead of using reused materials. Informant B1 highlights these issues. A lot of this can simply be blamed on human nature which informants D1 and D4 mention. It is easy for individuals to take distance from things that are new and unfamiliar, such as contractors and clients having to build with reused materials or rehabilitating buildings. The informants said they constantly work on changing these attitudes within their organizations, but that it takes time to take root and that the industry needs more experience with reuse and rehabilitation before everyone is onboard.

Further, we see from our data that the 'process of reusing materials as competence-intensive' as another large challenge. Several informants such as D2 say that the process of reusing materials is totally different from using new materials, that it requires more time, resources, and especially competence. They point out that there aren't many actors out there that can help them in reuse projects and that this is because it requires special competence that not many inhabit yet. Another informant (E2) points out that there will always be challenges regarding competence and knowledge when it comes to doing something new in the construction industry. The main challenge is because they need to create new techniques to carefully and efficiently dismantle and reuse materials, while ensuring that the material does not lose its integrity. They must think holistically but also detailed, which is difficult.

Related to this is the ‘lack of knowledge and solutions in the industry’ that the industry suffers from. Informant E2 mentions how there’s little overview and lacking knowledge in the industry about how to effectively reuse materials. They believe actors don’t really know what the large cost drivers are related to reuse, but that it could be mostly do with uncertainty because there is a lack of knowledge in the ‘reuse value chain’. Informant D5 simply says that there is a lack of knowledge of reuse projects in the industry for it to be competitive to the traditional ‘demolish and build new’ mantra of today.

The barriers and challenges towards getting more successful reuse projects are perhaps to be expected in an industry that has gotten comfortable with demolishing and building new buildings with new rather than reused materials. We have identified several barriers that must be overcome and challenges to be met to achieve a more circular construction industry, but what are some of the critical activities that must be put in place to make this transition easier?

4.3 Critical Activities for the Construction Industry

We can determine the crucial elements and procedures that underlie the success and efficiency of CE practices in the construction sector by looking at the key activities that make up the circular value creation system. This knowledge is essential for creating CBMs, strategies, and policies that assist the construction industry's transition to the circular economy. We recognized certain key activities from our informants that are essential to the operation of Sirkulær Ressurssentral and the flow of materials in the construction sector. Developing incentives and regulations for reuse, creating a marketplace, and ensuring implementation of take-back systems were identified as the most critical activities.

4.3.1 Regulations and Incentives

By establishing supportive environmental incentives and regulations authorities can encourage firms and individuals to adopt circular activities, such as the reuse of construction materials. For example, by providing financial incentives, tax breaks, grants, or subsidies. With the help of these incentives, adopting circular business models can become more appealing from an economic standpoint. On the other hand, regulations set forth precise rules and guidelines that encourage behavior change and guarantee adherence to sustainable practices. The use of recycled

materials is prohibited by the current business models, as stated by informant D5. Currently, if a client or contractor builds as usual, there are no penalties and reusing materials is not really rewarded. Hence, it makes sense to continue building in the same way that have been done in the past. Developing regulations and incentives suited for reuse and which rewards it is therefore a critical activity for ensuring more circulation of materials.

It is also essential to have requirements for reuse percentage in buildings. While building with 100% reused materials would be an ideal scenario for achieving maximum resource efficiency and minimal environmental impact, it may not always be practical or feasible in the current context. Given the current limitations and reality of the construction industry, A1 highlights that using 10-30 % reused materials in new construction is a realistic and a doable aim. In projects with a lower level of reuse, they shared that they experienced an economic and sustainability benefit.

4.3.2 Marketplace

In the building sector, developing a market for reused materials is crucial for enabling material exchange and improving accessibility. It plays a crucial role in the circular ecosystem, enabling the effective and efficient circulation of building materials and accelerating the shift to a more circular and sustainable construction industry. The creation of a balanced physical and digital marketplace for reused materials is likely the most crucial step to secure the reuse of building materials among the actors around the resource center, as highlighted by informant D5. However, Sirkulær Ressurssentral is still in its infancy and hasn't had an opportunity to develop into a physical marketplace that is substantial enough to guarantee reuse in the Norwegian building sector.

Some clients have experience with existing private marketplaces, but those are accessible exclusively to buyers who have paid. We discovered from elaborations by informant D2 and D4 that there is a demand and a desire for a free market where clients, contractors and insurance companies can exchange materials that may be able to be utilized in another project. It is therefore important to have a marketplace with open access and transparency.

4.3.3 Take-back Systems

Take-back systems have become a crucial component of the building sector, acting as the foundation of a circular economy model that prioritizes sustainability and resource efficiency. By recovering and reusing building materials that would otherwise be thrown away, these systems greatly reduce the amount of waste that is generated by the sector. However, despite its apparent benefits, there appears to be limited adoption of such practices within the industry. The statement from informant D1 underscores the creative and resourceful strategies that some companies are implementing in lieu of a more structured take-back system, revealing an evident gap in formalized industry practices. Another informant (D5) emphasized the novelty of this approach. This sentiment reinforces the historical practices and norms within the industry. In essence, the construction sector has often been slow to adopt new methods, often due to entrenched processes and the high-stakes nature of construction projects. The industry tends to prioritize proven, traditional methods to mitigate risks, even if innovative solutions could provide substantial long-term benefits. The limited adoption of take-back systems is not only due to historical precedence, but also meets significant challenges when it comes to the complexity of material recovery. Each construction project involves a broad array of materials, each with varying potential for recovery and reuse. Creating a system to identify, categorize, and extract these materials at the end of their lifecycle presents a formidable task, exacerbated by issues such as contamination, degradation, and the high costs of extraction and transportation.

The responsibility of implementing take-back systems in the construction industry is often proposed to rest with the owners of materials, particularly building and property owners, which is emphasized from the statement made by E1. Building and property owners are uniquely positioned to establish these systems, given their control over significant material stock and the spaces they command. They inherently have a vested interest in maximizing the value of their materials, which a well-structured take-back system could enhance by reducing waste and potentially generating cost savings. Additionally, by prioritizing reclaimed materials, they can drive demand in the market, encouraging wider industry participation.

5.0 Discussion

In this chapter we discuss our empirical findings and try to draw some parallels between them, and theory presented in the literature review in Chapter 2. We use our three sub-questions to guide the discussion, since these reveal the relationship between our case and the literature. The sub-questions are important steppingstones to answer before trying to answer our main research question, being:

Which areas of the current value creation system in the construction industry must be altered to facilitate increased reuse of materials?

5.1 Issues of the Current Business Model and Main Actors

Certain barriers and challenges need to be addressed and critical elements of main actors' business models are currently missing or need significant development for the transition to a CE in the construction industry to become a reality. We have identified various challenges for actors when they transition to a circular business model using the Business Model Canvas (see Table 3).

Table 3: Issues for actors transitioning to a circular business model

Actor	**Issue**
Clients	*Value Propositions:* Short-term costs and benefits focus conflicts with long-term, lifecycle considerations. *Customer Relationships:* Limited understanding about the benefits and practicalities of circular construction.
Architects	*Key Activities:* Emphasis on originality and aesthetics over recyclability or modularity. *Key Resources:* Design tools more suited to linear construction methods.
Consulting Engineers	*Value Propositions:* Expertise traditionally based on linear construction methods, incorporation of circular principles can be challenging. *Key Resources:* Existing tools and software geared towards linear construction methods.
Contractors	*Key Activities:* Standard practices are linear rather than circular. *Key Partnerships:* Need for forming new types of partnerships with recycling facilities or reusable building materials manufacturers.
Policymakers	*Customer Segments:* Balancing the needs and interests of many different stakeholders. *Key Activities:* Revising existing regulations and creating new ones to encourage circular practices is complex.

Clients in the construction industry often prioritize short-term costs and benefits in

their projects. This mindset, however, can pose a significant challenge in moving towards a circular construction model, which necessitates a broader consideration of long-term, lifecycle impacts. Furthermore, there's a lack of comprehensive understanding among clients about the tangible benefits and implementation aspects of circular construction. This gap in knowledge can result in resistance or hesitation in embracing circular practices (Kirchherr et al., 2018; Suzanne et al., 2020).

Architects are often trained and experienced in conventional architectural design which prioritizes originality and aesthetics. The principles of recyclability, modularity, and adaptability, key to a circular approach, can be difficult to incorporate into such traditional design philosophies. Like engineers, architects also rely heavily on design tools that are more suited to linear construction methods. Transitioning these resources to support circular design is a major challenge.

For consulting engineers, much of their expertise lies in linear construction methods. Incorporating circular principles into their design and consulting work can prove to be a considerable challenge. Additionally, the tools and resources at their disposal, including engineering software, are often geared towards traditional construction methods. Adapting to a circular approach may call for the development and adoption of new tools and methodologies, which can be time-consuming and require significant investment, but perhaps entirely necessary (Geissdoerfer et al., 2022; Grafström & Aasma, 2021).

Contractors, who are typically in charge of the tangible construction process, face challenges due to the entrenched nature of linear practices, such as demolition and waste disposal, in their work routines. These conventional methods contradict the principles of a circular economy, which emphasize waste reduction and resource efficiency (Geissdoerfer et al., 2020). Additionally, like emphasized by Kanda et al. (2021), shifting to a circular model often demands the forging of new types of partnerships. For instance, collaborations with recycling facilities or manufacturers of reusable building materials become imperative, which may require substantial changes in business networks and supply chain management.

For policy makers, the challenge lies in balancing the needs and interests of a wide

variety of stakeholders in the construction industry. Transitioning to a circular economy requires a shift in regulatory frameworks that can encourage and reward circular practices. The process of revising existing regulations and potentially creating new ones can be slow, complex, and fraught with opposition from various quarters (de Jesus & Mendonça, 2018).

A circular economy in the construction industry necessitates a substantial rethink of the involved actors' traditional business models and how value is created and captured. Sirkulær Ressurssentral is both a pilot and an ecosystem in the construction industry to look at ways to make this come true, and therefore the configuration of the actors and their activities in the ecosystem is interesting to look at. With regards to hierarchy in ecosystems and the "leader-follower" concept (Adner, 2017) as discussed in chapter 2.1, we like to think of Sirkulær Ressurssentral as being sort of a leader in the mission of ensuring more reuse of building materials in the industry. This is because they are at the center of the ecosystem and drive this transition forwards, which makes it perhaps not strange that they should take such a role. Meanwhile, we believe that the roles of actors in the ecosystem surrounding Sirkulær Ressurssentral is more nuanced than so. Our impression from the interviews was that since actors are specialized in different parts of a construction project's value chain, they will have their own challenges which need to be heard by the other actors. Since these challenges could be unique to one or a few actors in the ecosystem and since they have most knowledge and experience with it, we think that some actors in the ecosystem could claim more of a leading role in these instances (DeRue & Ashford, 2010), which could be another actor than Sirkulær Ressurssentral. This leads us to think that the ecosystem is not fully hierarchically controlled, which shares ideas of Jacobides et al. (2018).

Further, we have identified various obstacles for actors in Sirkulær Ressurssentral when they transition to a CE using the Business Model Canvas (Table 3), where the main challenge is linked to the actors' value creation. This is perhaps not surprising, as the main logic of a firm's business model is to create value (Osterwalder & Pigneur, 2010). Like discussed in chapter 2.1, Adner (2017) argues that value creation in an ecosystem is dependent on the actors' coordination and cooperation, and that this value creation is then aggregated to the ecosystem level, which benefits the whole ecosystem. We also believe this to be the case with Sirkulær

Ressurssentral, as the sharing of knowledge and experiences between actors is beneficial cooperation to understanding the mechanisms and main issues towards reuse in construction. This is something which the actors in the ecosystem do several times a year and which is arranged by Sirkulær Ressurssentral' owners, Pådriv (Pådriv, n.d.) The goal with these seminars is that actors learn from each other, understand each other's challenges with reuse, that actors form new partnerships, amongst other things, with hopes of creating more circular value. These ideas of collaboration and exploration among actors in a circular ecosystem is also shared by Kanda et al. (2021) as important to transitioning to circular business models.

5.2 Barriers and Challenges to a Circular Industry

To address the main research question of which areas of the current value creation system in the construction industry need to be altered to facilitate increased reuse of materials, it is necessary to critically examine the key challenges and barriers we identified in our findings. These challenges and barriers are Documentation and Regulations, Costs, and Competence and Culture. The literature review also provides context for the importance of addressing these issues.

5.2.1 Documentation and Verification

Our findings show that the lack of documentation and developing the appropriate documentation requirements are some of the largest challenges and barriers regarding reuse of construction materials for actors around Sirkulær Ressurssentral. For example, a contractor trying to reuse materials and large elements from 50 years ago often has a hard time finding the original documentation which says something about the materials' properties, lifetime, composition etc., which are important details when utilizing them in reuse projects. These barriers are not uncommon in CBMI as emphasized by Geissdoerfer et al. (2022), as the current product legislation often hinders the implementation of CE practices. The problem lies within the fact that existing regulations were crafted with the linear economy and not circular practices in mind, rather focusing on new materials. Suzanne et al. (2020), and de Jesus and Mendonça (2018) argue for the necessity of supportive policy and regulatory environments to facilitate the transition towards a circular economy. Therefore, it's necessary to establish a set of standards and guidelines that provide a clear, easy-to-follow framework for the documentation and use of

reused materials.

5.2.2 Costs

The findings also show costs to be a large barrier to the effective reuse of building materials for the actors around Sirkulær Ressurssentral, mainly being attributed to labor- and time-intensive costs and costs related to new and unknown processes. Informants pointed out that while reused materials appear cheaper initially, the various costs of inspection, testing, recertification, consultancy, and preparation often outweighs these initial savings. A large problem is the construction industry not being primed for the circular economy and unfortunately mostly looks at value creation through a linear lens and without systems in place to ensure good reuse of materials, making reuse measures costly. Additionally, the low costs of virgin materials found in Grafström and Aasma (2021) also seem to create a challenging economic environment for promoting reuse for actors involved in Sirkulær Ressurrsentral. However, there is widespread agreement that getting to higher degrees of circularity like more reuse of materials incurs high upfront investment costs (McKinsey & Company, 2016; Geissdoerfer et al., 2022; Grafström & Aasma, 2021), but with hopes of providing substantial cost-savings later when the systems to reuse are more effective. Therefore, perhaps the price to pay to get there is inevitable and is to be expected in such large strategic renewal processes and disruptive innovations such as going from a linear to a circular business model requires (Geissdoerfer et al., 2022).

5.2.3 Competence and Culture

The lack of adequate competence and the organizational culture of actors surrounding Sirkulær Ressurssentral is also a large barrier to reuse. Contrary to Adams et al. (2017) who saw that clients, designers and subcontractors were the least knowledgeable about CE in the industry, we didn't find it to belong to a specific actor but something which the whole industry struggles with. Our impression was that most actors in the industry are very aware and quite knowledgeable regarding CE and on board with the idea of more reuse as crucial to make the transition to a more circular construction industry. However, we don't know to what degree each actor we talked with is truly aware and knowledgeable of the CE. Like Adams et al. (2017) point out, most actors will rank themselves as very knowledgeable and aware, but it could turn out they are in fact not.

Another large challenge which is in line with Geissdoerfer et al. (2022), is that the industry simply doesn't have enough competence because it is a new way of operating, and the industry is only in the starting pit with the wheels still spinning with little traction yet. Like highlighted in Kircherr et al. (2018) and Tan et al. (2022), there are large barriers to implementing reuse of products such as lack in domain knowledge, technical know-how and circular design, and there has to be created a lot more competences, techniques, strategies etc. Increased experience with reuse projects is also needed to overcome the barrier. However, the importance of technical knowledge which is lacking to make the transition to a CE in the construction industry is somewhat controversial. Of course, new techniques are important in such a technical industry and should be explored, but according to Kircherr et al. (2018) it is not considered the most pressing barrier in the transition to CE, and we believe it's importance could be overexaggerated by the industry. Therefore, we think that there are other barriers and challenges which are more salient. Like one informant we talked to pointed out, the industry lacks a lot of economic analyses, like cost-benefit analyses, calculating costs of circular designs etc., which could be crucial knowledge to make the transition easier.

Closely related to the competence gap that is prevalent in the industry, is the organizational culture of many companies in the construction industry which hinders the will and motivation to reuse building materials. Like discussed in Kircherr et al. (2018), from our findings we saw that it is somewhat engrained in the culture of many companies that reuse is harder, more expensive, and more tiring than just buying new, and so consumers will simply prefer buying new. This, along with the challenges of organizational ambidexterity and organizational transformation challenges, is supported by Geissdoerfer et al. (2022) as large barriers to CBMI. Another issue is that most people in the industry seem to be on board with the importance and possibility of higher reuse percentages when discussed in meetings, but once they start planning their projects, they quickly leave the idea and buy new materials, because it is less risky, cheaper, and less cumbersome. This somewhat mirrors the "intention-action gap" found in Tan et al. (2022), where consumers might originally have an intention of buying reused, but they will often go with the safety of new materials since you have documentation and know what you are getting with regards to quality and price. This is also a trend

among actors in the construction industry, but probably mostly has to do with human nature and rooted in people's fear of new and uncertain things (Tan et al., 2022).

Addressing these cultural and competence-based challenges will require targeted efforts at multiple levels of the industry. On an individual level, training and education programs could help workers develop the skills and knowledge necessary for material reuse (Unal et al., 2019). On an organizational level, firms could benefit from fostering a culture of learning and innovation, promoting sustainable practices, and encouraging employees to challenge the status quo. On an industry level, awareness-raising campaigns could help to shift perceptions and norms around reuse, promoting it as a viable and desirable practice (Tavri et al., 2015).

From this discussion, we notice that the key areas of the construction industry's value creation system that experience barriers and challenges have to do with prioritizing building competence, sharing knowledge, and fostering cultural shifts that support reuse. More specifically, it requires transformation within documentation and regulations, cost structures, industry competence and culture. These changes could support a shift towards a more sustainable and circular construction industry, thus addressing the main research question and underscoring the value of tackling these challenges. In the following we discuss the key activities of how to tackle these challenges.

5.3 Critical Activities for a Circular Industry

Considering our literature review and findings, it is important to discuss the key activities for circular value creation in the construction industry - regulations and incentives, the creation of a marketplace, and the establishment of take-back systems. These three areas align with the SBMI framework highlighted by Bocken et al. (2014) and the value network concept discussed by Stabell & Fjeldstad (1998). By drawing parallels to these frameworks, our findings underscore the importance of these activities for answering the main research question.

5.3.1 Regulations and Incentives

The importance of regulations and incentives for facilitating increased reuse of materials has been confirmed in both literature and our findings. Osterwalder &

Pigneur (2010) and Chesbrough (2007a) emphasize the role of external incentives and barriers in shaping business model innovation. Similarly, our findings indicated the role of current business models in inhibiting the use of recycled materials due to lack of penalties and rewards. Internalizing costs such as the environmental impact, in the form of CO2 emissions, can also play a pivotal role in shifting towards a more sustainable model. As highlighted by Tan et al. (2022), the current cost disparity between linear and circular production systems often stems from not accounting for the negative externalities on society, the environment, and the economy in the pricing structure of linear systems. An internalizing of costs was also highlighted in our findings and by incorporating these costs into pricing structures, it provides a more accurate reflection of the true costs of production and can serve as a strong incentive for both companies and consumers to opt for circular practices.

Also, from our findings, we see that documentation regulations play a crucial role in promoting transparency, trust, and accountability within the industry. For reused materials, documentation regulations can ensure that all the necessary information about the material's origin, previous uses, safety considerations, and environmental impact are accurately recorded and made accessible (Kralj & Markič, 2008). This helps in alleviating concerns about the quality and safety of reused materials.

Regulations that mandate a minimum percentage of reused materials in new constructions could provide a robust guideline for firms to adhere to, aligning with Bocken et al. (2014) call for SBMI that is underpinned by circular economy principles. On the other hand, incentives can make circular business models economically viable and attractive to construction firms. As our informants suggested, incorporating a realistic aim of 30% reused materials in construction can lead to both economic and sustainability benefits, supporting the SBM notion of Bocken et al. (2014) and reflecting the value proposition element of CBMs identified by Geissdoerfer et al. (2020). Therefore, regulations and incentives have been identified as crucial elements for instigating a shift towards a circular economy in the construction industry. Furthermore, the research conducted by D'Amato et al. (2017) supports the proposition that public policy is an integral factor for facilitating and supporting sustainable practices, especially in industries as complex and diverse as construction. On the incentive front, financial motivators, including tax

breaks, grants, and subsidies, can be effective in enticing construction firms to incorporate circular practices. Economic incentives are pivotal for creating an enabling environment for transition towards a circular economy, as indicated in studies by Prieto-Sandoval et al. (2018) and Ghisellini et al. (2016). These insights resonate with the practical experiences of our informants, who stressed the significance of making circular business models economically attractive.

On the one hand, regulations guiding the reuse of materials can significantly shape the demand for Sirkulær Ressurssentral's services. For instance, if regulations mandate a minimum percentage of reused materials in new constructions, this will likely increase demand for reused materials, thereby potentially driving more businesses to Sirkulær Ressurssentral's platform. On the other hand, the role of incentives in encouraging circular business models could directly affect the attractiveness of Sirkulær Ressurssentral's value proposition. If financial incentives, such as tax breaks, grants, or subsidies, are provided for construction firms incorporating circular practices, it could make Sirkulær Ressurssentral's offerings more appealing to these firms.

In addition, regulations play a substantial role in ensuring adherence to sustainable practices, and a clear, enforceable framework can drive behavior change. Other literature suggests that regulations can promote innovation and foster the adoption of sustainable business practices (Ghisellini et al., 2016). In this regard, the construction industry can benefit from regulations mandating a minimum percentage of reused materials in new constructions. This approach reconciles the realities of the industry with the aspirational goal of a circular economy.

5.3.2 Marketplace

From our findings and literature such as Guerra et al. (2021), we argue that creating a marketplace for reused materials is critical to facilitating material exchange and improving accessibility, which is instrumental for the shift to a more circular construction industry. This aligns with the findings of Pieroni et al. (2018) who highlighted the need for network-centric approaches to the circular economy, where value creation is tied to a value chain or network. The informants recommended the need for an open, transparent marketplace for material exchange, thus fostering a network-centric approach to value creation.

The marketplace is a platform where all actors can interact, collaborate, and co-create value, resonating with the concept of value networks proposed by Stabell and Fjeldstad (1998). By encouraging collaboration, a marketplace can lead to more efficient use of resources and reduced waste, while also identifying opportunities for innovation and creating new solutions that are more sustainable and circular, as advocated by Spraul and Stumpf (2022). A marketplace for reused materials not only contributes to resource efficiency but also promotes collaboration and co-innovation among construction industry actors. Our informants suggested an open, transparent marketplace could lead to more efficient use of resources, reduced waste, and foster a network-centric approach to value creation, as proposed by Bocken et al. (2016).

The creation of an open and transparent marketplace resonates with Sirkulær Ressurssentral's mission to facilitate the exchange of materials. It provides an opportunity for Sirkulær Ressurssentral to leverage its platform and position within the industry to serve as a hub for the exchange of reused materials. An open and transparent marketplace would enable Sirkulær Ressurssentral to increase its reach, attract a wider range of stakeholders, and potentially drive higher volumes of material exchange.

5.3.3 Take-back Systems

Take-back systems are fundamental to the circular economy model, promoting sustainability and resource efficiency (Adams et al., 2017; Lewandowski, 2016). These emphasize the need for firm-level understanding of circular business models, highlighting the importance of take-back systems in this process. Our findings mirror this, suggesting that take-back systems can lead to significant reductions in construction waste. However, the limited adoption of take-back systems due to historical precedence and the complexity of material recovery (Adams et al., 2017; Guerra et al., 2021), underscores the challenge of this transition. Building and property owners, as the primary owners of materials, have been suggested as the likely implementers of take-back systems, highlighting their control over significant material stock. This is in line with the perspective of Stahel (2019) who stressed the necessity of stakeholders' active involvement in the shift towards a circular economy. According to our informants, building and property owners

should be responsible for putting take-back systems in place, which is aligned with the research by Huysman et al. (2017), who proposed that the owner of the materials plays a pivotal role in the process of value creation in the circular economy.

The development and implementation of take-back systems also align with the principles of a closed-loop supply chain and contribute to resource efficiency and waste reduction (Lieder & Rashid, 2016). However, as revealed by the findings, the adoption of these systems remains limited due to entrenched processes and the high-stakes nature of construction projects. Our findings also underscore the barriers that stand in the way of implementing take-back systems, namely the complexity of material recovery, issues of contamination and degradation, and high costs of extraction and transportation. These practical challenges align with theoretical difficulties recognized by scholars such as Ritzen & Sandström (2017), who discussed the intricacies of circular business models in the construction industry.

Take-back systems can directly contribute to the supply side of Sirkulær Ressurssentral's business. By encouraging building and property owners to establish take-back systems, Sirkulær Ressurssentral can facilitate the recovery and reuse of building materials, leading to an increase in the quantity and variety of materials available on its platform. However, the adoption of take-back systems also presents challenges. The complexities of material recovery, issues of contamination and degradation, and the costs of extraction and transportation are key barriers to be overcome. Sirkulær Ressurssentral would need to invest in developing capabilities to manage these challenges, possibly through technological solutions or strategic partnerships. It also suggests a role for Sirkulær Ressurssentral in advocating for broader industry and policy changes to support the implementation of take-back systems.

In conclusion, the three critical activities - regulations and incentives, marketplace, and take-back systems - are key areas of the value creation system in the construction industry that need to be altered for facilitating increased reuse of materials. By addressing these activities, the construction industry can move closer to a circular economy model, where resources are efficiently used, waste is minimized, and sustainable value is created.

5.4 Limitations

Applying the findings of our research to broader contexts or other industries might be met with challenges due to the inherent limitations of this study. Indeed, the results we have obtained may not necessarily translate to other industries, or even to other companies within the construction industry. This limitation is a natural consequence of our chosen single-case study design, which inherently curtails the range of our results' applicability.

In addition, the number of interviews conducted, a total of 11, could be perceived as insufficient to capture the full breadth and depth of perspectives within the industry. While the methodology adopted was considered optimal under the given circumstances, we recognize that a more extensive pool of informants might have provided a more comprehensive understanding of the issue under study. Interpretation of the data is another area where limitations exist. Data interpretation is inherently subject to a degree of subjectivity, leading to potential differences in the interpretation of the same data set by different researchers. Despite our attempts to minimize this by employing two authors for data analysis, providing an additional level of scrutiny, there is the possibility that some relevant data might still have been missed or underemphasized.

Lastly, our research has been conducted in a rapidly evolving field, which saw significant changes even in the course of our work. For example, mandatory regulations for reuse mapping in new construction projects have been proposed and implemented during the tenure of our research (Sirken, n.d.). The dynamic nature of the field could have implications for the relevance and applicability of our findings.

5.5 Future Research and Implications

The study underscores the early stage of the construction industry's transition from linear to more circular practices, highlighting a vast landscape yet to be explored. Crucial barriers related to documentation, costs, competence and culture present significant challenges to fostering circular value creation. To overcome these, critical activities, pertaining to regulatory changes and incentives, creation of a robust marketplace, and the development of effective take-back systems, are proposed.

5.5.1 Future Research

While this study contributes to the research on circular economy principles in the construction industry, it also highlights the need for ongoing investigation. Future research can build upon the findings and limitations of this study to continually refine our understanding and strategies for more material reuse and the transition to a circular economy.

Our study highlights the roles of different actors within the construction industry, using ecosystem theories (Adner, 2017; Jacobides et al., 2018). Our findings point to the need for a more common understanding of the roles and responsibilities of various actors, underlining the importance of cooperation and coordination for effective circular practices and the development of circular business ecosystems (Kanda et al., 2021). Furthermore, our study support the principles of the circular economy, as outlined by Geissdoerfer et al. (2020), where it illustrates the practical challenges of transitioning from a linear to a circular model, particularly in relation to material reuse. Moreover, our findings highlight the need to rethink traditional business models in the construction industry to foster circularity, particularly documentation and regulations, costs, and competence and culture. We believe this expands ideas related to barriers/challenges discussed in articles such as Grafström and Aasma (2021), Tan et al. (2022), and Suzanne et al. (2020). Also, the proposed critical activities to enhance material reuse add insights to the discussions by Stahel (2019) and Lewandowski (2016) on the implementation of circular economy principles. The identification and examination of these activities contribute to the emerging theoretical framework of circular business models in the construction industry.

An interesting avenue for future research could involve comparative case studies. This approach could deepen our understanding of the dynamics in different segments of the industry, various geographical locations, or contrasting regulatory environments. By comparing different contexts, researchers could discover further insights into the barriers and facilitators of material reuse, and the specific strategies that prove effective in diverse settings.

Studies involving multiple case companies could also provide valuable insights.

The transition to a circular economy is a complex, dynamic process that unfolds over time. Tracking the journeys of different companies as they navigate this transition could offer a more in-depth understanding of the challenges they face, the strategies they adopt, and the milestones they achieve over time. This could be particularly relevant in studying the evolution of cultural and competence-based barriers and the effectiveness of interventions to address them.

Another promising line of research could focus on the design of buildings for future reuse, rehabilitation, and disassembly, as this was highlighted by a several informants. Investigating the principles, practices, and challenges related to these concepts could significantly enhance our understanding of how to promote material circulation and resource efficiency. Also, future research could aim to refine life-cycle analyses and expected lifetime estimates for construction materials, as a few informants discussed the importance of this. Existing models may provide conservative estimates that undervalue the potential of reused materials. Developing more accurate models, grounded in empirical data, could contribute to a more realistic and optimistic assessment of the potential for material reuse, further promoting the shift to a circular economy.

5.5.2 Practical Implications

The study recommends efforts from all actors involved to drive regulatory changes in the construction industry. Actors like contractors and clients should continue to advocate for policies that better accommodate circular practices, such as making documentation requirements more suitable for reuse of materials. Another issue is related to costs, where we believe that regulators could help in building with reuse cheaper or creating regulations that penalize demolishing and building new, to a larger extent. It could also be beneficial to look at developing regulations that encourage and reward a certain percentage of reused materials in construction projects. Policymakers are urged to engage in deeper dialogues with industry actors to better understand these types of needs and challenges. Simultaneously, we believe that the creation of an efficient marketplace for reuse is vital, a type of Finn.no for the construction industry. While physical marketplaces like Sirkulær Ressurssentral are a step in the right direction and the experiences from it highly valuable, this needs to be complemented with a robust digital marketplace. We believe that the existing digital platforms connected to Sirkulær Ressurssentral need

better integration and transparency to avoid competition and facilitate standardization. Lastly, we think that the development of effective take-back systems can further incentivize the adoption of circular practices in the construction industry. This is especially crucial to contractors and clients, who are left with the job of dismantling buildings at the end of their lifetime. Having effective take-back systems that alleviate the challenges of reuse and circulation of materials will likely help in reducing waste and emissions in the industry, which of course is positive.

6.0 Conclusion

This study has aimed to identify the areas within the construction industry's value creation system that require transformation to enhance material reuse, reflecting a commitment towards circular economy. In this endeavor, it has offered both theoretical advancements and practical implications. We unveiled how actors such as policymakers, clients, contractors, and architects have different roles, face unique challenges, and may influence the shift towards a circular economy in distinct ways. By emphasizing the need for systemic and cultural change within these actor groups, the study points towards a collective approach to sustainability and circularity.

The study further highlights three primary barriers inhibiting the transition to a circular economy in the construction industry: 1) documentation and regulations, 2) costs, and 3) competence and culture. It underscores that a lack of consistent and comprehensive documentation requirements, short-term cost prioritization, gaps in competence and entrenched cultural norms act as roadblocks to sustainable practices.

Simultaneously, we identified three crucial activities necessary for promoting the reuse of materials and facilitating a circular construction industry: 1) creating supportive regulations and incentives, 2) developing a sufficient marketplace, and 3) establishing effective take-back systems. By aligning regulatory support with the demands of circular economy, developing both physical and digital marketplaces for reused materials, and implementing systems that prioritize reuse over disposal, the construction industry can hopefully inch a bit closer to more sustainable and circular practices.

In conclusion, this study offers valuable insights to the necessary transformation in the construction industry to achieve sustainability targets through the reuse of materials. It signifies a crucial step in understanding the dynamics of circular economies within a traditionally linear industry, offering clear directions for future action. By aligning the roles of different actors, overcoming key barriers, and focusing on strategic activities, the construction industry can indeed pave the way towards a more circular and sustainable future. The roadmap has been laid; yet the journey towards a circular economy in the construction industry has only just begun.

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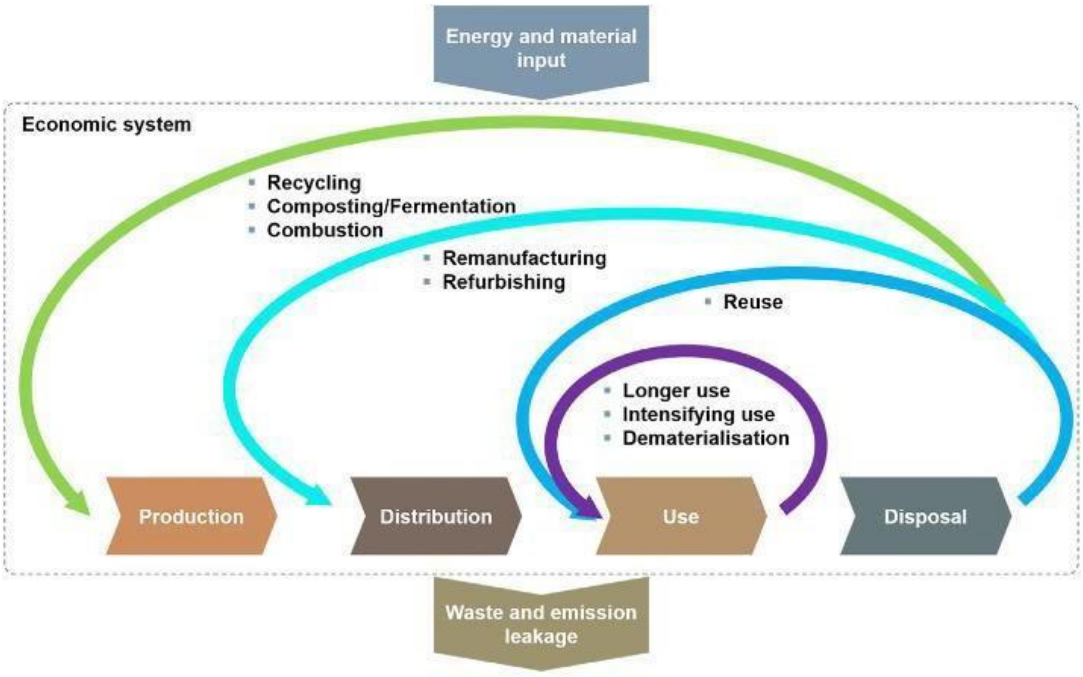
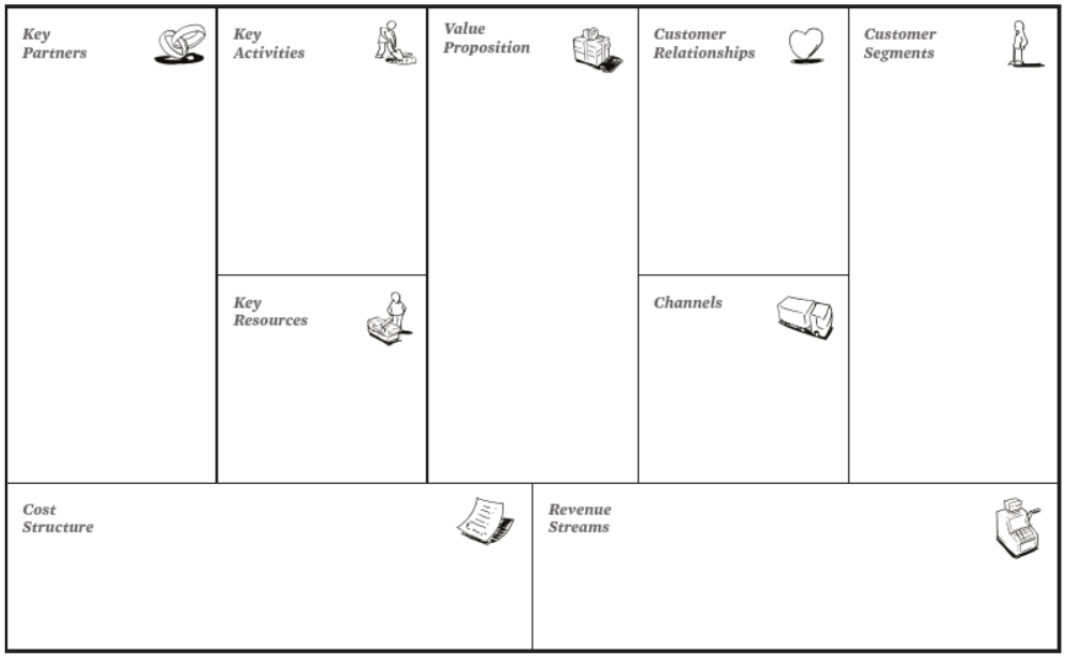
Appendix

Appendix A The Circular Economy



Source: Geissdoerfer et al. (2020)

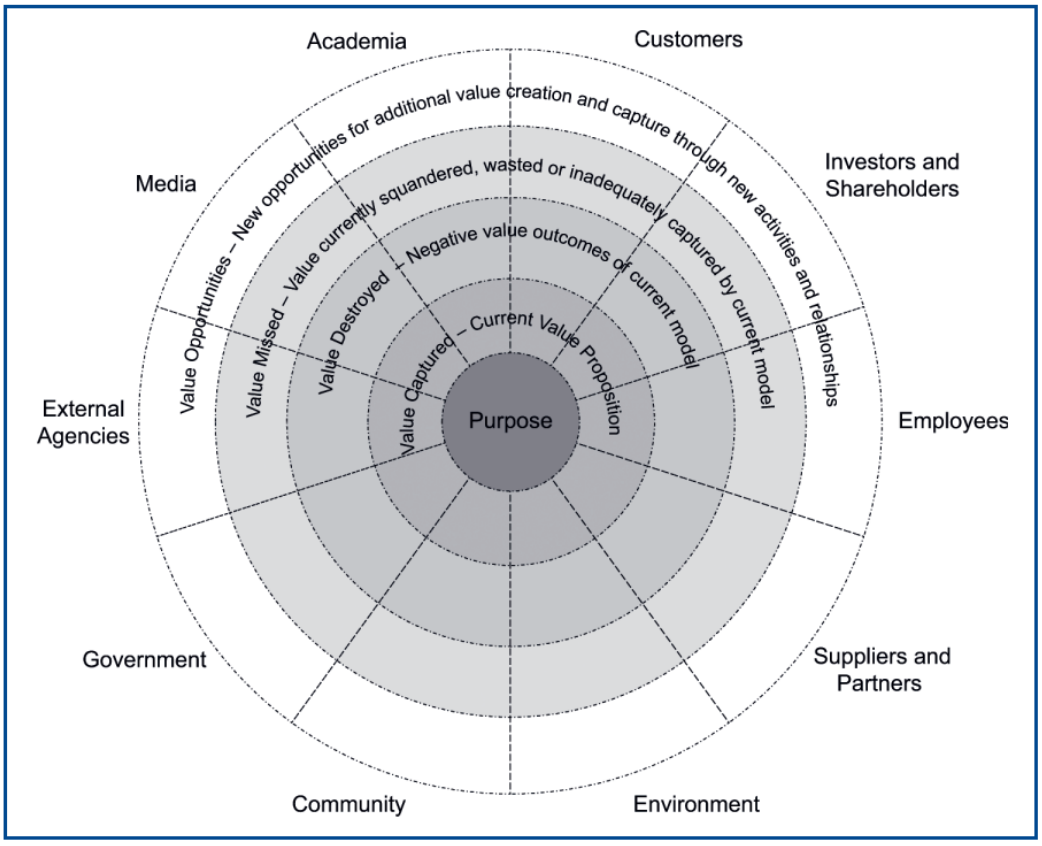
Appendix B The Business Model Canvas



Source: Osterwalder & Pigneur (2010)

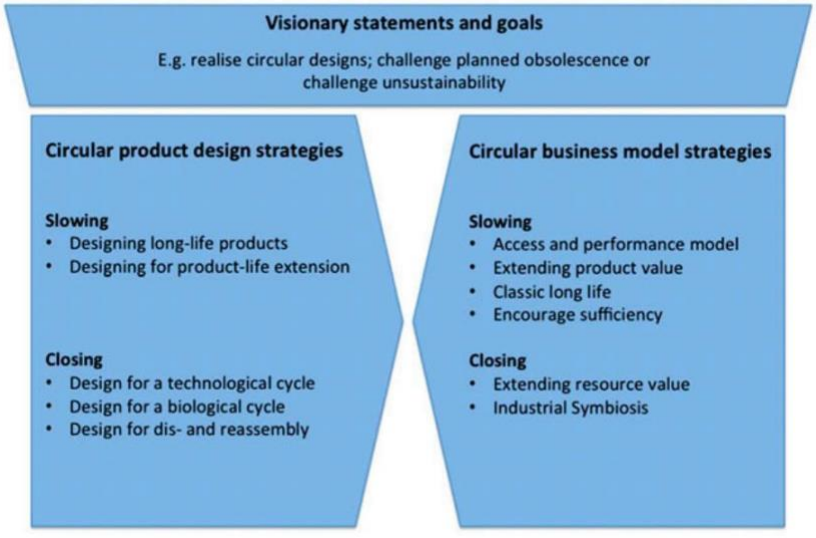
Appendix C Value Mapping Tool

Figure 2 Value mapping tool



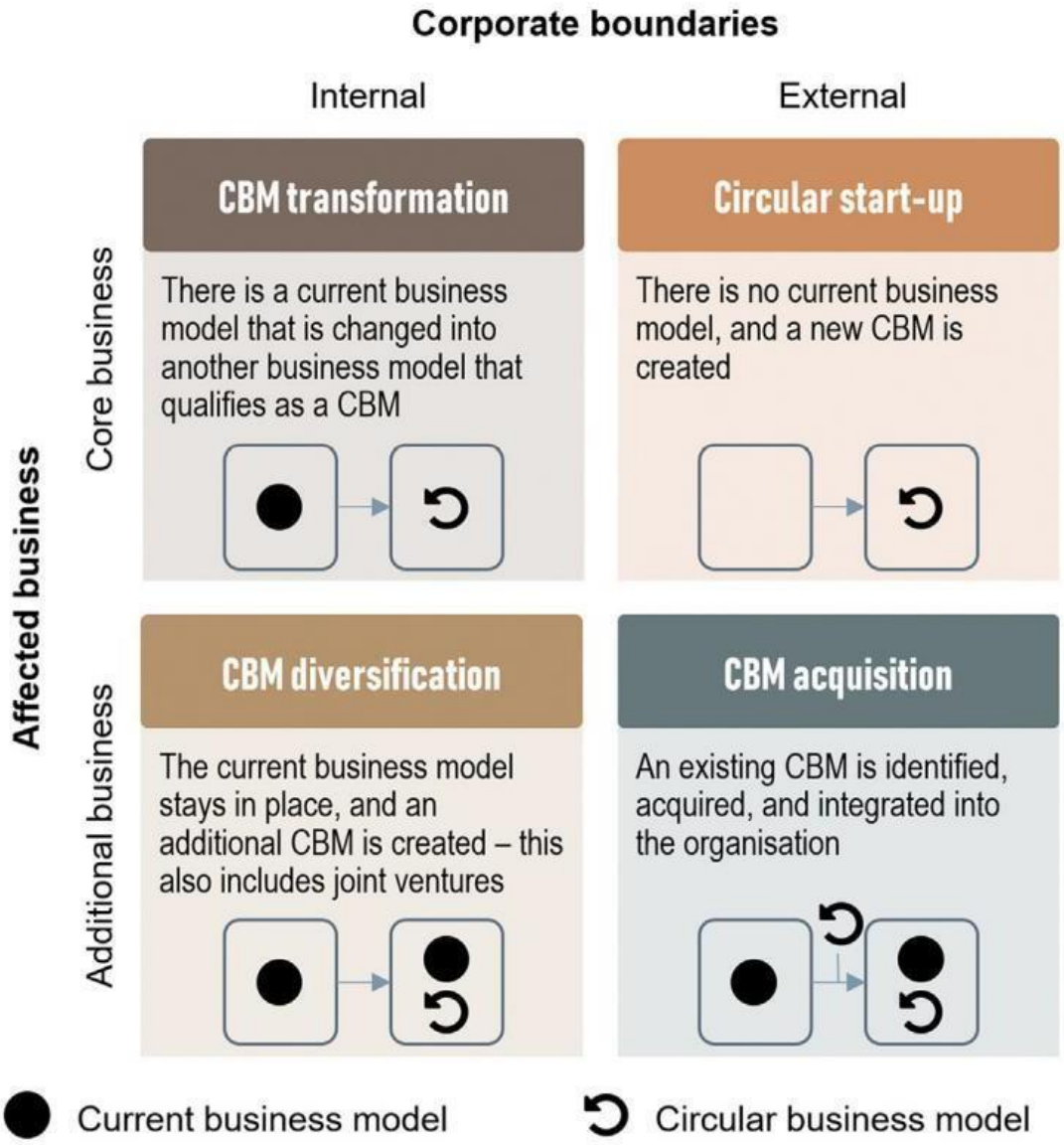
Source: Bocken et al. (2013)

Appendix D Circular Economy Product and Business Model Strategy Framework



Source: Bocken et al. (2016)

Appendix E Four Types of Circular Business Model Innovation



Source: Geissdoerfer et al. (2020)

Appendix F Key Business Model Considerations for the Circular Economy

Source: Geissdoerfer et al. (2020)

Appendix G The Circular Business Model Canvas

<table>
<tr>
<td rowspan="2">Partners
• Cooperative networks
• Types of collaboration</td>
<td>Activities
• Optimising performance
• Product Design
• Lobbying
• Remanufacturing, recycling
• Technology exchange</td>
<td rowspan="2">Value Proposition
• PSS
• Circular Product
• Virtual service
• Incentives for customers in Take-Back System</td>
<td>Customer Relations
• Produce on order
• Customer vote (design)
• Social-marketing strategies and relationships with community partners in Recycling 2.0</td>
<td rowspan="2">Customer Segments
• Customer types</td>
</tr>
<tr>
<td>Key Resources
• Better-performing materials
• Regeneration and restoring of natural capital
• Virtualization of materials
• Retrieved Resources (products, components, materials)</td>
<td>Channels
• Virtualization

Take-Back System
• Take-back management
• Channels
• Customer relations</td>
</tr>
<tr>
<td colspan="3">Cost Structure
• Evaluation criteria
• Value of incentives for customers
• Guidelines to account the costs of material flow</td>
<td colspan="2">Revenue Streams
• Input-based
• Availability-based
• Usage-based
• Performance-based
• Value of retrieved resources</td>
</tr>
<tr>
<td colspan="5">Adoption Factors
• Organizational capabilities
• PEST factors</td>
</tr>
</table>

Source: Lewandowski (2016)