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# Embarking upon circular construction

An exploration of circular value propositions and its potential to deliver superior customer value in the building construction sector

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# Abstract

The building industry consumes approximately 40 per cent of materials entering the global economy while facing significant challenges related to unsustainable consumption of natural resources and greenhouse gas emissions. The concept of the circular economy is gaining momentum as a solution which addresses these issues while generating economic benefits. To transition towards a circular economy, scholars and practitioners stress the need for new circular business models (CBMs). Today, the uptake of CBMs in the building sector remains limited. A fundamental factor for succeeding with CBM implementation is to design value propositions based on circular economy principles that are appealing to and accepted by customers. This study uses a case study approach to explore how a large manufacturing company in the building construction industry can create added customer value by re-defining its value proposition in line with circular economy principles. By means of a three-step business model innovation process for value proposition re-design, "*thinking, talking, testing",* three potential value propositions of façade elements are suggested. The findings suggest that CBMs can provide added customer value by delivering environmental, financial and end-user value. However, the financial value in terms of risk minimisation and reduced construction cost is a critical prerequisite for the viability of CBMs. Despite the potential added value creation, two key barriers to customer acceptance remain: split-incentives between actors in the value chain and the long lifecycles of buildings. The existence of these barriers suggests that a circular value proposition should be tailored to the span of responsibility of the customer and that the viability of CBMs, which generate value at end-of-life is dependent upon the effective delivery of other customer benefits. Future research may investigate the potential for value chain collaboration to stimulate the emergence of CBMs which create shared value and new financing models which promote circular construction.


**Keywords:** Circular economy; circular business model; business model innovation; building construction sector; value proposition re-design

# Executive Summary

The building construction industry has a significant contribution to environmental challenges, including the climate crisis, through large-scale use of natural resources, high energy use of raw materials, emissions of greenhouse gases and transport-related pollution. The concept of circular economy (CE) is introduced as a solution which generates both environmental and economic gains, through strategies to slow and close resource loops. Still, the implementation of circular business models (CBMs) in the building construction industry remains scarce and integrating circular strategies in the business models remains a challenge for practitioners. A fundamental factor for succeeding with business models based on CE principles is customer acceptance of new value propositions. Hence, anticipating customer acceptance of new value propositions is critical to address barriers related to the uncertainty of implementation. Still, practical experience and academic work on designing circular business models and value propositions that match customer needs in the building construction industry remain nascent.

This thesis employs a single case study of a manufacturing company to explore the potential for added customer value creation through implementation of circular strategies in the building construction industry. Based on a business model innovation approach, three re-designed value propositions are developed that have the potential to deliver added value to the case company's customers. The development process consisted of three iterative steps, *thinking*, *talking*, *testing* that were informed by an analysis of industry trends and drivers, interviews with the case company's customers and key stakeholders, and customers' assessment of the suggested value propositions.

Findings include three suggestions of re-designed CE-based value propositions that have the potential to gain customer acceptance. In addition, an overview is provided of the factors which need to be considered when implementing circular strategies to deliver customer value (including limitations of customers' acceptance towards CE-based value propositions), as well as an overview of trends in the Swedish and Danish building constructions industry, and various circular strategies' potential to deliver added customer value in the building construction industry. These findings are expected to provide relevant insight for companies within the building construction sector which seek to embark upon CE implementation, and for actors within the academic community by contributing to the highly emerging research stream of CBMs.

## *Research purpose and approach*

The main research question in this study was formulated as follows:

> *RQ: How can a large manufacturing company in the building construction industry create superior customer value by re-defining its value proposition in line with circular economy principles?*

The main research question involved four aspects: (i) explore how a process can be designed to help identify opportunities for adding value by the implementation of circular strategies; (ii) delineate the type of strategies which can be used to slow and close resource loops within the building construction industry (iii); identify the type of value prioritised by key stakeholders of the case company and (iv) identify the additional value that may be captured by re-defining the value proposition of the case company in accordance with circular economy principles.

The research approach was designed as an explorative case-study which leveraged data- and method triangulation to answer the posed research question in the context of the Swedish and Danish building construction industry. To deepen the understanding of factors which influence customer value creation in the building construction industry, a conceptual framework of

customer value was created building upon previous contributions in the area of CBMs, lean management and green buildings. In the conceptual framework, six categories of customer value were established: financial value, user, value, environmental value, social value, the value related to competitive advantage, and informational value.

A business model innovation approach was utilised to develop three re-designed value propositions. The approach builds upon the process for supporting organisations in the development of sustainable value propositions developed by Baldassarre, Calabretta, Bocken, & Jaskiewicz (2017) in the field of SBMI and covers three steps: (i) *thinking*, (ii) *talking*, (iii) *testing*. In the thinking phase, a literature review and business analysis were conducted to inform the talking phase and deepen the understanding of the business context. In the talking phase, insights from interviews with sixteen primary and secondary stakeholders and an assessment questionnaire were gathered, which led to the development of four re-designed value propositions. In the testing phase, customer acceptance of the value propositions was tested in a qualitative assessment questionnaire which led to the selection of three value propositions deemed to have the potential to contribute to creating superior customer value.

## *Findings*

Three suggestions for value propositions, based on CE principles, with the potential to deliver enhanced customer value, are developed. The value propositions may be implemented individually or combined.

**1) Value proposition building on principles of *longevity.***

This value proposition is based on slowing resource loops by extending the useful life of the façade elements. It provides additional value by minimising risk and reducing environmental impact.

**2) Value proposition building on *circular inputs.***

This value proposition is based on slowing resource loops through integrating reused inputs and components in the manufacturing of new façade elements. The value proposition offers additional environmental benefits by offsetting primary production.

**3) Value proposition building on *recyclability.***

This value proposition is based on closing or slowing resource loops through designing façade elements for reuse or recycling at EoL. The offer mainly provides environmental benefits at EoL.

The research involved an exploration of the type of value prioritised by key stakeholders of the case company and the opportunity for additional value creation by the adoption of circular strategies. In relation to the former, the findings indicate that the factors which contribute to customer value can be categorised into six categories: financial value, user value, environmental value, social value, informational value, and value derived from competitive advantage. Whereas informational value is seen as an *enhancer* of other values, competitive advantage is seen as an outcome of the *delivery* of other value categories. However, findings show that financial value, more specifically reduced costs and risk minimisation, dominates the perception of value creation among primary stakeholders. Critical aspects include the ability to deliver the project on time and ensuring the long-term viability of the building and components. Whereas previous research suggests that financial value can either be derived from lowering costs or charging a premium, the findings indicate that charging a premium is omitted as an opportunity associated with circular strategies as end-users are reluctant to pay for public environmental benefits of sustainable construction. In relation to the latter, it is suggested that embedding circular strategies in new value propositions can deliver added financial, environmental and end-user value. However, the prioritisation financial value implies that an offering based on circular strategies need to have a mechanism in place which ensures the delivery of equal or improved opportunities for risk- or cost reduction. The findings further indicate that offers which provide financial value during the operations phase are likely to be more suitable for clients who retain ownership of the building in this period and thus can reap the financial benefits.

To create added customer value by re-defining value propositions in-line with circular principles, the findings suggest that two barriers need to be managed. These barriers influence the acceptance of circular-based offers and include (i) *split-incentive* between actors and (ii) *the long lifecycles of buildings*. The *split-incentives* makes it crucial that different customers span of responsibility is taken into account when implementing value propositions based on CE principles, as actors who do not retain ownership of the building after construction may have a lack of incentive in investing in solutions which generate long-term benefits. The *long lifecycle of buildings* further makes actors at the beginning of the lifecycle reluctant to value potential benefits which may occur at end-of-life even in cases where the ownership retained. This implies that implementation of CBMs where the focal company seeks to retain ownership and, e.g. lease or implement a take-back system for façade elements is likely to face difficulties related to customer acceptance. Hence, customers are more likely to accept value propositions which embed circular design strategies to slow or close resource loops, when compared to circular strategies which necessitate a shift to alternative business models.

Whereas strategies to "narrow" resource loops were not included in the scope of this thesis, the findings indicate the need for accompanying circular strategies with strategies to narrow resource loops as the climate impact and resource efficiency of the early phases of construction is increasingly recognised in policy and environmental certification systems for buildings. Hence, designing value propositions in line with the aspects of focus in environmental certification schemes might be a potential avenue for proactively identifying opportunities for creating superior customer value.

## *Recommendations*

Based on the research, a number of recommendations for the case company and similar organisations that aim to implement circular strategies are formulated:

**Differentiate customer segments based on the type of property development and the actors' span of responsibility.** The results indicate how primary stakeholders tend to be more accepting of circular strategies from which they can reap the benefits off. Differentiating customer segments based on these factors might enable a better fit of the offer to the customer.

**Start with circular design strategies.** Circular design strategies, including design for adaptability, flexibility, disassembly or integration of reused or recycled inputs, are likely to require minor changes in the value creation and delivery and the value capture block of the existing business model of the case company. The findings further indicate a high degree of customer acceptance of circular design strategies. Notably, the financial viability of circular design strategies is likely to be critical to reaching customer acceptance of the offering.

**Explore opportunities for creating added value through closer customer relationship.** The findings of this study indicate that circular strategies which provide increased service or maintenance to customers to improve the longevity of the building can create additional customer value by minimising risk. However, this is likely to be most attractive for the primary stakeholders which retain responsibility or ownership through a significant time of the building lifecycle, and where the additional service provided complements the activities of, e.g. service departments already in place. Potentially, components more prone to degradation (such as window frames) can be targeted. Benefits for the focal company include revenue diversification and increased customer loyalty through maintaining a close relationship with the primary stakeholder.

**Keep track of environmental performance.** The business analysis and the interviews reveal an increased focus on environmental issues beyond the energy efficiency in the operations phase in the building lifecycle. Several initiatives are also emerging to push the industry toward disclosing more information on the environmental impacts of sourcing, manufacturing and transportation of materials and building components. Having and disclosing such information is likely to be increasingly demanded by customers in the building construction industry. This may also increase the importance of environmental performance as a competitive factor. To obtain the highest reductions in environmental impacts, complementing strategies to slow and close resource loops with efforts to narrow resource loops (i.e. increase efficiency) should be considered.

**Assess the implications of the proposed value propositions on the other business model building blocks.** The scope of this study implies that implications of the re-defined value propositions on the other building blocks of the business model are not investigated. To embark upon the implementation process, further investigation and test of required changes in the value creation and delivery and the value capture building block of the business model to support the innovation will be necessary. For example, circular design models are likely to require changes in the value creation and delivery block of the business model, e.g. the adoption of new processes, alternative product design, and partnerships to ensure the design supports circular strategies in the operations- or EoL phase. Circular use models are likely to require new capabilities which support the delivery of e.g. additional service, while influencing the economic and revenue model, e.g. in terms of diversifying the revenue stream.

**Establish the purpose and explore partnerships for circular economy implementation.** The process of developing a sustainable business model should start by defining a clear sustainability purpose of the company. Recognising the many barriers faced by single actors to contribute to a shift toward a circular economy, e.g. split incentives, there is a need for increased co-operation throughout the value chain. The current focus on the financial dimension of customer value may also inhibit the development of new solutions due to a focus on cost minimisation and risk reduction. Research suggests how CBMI between actors along the value chain provides an opportunity for co-creating business models and value networks which support the development of radical innovation. Working proactively with clients with similar ambitions or in projects with an increased focus on the total cost of operations may further provide additional room for testing and implementing CBMs.

## Conclusion

This study sought to contribute to the emerging field of CBMs innovation in the building construction industry by exploring customer acceptance of value propositions re-designed based on CE principles. Customer acceptance of new value propositions has been considered fundamental for succeeding with CBM implementation and by conceptualising the customer value in the building construction industry. The study contributes to the nascent literature on CE-based value proposition design in the building construction industry. A key finding is that the case company may improve the delivery of financial, environmental and user value by embedding circular strategies in their value proposition. The study further provides an overview of factors which need to be considered to achieve customer acceptance when implementing circular strategies. This includes that the value proposition needs to provide equal or similar financial value for the customer as the market competition and that more radical business model innovations such as leasing models of façade systems are found to have lower customer acceptance.

Future research may further investigate the potential for CBMI between value chain actors in the building construction industry to support the development of CBMs which more effectively distribute incentives for strategies which promote durability, reuse or recycling activities at EoL, in the early phases of the building lifecycle. Future research may also investigate the potential for new financing models that promote circular the adoption of circular strategies in the building construction sector.

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# Abbreviations

| | |
|---|---|
| CE | Circular economy |
| CBM | Circular business model |
| SBM | Sustainable business model |
| BMI | Business model innovation |
| CBMI | Circular business model innovation |
| SBMI | Sustainable business model innovation |
| EoL | End-of-life |
| MVP | Minimal viable product |

# 1 Introduction

## 1.1 Problem definition and background

The building industry is one of the highest consuming sectors of resources and raw materials today (Adams, Osmani, Thorpe, & Thornback, 2017). Estimates show that the building sector consumes approximatively 40 per cent of materials entering the global economy, of which only 20 to 30 per cent is recycled or reused at end-of-life (Leising, Quist, & Bocken, 2018). Overall, the per capita material footprint of developing countries increased from 5 metric tonnes in 2000 to 9 metric tons in 2017, mainly fuelled by an increase in the development of infrastructure and constructions (United Nations, n.d.). At the same time, the 2030 Agenda for Sustainable Development, adopted by all member countries of the UN in 2015, points to the decoupling of economic growth from resource use as one of the most critical challenges facing humanity (United Nations, n.d.).

So far, efforts to increase the sustainability of buildings have been primarily focused on reducing energy consumption and associated carbon emissions during the use-phase, resulting in a significant decrease of the energy use of buildings in a European context (Van Sante, 2017). This singular focus has caused scholars to argue that the environmental impacts associated with resource consumption are largely omitted (Ness & Xing, 2017). Pomponi & Moncaster (2017) further suggests how a sole focus on the operational stage is insufficient to significantly reduce the overall negative environmental impact of a building.

The current trend has caused business and governments to increasingly turn to the concept of the circular economy (CE) to increase resource efficiency (Geissdoerfer, Morioka, Carvalho, & Evans, 2018; Mont et al. 2017; Nußholz, 2017; Prendeville et al. 2017; Uusitalo & Antikainen, 2018). The concept of CE offers an alternative to the current linear economy by focusing on slowing, closing and narrowing resource loops (Bocken, Strupeit, Whalen & Nußholz, 2019). By reducing resource consumption, the concept promises a reduction in waste generation, pollution and greenhouse gas emissions (Ness & Xing, 2017; Pomponi & Moncaster, 2017; Van Sante, 2017). For example, estimations suggest that a 20 per cent reduction of resource consumption in the construction industry would generate yearly savings of approximately 3.4 million and 970 000 tonnes of $CO^2$ emissions in Sweden and Denmark respectively (Høibye & Sand, 2018).

The CE concept is also gaining traction in the building construction industry as a solution for improving resource efficiency and negative environmental impacts of buildings. On a policy level, the EU highlights the importance of choices in the design phase of the building to enable a reduction of the $CO^2$ emissions (COM(2011)571). The built environment represents one of the prioritised areas in the European Commission's strategy for a circular economy (COM(2015)614). On a sectoral level, the UK Green Building Council launched a circular economy guide for construction clients in April 2019. Several major construction companies in Europe are currently seeking to integrate CE thinking in their strategic planning, however, there is still a lack of widespread translation of CE strategies into practice (Jones & Comfort, 2018). In the Nordic context, few buildings have been reported to be built on or inspired by CE thinking (Høibye & Sand, 2018).

The main focus of previous academic research on the topic of CE in the construction sector can be divided into three streams: investigation of (i) the applicability of the CE in the context of the built environment (Arup, 2016; Jones & Comfort, 2018; Ness & Xing, 2017; Thelen et al., 2018), (ii) circular strategies for the building construction industry (Geldermans, 2016a; Kibert, 2003; Kyrö, Jylhä, & Peltokorpi, 2019; Lehmann, 2011; Minunno, O'Grady, Morrison, Gruner, & Colling, 2018) and (iii) enabling and hindering factors of a circular building construction industry (Adams et al., 2017; Hart, Adams, Giesekam, Tingley, & Pomponi, 2019). Despite how circular business models (CBMs) are considered critical to enabling a shift toward a more circular economy (Manninen et al., 2018; Urbinati, Chiaroni, & Chiesa, 2017; Vence & Pereira, 2019) and the need for new business models is emphasised in both grey and academic literature (Arup, 2016; Guglielmo & Nitesh, 2017; Guldager Jensen et al., 2019), the topic of CBMs in the building construction sector remains relatively unexplored (Tukker, 2015). Concurrently, construction and property professionals are struggling to apply a CE thinking to their business models (Rådström, 2015). Business model innovation (BMI) has been recognised as a process to support companies in embedding circularity into the value offer of the company (Schaltegger, Freund, & Hansen, 2012; Zhao, Chang, Hwang, & Deng, 2017; Nußholz & Milios, 2017) and ensuring business success (Chesbrough, 2007).

When embarking on the process of BMI, understanding and reconfiguration the value provided to stakeholders is of essence (Abuzeinab & Arif, 2013; Azcarate-aguerre et al. 2018). Accordingly, the creation of a new business model start with the design of a value proposition, which describes the embedded value in the product or service offered to customers (Osterwalder & Pigneur, 2010). When shifting to a CBM, re-designing the value proposition is critical (Uusitalo & Antikainen, 2018) as the successful implementation of a CBM is determined by the customer acceptance of the new value proposition (Abuzeinab & Arif, 2013; Azcarate-aguerre et al. 2018). Despite its importance, value proposition development represents an area of limited investigation in academic literature (Payne & Frow, 2014).

In the BMI literature, several case studies have been conducted on BMI tools to promote development and implementation of CBMs (Bocken, Strupeit, Whalen, & Nußholz, 2019; Guldmann, Bocken, & Brezet, 2019; Joyce, Paquin, & Pigneur, 2015; Nußholz, 2018; Pieroni, McAloone, & Pigosso, 2019). However, few have been tested in the context of the building construction sector. Furthermore, while individual studies have investigated value creation in the building sector (Ünal, Urbinati, Chiaroni, & Manzini, 2019), there is a lack of studies focusing explicitly on the value proposition of CBMs in the context of the building construction sector, despite how the sector is highly demand-driven (ING, 2019) and investors and developers have a critical influence on the processes and products used (Qian & Shoufeng, 2008). Thus, this thesis seeks to bridge this current knowledge gap investigating how a manufacturing company in the building construction sector can create superior customer value by re-defining its value proposition in line with circular economy principles.

## 1.2 Aim and research question

This study aims to explore how the value proposition of a manufacturing company within the building construction sector can be re-designed to help implement and capitalise on CE practices drawing upon BMI and experimentation.

In specific, the research question is formulated as follows:

- How can a large manufacturing company in the building construction industry create superior customer value by re-defining its value proposition in line with circular economy principles?

To address the aim and answer the stated research question, this study will fulfil four tasks:

1. Delineate the type of strategies which can be used to slow and close resource loops within the building construction industry.
2. Explore how a process can be designed to help identify opportunities for adding value by the implementation of circular strategies.
3. Identify the type of value prioritised by key stakeholders of the case company.
4. Identify the additional value that may be captured by re-defining the value proposition of the case company in accordance with circular economy principles.

## 1.3 Target audience

The target audience for this thesis is practitioners and researchers in the field of circular economy and construction. The thesis was carried out in collaboration with a manufacturing company in the building construction industry, which sought to investigate the opportunities associated with the implementation of circular strategies. Hence, the case company, but also other companies within the construction sector, are the primary audience for the research at hand. Additionally, it targets the academic community as it contributes to the highly emerging research stream of CBMs. Specifically, by identifying the perceived potential for added value creation by circular strategies and testing a process which supports the re-designing of value propositions.

## 1.4 Disposition

The contents of this research paper are structured as follows:

*Chapter one* provides an introduction to the research problem at hand.

*Chapter two* presents the literature review, the conceptual framework applied in this study, and a summary of the research gap this study aims to bridge. Relevant concepts are also introduced.

*Chapter three* introduces the case at hand and describes the methodology adopted in this study, including data collection and analysis procedures. This is followed by a discussion concerning scope and limitations, and ethical considerations.

*Chapter four* presents the findings and analysis, which supported the development of the value propositions.

*Chapter five* contextualises and discusses the significance of the findings and the contribution made to existing research. The chapter further outlines recommendations to the case company and provides a critical reflection on the research process, including the applicability of the conceptual framework and the limitations of the applied research methodology.

# 2 Literature review

This chapter seeks to fulfil four objectives. These include (i) introducing the concept of circular economy (CE) business models; (ii) fulfilling task one by delineating the type of strategies which can contribute to closing, slowing and narrowing resource loops within the building construction industry; (iii) providing an overview of business model innovation processes which informed the design of the process in this thesis; and finally (iv) presenting the conceptual framework which aim to illustrate the value prioritised by stakeholders in the building construction industry.

## 2.1 Circular Business Models

### 2.1.1 The circular economy

The circular economy (CE) offers an alternative to the current *"take, make, dispose"* linear economic model which relies on the extraction of large quantities of materials which are eventually turned into waste (Blomsma & Brennan, 2017; Bocken, Boons, & Baldassarre, 2019; Bocken et al. 2016). The current dominance of the concept in the resource and waste management debate was boosted by promotional efforts of the Ellen MacArthur Foundation (EMF) and the World Economic Forum in 2014 (Blomsma & Brennan, 2017). Despite its recent popularisation, the concept of CE unifies ideas by a wide variety of schools of thoughts which dates back to the 1960s (Blomsma & Brennan, 2017). These include Industrial Ecology, Cradle to Cradle, Biomimicry, Performance Economy, Regenerative Design, Blue Economy, Natural Capitalism, Industrial Symbiosis and others (Geissdoerfer et al., 2018; Korhonen, Nuur, Feldmann, & Birkie, 2018; Lewandowski, 2016). As the concept has its roots in such a wide variety of schools of thoughts, scholars tend to refer to different starting points for its introduction. For example, Zucchella & Previtali (2019) suggest that the concept was coined by David Peace in 1990, whereas Geissdoerfer et al. (2018) propose that it was introduced even earlier, by Walter R. Stahel in 1983, who discussed the idea of a closed-loop economy (Geissdoerfer et al., 2018; Murray, Skene, & Haynes, 2017).

By decoupling economic growth from resource consumption, the CE is assumed to generate economic and environmental gains. For example, in the EU Action Plan for the Circular Economy, the transition to a more circular economy is considered to boost the competitiveness of the European market by unlocking economic and environmental opportunities (COM(2015)614.) Economic gains are commonly described as mitigation of resource price volatility, cost savings, increased employment rates due to promotion of labour-intensive activities and mitigation of supply chain risks (Ellen MacArthur Foundation, 2015a; Lewandowski, 2016; Ness & Xing, 2017). By reducing resource consumption, a reduction of waste, pollution and greenhouse gases is promised (Ness & Xing, 2017). Indeed, the benefits of the CE are primarily framed in terms of economic and environmental gains, whereas merely implicit social gains are discussed (Geissdoerfer, Savaget, Bocken, & Hultink, 2017).

The increasing popularity of the CE concept has given rise to a variety of conceptualisations in both the academic and grey literature (Zucchella & Previtali, 2019). The Ellen MacArthur Foundation (2015b) describes the three principles of the CE as (i) *Preserve and enhance natural capital* (ii) *Optimise resource yield* and (iii) *Foster system effectiveness by revealing and designing out negative externalities.* The CE is further described as a closed-loop system where resources are cycled through technical and biological cycles, while kept at their highest value at all times. In biological cycles, materials are designed to feed back into the system through natural processes, such as composting. In the technical cycle, resources are recovered and restored through circular strategies (Ellen MacArthur Foundation, 2015b). Murray et al. (2017) provide a simplified description of the CE by referring to it as *"a general term covering all activities that reduce, reuse, and recycle materials in production, distribution, and consumption processes"* (Murray et al. 2017, p.373).

While the concept is commonly discussed in connection with the concept of sustainability, the relationships between CE and sustainability has been considered ambiguous (Geissdoerfer et al., 2017). For example, Geissdoerfer et al. (2017) found that the relationship between the CE and sustainability is either described as conditional, beneficial or compromising in the existing literature. It has further been proposed that, in principle, the potential of the CE to deliver the intended environmental value is dependent on whether or not the cycling of products and material offsets primary production (Mont et al., 2017; Zink & Geyer, 2017). To clarify the relationship between the concepts, Geissdoerfer et al. (2017) proposed a conceptualisation of the CE as *"a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling"* (Geissdoerfer et al. 2017, p. 777). Despite how the definition does not adequately consider the condition for environmental gains in terms of offsetting primary production, it clarifies the expected environmental benefits of the CE concept which the description by Murray et al. (2017) is lacking.

The realisation of the CE can be promoted either top-down (macro-level) through regulation or bottom-up (micro-level) through firm competitiveness (Oghazi & Mostaghel, 2018). Planing (2015) outlines four building blocks necessary in a transition toward a circular economy: (i) Materials and product design; (ii) new business models; (iii) global reverse networks and (iv) enabling conditions. Focusing on the second building block as defined by Planing (2015), this study will seek to contribute to the research on the micro-level of the CE system.

### 2.1.2 The business model concept

There are a variety of definitions of the term business model in the literature. For example, Beattie & Smith (2013) define the business model as a holistic description of how a firm conducts business. However, in their review on business model innovation, Foss & Saebi (2016) found that the preferred definition of the business model concept in recent contributions is: *"the description of the design or architecture of the value creation, delivery and capture mechanisms employed"* (Teece, 2010: 172).

The business model canvas developed by Osterwalder & Pigneur (2010) is a well-established framework to support business modelling processes which breaks down the concept into nine building blocks (Bocken, Short, Rana, & Evans, 2013; Bocken, Miller, Weissbrod, Holgado, & Evans, 2017). The *customer segments* outline the people or organisations which the business aims to reach, the *value proposition* describes the embedded value in the product or service offered to customers, the *channels* describes how the business reaches the customer segments and delivers the value proposition, and the *customer segments* describe the relationships which the business seek to establish with its customer segments. Moreover, *revenue streams* outline how the business generates cash from each customer segment, and the *cost structure* provides an overview of all the costs associated with operating the business models. Finally, *key resources* describe the assets required to ensure the functioning of the business model, while *key activities* represent the necessary activities and *key partnerships* the network of partners and suppliers needed (Alexander Osterwalder & Pigneur, 2010).

Richardson (2008) simplifies the nine building blocks into three key elements: the value proposition, value creation and delivery, and value capture (see Figure 2-1). The value proposition defines the reason why a customer should value the product or service offered by the company and encompasses the offering as well as the targeted market or customer and the customer relationship. Thus, it describes the embedded value in the product or service offered to customers Richardson (2008). The value proposition should include aspects which contribute to creating competitive advantage, such as a superior or differentiating offering (Boons & Lüdeke-Freund, 2013). On the other hand, value creation and delivery include the various activities necessary for the functioning of the business model, illustrated by the value chain and value network of the company. For example, activities, distribution channels, resources and partners might be included (Boons & Lüdeke-Freund, 2013). Finally, the value capture is made up from the revenue model, which describes the sources of revenue in exchange for product or services, and the economic model, which covers other financial aspects of the business including costs and margins. In this study, the definition and categorisation of the business model concept by Richardson (2008) is used.


*Figure 2-1. 'Business Model Building Blocks'*

*Source: By author based on Richardson (2008).*

### 2.1.3 Circular business models

The concept of business models has been merged with the concepts of sustainability and CE, generating the taxonomies of the sustainable business model (SBM) and circular business model (CBM). A sustainable business model is defined by Lüdeke-Freund (2010) as *"a business model that create competitive advantage through superior customer value while contributing to sustainable development of the company and society"* (Lüdeke-Freund, 2010, p.23). It has been suggested that, in principle, what differentiates a SBM from a traditional business model is the definition of the purpose and performance of the firm from a triple-bottom-line perspective, the consideration of the needs of all stakeholders of the firm, and the recognition of the need for driving sustainability on both firm and system-level (Stubbs & Cocklin, 2008). Hence, the scope of the value proposition goes beyond economic transactions and value creation for the end-user, which is at the focus in a traditional business model, and also considers the ecological and social value offered by the firm (Evans et al., 2017; Bocken et al., 2014).

CBMs tend to be positioned as a subset to SBMs (Bocken, Short, Rana, & Evans, 2014; Geissdoerfer et al., 2018; Whalen, 2019), although Pieroni et al., (2019) suggests that the link between CBMs and sustainability is not well-founded in the academic literature. The research on CBMs tends to combine a focus on business models and circular strategies, drawing on the fields of business management and resource efficiency (Nußholz, 2017). Bocken, de Pauw, Bakker, & van der Grinten (2016) distinguishes CBMs from linear business models by outlining design and business models strategies by the principles of which material flow through a system. They define two main strategies which refer to the technical and biological nutrient cycles of the Circular Economy concept: slowing resource loops and closing resource loops. Slowing loops entails extending or intensifying the utilisation period of products to slow the flow of resources in the system. This is realised by designing long-life products or implementing efforts to extend the useful product life, such as repair or remanufacturing of products and components. In contrast, closing resource loops is realised by recycling efforts which close the gap between end-of-life and production (Bocken et al. 2016). To reap the highest environmental and economic benefits, an emphasis is put on keeping products in the "inner loops", which favours activities which preserve the complexity and original use of the product (Ellen MacArthur Foundation, 2015b; Guldmann et al., 2019).

Despite not addressing the cycling of products and components per se, the role of narrowing resource loops, i.e. strategies to improve resource efficiency, is also discussed in the CBM literature (Bocken et al., 2017; Geissdoerfer et al., 2018, 2017). These strategies are already widespread in the linear economy, building off the lean philosophy (Bocken et al., 2016). While the more comprehensive definitions include all three categorisations of strategies (Geissdoerfer et al., 2017; Oghazi & Mostaghel, 2018), others exclude resource efficiency strategies from the definition of circular strategies (Bocken et al., 2016; Nußholz, 2017). As several scholars suggest that circular strategies do not necessarily lead to resource efficiency or increased sustainability performance (Bocken, Strupeit, Whalen, & Nußholz, 2019; Nußholz, 2017; Pádua, Pigosso, & Mcaloone, 2018), the economic and environmental potential of applying strategies for narrowing resource loops in conjunction with circular strategies has been asserted (Bocken et al., 2016; Guldmann et al., 2019). Geissdoerfer, Morioka, Carvalho, & Evans (2018) further adds intensifying and dematerialising resource loops as circular strategies, stressing the environmental benefits of intensifying the use phase and substituting product utility through services or software solutions.

As indicated above, the concept of CBM is not consistently defined in the literature, resulting in a lack of consensus concerning the type of resource efficiency strategies necessary to make a business model circular (Nußholz, 2017). However, Lewandowski (2016) suggests that most CBMs can be categorised according to the ReSOLVE framework developed by the Ellen MacArthur Foundation (2015b). The ReSOLVE framework builds upon the three principles of the circular economy introduced in section 2.1.1., and establishes six business actions for implementation of CE principles (Ellen MacArthur Foundation, 2015b):

- **Regenerate.** A shift to renewable sources and materials is emphasised, along with the closing of biological loops through returning biological resources to the biosphere.
- **Share**. Slowing resource loops and maximizing utilisation of products or assets.
- **Optimise**. Increased efficiency and mitigation of waste by leveraging big data, sensing and automation.
- **Loop**. Keeping materials and components in closed loops, with a prioritisation of inner loops in the technical or the biological cycles, depending on the characteristics of the material. Actions include remanufacturing, recycling and digestion.
- **Virtualise**. Dematerialise resource use by delivering or providing a service or product virtually.
- **Exchange**. Apply new technologies which support longer lifecycles, repair and reparability. Use of new materials which slowing and closing of resource flows.

While the ReSOLVE framework offers a categorisation of CBMs, it has been suggested that there are no such thing as a fully circular business model yet (Lewandowski, 2016; Pieroni et al., 2019). Instead, every business model will have both linear and circular features, incorporating certain practices which fit with the principles of the CE (Lewandowski, 2016). The process of incorporating circular principles into the business model may occur to a varying degree depending on the strategy and ambition of the company itself (Pieroni et al., 2019; Urbinati et al., 2017). To illustrate, Urbinati et al. (2017) propose three modes of CE integration in the business model of a company:

- **Downstream circular** describes business models where the value creation and capture are altered with a high focus on communication. This may include the adoption of a price scheme or marketing campaign based on the use and reuse of products, e.g. pay-per-use models, to achieve market penetration. No changes are made in terms of product design, supplier relationship or internal activities.
- **Upstream circular** refers to business models where the value creation system is changed. Circular strategies are incorporated into the product design, and new relationships with suppliers are formed to increase cost-efficiency. However, these changes are not communicated to the customer nor is reflected in the price or products.
- **Fully circular** combining both the downstream circular and upstream circular adoption mode. This mode is associated with the highest potential impact in terms of economic and environmental benefits.

In this study, Nußholz's (2017) definition of CBMs is adopted. The definition suggests that a CBM encompass *"how a company creates, captures, and delivers value with the value creation logic designed to improve resource efficiency through contributing to extending useful life of products and parts (e.g., through long-life design, repair and remanufacturing) and closing material loops"* (Nußholz, 2017, p. 13). The definition includes all three modes of CE integration modes in a business model as defined by Urbinati et al. (2017). The definition includes strategies to slow and close resource loops but excludes strategies to narrow, dematerialise or intensify resource loops, as such does not address the cycling of resources per se. Hence, a business model embedding "optimisation" or "virtualisation" strategies as proposed by ReSOLVE framework, is not considered a CBM by definition. However, such strategies are assumed to play a complementary role to circular strategies.

## 2.2 Circular business models in the building construction industry

### 2.2.1 An overview of circular strategies in the building value chain

The Nordic Council of Ministers states how *"the objective of a transition toward a circular economy in the construction sector is to maintain, reuse, refurbish and/or recycle resources and materials used in all parts of the value chain."* (Høibye & Sand, 2018, p.11). Hence, a transition toward the CE in the building construction industry necessitates the involvement of the entire value chain (Jones & Comfort, 2018; Surgenor, Winch, Moodey, & Mant, 2018; Van Sante, 2017). It has further been asserted how circular strategies needs to be applied in cohesion to enable a system shift and avoid fragmented solutions (Nußholz & Milios, 2017). With this in mind, there are several circular strategies which can be employed in the different parts of the building value chain (see Figure 2-2) to support closing and slowing of resource flows in the building construction sector. To fulfil the second task of this thesis, this section will provide an overview of these strategies (for an overview, see Table 2-1). The section will further include strategies to narrow resource loops. Despite how these are not considered circular strategies by definition in this study, strategies to narrow resource loops may contribute to addressing the underlying environmental issues circular strategies seek to solve, such as mitigating resource scarcity and reducing embodied emissions of materials and components. Thus, they are considered complementary to circular strategies.

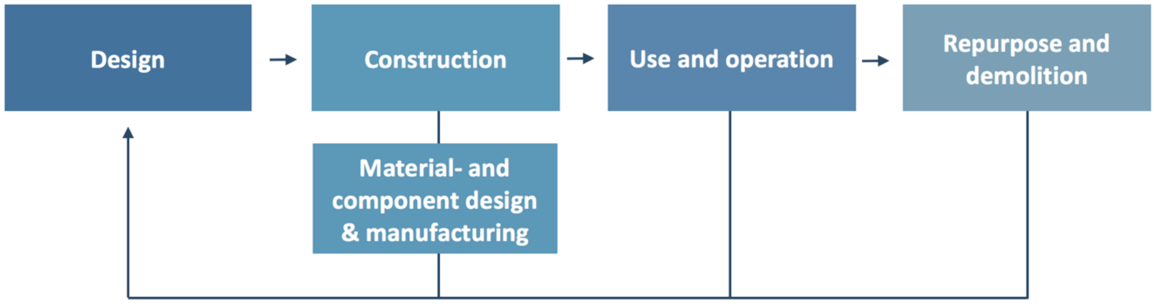


*Figure 2-2. Simplified illustration of the value chain for buildings.*

*Source: Developed by author after Høibye & Sand (2018), Nußholz & Milios (2017) and Debacker & Manshoven (2016).*

### Design

Decisions taken in the design phase of a building has a significant impact on the operation, repurposing and end-of-life management of a building and its components (Arup, 2016; Nußholz & Milios, 2017). Thus, the designing of buildings is critical when seeking to slow or close resource loops. There are several design approaches emphasised in the academic literature, including "design for longevity", "design for adaptability", "design for flexibility", "design for modularity" and "design for standardisation". The primary purpose of these seems to be twofold: to enable an extension of the useful life of an building (slowing resource loops) and/or to enable reuse or recycling of building components and materials at end-of-life (closing resource loops) (Adams et al., 2017; Arup, 2016; Geldermans, 2016; Guglielmo & Nitesh, 2017; Minunno et al., 2018; Nußholz & Milios, 2017).

Longevity can be achieved through designing for flexibility or adaptability. These strategies promote an extension of the useful life of building through flexible spaces and adaptable elements which hinders it from becoming obsolete in case of occupancy changes (Geldermans, 2016; Minunno et al., 2018). While designing for flexibility is conducted to balance present and future needs, and thus enables frequent reconfiguration, designing for adaptability has the goal of meeting the needs of the present while taking future changes into account. Therefore, adaptability supports period rather than frequent remodelling (Surgenor et al., 2018). As the adaptability of a building is closely related to the movability of the building itself and its components, standardisation and modular design are strategies which support a higher degree of adaptability and overcomes the current barrier which is the monolithic nature of traditional buildings (Geldermans, 2016; Minunno et al., 2018). It is suggested that the benefits of designing for flexibility and adaptability include savings of greenhouse gas emissions throughout the lifecycle, a marketing opportunity for future tenants by highlighting the potential of flexible or adaptable spaces, retainment of asset value and long-term cost savings (Surgenor et al., 2018).

From an end-of-life perspective, the design phase is crucial to realise efficient reuse of secondary components and materials (Kibert, 2003; Lehmann, 2011; Thelen et al., 2018). Promotion of the use of secondary materials and components can be achieved by its integration into the design of the building. Higher reuse and recycling rates of materials and components at end-of-life can be achieved through design for disassembly practices (Arup, 2016; Minunno et al., 2018; Nußholz & Milios, 2017). The use of standardised elements and modular design also has the potential to reduce construction waste and simplify reuse and recycling activities at EoL (Surgenor et al., 2018). By designing the building to be disassembled part by part, it is also possible for the tenant to remain in the building while work is conducted, reducing disruption and void periods (Surgenor et al., 2018).

### *Material- and component design and manufacturing*

Minunno et al. (2018) highlight two main circular strategies related to material and component production: integration of secondary raw materials into new components and reuse of second-life components. Reuse- and recycling practices at end-of-life are facilitated by the use of fewer hazardous materials in new products, design approaches which enables disassembly and recycling practices, and take-back schemes for materials and components (Adams et al., 2017; Guglielmo & Nitesh, 2017; Nußholz & Milios, 2017). Benefits associated with reuse of elements and components include potential cost savings, contribution toward reuse and recycling targets and saving of greenhouse gas emissions (Surgenor et al., 2018). According to Evans et al. (2017), take-back schemes further internalise externalities by allocating the responsibility for the economic, social and environmental issues throughout the lifecycle of the product to the manufacturer or service provider.

In this phase, strategies to narrow resource loops are highlighted in grey literature. For example, Surgenor et al., (2018) emphasise the need of selecting low impact materials, Thelen et al. (2018) suggests that bio-based, renewable, local and abundant materials should be prioritised and Guldager Jensen et al. (2019) emphasises fully renewable, recyclable and biodegradable materials.

### *Construction*

Strategies in the construction phase of the value chain fall into the category of narrowing resource loops as the primary focus is the elimination or minimisation of waste from construction sites (Adams et al., 2017; Arup, 2016; Minunno et al., 2018). Despite not being categorised as *circular* per se, the potential of strategies such as off-site manufacturing and prefabrication to contribute to a reduction of construction waste is considered high (Adams et al., 2017; Arup, 2016). In comparison to most strategies seeking to slow or close resource loops, these strategies are relatively well-established within the industry (Arup, 2016).

### *Use and operation*

In line with the principle of the circular economy to keep products and materials in use (Ellen MacArthur Foundation, 2016), strategies in the use- and operation phase are mostly concerned with the optimisation of the existing building stock (Ness & Xing, 2017). Despite how the use-phase receives limited attention in the reviewed literature, Ness & Xing (2017) argues that it can provide significant environmental benefits by negating the need for new assets. Here, effective utilisation of existing buildings and maintaining and improvement of its quality is emphasised. To illustrate, Thelen et al. (2018) and Guldager Jensen et al. (2019) highlights the sharing economy's potential to combat underutilisation of buildings and Kyrö, Jylhä, & Peltokorpi (2019) suggests that relocatable buildings offer a viable option for cities struggling with fluctuating demand of space. In relation to the latter, a shift from development to maintenance have been advocate, which may be supported by product-service-systems where sales of services (e.g. property management) rather than products (e.g. properties) is a strategy to improve the life cycle management of buildings, and thus extending its useful life (Guldager Jensen et al., 2019; Ness & Xing, 2017; Surgenor et al., 2018). This way, the developer or producer stays in control of the raw materials and thus secures its residual value, which may support dematerialisation (Thelen et al., 2018), internalise externalities (Evans et al 2017) and provide benefits such as proactive maintenance, waste minimisation by designing components for reuse or repurposing, and avoidance of unplanned downtime (Surgenor et al., 2018).

### Repurpose and demolition

To close or slow resource loop, strategies in the end-life-life stage seek to achieve reintegration of materials and components into the value chain through reuse and recycling activities (Adams et al., 2017; Guldager Jensen et al., 2019; Ness & Xing, 2017; Nußholz & Milios, 2017). Both closed-loop recycling and open-loop recycling are identified as circular strategies in the literature (Hart et al., 2019; Nußholz & Milios, 2017), despite how open-loop recycling in practice often entails downcycling of materials (Minunno et al., 2018).

The UK Green Building Council (2019) states that materials and components should primarily be reused on-site, and if not possible, sent for onward reuse or to material suppliers for refurbishing, repurposing or recycling purposes. Components and materials need to be disassembled and sorted to achieve reintegration into the value chain at the highest value possible. To enable this, strategies such as disassembly and selective demolition (Adams et al., 2017; Kibert, 2003; Nußholz & Milios, 2017) are proposed. Benefits associated with increased reuse and recycling are commonly proclaimed as a reduction in landfill costs, reduced waste generation, savings of greenhouse gas emissions and increased social value of development (Surgenor et al., 2018).

The feasibility of strategies which seek to reintegrate materials and components into the value chain is highly dependent on the ease of disassembly at EoL, which is influenced by the degree of standardisation and absence of toxic materials, factors which are largely determined in the early lifecycle stages (Kibert, 2003). The lack of transparency in the supply chain and the long lifecycles have been found to impose difficulties for actors at the end of the value chain to assess the properties of the building, and thus the recycling- and reuse potential of materials and components (Adams et al., 2017; Arup, 2016). To address such issues, improving information flows throughout the value chain as a way to enable implementation of CE strategies has been emphasised in the literature (Arup, 2016; Guldager Jensen et al., 2019). This can be achieved through the use of material passports, which are sets of data which supports identification of materials and components potential for reuse, remanufacturing and recycling activities by tracking the characteristics, location, age and expected lifecycle throughout the lifecycle (Arup, 2016; Guldager Jensen et al., 2019; Minunno et al., 2018).

*Table 2-1. Overview of circular strategies*

| | **1. Material- and component design and manufacturing** |
|---|---|
| **Slow resource loops** | • Use of secondary components and materials (Adams et al., 2017; Arup, 2016; Nußholz & Milios, 2017)<br>• Use of fewer hazardous materials (Adams et al., 2017; Minunno et al., 2018; Nußholz & Milios, 2017)<br>• Design for product disassembly (Nußholz & Milios, 2017)<br>• Design for product longevity (Adams et al., 2017; Arup, 2016)<br>• Design for product flexibility/adaptability (Arup, 2016)<br>• Take-back schemes (Adams et al., 2017; Nußholz & Milios, 2017) |
| **Close resource loops** | • Design for product disassembly (Nußholz & Milios, 2017)<br>• Material passports/specification of recyclable materials.<br>• Use of recycled inputs (Adams et al., 2017; Minunno et al., 2018; Nußholz & Milios, 2017) |
| ***Narrow resource loops*** | • *Use of bio-based, local, renewable, abundant or low impact material (Surgenor et al., 2018; Thelen et al., 2018)* |

| | |
|---|---|
| | • *Design out the need for components and materials (Adams et al., 2017; Nußholz & Milios, 2017)* |
| | **2. Design** |
| **Slow resource loops** | • Design for adaptability or flexibility (Arup, 2016; Geldermans, 2016; Minunno et al., 2018; Ness & Xing, 2017; Nußholz & Milios, 2017)<br>• Design for longevity (Adams et al., 2017; Arup, 2016; Geldermans, 2016; Guglielmo & Nitesh, 2017; Minunno et al., 2018; J. Nußholz & Milios, 2017)<br>• Design for disassembly (Adams et al., 2017; Arup, 2016; Kibert, 2003; Ness & Xing, 2017; Nußholz & Milios, 2017; Surgenor et al., 2018; Thelen et al., 2018) |
| **Close resource loops** | • Design for disassembly (Adams et al., 2017; Arup, 2016; Kibert, 2003; Ness & Xing, 2017; Nußholz & Milios, 2017; Surgenor et al., 2018; Thelen et al., 2018)<br>• Design for use of secondary materials and components (Nußholz & Milios, 2017) |
| ***Narrow resource loops*** | • *Design out the need for components and materials (Adams et al., 2017; Nußholz & Milios, 2017)* |
| | **3. Construction** |
| ***Narrow resource loops*** | • *Lean production chain (Adams et al., 2017; Arup, 2016; Minunno et al., 2018)*<br>• *Off-site manufacturing and prefabrication(Adams et al., 2017; Arup, 2016)* |
| | **4. Use and operation** |
| **Slow resource loops** | • Sharing services (Ness & Xing, 2017; Thelen et al., 2018)<br>• Product-as-a-service system (Ness & Xing, 2017; Surgenor et al., 2018)<br>• "Harvesting" of components and materials for reuse during repurposing (Arup, 2016)<br>• Use of relocating buildings (Kyrö et al., 2019) |
| | **5. Repurpose and demolition** |
| **Slow resource loops** | • Disassembly (Adams et al., 2017; Kibert, 2003; Nußholz & Milios, 2017)<br>• Selective demolition (Adams et al., 2017; Kibert, 2003; Nußholz & Milios, 2017)<br>• Reuse of components and materials (Ness & Xing, 2017; Nußholz & Milios, 2017; Adams et al, 2017) |
| **Close resource loops** | • Disassembly (Adams et al., 2017; Kibert, 2003; Nußholz & Milios, 2017)<br>• Selective demolition (Adams et al., 2017; Kibert, 2003; Nußholz & Milios, 2017)<br>• Closed loop recycling (Adams et al., 2017; Minunno et al., 2018; Nußholz & Milios, 2017)<br>• Open loop recycling (Adams et al., 2017; Minunno et al., 2018; Nußholz & Milios, 2017) |

*Source: By author*

### 2.2.2 Categorisation of circular business models in the building construction industry

The previous section illustrated the applicability of numerous circular strategies to the building construction industry. Previous research has described how the adoption of green construction methods may lead to necessary reconfigurations of the business model of construction companies (Abuzeinab & Arif, 2013; Mokhlesian & Holmén, 2012). Nonetheless, limited contributions have been made so far in the context of CBMs for the building construction industry. A broad categorisation of CBMs for the building construction industry which embeds the circular strategies presented in the previous section is offered by Guglielmo & Nitesh (2017). These cover three categories: (i) *Circular design models* which include strategies to maintain the residual value of buildings, components and materials, through design changes; (ii) *Circular use models* where the control over an asset or component is maintained (e.g. through leasing services) to retain its value, or maintenance to support life-extension is provided; and (iii) *Circular recovery models* which entail transforming existing products or components into new ones underpinned by solutions such as reverse logistics to recapture material. However, Guglielmo & Nitesh (2017) only vaguely describe what a circular recovery model entails in practice and do not specify whether it includes both efforts to slow (e.g. reuse or refurbish) and close (e.g. recycling) resource loops.

Guglielmo & Nitesh (2017) further propose that all circular business models are expected to require, in varying extent, a move toward a circular value chain which builds upon collaboration and information sharing between actors throughout the lifecycle of a building (Guglielmo & Nitesh, 2017). This is expected to increase the complexity of implementation, yet, also stimulate value creation for a broader range of stakeholders (Ünal et al., 2019). Guglielmo & Nitesh (2017) further argues that CBM implementation necessitates changes to the building blocks of the business models, as outlined below (see Table 2-2). Arguably, the changes necessary for the adoption of a CBM is likely to vary depending on a variety of factors. For example, the existing set-up of the business model, including internal capabilities, targeted customer segments and the company's position in the value chain. These factors are not taken into consideration by Guglielmo & Nitesh (2017). Hence, the foreseen changes to the building blocks of the business model can be considered indicative.

*Table 2-2. Predicted changes to the business model building blocks*

| Circular business model | Value proposition | Value creation and delivery | Value capture |
|---|---|---|---|
| Circular Design Models | Increased flexibility of the building to respond to changes in demand and market<br>Increased residual value of building components<br>Reduce construction time<br>Optimised workflows<br>Simplified maintenance | Changes in product design<br>Sourcing and use of reuse or recyclable inputs<br>New processes to increase reuse and recyclability of secondary components, materials & by-products<br>Collaboration with actors' post-initial use to ensure the design is in-line with circular strategies in later lifecycle stages. | No changes |
| Circular Use Models | Expansion of customer segment by offering a wider variety of services. | Developing new capabilities to provide additional services to support product-life extension, facilitating tracing and trade of secondary components, and materials. | Diversified revenue stream by a shift to maintenance, repair and replacement activities. |
| Circular Recovery Models | Offering secondary products and materials<br>Provides take-back system or collection services | Developing new capabilities to support reverse logistics and recycling, remanufacturing or refurbishing activities. | Added costs of reverse logistics.<br>Increase material security |

*Source: By author after Guglielmo & Nitesh (2017) and Guldager Jensen et al., (2019)*

### 2.2.3 Barriers and drivers of circular business model implementation in the building construction industry

#### *Barriers of circular business model implementation*

The limited dissemination of CBMs thus far has caused scholars to investigate barriers and enabling factors for the adoption of CBMs both in general (see, e.g. Linder & Williander, 2017 or Vermunt et al., 2019) and in the building construction sector (Hart et al., 2019)(Adams et al., 2017; Debacker & Manshoven, 2016; Hart et al., 2019). Linder & Williander (2017) investigated the challenges of CBMI for business models based on remanufacturing and reuse practices. They found that CBMs increased the uncertainty and business risk for the entrepreneur when compared to linear business models due to several inhibiting factors, although the severity of these factors varies depending on the type of business model adopted, product offered and customer targeted. These include:

- **Product-services systems**, i.e. where products are rented rather than sold, was found to face several challenges related to predictability and reliability of return flows, increased operational risk, and tied up capital by transferring parts of the financial from the customer to the producer (Guglielmo & Nitesh, 2017; Linder & Williander, 2017). In a recent project piloting a product-service model for integrated façade elements in the construction sector, challenges related to ownership and contract set-up are identified. However, the BM is still considered to be in reach under the current economic and legal context (Azcarate-aguerre, Klein, & Heijer, 2016).
- **Business models based on remanufacturing** was found only to suit a specific type of customer, restricting the type of products that could be sold (as all products are not suitable for remanufacturing) and requiring significant technological expertise of the company.
- **Designing long-life products** face the challenges of the company being unable to respond to fashion changes and also risks leading to cannibalisation, i.e. resulting in a decrease in overall sales which might negatively affect the revenue stream of the company.

Jones & Comfort (2018) suggests that there are several sector-specific issues which hinder the adoption of CE strategies in the building construction industry. First of all, the sector's complexity and the many actors involved in the different lifecycle stages of a building (Jones & Comfort, 2018a). During the lifecycle of a building, ownership is often shifting, and actors responsible in the early lifecycle stages (such as design) are seldom accountable for the outcomes in other lifecycle stages, such as end-of-life (Adams et al., 2017; Arup, 2016; Kibert, 2003). The long lifecycles in combination with short-term thinking of actors involved in the construction process have been considered significant barriers toward implementation of circular strategies in construction (Adams et al., 2017; Hart et al., 2019; Jones & Comfort, 2018; Kibert, 2003). Even more so as circular strategies can seldom be realised within a company's processes, but requires collaboration across the value chain (Leising, Quist, & Bocken, 2018; Nußholz & Milios, 2017).

Second of all, the price of a real estate is further determined to a higher degree by location, than by material design and use, which limits the added short-term financial value of circular strategies. Also, the investor or the developer of a property is seldom the actor inhabiting the property during the use-phase. These two factors have been found to give rise to a split-incentive, where the cost of the building is borne by the investor who has a more short-term focus and is unable to reap the long-term benefits from, e.g. circular strategies (ING, 2019). This phenomenon has also been identified by Kylili & Fokaides (2017), who suggested that life cycle cost analysis is difficult to employ in the building construction industry due to the split-incentive (Kylili & Fokaides, 2017). Arguably, this would be the case mostly for speculative investors who do not attain ownership throughout the building's lifecycle.

Thirdly, lack of economic incentives for reuse and recycling of materials is considered a barrier. Even when recycling and reuse of materials and components may be technically feasible, demolition is often preferred over methods such as disassembly (Minunno et al., 2018; Nußholz & Milios, 2017). The time-consuming nature of disassembly practices and the need for storing, testing and re-certification of components and materials further hinders reuse practices (Minunno et al., 2018). Meanwhile, the price of virgin materials has remained low (Thelen et al., 2018), providing limited market incentives for actors to re-integrate secondary materials and components in production and construction.

Fourthly, when aiming to use secondary components and materials, companies tend to face difficulties related to the acquisition of secondary materials. On the other hand, when reuse options are in-place, there seems to be an insufficient market demand, often due to users concerns regarding quality and functionality of the material (Nußholz & Milios, 2017). Finally, among the regulatory barriers emphasised in the literature, limited use of circular criteria in public procurement and lack of standards which enables reuse of products and materials are stressed (Adams et al., 2017; Hart et al., 2019; Thelen et al., 2018).

### *Drivers of circular business model implementation*

Drivers both circular strategies and CBM adoption are identified in previous literature. For example, Winter (2014) suggests several conditions which need to be met to secure the profitability of business models based on closed loops strategies. These include having sufficiently valuable materials and products, ease of reuse and remanufacturing activities, and keeping materials concentrated and avoiding contamination. For adoption of CBMs, critical internal factors identified in the literature include leadership, team commitment toward the integration of circular strategies in the business model, and in-house expertise and capabilities (de Mattos & de Albuquerque, 2018; Lewandowski, 2016; Urbinati et al., 2017). On the other hand, essential external factors are governmental support, legislation, geographical proximity to facilitate resource exchange between companies, value chain collaboration and customer behaviour (de Mattos & de Albuquerque, 2018; Lewandowski, 2016; Planing, 2015). When embarking on the process of integrating circular strategies in the business model, new collaboration partners and re-design of the value offered to stakeholders has further been found crucial, which is supported by business model innovation (BMI) (de Mattos & de Albuquerque, 2018).

## 2.3 Business model innovation and value proposition re-design

The field of BMI recognises the business model as a unit for innovation, a perspective which has gained increased attention during the last 15 years in academic research (Foss & Saebi, 2016). For a start-up, BMI might support the creation of an entirely new business model, while for an incumbent firm, it is more likely to support the process of developing novel configurations of the already existing business model (Guldmann et al., 2019). Despite a lack of consensus in the field concerning the extent to which the components of the business model must change to classify as BMI, Foss & Saebi (2016) defines BMI as "*designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements*" (Foss & Saebi, 2016, p. 201)

Similar to the traditional business model concept, the concept of BMI has been applied in a number of fields, including sustainability, where it has been recognised for its potential to support companies in creating a business case for sustainability by the process of adapting or changing the company's business model in line with a sustainable development (Schaltegger et al., 2012; Zhao et al., 2017). Still, Foss & Saebi (2016) suggest that the question of how practitioners can innovate the business model to embed sustainability has not been sufficiently addressed to date. Bocken et al (2014) defines business model innovation for sustainability as: "*Innovations that create significant positive and/or significantly reduced negative impacts for the environment and/or society, through changes in the way the organisation and its value-network create, deliver value and capture value (i.e. create economic value) or change their value propositions"* (Bocken et al., 2014, p. 44). Due to the rising popularity of the CE concept, there has also been a growing interest in the sub-area of BMI for sustainability focusing explicitly on circularity under the taxonomy of Circular Business Model Innovation (CBMI). Notably, BMI has been described as a complex and lengthy process, particularly in the case of CBMI, which often introduces a new business logic (Guldmann et al., 2019). Chesbrough (2007) suggests that two to three years is usually too short of a time to go through the full-scale process of business model innovation, including developing business model experiments, interpreting and analysing the findings, and implementing the results.

Experimentation processes as such have been considered a potential driver for BMI (Bocken, Miller, Weissbrod, Holgado, & Evans, 2017). In experiments, minimal viable parts of a business model or a product are used to test separate assumptions. Hence, it is not used to test the functioning of a new business model as a whole, which is rather done through field experiment or pilot projects (Bocken, Schuit, & Kraaijenhagen, 2018). Business model experimentation seems to serve a dual purpose in the literature: to identify, test and learn about potential circular business models and to build internal engagement and innovation capabilities (Bocken, Schuit, & Kraaijenhagen, 2018). Indeed, systematically identifying, testing and learning about different value creation strategies through experimentation processes has been found to mitigate uncertainties associated with the development and implementation of CBMs (Bocken et al., 2017; Linder & Williander, 2017). Previous research has attempted to conceptualise approaches and tools for business model experimentation to embed sustainability or CE principles (Bocken & Antikainen, 2018; Bocken et al. 2019; Antikainen, & Aminoff, 2017). Bocken & Antikainen (2018) identifies four general approaches to CBM experimentation building on conventional management literature: Design thinking, lean start-up type of approaches, effectuation and approaches grounded in business modelling.

A fundamental factor for succeeding with a CBM is customer acceptance of new value propositions (Abuzeinab & Arif, 2013; Azcarate-aguerre et al., 2018; Lieder et al., 2018). Indeed, Bocken & Antikainen (2018) suggests how the BMI process should start with defining the purpose of the company and re-designing the value proposition. Several features have been proposed in the BMI literature to distinguish value propositions in traditional BMs from those in SBMs or CBMs. According to Baldassarre, Calabretta, Bocken, & Jaskiewicz (2017), a sustainable value proposition encompasses three blocks: creating shared value for the value network, addressing a sustainability problem, and having a product or service which solves this sustainability problem while taking the stakeholders into account. In a CBM, several aspects need to be considered when redesigning the value proposition (for an overview, see Table 2-3). First, the value proposition should embed a circular strategy to create value (Nußholz, 2017; Uusitalo & Antikainen, 2018). In line with the core principles of the CE, the offer should be designed to support proactive preservation of the embedded value of products and components at the highest level possible (Nußholz, 2017; Uusitalo & Antikainen, 2018; Whalen, 2019) and include a lifecycle thinking approach (Manninen et al., 2018; Pádua et al., 2018). The value proposition should further internalise externalities, aim for radical innovation and integrate multidisciplinary knowledge (Evans et al., 2017; Geissdoerfer et al., 2018; Pádua et al., 2018; Rohrbeck, Konnertz, & Knab, 2013). Finally, it needs to deliver superior value in comparison with market competition (Lewandowski, 2016; Pádua et al., 2018). Pádua et al., (2018) further stress how companies need to integrate sustainability as a stronger basis in the development of new CBMs, viewing it mainly as a strategy towards sustainable development which might need to be complemented with other sustainability actions.

*Table 2-3. Criteria for sustainable value propositions in CBMs.*

| **Criteria** | **Reference** |
|---|---|
| The value proposition embeds circular strategies | Geissdoerfer et al., 2018; Manninen et al., 2018; Nußholz, 2017 |
| The value proposition supports the proactive preservation of the embedded value of products and components at the highest level possible | Nußholz, 2017; Uusitalo & Antikainen, 2018; Whalen, 2019 |
| The value proposition is based on an assessment over time regarding the value created and delivered, destroyed or missed and opportunities to be captured in the future. | Pádua et al. 2018; Bocken et al., 2013; Geissdoerfer, Bocken, & Hultink, 2016 |
| The value proposition includes of a lifecycle-thinking approach meaning that the value proposition and identified opportunities address the beginning, middle and end of the lifecycle. | Manninen et al., 2018; Pádua et al., 2018 |
| The value proposition balances the needs from a triple-bottom-line perspective and ensures societal well-being. | Baldassarre et al., 2017; Boons & Lüdeke-Freund, 2013; Evans et al., 2017; Geissdoerfer et al., 2018; Pádua et al., 2018 |
| The value proposition internalises externalities. | Evans et al., 2017; Geissdoerfer et al., 2018; Pádua et al., 2018 |
| The value proposition adds extra value or benefits in comparison to market competition | Lewandowski, 2016; Pádua et al., 2018 |
| The value proposition aims for radical innovation. | Pádua et al. 2018; Rohrbeck, Konnertz, & Knab, 2013. |
| The value proposition integrates multi-disciplinary knowledge. | Pádua et al. 2018 |

*Source: By author*

There are existing tools for developing and testing value propositions in conventional business models (Bocken et al., 2013). One of the most widely used is the value proposition canvas, which maps out the fit between the value proposition and the customer segments by outlining each customer segments perception of the jobs-to-be-done, including negative aspects and gains (Alex Osterwalder, Pigneur, Bernada, & Smith, 2014). However, few tools exist for supporting the process of developing value propositions in SBM or CBMs (Bocken et al., 2013), despite how recent contributions in the field have sought to bridge this gap.

In the SBMI literature, Bocken et al., (2013) developed a value mapping tool for sustainable business modelling to support the creation of a value proposition based on qualitative value analysis. The tool sought to provide an understanding of the positive and negative aspects which the value proposition created for the stakeholder network, highlight conflicting values between stakeholders, and identify opportunities for re-designing the business model. It allows for initial identification of stakeholder's needs as a first step of the process of re-designing or formulating the value proposition. Geissdoerfer, Bocken, & Hultink (2016) further developed a workshop framework based on the value mapping tool and design-thinking and found how the integration of the practices was suitable for sustainable business modelling. Moving one step further, Baldassarre, Calabretta, Bocken, & Jaskiewicz (2017) defines a process for sustainable value proposition design which supports the formulation of a final value proposition through several iterations, building upon previous contributions within the fields of SBMs, user-driven innovation and design thinking. User-driven innovation refers to processes for identification of business opportunities by the active involvement of stakeholder groups, e.g. customers or end-users (Baldwin & von Hippel, 2011). Design thinking is an approach within the field of user-driven innovation, which puts the values, concerns and interests of users at the centre of the design process. It is iterative by nature and seeks to rapidly develop and test a variety of solutions to identify the optimal one (Brown, 2008). The process developed by Baldassare et al. (2017) was found suitable to address the energy efficiency challenge, which was the main focus of the case study. However, the scholars call for research to validate the suitability of the process in other cases, as innovations to overcome other sustainability challenges may clash with contrasting interests of stakeholders, or a resistance to change, which was not experienced in the case at hand (Baldassarre et al., 2017).

## 2.4 Conceptualising customer value in the building construction industry: A framework

Customer value is central in any business model and is commonly understood as the difference between the benefits and sacrifices incurred by the customer from a product or service (Bounds, 1994). Dlouhy, Wans, & Haghsheno (2018) describes how customer value is not equal to the ethical values, requirements or goals of the customer but should instead be understood as "*the sum of the attributes and consequences which the customer has evaluated as useful for achieving his or her goals*" (Dlouhy et al., 2018, p. 204). Hence, it is the attributes of the service or product offering that generate customer value. According to Schenkel et al. (2019) superior customer value is generated by increasing customer satisfaction, which can be achieved through the improvement of the *customer service*, the *customer offerings* or the *corporate image* of the customer. While limited previous research has conceptualised customer value in the context of the building construction industry and CE strategies, certain dimensions of customer value can be identified in previous contributions in the areas of CBMs (Lieder et al., 2018; Schenkel, Krikke, Caniëls, & der Laan, 2015); SBMs (Witjes & Lozano, 2016); and lean management and green buildings (Anker, Voordt, Insight, & Voordt, 2015; Leaman, Thomas, & Vandenberg, 2007; Leidy Klotz and Mark Bodenschatz, 2007; Thomson et al, 2006; Zaeri, Rotimi, & Owolabi, 2016).

First, financial value is likely to constitute a main driver of customer value as economic sustainability is a prerequisite to any business model (Schaltegger et al., 2012). Superior profitability for companies within the construction sector derives either from setting a higher price, i.e. being able to charge a premium, or having lower costs, than the competitors (Leidy Klotz and Mark Bodenschatz, 2007; Ngowi, 2001; Schenkel et al., 2015; Witjes & Lozano, 2016). Beyond opportunities for cost reduction and additional revenue generation, Schenkel et al. (2015), add risk reduction as an important financial value. In practice, these dimensions may include low cost per square meter, reduced lead times and material costs, and provision of quality assurance (Azcarate-aguerre et al., 2018; Debacker & Manshoven, 2016). It has been suggested that developers and investors tend to prioritise a reduction in the initial investment cost rather than the total lifecycle cost of a building, despite how savings in the initial investment may increase costs acquired throughout the lifecycle (Debacker & Manshoven, 2016; Azcarate-aguerre et al. 2018). This may, however, depend on the nature of the investor or developer's business model. For speculative clients, short-term financial value seem to be prioritised over strategies which secure a higher financial value of components or raw materials at end-of-life, if it does increase sales value (Debacker & Manshoven, 2016). Mokhlesian & Holmén (2012) describes how end-users tend to be reluctant to pay for public environmental benefits, resulting in a lack of financial incentives for developers, investors and contractors to improve the environmental performance beyond compliance. However, developers who retain ownership of the building may be more inclined to recognise other financial values, including residual value, return on investment and life cycle cost (Azcarate-aguerre et al., 2018).

Secondly, value creation for the end-user may constitute an important dimension of customer value as it is likely to influence the developer or investors ability to fulfil their respective client's needs, especially in cases where the organizational performance is affected by the building (Azcarate-aguerre et al., 2018). Preiser & Vischer, (2005) suggests that the end-user's perception of the value of a building is tied to its functional and technical solutions. Aspects such as convenience, functionality, design, and contribution to wellbeing have also been found to determine value creation for end-users (Bocken et al., 2013; Leidy Klotz and Mark Bodenschatz, 2007; Schenkel et al., 2015). However, there are challenges to understanding customer value from the perspective of the end-user in the building construction sector. These include the limited access to future property users in the construction phases and the long-life cycle of buildings, which makes it likely that end-users will change over time (Debacker & Manshoven, 2016). Arguably, this may hinder developers or investor to properly take the end-users needs into account.

Thirdly, improvement of competitive advantage has been identified as an essential source of customer value (Schenkel et al., 2015). In the literature on green construction, it has been suggested that the adoption of green construction methods or business models may improve stakeholder relations and brand reputation, provide innovation opportunities, and increase productivity, which all can be related to improvement of competitive advantage (Abuzeinab & Arif, 2013; Mokhlesian & Holmén, 2012). ING (2019) further suggests how embracing circular strategies may enhance brand equity by making companies perceive as innovative and sustainable, lead to customer loyalty, and generate opportunities for diversifying the revenue stream of the company through the employment of service models.

Fourthly, recent contributions in the business model literature, such as Porter & Kramer's (2011) idea of shared value, emphasise the need for companies to move beyond the traditional focus on financial value. Rather than focus solely on how to create economic value, companies should actively contribute to the creation of social value and letting societal needs define the market (Porter & Kramer, 2011). Hence, the environmental and social value may both constitute dimensions of customer value (Leidy Klotz and Mark Bodenschatz, 2007; Schenkel et al., 2015; Witjes & Lozano, 2016). Increasing resource and energy efficiency, reducing embodied carbon, lowering emissions and noise, and mitigating resource depletion are all topics discussed in the area of sustainable construction (Kyrö et al., 2019; Surgenor et al., 2018). However, the discussion on social value creation is limited in the construction literature. In grey literature on CE, improved local employment opportunities are often discussed as the primary social benefit arising from the implementation of CBMs (The Ellen MacArthur Foundation, 2015).

Finally, Schenkel et al. (2015) also add informational value as a value dimension in CBMs as the information itself may enhance the creation of other types of values. Arguably, informational value is relevant in the context of the construction sector, as strategies which improve information flows have been found to support reuse or recycling activities (BAMB, 2016; Heinrich & Lang, 2019)

Building upon previous contribution, customer value is divided into six categories: (1) financial value; (2) user value; (3) environmental value; (4) social value; (5) value from competitive advantage and (6) informational value (see Figure 2-3). These aspects may be derived either from improvements of the (i) customer service, (ii) customer offering or (iii) the corporate image of the customer. It should be noted that the overlaps between categories may occur, e.g. as improvement of competitive advantage is derived from a circumstance which puts a company in a favourable position, which may be tied to, e.g. the environmental or financial value received. This may also occur for other categories such as environmental value, where e.g. improvement of energy efficiency may provide both financial and environmental value for the customer. Hence, this will be taken into account during the analysis. Furthermore, social value is included in the conceptual framework, despite how Geissdoerfer et al., (2017) suggests that environmental and economic value is prioritised over social value in the emerging literature CBMs. Still, the environmental- and social value represents the cornerstones of the SBM literature and the need for recognising the social value in CBMs has been emphasised by scholars (Oghazi & Mostaghel, 2018).

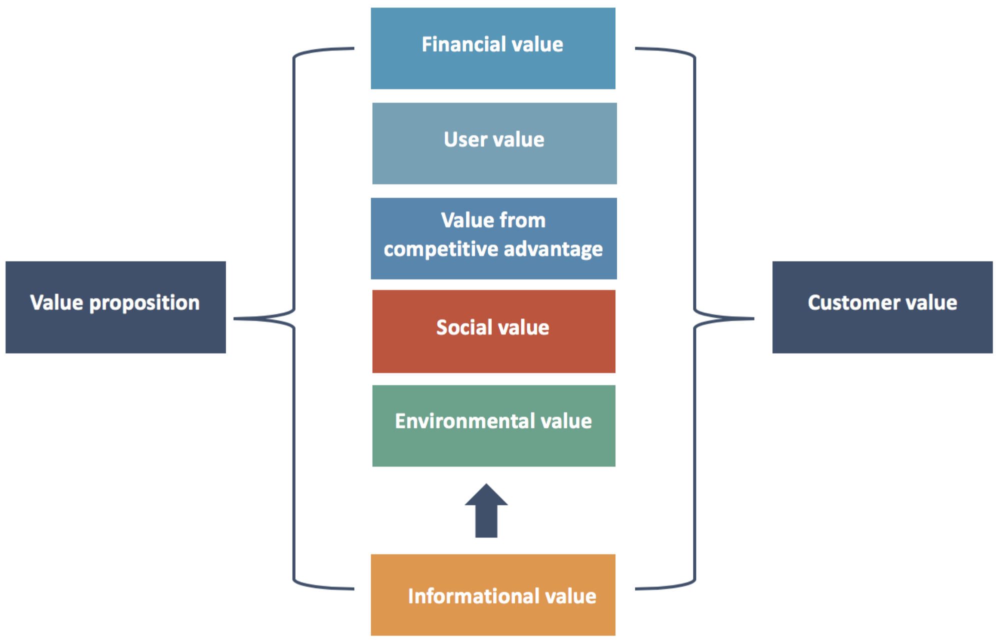


*Figure 2-3. Overview of value categories*

*Source: Developed by the author based on conceptualisation of value categories*

## 2.5 Summary and research gap

The literature review reveals that the topic of CBMs in the context of the building construction sector remains relatively unexplored, although prior research has been conducted in related fields such as green construction and resource-efficient building management. Emerging literature offers a translation of CE principles into circular strategies for the building construction sector and investigates enabling and hindering factors in the transition toward a circular building construction industry. The review suggests that there are several features of the building construction industry, which poses challenges to CBM adoption, such as the complexity and fragmentation of the value chain and the long lifecycles of buildings. In itself, such features provide a compelling case for investigating opportunities for value creation by circular strategies further. The literature review further indicates a lack of studies focusing explicitly on the customer value and the opportunities for firms associated with value proposition re-design in line with CE principles. Concurrently, customer acceptance of new value propositions has been considered fundamental for succeeding with CBM implementation. In the construction sector, the influence of the client (i.e. developer or investor) on the processes and products used has further been asserted. Hence, understanding the dimensions for customer value in the building construction industry, as well as its implication on the opportunity for value creation through adoption of circular strategies by manufacturers in the building construction industry, can potentially bridge this knowledge gap and provide valuable insights to practitioners in the industry and scholars concerning the opportunities and barriers for value creation among customers and stakeholders.

The literature further reveals that although a variety of CBMI tools and approaches has been developed to support companies in embedding circular strategies in their business model, few of them have focused explicitly on the value proposition. Nonetheless, it is suggested that a BMI process should start with the overall purpose of the company and the value proposition, which makes tools and approaches which supports re-definition of value propositions in line with circular principles of interest for practitioners seeking to approach CE implementation. Previous contributions have developed criteria for ensuring that value propositions in CBMs and SBMs are in line with the expected delivery of sustainability outcomes. Among the suggested approaches for value proposition re-design in SBMs and CBMs is the value mapping tool by Bocken et al. (2014) and the process for sustainable value proposition design proposed by Baldassare et al. (2017). While the former allows for initial identification of stakeholder's need, the latter provides a complete process for the development of a final sustainable value proposition. The literature review indicates how the identified tools, approaches and criteria for SBMI and CBMI lacks comprehensive testing in practice which limits its empirical validity. Therefore, examining and validating the applicability of such in the context of CBMI in the building construction industry is arguably of both academic and practical relevance.

# 3 Methodology

This chapter explains the methodology of the thesis to provide transparency with regards to how knowledge was produced and to enable replicability of the research process (Walliman, 2006; Yin 2009). It introduces the single case study design, the case company, the research approach, the methods for data collection and analysis, discusses the scope and limitation of this study, and finally provides a reflection concerning ethical considerations associated with the research.

## 3.1 Single case study

This thesis employs a single case study design to explore potential re-design of the value propositions of a manufacturing company within the building industry. Single-case study approaches are suitable when the research focuses on an emerging topic (Gerring, 2004; Creswell, 2014) as it allows for in-depth research and contextualised descriptions, in contrast to multiple case studies which test or generalise theoretical constructs across cases (Eriksson & Kovalainen, 2011). Hence, it is commonly employed in situations where the researcher seeks to understand a real-life phenomenon in depth (Yin, 2009).

Several characteristics of single case-study design make it suitable for fulfilling the objective of this research. Firstly, the nascent state of the art of the topic of CBM in the building industry and the limited investigation of the customer- and stakeholder perception on value creation of CBMs in existing literature (Uusitalo & Antikainen, 2018), make a single case study suitable to gain in-depth, explorative research endeavours. Secondly, a single case study responds to the need for applied research and case studies to provide examples of how companies may innovative their business models in line with circular principles which has been asserted by scholars (Bocken & Antikainen, 2018; Zucchella & Previtali, 2019; Hart et al. 2019). Thirdly, the real-life setting, which provides a nuanced view of reality and thus reflects the context of which actors operate in (Flyvbjerg, 2006), is considered both crucial to explore how the value proposition of the case company can be re-designed to help implement and capitalise on CE practices, and challenging to obtain through other methods of inquiry (Yin, 2009). Fourthly, as the target audience of this thesis are researchers and practitioners operating within the field of building construction or circular economy, a single case study is deemed suitable to generate context-dependent knowledge on the topic (Flyvbjerg, 2006). Lastly, the suitability of a single case study design is further demonstrated by its adoption in related studies which investigates value proposition re-design and business model innovation (see, e.g. Baldassarre et al. 2017, and Bocken et al., 2013).

### 3.1.1 Case description

This section introduces the case by providing a brief description of the case company's current offer and business model and a justification for the case selection.

The case selected for this thesis is a company operating within the building construction industry as a provider of prefabricated building envelopes (the exterior of the building) and single façade elements. An overview of the main building blocks of the company's current business model is provided in Table 3-1. The company is specialised in mid- and tall- rise buildings for residential and non-residential use and offers a holistic construction concept with the delivery of the building envelope or single elements. The company is positioned in the early lifecycle stages of the building; including the (i) design and (ii) the construction of the building. In the design-phase, a building construction project is often coordinated by the architect or the design team and the traditional material supplier has a critical role in providing the information necessary for the development of the building design. In the construction phase, the responsibility usually shifts to a contractor or sub-contractor (Debacker & Manshoven, 2016) and the role of the material supplier is centred around the development, manufacturing and delivery of building materials and products (Debacker & Manshoven, 2016). As the offering of the case company is based on the provision of a construction concept, the company strives for early involvement in the planning- and design phase of new developments.

The product offered by the company is customised to the specific construction project with limited standardisation of components. The company manufactures the building structure and façade elements mainly in concrete, although finishing consists of a variety of materials including bricks, stone, wood or aluminium. To reduce the construction time and increase control over the construction processes, the company leverages manufacturing methods such as prefabrication. By manufacturing most of the building components off-site, the company can deliver customer assurance of the water- and wind tightness of the building envelope.

The case company's stakeholders can be categorised into two groups: primary and secondary stakeholders. According to Clarkson (1995), the primary stakeholder group includes the actors which focal company create value for (customers) and with (suppliers), whereas the secondary stakeholder group include the actors who are affected or influenced by the value created. The primary customers of the case company at hand include developers, investors and contractor. The delivery of the building system is further dependent upon functioning collaboration with other actors in the value chain, i.e. secondary stakeholders. For example, the architects appointed to manage the design phase of the building and the contractors responsible for the execution of the construction phase.

*Table 3-1. Overview of the current business model of the case company*

| Value proposition | Value creation and delivery | Value capture |
|---|---|---|
| • High aesthetical quality<br>• Cost management<br>• Reduced construction time<br>• Predictability of functioning of the component.<br>• Reduced transports to- and on-site. | • High customisation<br>• Prefabricated building structures and façade elements<br>• Off-site production<br>• Customer guarantee of wind- and water tightness<br>• Engineering and installation expertise | • Sale of complete building structures<br>• Sale of loose elements<br>• Costs (e.g. sourcing of raw materials, operations, transportation and construction). |

*Source: By author*

The rationale for selecting the case at hand is its representation of a typical case in the building construction industry (Yin, 2009). The case company offers products (prefabricated building systems and separate components), which are offered by a variety of companies in the industry. Investigating the potential for additional value creation through implementation of CE strategies is thus of interest not only for the case company per se but also for other actors in the industry. That being said, this study does not make any claim for generalizability, which is further discussed in section 3.5.

## 3.2 Business model innovation process: thinking, talking, testing

This section introduces the research approach and provides an overview of the BMI process used in this thesis.

In this thesis, an explorative research approach is employed to answer the main research question of this study, i.e. investigate how a large manufacturing company in the building construction industry can create superior customer value by re-defining its value proposition in line with circular economy principles. An explorative research approach is iterative by nature, which provides the researcher with a high degree of flexibility in terms of research design and data collection, suitable for investigation of emerging topics (Streb, 2012). The rationale for selecting an explorative research approach is based on the emergent state of the topic and the high flexibility which is well-aligned with the approaches formulated in the BMI literature. In specific, the research approach employed in this study builds upon the BMI process for supporting organisations in the development of sustainable value propositions developed by Baldassarre, Calabretta, Bocken, & Jaskiewicz (2017) in the field of SBMI. The value propositions are developed through a process consisting of three steps: (i) *thinking*, (ii) *talking* and (iii) *testing* (see Figure 3-1). In this section, a brief overview of the three steps is provided, whereas a more in-depth explanation of the specific activities that were part of the research steps are provided in the following sections.

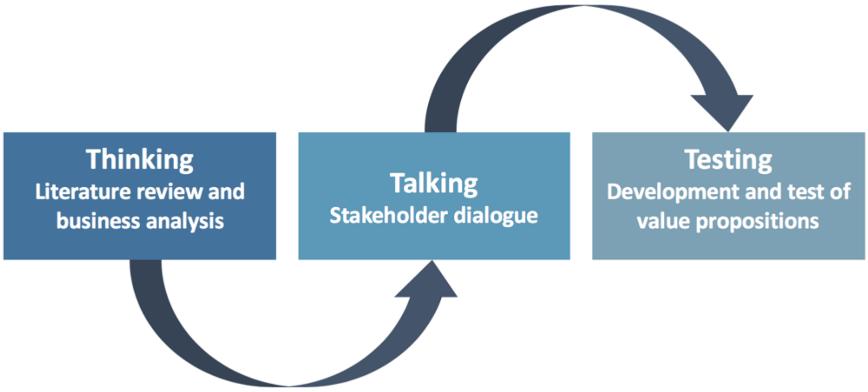


*Figure 3-1. Overview of the process for value proposition re-design*

*Source: Developed by the author based on Baldassare et al. (2017).*

In the *thinking* phase, a literature review and business analysis are conducted. The objective of this phase is to (i) create an initial understanding of customer value in the building construction industry and (ii) identify a selection of circular strategies relevant for the case company. The findings of this phase further inform the development of the questionnaires in the *talking* phase.

In the *talking* phase, communication with stakeholders is conducted to attain their perspective on (i) the potential for value creation by circular strategies (ii) the type of value prioritised when selecting products similar to the product offered by the case company and (iii) the challenges and demands from stakeholders experienced by actors in the building value chain. While practices such as co-creation workshops are standard in user-driven innovation to ensure that the stakeholders' needs are addressed (Schneider & Stickdorn, 2011), the timing of this thesis and the geographical distance between stakeholders did such practices challenging to purse within the scope of this thesis. Instead, data collection methods include semi-structured interviews and an assessment questionnaire.

In the *testing* phase, the value propositions are developed based on the data collected in the *thinking* and *talking* phases. The value propositions are tested in a user-driven process and by comparing their alignment with the criteria for developing sustainable value propositions in CBMs outlined in Table 2-3 in section 2.3. In this phase, stakeholders are provided with a description of the value propositions and an assessment questionnaire. While a broader stakeholder group was sought in the initial interviews, the value propositions are only sent out to the interviewees categorised as primary stakeholders (eight respondents). In the process defined by Baldassare et al. (2017), a minimum viable product (MVP) was built to develop the value proposition toward an improved problem-solution fit. The problem-solution fit represents the alignment between the customer's expectations from the solution based on their needs, and what the product or service actually delivers (Romero & Molina, 2016). However, developing an MVP is considered unfeasible due to the nature of the product offered by the case company and the limited time available. In line with the purpose of this study, the end-goal of the process is not to have developed a final value proposition tested in practice, but rather to explore the opportunities for adding value by the implementation of circular strategies. A more detailed overview of the methods deployed in the various steps for data collection and analysis is provided in the following sections.

## 3.3 Methods of data collection

This section presents the data collection methods employed, which includes a literature review, semi-structured interviews and an assessment questionnaire handed out to the primary stakeholders identified in this study. Multiple sources of evidence were gathered to construct internal validity (Yin, 2009). Hence, a rich set of data is achieved by combining multiple data collection methods and involving stakeholders in different phases of the research process.

### 3.3.1 Literature review

As the first step of data collection, a literature review was conducted to summarise previous research on the topic at hand. It was also used to identify a process for value proposition re-design, conceptualise the concept of customer value in the building construction industry, and to fulfil objective one of this study: to outline the type strategies which can be used to close, slow or narrow resource loops within the building sector. This process followed five steps: (1) identification of key search words; (2) searching; (3) location of relevant literature; (4) drafting of summaries of the most relevant articles; (5) and "snowballing" of additional articles of relevance based on previous findings. This process was iterated until theoretical saturation was reached.

The key search words included "circular economy" AND "construction industry" OR "building sector" OR "business model"; "business model innovation" AND "resource efficiency" AND "construction industry" OR "building sector" AND "experimentation" OR "building sector" OR "construction industry" OR "Circular economy" OR "sustainability"; "value proposition" AND "circular economy" OR "sustainable business model" OR "circular business model"; and finally "customer value" AND "building sector" OR "construction industry" OR "Circular economy".

The literature was selected based on its relevance to the four objectives of this study. As the CBM literature is still emerging, especially in the context of the building construction industry, no criteria related to geography, design of studies or year produced were applied. To get insights from the latest development in the field as well as to ensure academic rigors of the literature review, the selected sample included both academic articles and grey literature including conference papers from academic institutions and publications from organisations in the field of Circular Economy and the built environment, e.g. the Ellen MacArthur Foundation and Arup.

### 3.3.2 Semi-structured interviews

In the second step of data collection, sixteen semi-structured interviews were conducted. Semi-structured interviews as data collection method were found appropriate as it captures the story behind the stakeholder's experiences, provides in-depth information about the topic and is useful when the participants cannot be directly observed. It further allows for the flexibility needed to capture the attitudes of the interviewee while still providing a structure to the conversation (Creswell, 2014).

#### *Sampling process*

The sample of interviewees was identified in collaboration between the author of this thesis and a case company representative and via "snowballing", i.e. interviewees suggested other participants who could be of interest to interview for this study. The sample of interviewees was purposefully selected based on their ability to provide useful information to this study (Creswell, 2014), specifically concerning the customer value of different CE strategies.

The interviewees are categorised into two groups: primary stakeholders and secondary stakeholders. The data collected from both groups were given equal weight as the basis for the development of the re-designed value propositions. The interviewees in the primary stakeholder group represent actors who could potentially take the customer role in the interaction with the case company, i.e. investors, developers or contractors. However, it should be noted that not all of the primary stakeholders were current customers of the case company. The secondary stakeholder group consists of actors which are either involved in the building lifecycle, such as architectural firms, demolition firms, or consultants; or has a supporting role in the construction ecosystem, such as building network organisations, investment promotion organisations or business development organisations. Since the scope of this research includes both the Swedish and Danish market, a balance was sought between representatives from each of these geographical contexts in the extent possible.

The decision to interview both primary and secondary stakeholders was motivated by three consideration: First, the sustainable business model literature emphasises the need for considering value creation for a broader set of stakeholder groups than merely focusing on the customer (see for example Bocken, Short, Rana, & Evans (2013). Secondly, the long-life cycles of buildings make it essential to consider the effects of new value propositions on actors operating in different stages of the value chain although these may not inhibit the role as customers of the case company. Thirdly, these stakeholders provide a perspective on the building construction industry at large, which may not be attained by focusing merely on the primary stakeholders.

In section 4 of this thesis, interviewees will be referred to by a numerical pseudonym, such as "primary stakeholder 1" or "primary stakeholder 2". An overview of the interviewees, including the type of organisation, country of operation and position, is provided in Appendix A - Overview of interviewees.

#### *Execution- and documentation process*

Eight of the interviews were carried out in Swedish and eight in English. Hence, several quotes used in the "results and analysis" section of this thesis has been translated by the author. The interviewees were asked a combination of open- and close-ended questions, followed by probes which were either-open ended or specific to the participant's comment or existing theory (Hsieh & Shannon, 2005). To create internal validity, key concepts were explained to ensure that interviewees interpreted the meaning of concepts in the same manner. The interview guide was developed based on the findings of the thinking phase, i.e. the results from the literature review and business analysis. In-line with an exploratory approach, the interview guide was slightly adapt based on knowledge generated and the parties interviewed. A consolidated version of the interview guide is found in

Appendix B - Sample interview guide.

The interviews were executed face-to-face, via online meetings or telephone, depending on the location and availability of the interviewee. All interviews were transcribed by the researcher manually to reduce bias and to allow for thematic content analysis (Walliman, 2006). Several conversational interactions were held with two employees at the case company selected for this study to attain information about the company and the current business model. These interactions were documented by note-taking.

### 3.3.3 Assessment questionnaire

An assessment questionnaire was used as part of both the *talking* and *testing* phase of this study. As part of the *talking* phase, the objective of the questionnaire was to validate the relevance of the different factors driving customer value identified in the semi-structured interviews, through method triangulation. As part of the *testing* phase, the questionnaire was used to test the developed value propositions on respondents in the primary stakeholder group.

To achieve the first aim, a table was provided to the respondent with different offering characteristics relevant to the product in question (façade elements). The respondents were then asked to rank the importance of different offering characteristics where 0 = not relevant; 1 = could be considered; 2 = important yet not decisive; 3 = crucial. The characteristics were selected based on the findings from the semi-structured interviews.

To achieve the second aim, the four developed value propositions were described in a PowerPoint presentation sent to the respondents. Each respondent was asked about their reaction to the suggested value proposition by filling in three alternatives (1 = it could be a viable solution; 2 = I do not think it could be a viable solution; 3 = I do not know). The option to motivate the answer was provided to achieve a better understanding of the respondent's answer.

It should be noted that in both instances, the questionnaire was directed only toward the primary stakeholders interviewed for this study (eight respondents), i.e. the sample cannot be considered representative of the total population per se. The response rate was further low, with three respondents submitting the questionnaire as part of the talking phase and four respondents submitting the questionnaire as part of the testing phase. Response bias, i.e. whether the responses from non-respondents would have changed the results significantly (Creswell, 2014), was not accounted for. Hence, this strictly limits the generalisability of the results.

## 3.4 Methods of data analysis

This section presents the methods for data analysis employed, which includes a PESTEL analysis and a content analysis. By triangulating the data from interviews with public documents and grey literature, disadvantages inherent to each of the data collection methods are mitigated. Whereas the collected interview data and data from the assessment questionnaire are unavoidably influenced by the perspective of the interviewee (Creswell, 2014), the business analysis provides a broader picture of the business environment in which they operate.

### 3.4.1 PESTEL analysis

The business environment of the case company is analysed through a PESTEL analysis of the Swedish and Danish building construction industry. The analysis built upon (i) a review of public documents and grey literature; and (ii) follow up on themes or trends mentioned by interviewees. The collected data were categorised according to the themes in a PESTEL analysis, which includes political, economic, social, technological, environmental and social factors.

### 3.4.2 Directed content analysis

A conventional content analysis was conducted to fulfil task three and four of this study. The approach followed three main steps: (i) transcription of interviews; (ii) read-through of all the data to get a sense of the whole; and (iii) coding (Creswell, 2014). As a directed content analysis as conducted, the data was coded using the conceptual framework of customer value presented in section 2.4**.**

The approach was found suitable as it enables a more focused interview process and gives predictions about variables of interest. The coding process was conducted for all interviews, after which the information was clustered into themes based on the conceptual framework (Hsieh & Shannon, 2005). The result was compared with existing theory and used to inform the process of value proposition re-design.

A limitation of using directed content analysis lies in the use of existing theory to pre-determine categories, which may enforce bias (Hsieh & Shannon, 2005). To reduce the risk of bias, the researcher sought to use probes relating to existing theory only to clarify and enrich the respondents answer in some instances (e.g. when asking about what benefits were considered necessary, probing was used if no clear answer was provided to assess whether factors defined in the conceptual framework were considered). Also, the use of new or alternative codes was considered during the coding process to ensure the analysis reflected the collected data.

## 3.5 Scope and limitations

The focus of this study is limited to the value proposition, one of three blocks of the business model, as proposed by Richardson (2008). Hence, assumptions are tested on a separate block of the business model and impacts on other business model elements are not considered. A drawback of this approach is that large scale experiments or tests of the re-defined value propositions are necessary before scale up (Bocken et al., 2018). Nonetheless, the scope is considered reasonable, as full-scale BMI processes have been found to exceed two to three years (Chesbrough, 2007), whereas the time frame of this study is limited.

A limitation of this study lies in the exploration of the potential opportunities for added value creation by the implementation of circular strategies and stakeholder's perception of the benefits it may provide. Hence, the ability of the circular strategies to deliver the promised benefit is not verified. This seems reasonable considering that (i) the scope is focused merely on the value proposition and (ii) CBM implementation in the building construction industry remains limited, which makes it difficult to assess the functioning of all circular strategies in practice. However, the limited implementation of CBM in practice implies that stakeholders' perceptions on the benefits and disadvantages of circular strategies may not reflect their functioning in practice propositions. Still, as customers' acceptance of new value propositions is central in CBM implementation (Abuzeinab & Arif, 2013; Azcarate-aguerre et al. 2018; Lieder et al. 2018), investigating their perspective is of both practical and academic interest.

By design, the scope of this study is limited to the investigation of one company. This has implications for the generalisability of the findings, as it is often claimed that one cannot generalise based on a single case (Walliman, 2006). However, Flyvbjerg (2006) suggests that *"formal generalisation is overvalued as a source of scientific development, whereas "the force of example" is underestimated"* (Flyvbjerg, 2006, p. 228). In the case of CBMs and SBMs, it has been argued that a lack of case studies makes it difficult for firms to understand how to identify, develop, and assess alternative business models (Evans et al., 2017). Hence, it is inferred that the "force of example" is of high relevance to the topic of this study. Therefore, this study makes no claim on generalizability.

## 3.6 Ethical considerations

This research was carried out in collaboration with the manufacturing company used as a case in this study. However, no financial reimbursement was provided for the execution of this study. The role of the company was mainly to provide information concerning their current business model. Hence, the conduct of this research and the findings has not been influenced by the company or its representatives.

The primary ethical considerations in this study concern the process of data collection and analysis of interview data. Hence, a policy of prior informed consent was applied. All individuals approached in this study was informed about the purpose of the study, the nature of the collaboration with the case company, and the planned use of the information obtained. During all interviews, audio recordings were commenced only with the consent of the interviewee. The interviewees were also informed in advance that participation was voluntary and that they were not obliged to answer any of the questions posed. If any of the interviewees indicated that they did not want their answers to be recorded, this information was deleted from the script. All of the interviewees were kept anonymous and given a pseudonym as described in section 3.4.2, to preserve the confidentiality of the individuals who participated in this study.

# 4 Analysis

In this section, the data and insights that informed the development of the final value propositions are presented. This includes results and analysis of the (i) *talking* (ii) *thinking* and *(iii) testing* phases of the value proposition development process.

## 4.1 Thinking phase: PESTEL analysis

In this section, a summary of the business analysis conducted as part of the *thinking* phase is presented. More specifically, the analysis of the key external factors affecting the design- and construction of buildings in Sweden and Denmark are summarised. It should be noted that the purpose of the analysis is to provide a brief overview of the current- and future direction of the building construction industry. Thus, it does not aim to provide a full description of the state of the industry per se. The analysis is conducted using the PESTEL framework, which outlines political, economic, social, technological, environmental and legal factors. The complete analysis is provided in Appendix C - PESTEL analysis.

### 4.1.1 Political trends

The political trends in this analysis indicate that a significant focus is placed on (i) increasing the environmental performance of the construction sector and (ii) improving the competition in the construction sector. On an EU level, the Strategy for the Sustainable Competitiveness of the Construction Sector and its Enterprises communicated by the European Commission in 2012 seeks to stimulate businesses in the construction sector and increase competition. The strategy outlines both short- and long-term measures to boost resource efficiency and environmental performance, improve the human-capital basis, and create business opportunities and favourable investment conditions (COM(2012)433). In Sweden, initiatives to support increased standardisation and resource efficiency of construction materials has been suggested to improve competition on the market.

Further initiatives are emerging on both EU and national level, which suggests that energy efficiency will continue to constitute a political priority, although accompanied by increasing political efforts to increase resource efficiency and reduce the climate impact of the building construction industry. On an EU level, the built environment and the construction sector constitutes prioritised areas in the initiative Closing the loop - European Action Plan for Circular Economy (COM(2015)614) which presents the action plan for how EU shall realise the vision of a transition to a circular economy, and the Roadmap to a Resource-Efficient Europe communicated by the European Commission in 2011 (COM(2011)571) which sets out the vision for an EU economy developed with respect for resource constraints and within the limits of the planetary boundaries. In both communications, the importance of decisions in the planning and design phase is emphasised, as the choice of construction materials to a great extent determine the resource use in buildings. Measures to stimulate design improvements to reduce the environmental impacts of buildings and support life-extension through design for durability and recyclability of components is further suggested. To support the implementation of CE strategies and improve the sustainability performance of buildings, the European Commission introduced the voluntary reporting framework Level(s) in 2017. The framework integrates existing standards to provide a common approach to assessing environmental performance in the built environment in the EU. It seeks to support lifecycle thinking as well as progress toward the sustainability issues prioritised on an EU level (European Union, 2017).

Initiatives to support the improvement of the sustainability performance of buildings has been undertaken in both Sweden and Denmark. In Sweden, the climate impact of buildings has gained increasing attention, and current proposals emphasise the need for developing guidelines for life cycle assessments of buildings and increasing the emphasis on reducing greenhouse gas emissions of buildings in procurement. Alternative policy instruments to further stimulate emissions reductions have also been suggested, including investment support to developers (The national board of Housing Planning and Building, 2018:5). A focus on climate neutrality also dominates the political agenda of the construction industry. In 2015, the initiative fossil-free Sweden was initiated by the Swedish Government to accelerate the country's transition toward a fossil-free nation. The initiative seeks to provide a platform for actors in the industry to take action to reduce fossil fuel use (Fossil Free Sweden & The Concrete Initiative, 2018). Following the government initiative, roadmaps for achieving climate neutrality by 2045 on a sectoral level have been developed by both the building construction industry and the concrete industry (Fossil Free Sweden, 2018a). On a local level, actors within the building- and construction industry have developed their roadmap for achieving a climate-neutral building- and construction industry in the city of Malmö by 2030, reducing the time for goal fulfilment significantly. Current estimations suggest how current technology might support a reduction of the climate impact of the sector by 50 per cent by 2030. However, to reach climate neutrality, there is a need for new technologies and commercialisation of innovations. To support this development, increased cooperation, supporting policies, efficient-use of bio-based resources, public procurement, and the adoption of a lifecycle perspective in the built environment is advocated. The potential of circular strategies to reduce the negative climate impact and contribute to cost reductions by minimising waste and increasing resource efficiency is further stressed (Fossil Free Sweden, 2018a; LFM30, 2019).

In Denmark, it is expected that the newly elected government will raise the country's climate targets by promising a new political direction based on an ambitious climate manifesto (Farand, 2019). Initiatives to support the improvement of the sustainability performance of buildings have also been taken on a local level, e.g. by developing environmental criteria for public procurement of building and construction projects which includes resource efficiency, recycling and the reuse of material and stipulates the need for lifecycle assessment of materials (Alhola, Salmenperä, Ryding, & Busch, 2017). Sustainable construction is further pointed out by the Danish government as a Danish stronghold where the CE offers the potential for further expansion. The national strategy for a circular economy realised in 2018 describes several initiatives which are likely to impact the construction industry. These include, among others, the development of a voluntary sustainability class, propagating selective demolition and an increased focus on the total cost of ownership in public procurement (Ministry of Environment and Food & Ministry of Industry, Business and Financial Affairs, 2018).

### 4.1.2 Economic trends

Material prices in the European construction market seem to be in a rising trend. In 2013, residential demand seemed to push up material prices in the EU (Kylili & Fokaides, 2017), which has put pressure on the margins in the European construction market (Deloitte, 2018). Kylili & Fokaides (2017) suggest that this development may push the industry toward adopting alternative production methods in the manufacturing process of building materials to cut production costs, which may potentially benefit the use of more sustainable construction materials.

On the European market, Debacker & Manshoven (2016) points to an increase in building vacancies due to an un-match between the building stock and the market demand, which results in loss of real estate value. At the same time, the scholars also suggest that it is becoming increasingly common to demolish modern and post-modern buildings before they have reached their technical and functional service life of 50 to 75 years, motivated by the need for space for new construction which more effectively meets the requirement of the end-user. The financial implication of the current development is that the return on investment is becoming shorter (Debacker & Manshoven, 2016) with the perceived risk on investment based on a shorter time frame than the technical lifetime of the building (Guldager Jensen et al., 2019).

In Sweden, total building investment is set to decrease between 2018 and 2020 due to a decline in the new production of housing developments, although an expected increase in non-residential construction somewhat mitigates the trend. In Denmark, residential construction is expected to reach its peak in 2019 with a decrease in dwellings expected in 2020, whereas non-residential building investments are expected to continue to grow in 2020. In both countries, construction costs have increased since 2010, mainly driven by a significant increase in labour and material prices (The National Board of Housing Planning and Building, 2018c; European Construction Sector Observatory, 2018a). In Denmark, limited access to labour have constrained production, and access to skilled labour is likely to constitute a considerable challenge during the forthcoming years (European Construction Sector Observatory, 2018a).

Low labour-productivity growth in the construction sector is a global phenomenon (McKinsey Global Institute, 2017), also experienced in the Swedish (The National Board of Housing Planning and Building, 2018c) and Danish market (The Danish Construction Association, 2019). Both markets are also facing limited competition, which lowers investments in the sector (The National Board of Housing Planning and Building, 2018c).

### 4.1.3 Social trends

Demographic changes in both Sweden and Denmark are likely to increase the pressure on cities to develop housing and infrastructure for a growing population (Grunfelder, Rispling, & Norlé, 2018), suggesting that the need for new developments will be focused in cities. This is demonstrated by the city plans of both Stockholm and Copenhagen, where 100,000 new homes are to be built by 2030 in Stockholm (Stockholm stad, 2013) and 45,000 new homes are to be built by 2027 in Copenhagen (Københavns Kommune, 2015). From a client- and user perspective, increasing user demands on of flexibility of space, healthy interiors, and improved sustainability performance of buildings are likely to have to be addressed (Høibye & Sand, 2018). The interviewees in this study further suggested that they expect co-living how co-working solutions to rise in popularity (secondary stakeholder 2), which are considered likely to influence how buildings are designed and managed (primary stakeholder 1-3; primary stakeholder 5).

The sharing economy has also gained popularity with scholars arguing that it may be particularly beneficial for activities with a high-emission intensity, such as housing (Kyrö et al., 2019). In a study by Kyrö et al. (2019) on the potential for relocatable buildings to deliver circularity, they found that users were positive toward leasing and reusing buildings, indicating a shift in the paradigm of ownership from owning to sharing.

An increase in demand for voluntary environmental certifications of buildings has been noticeable in both Sweden and Denmark (DK-GBC, 2019; Fossil Free Sweden, 2018a). While specific requirements in different environmental certification systems may reflect the national prioritises and local circumstances, the common denominators between different systems are defined by Krizmane, Slihte, & Borodinecs (2016) as (i) *ensuring environmental production*, (ii) *encourage resource efficiency*, (iii) *reduce energy consumption* and (iii) *promote innovation and ambition*. Whereas some argue that the growth in demand is due to an increase in environmental consciousness among the population (ByggNorden, 2019), others have pointed to how environmentally certified buildings may bring a competitive advantage and is used as a strategy for differentiation on the market (Szecsödy, 2016).

### 4.1.4 Technological trends

As for most sectors, digitalisation is expected to have a significant impact on the building construction industry (Circle Economy, 2015; Renz & Zafra, 2016) despite how the level of digitalisation so far remains low in comparison with other sectors (The National Board of Housing Planning and Building, 2018c). The organisation Circle Economy (2015) states that digitalisation has the potential to deliver increased access to information throughout the value chain of the building, which may support resource efficiency measures in the sector. An example is through Building Information Modelling (BIM) (Azhar, 2011), which supports virtual construction of buildings and provides information concerning the functional and physical characteristics of the building and improves the efficiency of the construction process. The use of BIM is relatively wide-spread in the building construction industry (Guglielmo & Nitesh, 2017), although the adoption rate varies between countries in the EU (McCormick, 2016). The opportunities associated with the adoption of BIM is commonly denounced as increased quality, strengthening of preventative maintenance and thus reduction of failure costs, and increased of life-cycle thinking (Circle Economy, 2015; Zupancic et al., 2018).

Complementary to BIM, the concept of material passports (also referred to as product passports or circularity passports) is starting to gain traction amongst both scholars and politicians. Material passports are digital datasets to store and provide information concerning the circular economy characteristics of building products, components and materials (BAMB, 2016). It has been suggested that existing solutions in this area tend to be limited to defined areas, such as providing information on, e.g. health impacts of materials and thus lack a holistic perspective (Heinrich & Lang, 2019). However, initiatives such as the Horizon-2020 funded project Buildings-as-material-banks (BAMB), aim to develop electronic material passports which can meet the requirements concerning the information needed to support the slowing and closing of resource loops within the building construction industry (BAMB, 2016).

With regards to the operation phase, there also seem to be a rapid increase in the number of IoT devices in buildings (Debacker & Manshoven, 2016; Guglielmo & Nitesh, 2017). Debacker & Manshoven (2016) suggest that we since the 1980s have gone through the development of automated buildings, to smart buildings and finally arrived at the age of cognitive buildings. While smart buildings mainly supported analysis of energy consumption, cognitive buildings can provide insights, learn behaviour and deploy changes to building operations (IBM Global Business Services, 2016). With more companies specialised in innovative technologies and services entering the building construction industry (Deloitte, 2018), the sector may be disrupted by innovation and digitisation in the area of technology.

With regards to the construction phase, the adoption of alternative design, manufacturing- and construction techniques is expected to increase during the forthcoming years (Renz & Zafra, 2016). Whereas relatively immature technologies such as 3D-printing could have a potentially disruptive impact on the building construction industry (Deloitte, 2018; Renz & Zafra, 2016; The Ellen MacArthur Foundation, 2015), whether it will reach economies of scale is still uncertain (Renz & Zafra, 2016). Other more wide-spread production- and design processes are, however, gaining momentum in the construction sector. These include standardisation, modular design and prefabrication, which are associated with higher construction efficiency, reduced project delivery time, lower costs and safer working environments (Deloitte, 2018).

Advanced building and finishing materials represent an area where solutions emerging from the industry are numerous (Deloitte, 2018; Renz & Zafra, 2016). It has been suggested how the increased sustainability of buildings will derive partly form the use of alternative, natural, unconventional and recycled building- and thermal insulation materials (Kylili & Fokaides, 2017). However, these often fail to achieve wide-spread acceptance due to several factors, such as lack of track record and information, and high initial investments (Renz & Zafra, 2016). One material in particular, which has received much attention in term of technological development is cementitious materials, potentially due to its large-scale use in the building construction industry combined with a high environmental impact in terms of $CO^2$emissions. Current solutions to reduce the $CO^2$emissions include substitution of cement for other inputs, use of admixtures, and using recycled concrete as aggregates. However, the quality of secondary aggregates varies, and the use of it tend to require additional cement to achieve the same strength as concrete based on virgin aggregates (Favier, De Wolf, Scrivener, & Habert, 2018; Sørensen, Bilberg Olesen, Ørskov Dall, Hartung, & N. Larsen, 2019). This may reduce the environmental benefits from using secondary aggregates, as the main $CO^2$ emissions derive from the cement production. However, progress in optimising the processing of secondary aggregates is underway, which may improve the suitability of secondary aggregates in the production of virgin concrete (Sørensen et al., 2019). On a structural level, the primary strategies for reducing the climate impact of concrete structures include optimising the structure to use less concrete by elements. Reuse of elements in their original form has also been tested, although it is far from common practice (Favier et al., 2018; Sørensen et al., 2019). The potential for reducing the embodied $CO^2$ through reuse is high, with the energy consumption deriving only from transportation. Limitations to achieving reuse at a larger scale are the availability of elements, need for materials to compensate for lack of connection between elements, and the risk of elements available today being outdated quicker than new alternatives. Thus, designing for flexibility will be essential to enable an increase in reuse of elements in the future (Favier et al., 2018).

### 4.1.5 Environmental trends

The construction sector has a significant impact on the environment through large-scale use of raw material; high energy use of raw materials; emission of greenhouse gases and particulates; transport-related pollution; and the secondary impact caused by noise, dust, waste and contamination. In both Sweden and Denmark, the environmental impact of construction has in some respects increased since 2010 (The National Board of Housing Planning and Building, 2019; Deloitte, 2014), which could be explained by an increase in building investments during this period. During the last 30 years, the climate impact from the use phase of buildings has been significantly lowered, which has resulted in increased attention being put on material and product choice (The National Board of Housing Planning and Building, 2018d). Currently, the climate impact from the building production phase (including manufacturing of building products and construction) and the use-phase is estimated by the National Board of Housing, Planning and Building to be on an equal level (The National Board of Housing Planning and Building, 2018d). In Denmark, the development is further characterised by a strong ambition to improve the up-cycling of materials and products for direct reuse (The Danish Government, 2015).

### 4.1.6 Legal trends

Legislation which refers solely to construction materials on an EU level considers the removal of technical barriers which may inhibit trading within the market (Regulation No 305/2011). This is mainly achieved through (i) the establishment of harmonised technical specifications of the assessment of the performance of construction products, and (ii) the use of a CE marking on construction materials, which is necessary to obtain in order to legally place the construction product on the market of the member states. Nevertheless, Kylili & Fokaides (2017) suggest that the requirements established by EU directives mainly determine the evolution of construction materials in the EU. In this respect, energy efficiency has received a high level of attention and continue being a prioritised issue (Herczeg et al., 2013). For example, the Energy Performance of Buildings Directive (EPBD) (Directive 2010/31/EU, 2010) has greatly influenced the design- and construction process of buildings by putting an enormous pressure on the industry (Debacker & Manshoven, 2016; Kylili & Fokaides, 2017), e.g. by stipulating that all new buildings must be nearly zero-energy buildings (NZEB) by 2020 (European Commission, n.d.-b).

Despite how the focus so far has been primarily dominated by efforts to improve energy efficiency, Debacker & Manshoven (2016) suggest that the emergence of new policies which seeks to promote resource efficiency within the construction sector is a signal that the development of regulations moving forward will have an increased focus on materials. So far, the Waste Framework Directive (2008/98/ec) stipulates that a minimum of 70 per cent of non-hazardous CDW by weight shall be prepared for reuse, recycling or material recovery by 2020. Construction- and demolition waste (CDW) has also been identified as a priority waste stream for increased reuse and recycling by the European Union, mainly due to its volume and the high residual value of specific components (European Commission, 2018a). In practice, the level of recycling and material recovery of CDW still varies significantly across member states (European Commission, 2018a) due to challenges related to identification, collection, separation and recovery of materials and components (European Commission, 2018b)

Legislative efforts have been made to improve the competition on the market in both Sweden and Denmark. In Sweden, the possibility for local governments to impose additional technical requirements on buildings beyond the national plan- and building regulations have been strictly limited since 2015 (Sveriges Kommuner och Landsting, 2014). In Denmark, changes in the building permit process have been made. This includes the introduction of a certification system which removes the responsibility of municipalities to control that the technical requirements of a building are fulfilled. Instead, the developer will have to involve certified counsellors in the construction process, which is expected to reduce differences in requirements between municipalities and increased predictability of the building permit process (The National Board of Housing Planning and Building, 2018c).

Legislative efforts have also been made to push the industry toward disclosing the environmental impact of construction. In Sweden, a proposal for the introduction of climate declaration was passed by the Swedish Government in June 2019 and is expected to be introduced the 1$^{st}$ of January 2022 (The Swedish Government Offices, 2019). The proposal outlines a minimum level of climate declaration for all new building, with certain exceptions, covering the product stage and the construction process stage (including raw material sourcing in the product stage, transport in the product phase, manufacturing in the product phase, transport and building- and installation (The national board of Housing Planning and Building, 2018:5).

## 4.2 Talking phase: Uncovering stakeholder perception of CE strategies

This section introduces the findings related to stakeholder perception of CE strategies, including the benefits and disadvantages associated with such. By doing so, it seeks to contribute to task four of this thesis, which is to identify the additional value that may be captured by revising the value proposition of the case company in accordance with circular economy principles. The findings are structured according to the categorisation of circular business models presented in section 2.2.2.

### 4.2.1 Circular design models

#### *Design for flexibility or adaptability*

Increased adaptability or flexibility of building elements was something that most interviewees could see a direct value of (primary stakeholder 1, 4, 5, 7; secondary stakeholder 1, 4, 8). The ability to adjust to changing demands was a direct benefit identified by developers operating in the rental housing market (primary stakeholder 1, 3, 4). Specifically, being able to adjust the planning of apartments in both a short-term and long-term perspective (primary stakeholder 1, 3), through e.g., movable walls (primary stakeholder 1), and repurpose buildings aimed for housing to other purposes (primary stakeholder 1, 3). For a developer involved mainly in the earlier lifecycle stages of the building, enabling modification or repurposing of a building to a low cost was considered beneficial as it could increase their investors' long-term return on investment by reducing costs later in the lifecycle (primary stakeholder 5).

However, one developer indicated that for their organisation, adaptability of space was a minor issue during the first 30 to 50 years a building's lifecycle. The interviewee stated that *"I have trouble seeing the advantages of such solutions [design for flexibility or adaptability] in our current context."* (primary stakeholder 2). However, the same interviewee also mentioned how changes in living patterns might increase the pressure on improving flexibility in housing the coming years (primary stakeholder 2), suggesting that it may become more critical in the future.

In some cases, flexibility was already considered, to a certain degree. For example, designing the ground floor to be used for both housing and commercial purposes (primary stakeholder 1; primary stakeholder 3) or incorporating requirements related to flexibility of use in tenders with the purpose of enabling facilities used primary for daily activities (e.g. schools) to also be used for other purposes during evenings (primary stakeholder 6). One interviewee mentioned how they had worked with projects where increased flexibility was a requirement from the customer, both in terms of short-term adjustment such as changing of walls, and long-term adjustments including the ability to change the use of the building from e.g. parking space to housing or office space in the future (primary stakeholder 7).

On a sector level, one of the interviewees stated that flexibility is likely to become a critical issue if high impact materials are continued to be used in new developments. In specific, the interviewee suggested that *"If you're working with high impact materials and compositions, you need to make them flexible. We need to make sure that they can work on loads of different applications and that it is believable that they can be reused again and again and again"* (Secondary stakeholder 8). The ability for buildings to adapt to future needs was also asserted by one interviewee stating that *"we have to live in buildings for years, so we have to have a long-term perspective on how to change buildings. For example, there is a lack of schools right now, but the population changes all the time, so buildings need to be convertible and changeable."* (Secondary stakeholder 4).

*Table 4-1. Summary: Perception of design for flexibility or adaptability*

| **OPPORTUNITIES** |
| --- |
| • Improved ability to adjust space to tenants needs<br>• Improved ability to repurpose buildings to fit new purposes and societal context<br>• Reduced cost of repurposing<br>• Improved return on investment through reduced life cycle costs |
| **BARRIERS** |

| |
|---|
| • Lack of incentives: Flexibility or adaptability of space is a minor issue during the first 10-30 years |

### *Design for disassembly*

Several of the interviewees suggested that, despite how design practices to enable deconstruction of a building at EoL might provide long-term benefits, the time horizon made it difficult for them to see any direct value of such practices (primary stakeholder 1; 3; 5). For example, one developer stated that *"The idea is good, I think, that one should almost be able to disassemble the building in blocks, and that would well - in the long run, it might be good. However, it is a little early for us to do it for a whole building when we do not know how the needs will look like in 100 years, which is the time horizon we are working with" (Primary stakeholder 1).* Another other developer stated expressed that did not currently work with design for disassembly. When asked why the interviewee responded *"I think it is because the lifetime of a building is at least for 50 to 60 years. So, I do not think we have that in mind. I think the time horizon is too long… We would love to build something that stands for many, many years…. We look more at low operating* costs" (primary stakeholder 4).

In contrast, another developer stated that design for deconstruction to ensure reuse or recyclability at the EoL could be a potential strategy for them (primary stakeholder 3). Likewise, one interviewee described how requirements related to deconstruction to enable reuse and recycling practices of building component was something they worked toward including as a requirement in tenders. Despite how the lifetime of the building was still perceived to be a barrier, the interviewee stated that "*We have to work according to the knowledge we have today, and then I believe that the technology will evolve. They will certainly, based on what we could do today, have a solution in 50 to 100 years to reuse it in some way. For me, it is not an argument to say that "I don't have to act because I am uncertain for what the future might entail" (primary stakeholder 6).* On an industry level, design for disassembly was said to gain increasing traction in the Danish building construction industry and that it could be expected to become increasingly common in the near future (secondary stakeholder 8)

*Table 4-2. Summary: Perception of design for disassembly*

| **OPPORTUNITIES** |
|---|
| • Improve recyclability or reusability at EoL |
| **BARRIERS** |
| • The long lifecycle of buildings creates uncertainty concerning potential benefits |

### *Use of non-toxic, reused or recyclable materials*

When asked about characteristics of importance when selecting materials, minimising toxicity was a critical factor among both developers and contractors (primary stakeholder 1; 3; 5; 8). Actors either emphasised how they made sure to comply with regulatory requirements (primary stakeholder 5; 8) or worked proactively with minimising toxic materials by introducing requirements for contractors to adhere to (primary stakeholder 1).

Other benefits of importance were high-quality and durability. More precisely, predictability concerning the long-term durability of materials (primary stakeholder 2; 3; 4; 8). When asked about what circular strategies they thought could bring the most value to them, one interviewee responded that it had to be something that provided *"the security of, this feeling of, receiving products that have long lifespans. That can last for a very long time without demolishing or losing efficiency. That would be of the highest value for us."* (primary stakeholder 4).

When asked whether they considered using alternative materials which may support circular strategies (e.g. secondary materials) one interviewee stated that "*We are thinking about it [using alternative materials], but it could be a quality and price issue. And usually, when you have issues with the quality or price, people de-select the materials"* (primary stakeholder 8).

The interviewees mentioned the use of wood-based, reused or recyclable materials as examples of alternative materials they did consider (primary stakeholder 1; 2; 3). Two of the interviewees explained how this was motivated by the climate impact of construction materials, where e.g. wood-based materials had been found to perform better than cementitious materials in most life cycle assessments (primary stakeholder 1; primary stakeholder 2). Thus, relying more on the use of wood as the primary material in building structures was described as gaining traction in the industry, despite how it requires thicker structural elements which decrease the rentable space (primary stakeholder 1; primary stakeholder 2). Still, two of the interviewees considered it likely that they would increase the use of wooden structures in the future (primary stakeholder 1; primary stakeholder 2).

Similarly, reducing the climate impact of the development of new properties was mentioned by one interviewee as the driving factor for their interest in using reused materials (primary stakeholder, 6). Some interviewees also noted how using reused materials may improve the aesthetical value of the building (primary stakeholder 4; primary stakeholder 6), support their positioning on the market and increase their attractiveness among new tenants (primary stakeholder 4). However, others identified several barriers which made them reluctant to integrate reused materials in new properties, including the risk of toxicity (primary stakeholder 1; primary stakeholder 3; primary stakeholder 8) and the insecurity related to the durability of the material over time (primary stakeholder 3; primary stakeholder 8). On an industry-wide level, the challenge of scalability, i.e. the notion of relying on large-scale production of buildings components based on reused materials or components, was pointed out as a major challenge for the industry (secondary stakeholder 6).

When asked about essential aspects for the manufacturer to consider in the design to enable reuse of façade elements at EoL, an interviewee operating at the end of the value chain stated that demand, volume and ease of deconstruction was the most critical factors in the end-of-life to enable reuse of materials and components (secondary stakeholder 2). In addition, factors such as the ability to guarantee non-toxicity of materials; the shape, function and condition of the material or product; age; and foresight in terms of knowing the availability of materials in advance to enable matching with a client, as storing solutions are seldom financially viable (secondary stakeholder 2). With regards to critical aspects to consider at the beginning of the value chain, the same interviewee emphasised how reused materials should be selected in new construction to reduce the overall environmental impact. Another interviewee, also operating at the end-of-the value chain, emphasised the need to choose materials with a functioning secondary market. For example, avoiding mixed materials which cannot be reused or recycled at end-of-life. The interview stated that *"Sometimes we see that, generally, if plastics are mixed with wooden fibres, then yes, it is possible to use recycled plastic in the construction. However, the material is destroyed. It can only pass through once cycle before it has to be incinerated" (secondary stakeholder 3).* Also, using materials or designing components in a way that allows for mechanical separation at end-of-life was considered crucial, as it is a precondition for material recycling (secondary stakeholder 3).

*Table 4-3. Summary: Perception of the use of non-toxic, reused or recyclable materials*

| **OPPORTUNITIES** |
| --- |

| |
|---|
| • Use of non-toxic materials is a highly prioritised<br>• Shifting to "alternative materials" (e.g. reused or renewable) may reduce climate impact<br>• Increased predictability concerning the long-term durability of materials would create significant benefits<br>• Use of reused material may provide aesthetical values and position the developer on the market<br>• Use of materials with a functioning secondary market, design components for mechanical separation and/or ease of disassembly enables recyclability at EoL |
| **BARRIERS** |
| • Actors are reluctant to use reused materials due to perceived risks concerning toxicity levels and long-term durability.<br>• Scalability is a challenge to enable reuse of components and materials in large scale production |

## 4.2.2 Circular use models

### *Leasing systems*

The long-term horizon of properties was further raised as a barrier to the implementation of leasing models, i.e. business models where the supplier would lease rather than sell building components (primary stakeholder 1; 8). On a firm level, one interviewee expressed that *"it is a thrilling idea and I understand what you are after and all that. However, we are not there yet. There is, of course, a purpose for the person who rents it out and then reuses it, so it is brilliant in its own way. At the same time, I do not know what property owners with long-term management think about it." (primary stakeholder 1).* Another interviewee stated that *"the problem is that there are many people working in offices and talking about this who thinks it is a great idea. However, when it comes to the contractor, client and end-users, it makes no sense to them." (primary stakeholder 8).* Hence, questioning the value leasing models would bring to the actors responsible in the construction phase.

Two of the developers did express an interest in leasing models, suggesting that they would consider it if introduced to a similar solution (primary stakeholder 4; 5). One of the developers pointed out, however, that their interest in a leasing model would be dependent upon the product characteristics in terms of aesthetical and environmental benefits. More precisely, providing good insulation and solar shading was considered critical (primary stakeholder 5).

On an industry level, one of the interviewees suggested that rent or lease-based models may become more common in the industry, although emphasising that it is far from conventional models in the industry (secondary stakeholder 6). Another interviewee described how leasing models might support the separation of the element lifespan from that of the building. The interviewee stated that "*that we see today is that usually, we build concrete buildings all the time, and after 40 years they are being torn down, and everything is being demolished and used on the roads or as gravel…A concept like a facade leasing would be interesting. If the ownership ends up meaning that we demolish these things and throw them on the road somewhere, then I think we are better off with someone else like with the manufacturer owning them, and we can use them and then they can reuse them.*" (secondary stakeholder 8). The interviewee further pointed out how for designing disassembly would be insufficient if the responsibility or incentive for reusing of façade elements is not allocated to a specific actor (secondary stakeholder 8).

*Table 4-4. Summary: Perception of leasing models*

| **OPPORTUNITIES** |
|---|

| |
|---|
| • Might be considered if the desired product characteristics are delivered (e.g. environmental and aesthetical values).<br>• Potential to increase reuse of building components by allocating responsibility |
| **BARRIERS** |
| • Lack of perceived benefits for the contractor, client and end-user<br>• Long-term lifecycle of buildings<br>• Leasing models are new to the industry |

### *Maintenance or service models*

The perceived benefits of offers centred around increased maintenance or service throughout the building lifecycle varied among the interviewees. Three of the primary stakeholders suggested that the additional value such models would provide would be limited. Two interviewees suggested that it was common practice to have a service unit in place, at least for developers who were operating within the rental housing market (primary stakeholder 1; 2). Furthermore, the guarantee for roof and façade elements usually covered the first 15 years of the building, and that materials with limited need for maintenance were selected to reduce the need for maintenance (primary stakeholder 1). Likewise, a developer specialised in the development and sales of private properties was sceptical to whether an upfront investment in maintenance would be able to generate the necessary return on investment, even though their clients do take operation and maintenance cost into consideration to a certain degree (primary stakeholder 5).

However, some of the interviewees did express an interest in maintenance- or service models. For example, one contractor suggested that it might be valuable for them in public-private partnership where their responsibility for the functioning of the building usually was extended to a period of 20 to 25 years, in comparison to the 5 years after handover which they usually had to guarantee the quality of the building (primary stakeholder 8). Another developer suggested that choosing a material where there is a strategy in place to ensure durability throughout the lifecycle, e.g. by the provision of maintenance, may increase their likelihood of selecting the product. The interviewee expressed it as "*if we as an organization own all the risk, then it is, of course, easier to choose something you are certain on. That you can guarantee overtime*" (primary stakeholder 3). Thus, suggesting that risk minimization would be a compelling benefit. The interviewee further stated that a similar solution might be attractive when producing tenant-ownership housing rather than rental housing, as the building is handed over to a private buyer and the tenant owner's association does not necessarily inhibit the knowledge to handle the materials and components to ensure durability (primary stakeholder 3).

On a sector level, one of the interviewees suggested that a development toward service-based models for actors involved in the initial phases of the building (e.g. suppliers of building products and developers) is likely to occur in the future as a strategy to reap the financial benefits of the building throughout its lifespan. The interviewee expressed it as *"the common business model today is that you're only in for the fraction of the time of the building's lifetime. But the ones actually being there in the facility management, that's where the potential [financial] value is. So why not lowering… the price for the construction of the projects or the building and then transform the value creation onto the service part"* and that *"I think the prosperous developer of the future will be the developer that clearly thinks along the lines of TCO. Because the ownership in the facility management development phase is potentially much more profitable than actually building the project"*. The interviewee further stated the increasing discussions are being held with developers which think are getting more focused on delivering an array of services related to the purpose of the building (e.g. office space or housing), rather than just the building, and that *"going five years ahead, I think that will be the mainstream agendas"* (secondary stakeholder 6).

*Table 4-5. Summary: Perception of maintenance- or service models*

| OPPORTUNITIES |
|---|
| • Risk reduction for the developer or contractor<br>• May enable developers to reap financial benefits throughout the building's lifespan |
| **BARRIERS** |
| • Having a service unit in place diminishes the perceived added value of improved maintenance<br>• Existing guarantees on roofs and façade elements diminishes the perceived added value of improved maintenance.<br>• The return on investment might not compensate for upstream investment in maintenance. |

### *Improved traceability and information provision*

The benefits of offers which improves traceability and provides information regarding material characteristics with the purpose of supporting CE strategies, was mainly discussed in relation to quality assurance, e.g. ensuring that materials are free from toxic compounds (primary stakeholder 1; 3; 6) and the long-term functioning of the building, e.g. through improving maintenance (primary stakeholder 1; 2; 4). One interviewee expressed that *"This is what I think digitalisation might solve for us. That we would be able to deliver a model to the organisation responsible for the management phase of the building, and when a problem arises, it would be possible to visualise, e.g. what material has been used. But we are not there yet." (primary stakeholder 1).* Likewise, another interviewee highlighted the value of supplying the right information when handing over the building to the department responsible for management (primary stakeholder 4).

Despite how improved information flows throughout the lifecycle of the building was considered to provide benefits in a long-term perspective, some stakeholders highlighted how such issues currently receives limited attention (primary stakeholder 3; primary stakeholder 8) and that there is a lack of demand from their clients concerning provision of additional information (Primary stakeholder 8). Another interviewee suggested that although it may be beneficial from a lifecycle perspective, the organisation's current service unit was to a great extent familiar with the materials used in the buildings, as they used equivalent materials in all new developments (primary stakeholder 2). Hence, the added value of such solutions would be limited for their organisation.

On an industry level, the importance of improved information flows to drive sustainability initiatives, and circular thinking in the construction sector was emphasised (secondary stakeholder 1; 4; 6; 8). Documentation of the $CO^2$ footprint of building components and products was predicted to become increasingly common during the forthcoming year (secondary stakeholder 6), potentially encouraging a shit to new materials. Material passports were considered a potential driver for promoting circular thinking in the industry, pushing actors in the early lifecycle stages to adopt a lifecycle perspective to a greater extent than what is currently done (secondary stakeholder 1). Information provision was regarded as critical to enable reuse practices, by the ability to locate materials, its content and quantity (secondary stakeholder 8). The importance of actors within the industry also having the ability to interpret and use the information supplied to them was emphasised by one interviewee, stating that *"I* *think information is key…. However, I think what we have to do is to make sure is that the product manufacturers supply the right information and that architects can take in and understand it"* (secondary stakeholder 8).

From an end-of-life perspective, the value of additional information provided to the demolisher concerning the properties of materials in a building was considered marginal (secondary stakeholder 2; secondary stakeholder 3), as it was not found to be able to substitute the need for testing the suitability of materials for reuse. Also, the relatively simple process of identifying the type and characteristics of materials in a building was considered to reduce the need for additional information (secondary stakeholder 2).

*Table 4-6. Summary: Perception of improved traceability and information provision*

| **OPPORTUNITIES** |
|---|
| • Provide quality assurance (e.g. free from toxic compounds)<br>• Support the long-term functioning of the building through improved maintenance<br>• Information flows may support the adoption of a lifecycle perspective in the sector<br>• Might enable reuse practices |
| **BARRIERS** |
| • Information provision not a prioritised issue/lack of demand among clients<br>• High familiarity with the material used in buildings diminishes the added value<br>• Does not substitute the need for quality-testing of materials and components for reuse |

### 4.2.3 Circular recovery models

#### *Take-back systems*

Few of the interviewees in the primary stakeholder group could identify any direct benefits for their organisations with a value offering based on a take-back system where the supplier would be responsible for retrieving and handling building components or façade elements at EoL. However, one interviewee suggested that it would facilitate their choice of products if they knew who would handle it at EoL. The interviewee expressed it as *"I guess that is a good idea. That the manufacturer also recycles it. You can almost think that it is a fair requirement – that one should not manufacture something you cannot take care of… Then we would know who will and can handle it in the end which assure that it actually will be recycled, not only that it could be*" (primary stakeholder 3). Other interviewees mentioned several barriers which could make it challenging to implement a take-back system for components in the building construction industry, such as a lack of market incentives (primary stakeholder 8) and the long timespan of the use- and operation phase of e.g. façade elements which made it difficult for some the developers to imagine how it would be implemented in practice (primary stakeholder 3; primary stakeholder 4). One of the interviewees stated that "*We have never met it before, but if that would be a possibility of course… But I mean many companies are dead and gone when the buildings are supposed to be torn down so. I have a hard time seeing how to do that in practice because it would be your grandchildren that have the responsibility. So, you will pass on the responsibility and that's, of course, easy to do, but it is not certain that they are willing to take it on"* (primary stakeholder 4).

*Table 4-7. Summary: Perception of take-back system*

| **OPPORTUNITIES** |
|---|

| |
|---|
| • Ensures recyclability or reusability at EoL |
| **BARRIERS** |
| • Lack of incentives for actors<br>• The long lifespan of buildings makes it difficult to imagine functioning implementation<br>• Uncertainty concerning long-term capacity and responsibility of the supplier |

## 4.3 Talking phase: Customer value dimensions

This section introduces the findings related to this study, which was to identify the type of value prioritised by key stakeholders of the case company. The findings of this section are presented according to the conceptualisation of value categories provided in section 2.4.

### 4.3.1 Financial value

All interviewees in the primary stakeholder group highlighted financial cost as an essential factor with regards to the selection of building components. It was also mentioned by interviewees in the secondary stakeholder group, with one interviewee concluding that *"at the end of the day, it's still all about the money"* (secondary stakeholder 4) when asked about the type of benefits prioritised by developers and contractors when choosing suppliers. Although keeping construction costs low were stressed by all interviewees, differences in prioritisation and motivation was noticeable among developers.

For examples, a developer operating in the beginning of the lifecycle of the building (i.e. developed and sold properties directly after construction) stated how any solution offered to them must be financially competitive as the cost per square meter is one of the most decisive factors when selecting suppliers, which includes construction cost (especially emphasising the cost of man-hours), material cost and lead time (primary stakeholder 5). Reducing the lead time was critical not only to reduce costs of construction on-site but also for the developer to be able to meet customer demands for office space. The interviewee explained that while companies had a 6 to 12 months' time horizon with regards to finding a new office space, they usually had a time horizon of 16 to 24 months of delivering the same space (primary stakeholder 5). Hence, reducing the lead time enabled them to meet their customer demands more effectively. On the other hand, an interviewee representing a public developer of rental housing emphasised how keeping construction costs low was a critical factor to be able to deliver rental housing with viable rents for low-income groups (primary stakeholder 1).

The interview data indicate that developers which retain ownership throughout the lifecycle of the building, tend to emphasise life cycle costs in terms of the future cost of operation to a greater extent when choosing suppliers, than developers who do not retain ownership once the property is constructed. This seems to be due to a consideration of costs borne by the own organisation, where the long-term costs of operations (e.g. maintenance) were considered a cost driver for the own organisation for developers of rental housing. Characteristics of building components, such as long-term durability to reduce maintenance costs but also energy efficiency were mentioned as strategies to reduce operating costs for the own organisation (primary stakeholder 1; 2; 3; 4; 7). One of the interviewees expressed it as *"A lot of other developers are working in the way of you know - buying, building and selling. Moreover, it goes so quickly. For us, we buy and build and keep properties. And that means that we have an interest in building all our properties in a good way, so we might keep it for a long time without spending much money on maintenance and stuff like that"* (primary stakeholder 4).

Two of the interviewees, operating in the Danish market, highlighted how lifecycle cost rather than construction costs is commonly used as a competitive factor in public-private partnership (PPP) projects (primary stakeholder 8; secondary stakeholder 8). One interviewee stated that *"…in public-private partnerships, you can see that the lifecycle cost is much more important than the initial cost. So, in that context, it is much easier to talk about circular gains. Where if you are doing a strict in-and-out kind of thing where you construct the building and then you are out, and the people that own it are probably going to own it for five years or similar… Then it is impossible to have this long-term discussion about the value created down the line, whatever value that is." (*secondary stakeholder 8).

Risk minimization was also a critical feature amongst both developers and contractors (primary stakeholder 2; 3; 4), mainly concerning the long-term viability of the building but also the delivery of the project on time (secondary stakeholder 8). For example, one developer states how they were reluctant to use new building materials as they had issues with failure in previous projects (primary stakeholder 4). Likewise, another developer expressed how using new materials constituted a financial risk in terms of insecurity related to the durability of the material (primary stakeholder 2). In general, the high cost associated with failure in the construction process of the operation phase was considered to inhibit innovation and contribute to the conservative nature of the industry (primary stakeholder 5; 8; secondary stakeholder 1).

One of the contractors stated how introducing sustainability-related features in tenders may increase the chances of getting it accepted, as long as it did not entail an increase in price (primary stakeholder 8). Likewise, another interviewee stated that even if they would like to put a higher emphasis on environmental factors procurement, they have to fulfil the investors' requirement on return on investment while also taken into consideration how much rent an office building can generate. They had found that tenants were reluctant to pay more for environmental sustainability-related features, which made it difficult for them to financially justify extra spending on reducing the environmental impact of either the construction or the operation phase (primary stakeholder 5).

On an industry level, one of the interviewees emphasised the importance of speaking the language of the investor when introducing circular strategies or CBMs in the construction sector. The interviewee continued to state that the language among investors such as developers and pension funds *"is very much about the cost per square meter and gain per square meter. So, if you do not tap into that terminology and document that the solutions based on circular suggestions, based on circular solutions, are as beneficial and economically viable as average or general projects. You will not see an exponential rise in projects"* (secondary stakeholder 6).

*Table 4-8. Summary of financial value*

| **EXPECTED VALUE** |
|---|
| • Improved ability to charge a premium<br>• Low or reduced construction cost per square meter<br>• Risk reduction/quality assurance/reduced lead time<br>• Improved access to capital<br>• Residual value<br>• Return on investment<br>• Lifecycle cost |
| **DEMONSTRATED VALUE** |

| |
|---|
| • Low or reduced construction cost per square meter |
| • Risk reduction: long-term viability of building and components, the ability to deliver the project on time. |
| • Reduced lead times |
| • Fulfilment of requirement on return on investment |
| • Improved ability to get tenders accepted |
| • Lifecycle costs: durability of materials and improved energy efficiency |

### 4.3.2 User value

When asked about end-users' requirements on new buildings, one of the interviewees suggested that end-user tend to be distant in the design- and construction phase of the building lifecycle. Furthermore, how limited attention is paid to the requirements of end-users in these phases (secondary stakeholder 1). Another developer suggested that their customers are mainly focused on the quality of the standard of living and that no customer requirements concerning, e.g. environmental sustainability, had been experienced by the organisation (primary stakeholder 3).

However, several factors were considered by developers and contractors related to the end-user's experience of the building. For example, the aesthetical quality was a characteristic of importance when selecting façade elements (primary stakeholder 4; 5; 8), with one interviewee suggesting that besides price and risk reduction, it was the main criteria taken into consideration (primary stakeholder 8). Furthermore, one developer described how their concept of reuse of building components and products had become a vital aspect of their offer to tenants, as it was perceived aesthetical appealing (primary stakeholder 4).

Other aspects emphasised to ensure high quality for end-users was attractive interior (primary stakeholder 3), creating pleasant and socially secure environments (primary stakeholder 1), ease of maintenance through the lifecycle (primary stakeholder 3) and good indoor climate (primary stakeholder 3; 5; 8). The latter was mentioned both concerning avoiding over-heating (primary stakeholder 5) and creating safe indoor environments through the use of non-toxic materials (primary stakeholder 8). The noise-resistance of building materials was further considered essential to ensure the well-being and a feeling of security among tenants, making it an important driver of customer satisfaction (primary stakeholder 2).

One developer described how the ability to adjust to changing demand among tenants was an important issue for the organization. He stated that *"For us, it has been a lot about how people will live in the future. In five years, will young people want to live in their own apartments? Will co-living become more common, and if, how can we construct our buildings to meet that changing need? Maybe people will also change the type of accommodation more often depending on their current needs. Overall, it is likely that this will also influence our choice of materials and components in the future."* (primary stakeholder 2). Hence, suggesting that flexibility is an important feature to ensure that the building stock meets the demands of end-users.

*Table 4-9. Summary of user value*

| **EXPECTED VALUE** |
|---|
| • Convenience/functionality/ease-of-use<br>• Aesthetical value |

| |
|---|
| • Contribution to well-being and/or organisational performance |
| **DEMONSTRATED VALUE** |
| • Quality of living or working standard: Good indoor-climate, attractive interior, noise-resistant environments.<br>• Aesthetical value<br>• Pleasant and socially secure environments<br>• Functionality: the ability to adapt to changing user demands |

### 4.3.3 Environmental value

Energy efficiency and reducing the use of toxic materials were the environmental issues which most primary stakeholders stated to prioritise in the development of new properties (primary stakeholder 1-5); primary stakeholder 7-8). One interviewee explained that "*as we retain ownership of the buildings throughout the building lifecycle, we also have to consider a life cycle perspective. Therefore, energy efficiency in the use-phase has been a key issue for our organisation*" (primary stakeholder 2). Likewise, a contractor stated that energy efficiency was the main environmental requirement put forward by their customers (primary stakeholder 8).

Although it was clear from the interviewees that energy efficiency had, to a certain extent, dominated the environmental agenda, there were also signs that increasing attention was given to the $CO^2$ of footprint of construction in both the Danish (primary stakeholder 4; primary stakeholder 5O) and the Swedish building construction industry (primary stakeholder 1; primary stakeholder 7; primary stakeholder 6). In Denmark, one interviewee expressed that *"Energy efficiency has been really high on the agenda. And we are now constructing almost zero energy buildings… But if you look at how much energy is embedded in the materials and the $CO^2$ embedded in the materials, it far outweighs the performance side of the building… We are going to, and more and more, we are, looking at the embedded impacts"* (secondary stakeholder 8). Another interviewee stated that *"… I think it [greenhouse gas emissions] is driving the industry just as it's driving any other industry. I think that this industry, though has not realised yet the impact that it potentially has on combating climate change"* (secondary stakeholder 6).

When reflecting on the type of requirements put forward by developers, an interviewee described the development in the Swedish construction market as *"Actors are getting started [with a focus on climate neutrality]. For a long time, the operation phase has been the only focus, while in recent years toxic compounds have gained increased attention. Some [developers] have requirements on the use of environmentally approved building products, and some are still only looking at a selection of chemicals. And then there are also projects with Miljöbyggnad [a Swedish building certification system] or other certification schemes. At the same time, many actors are getting started with training and business development to be able to put new requirements relating to climate impact.*" (primary stakeholder 7).

One developer foresaw that, in addition to cost and aesthetical quality, energy efficiency during operations and the $CO^2$ footprint of the manufacturing and transportation of components, were parameters that would gain important when selecting building components in the future (primary stakeholder 5). The potential for synergies between increased resource efficiency and lowering of the $CO^2$ footprint in the early phases of the building lifecycle (including resource use, transportation and manufacturing) was also highlighted by stakeholders (primary stakeholder 6;7). Efforts to reduce the $CO^2$ footprint was further considered to have consequences on the choice of materials, e.g. by making the use of concrete elements less attractive due to its relatively high carbon intensity (primary stakeholder 5; secondary stakeholder 7; 8).

Several interviewees referred to the requirements in environmental certification systems when asked about the type of environmental issues prioritised by the organisation, suggesting that environmental certification systems might highly influence the environmental issues addressed in the construction sector (primary stakeholder 1; 2; 3; 5; 6; 8). In the Swedish context, the Swedish Environmental Certification System "Miljöbyggnad" was mainly referred to, where a level of silver or gold was commonly aspired (primary stakeholder 1; 2; 3; 6). In the Danish context, the Nordic Swan or the Danish DGNB certification system was mentioned (primary stakeholder 5, 8). In the latter, a certification level of gold (next highest) or platinum (highest) was commonly asked for by investors (primary stakeholder 5). Despite how environmental certification of the building seemed to be increasingly demanded by investors, investors' lack of willingness to pay for environmental benefits was considered an issue (primary stakeholder 5; 8).

*Table 4-10. Summary of environmental value*

| **EXPECTED VALUE** |
| --- |
| • Improvement of energy efficiency<br>• Improvement of resource efficiency<br>• Reduced embodied carbon<br>• Lower emissions and noise<br>• Mitigation of resource depletion |
| **DEMONSTRATED VALUE** |
| • Improvement of energy efficiency<br>• Reducing toxicity<br>• Reducing climate impact (mainly concerning material manufacturing and transports)<br>• Resource efficiency as a driver for reducing climate impact |

### 4.3.4 Social value

The security of the workplace and safe montage was considered a critical factor when selecting building components, particularly in dealing with the building structure (primary stakeholder 2). Besides that, the social value was mainly described as something actors in the primary stakeholder group sought to contribute to, rather something that would create value for them. For example, efforts mentioned included provision of rental housing to people with limited economic resources (primary stakeholder 1), job opportunities (primary stakeholder 7), producing a mix of rental and owner rights in new developments, selecting local contractors to support the local economy (primary stakeholder 3) and improving the quality of life of people (secondary stakeholder 4). One of the interviewees expressed it *as "our ambition is that all our projects shall contribute to social sustainability. However, it is a bit difficult to get to an exact definition of social sustainability and what the solution to achieve that is."* (primary stakeholder 3).

*Table 4-11. Summary of social value*

| **EXPECTED VALUE** |
| --- |
| • Provision of local job opportunities |

| DEMONSTRATED VALUE |
| --- |
| • Improved security of the workplace: safe montage |

### 4.3.5 Competitive advantage

Factors related to competitive advantage was only touched upon by a few actors. For example, an interviewee representing a publicly owned developer mentioned the importance of the connection between their image as a company and the public view of the municipality as a whole, although emphasising that sustainability-related initiatives may strengthen their image among some tenants which care about such issues, but not necessarily among all of them (primary stakeholder 1).

In some cases, the motivation for adopting circular strategies was tied to the image of the company and its positioning in the market (primary stakeholder 4) or the ability to "tell a story" about the building and its materials to improve the attractiveness of projects amongst investors (primary stakeholder 5; primary stakeholder 8). One interviewee expressed that their motivation for using reused materials and components in new developments was derived from the ability to sell and introduce themselves in the tenant market through the image of "reusing" (primary stakeholder 4). Two other interviewees, one contractor and one developer focusing on developing and selling properties, expressed how circular design strategies may provide a good selling point to the customer (primary stakeholder 5,8). Although, doubting that it would enable them to charge a higher price. One interviewee expressed it as *"I doubt that it gives a higher price per square meter, but I think it does help us in our sales, in our marketing campaigns. And I think it's the same for us, if it' is a good story in the material and it is still competitive cost-wise, we'll choose it" (primary stakeholder 5).* A similar perspective was provided by a secondary stakeholder, suggesting that it is the story around a circular economy which has to sell it and create the extra value (secondary stakeholder 5).

On an industry level, the increased focus on sustainable construction and a circular economy amongst actors in the building construction industry were considered by some to reflect an ambition to improve the corporate image (secondary stakeholder 1; secondary stakeholder 5; secondary stakeholder 6). From the developer's perspective, it was suggested that the sustainable profile of a company is becoming more critical, as competition is increasingly based on environmental and circular economy parameters. It was further argued how circular strategies were unlikely to entail cost savings. However, the benefit lies in the prospects of securing a competitive advantage (secondary stakeholder, 5).

*Table 4-12. Summary of value related to competitive advantage*

| EXPECTED VALUE |
| --- |
| • Improving brand reputation |
| • Improvement of stakeholder relations |
| • Innovation opportunities |
| • Increased productivity |
| **DEMONSTRATED VALUE** |
| • Improving attractiveness to investors |
| • Positioning in the market through material selection in-line with the corporate image |
| • Improving brand reputation through sustainable construction and/or CE initiatives |

### 4.3.6 Informational value

As discussed in section 4.2.1., informational provision was mainly identified by stakeholders as beneficial to support quality assurance of materials (e.g. related to toxicity) (primary stakeholder 1; 3; 6) and the long-term functioning of the building, which may be supported by information flows which improves proactive maintenance (primary stakeholder 1; 2; 4). In the Swedish context, the selection of materials was to a certain extent supported by information delivery by the non-profit organization "Byggvarubedömningen" which provides assessments of materials based on criteria on chemical content and life cycle performance (primary stakeholder 1). One of the interviewees further mentioned how they are introducing climate declarations for new developments, to support a selection of materials and construction processes which reduce the climate impact of construction (primary stakeholder 7). Improved information flows were also considered to support initiatives to improve sustainability and increase circular thinking in the construction sector at large (secondary stakeholder 1,4,6,8).

*Table 4-13. Summary of informational value*

| **EXPECTED VALUE** |
|---|
| • May enhance the creation of other types of values |
| **DEMONSTRATED VALUE** |
| • Provide quality assurance: ensure materials are free from toxic compounds<br>• Support the long-term functioning of the building: improved maintenance and service.<br>• Support selection of materials or construction processes which reduce climate impact |

### 4.3.7 Validation of value dimensions

Data was collected through an assessment questionnaire to gain insights into the relative importance of the main factors identified in the interview data. The result is presented in Figure 4-1 below (where 0 = not relevant; 1 = could be considered; 2 = important yet not decisive; 3 = crucial).

The results indicate that there is a discrepancy between the perceived relative importance of factors among the respondents, where e.g. low carbon footprint of construction is considered crucial by one respondent but less so by the other respondents. Still, the data demonstrate the importance of financial value, by the high level of importance given to aspects such as the reduced risk of failure, low maintenance costs and reduced construction cost. The data further indicate that reduced toxicity and high energy efficiency is prioritised environmental aspects, which is in-line with previous prioritisations in policy and legislation on both EU and national level, as indicated by the PESTEL analysis.

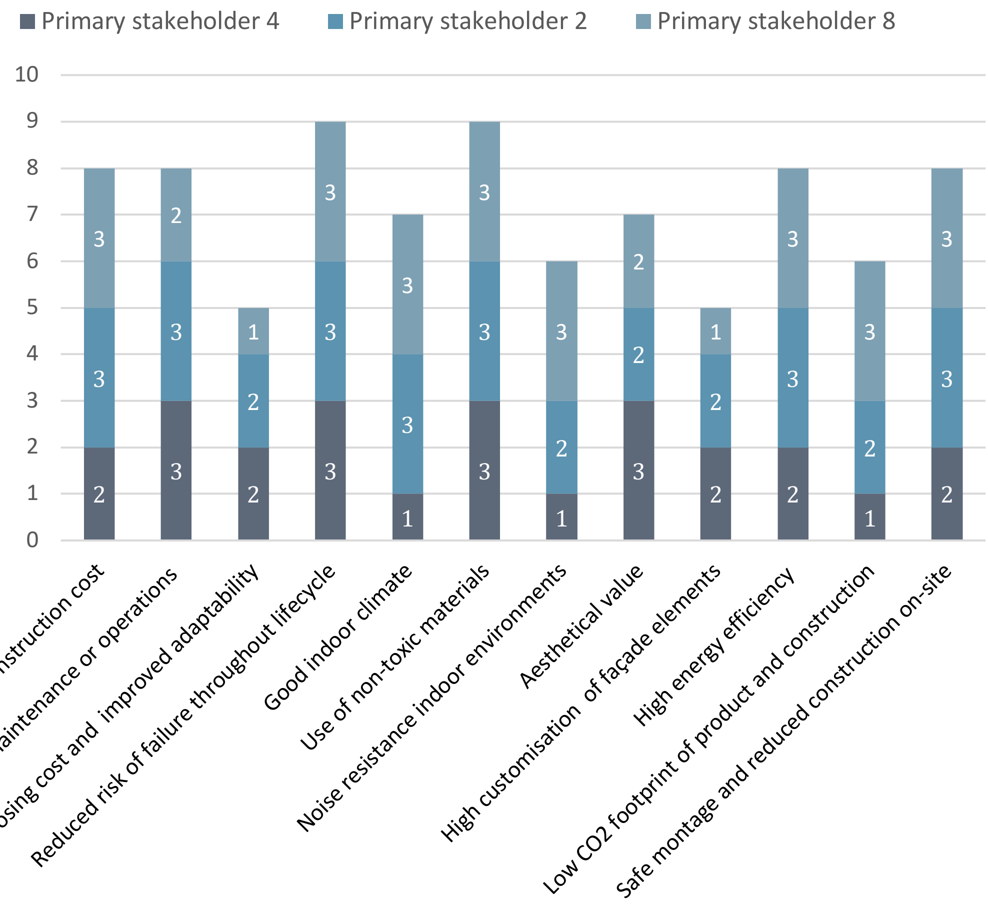


*Figure 4-1. Overview of results from the assessment questionnaire*

*Source: By author*

## 4.4 Testing phase: Assessing customer acceptance and comparing value propositions

This section presents the result of the *testing* phase. Based on the findings from the *thinking* and *talking* phase four value propositions were developed embedding different circular strategies and addressing different parts of the lifecycle. The *testing* phase sought to provide early testing of the developed value propositions with relevant stakeholders and a qualitative evaluation of its sustainability potential by using the criteria for sustainable value propositions for CBMs synthesised in section 2.3.

### 4.4.1 Expected customer acceptance of re-designed value propositions

#### *Value proposition 1: Longevity*

#### *Description*

The first value proposition depicts an offer which seeks to slow resource loops by promoting longevity of façade elements and thus proactively supporting the preservation of the embedded value of components at the highest value possible. Service- and product features include the design of the product to enable modification and repurposing of the building's outer layer, improved maintenance based on use data, and warranty provided by the supplier. The customer benefits include financial value provision through financial risk minimisation and reduced lifecycle cost, end-user value provision through simplified maintenance and repurposing, and environmental value provision through reduced environmental impact. For an overview, see Figure 4-2 below.

### *Expected customer acceptance*

Two out of four respondents answered that it could be a viable solution. One respondent stated that reducing maintenance cost was of high value to them as the organisation developed and offered rental apartments to tenants (primary stakeholder 4), whereas the other respondent stressed how property owners were likely to find the offering interesting based on its potential to reduce risk and environmental impact.

The respondents who indicated that it was not a viable solution motivated that (i) the offering was not likely to be worth the investment and (ii) lack of demand for such offering among their clients. For example, it was suggested that the maintenance for rental properties during the first 40 to 50 years mainly include repairing the joints and repainting the facades. Hence, diminishing the need for additional maintenance (primary stakeholder 2). A respondent further stated that that durability rather than modification of the outer layer of the building was desired among investors (primary stakeholder 8).

| | Service- and product features | Customer benefits |
|---|---|---|
| **Value Proposition 1: Longevity** | • A building system which enables modification and repurposing of the building's outer layer through adaptable, flexible and upgradable elements<br>• Optimised maintenance based on use data<br>• Replaceable facade elements with warranty | • Reduced risks of with failure<br>• Reduced lifecycle cost<br>• Simplified maintenance<br>• Simplified repurposing of the building to ensure future ability to adjust to changing user needs, climate patterns and aesthetical features<br>• Reduced environmental impact of repurposing activities. |

*Figure 4-2. Overview of value proposition 1: Longevity*

*Source: Developed by author*

### *Value proposition 2: Circular inputs*

### *Description*

The second value proposition depicts an offer which seeks to slow or close resource loops by integrating secondary (reused or recycled) inputs and components into new façade elements. The customer benefits primarily originate from environmental value creation, where the use of secondary inputs is assumed to reduce the environmental impact of the product and support the market of reused and recycled materials. An overview is provided in Figure 4-3.

### *Expected customer acceptance*

All four respondents answered that it could be a viable offering. This was motivated by increasing demand of sustainable solutions among clients, the potential of the offering to strengthen the brand reputation as reuse of materials is becoming more attractive on the market, and external pressure to work toward a higher degree of reuse (primary stakeholder 2; 4; 8). One respondent expressed how *"We will always use the most environmental-friendly solution if possible"* (primary stakeholder 8). However, the need for the product to still deliver the same quality and prize as competing products was emphasised (primary stakeholder 1; 4). More specifically, one respondent suggested that the offering might be relevant for actors with high sustainability standard, yet, that it is not viable to merely consider the environmental impact and not the cost of the product.

| | Service- and product features | Customer benefits |
|---|---|---|
| Value Proposition 2: Circular inputs | • Use of secondary inputs and components in new façade elements | • Reduce environmental impact of façade elements |

*Figure 4-3. Overview of value proposition 2: Circular inputs*

*Source: Developed by author*

## Value proposition 3: Recyclability

### Description

The third value proposition depicts an offer which supports activities to slow (reuse) or close (recycling) resource loops at EoL. The product features include façade elements manufactured from materials with a high residual value, which can be disassembled and reused or recycled at end-of-life. The customer benefits include long-term environmental benefits by off-setting primary production and financial value by increasing the residual value of components. The benefits would be expected to occur mainly at EoL. An overview is provided in Figure 4-4.

### Expected customer acceptance

All four respondents stated that it could be a viable offering, although one implied that to be feasible, the industry as a whole would need to move toward a circular economy (primary stakeholder 1). One actor, which already worked with reuse of materials and components, pointed to the current economic costs of deconstruction and that designing products with preliminary approvals of their demolishment abilities could save expenses in that process (primary stakeholder 4). The external societal pressure for the design for disassembly and material recycling was further emphasised (primary stakeholder 2; 4; 8), although one respondent also highlighted potential difficulties related to ensuring that the components have the right technical specification to be appropriately handled at EoL (primary stakeholder 8).

| | Service- and product features | Customer benefits |
|---|---|---|
| Value Proposition 3: Recyclability | • Designed for disassembly and material recycling<br>• Use of materials with a high residual value and potential for recyclability | • Long-term environmental benefits by ensuring that the material can be reused or recycled at end-of-life<br>• Increased residual value of components due to design for reusability |

*Figure 4-4. Overview of value proposition 3: Recyclability*

*Source: Developed by author*

### *Value proposition 4: Reusability*

### *Description*

The fourth value proposition depicts an offer which seeks to slow resource loops through supporting the reuse of façade elements. The product is designed for disassembly and standardised, and data on properties and characteristics are provided throughout the lifecycle of the building to support reuse after the initial use-phase. It is further assumed that increasing the span of responsibility of the focal company in the use-phase creates an incentive for reuse at EoL. Accordingly, the offer depicts a deposit-system and leasing system. Customer benefits derive from financial value creation by reducing the initial investment or long-term cost through alternative business models, and environmental value creation through off-setting primary production. An overview is provided in Figure 4-5.

### *Expected customer acceptance*

Three respondents answered that the offering would not be viable. One of the respondents stated that their property portfolio was highly diverse, which would require a substantial range of products to fit their business model. The respondent also suggested that as they retained ownership of the building, a leasing- or deposit system is of less relevance for them (primary stakeholder 4). The lack of a business case was further identified as a factor which inhibits the viability of the value proposition, with one respondent stating that their clients demand durable buildings which are not demolished in a short-term perspective (primary stakeholder 8). It was also suggested that the industry is not ready for business models based on the options described in the service- and product features, mainly due to the low-tech properties of façade elements. Still, one respondent suggested that option one might be viable in the future (primary stakeholder 1).

The respondent which selected the option “I do not know” emphasised the offerings potential to reduce the environmental impact from building materials and the current trend toward a higher residual value of building components. However, the respondent stated that it was difficult to predict how business models to secure the residual value of building components can be designed (primary stakeholder 2).

| | Service- and product features | Customer benefits |
|---|---|---|
| **Value Proposition 4: Reusability** | • A system for reuse in place:<br>Option 1: deposit-system where the owner of the property receives a rebate once the façade elements are returned at the end of the initial use phase.<br>Option 2: Leasing system where the façade elements are rented on e.g. yearly basis.<br>• Data on element properties and characteristics to support reuse after the initial use phase<br>• Designed for disassembly<br>• Standardised façade elements | • Reduced initial investment or long-term costs through alternative business models<br>• Reduced environmental impact through offsetting primary production |

*Figure 4-5. Overview of value proposition 4: Reusability*

*Source: Developed by author*

### 4.4.2 Comparing value propositions

Several criteria for assessing the sustainability potential of the value propositions in CBMs were identified in the literature review. To test the extent to which the developed value proposition meets the criterion, these were evaluated accordingly (see Table 4-14). The results demonstrate how none of the developed value propositions meets all of the criteria, suggesting that combining value propositions into one offer might be a suitable approach to improve its sustainability potential. More specifically, this would allow for a higher degree of a lifecycle approach, as the circular strategies embedded in the developed value propositions tend to address different stages of the lifecycle stage of the building. Whereas the value proposition referred to as reusability meets most of the criteria, this value proposition was also the only value proposition which did not seem to add extra benefits in comparison to market competition, which is critical for achieving customer acceptance.

*Table 4-14. Comparison of value propositions*

| **Criteria** | **Circular value proposition** | | | |
|---|---|---|---|---|
| | Longevity | Circular inputs | Recyclability | Reusability |
| The value proposition embeds circular strategies | x | x | x | x |
| The value proposition supports the proactive preservation of the embedded value of products and components at the highest level possible | x | | x | x |
| The value proposition includes of a lifecycle thinking approach meaning that the value proposition and identified opportunities address the beginning, middle and end of the lifecycle. | | | | x |
| The value proposition balances the needs from a triple-bottom line perspective and ensures societal well-being | x | | | |
| The value proposition internalises externalities | | | | x |
| The value proposition adds extra value or benefits in comparison to market competition | x | x | x | |
| The value proposition aims for radical innovation | | | | x |
| The value proposition integrates multi-disciplinary knowledge. | | | | |

*Source: By author*

# 5 Findings and discussion

This chapter discusses the findings of this thesis and ties together the result of the second, third and fourth task with the purpose of fulfilling the overarching objective of this study. Section 5.1. discusses the findings related to task three, which was to identify the type of value prioritised by key stakeholders of the case company. Section 5.2. discusses the findings related to task four, which was to identify the additional value that may be captured by revising the value proposition of the case company in accordance with circular economy principles. In section 5.3, recommendations to the case company are provided based on the findings of this thesis. A discussion concerning the findings related to task two, which was to explore how a process can be designed to help to identify opportunities for adding value by circular economy implementation and re-defining value propositions, is presented in section 5.4. Implications of methodological choices are provided through a discussion of how the methodological choice, scope and analytical framework might affect the result of this study.

## 5.1 Key value drivers

### 5.1.1 Financial factors dominate the perception of customer value

The results indicate that financial value is a critical factor for determining the delivered customer value. It is illustrated by both how the perceived opportunities and barriers to circular strategies are primarily of financial nature, e.g. the more positive reaction to design strategies which could improve adaptability of buildings as it may reduce repurposing costs, and the reluctance to integrate reused materials in new constructions due to perceived risks to the long-term durability of the materials. Furthermore, all primary stakeholders highlighted financial value as a critical driver for value creation, whereas the responses from the secondary stakeholders suggest that this is characterising the industry at large. The dominance of the financial value category is well-in line with the findings of previous study on green construction which emphasise the importance of financial value creation (Vatalis et al., 2011; Mokhlesian & Holmén, 2012) and the business model literature at large which states that economic sustainability is a prerequisite to any business model (Schaltegger et al., 2012). However, while the literature suggests that financial value is derived from the ability to charge a premium or from lowering costs, the results indicate prioritisation of the latter. The ability to charge a premium was not mentioned by any interviewee.

Similar to the findings by Vatalis et al. (2011), some of the interviewees' associated investments in improving the sustainability of the building with cost increases while not generating the possibility to charge a premium. This is further in-line with the findings of Mokhlesian & Holmén (2012), who suggests that end-users are unwilling to pay for public environmental benefits. The exception was developers who also reaped the financial gains of improving energy efficiency in operations, which was mostly the case for developers who retained ownership of the building throughout the lifecycle. In general, these were found to be more inclined to consider long-term financial gains in addition to short-term financial gains. For example, one interviewee stated that "*as we retain ownership of the buildings throughout the building lifecycle, we also have to consider a life cycle perspective. Therefore, energy efficiency in the use-phase has been a key issue for our organisation*" (primary stakeholder 2). Similar results were found by Debacker & Manshoven (2016), who suggests in their state-of-the-art of the building construction industry how speculative clients may prioritise shorter-term financial value over strategies which secure a high financial value of components at end-of-life. Likewise, Azcarate-aguerre et al. (2018) suggest how the owner of the building is likely to focus on financial factors such as residual value and life cycle costs. However, this study indicates that the residual value of the building is largely omitted as a potential avenue for value creation even for the developers who retain ownership of the building. A possible explanation might be the long lifecycles of buildings, with one the developer planning for a period of use of between 70 to 100 years, which has been identified as a barrier to CBM implementation in the construction sector by Adams et al., (2017) and Arup (2016).

Risk reduction in terms of ability to deliver the project on time and ensuring the long-term viability of the building and components was found to be a key priority for stakeholders, and thus a critical factor influencing the financial value as suggested by Schenkel et al. (2015). The prioritisation of risk reduction may be explained by the high costs associated with both (i) inability to deliver the building on time and (ii) failure of the building or components. Risk reduction further seemed to be closely tied to the responsibility of the company, as illustrated by one interviewee who suggested that they would be interested in more maintenance based business models in projects where they had a long-term responsibility of the functioning of the building, as this would reduce the risk for the company itself.

Hence, these findings suggest that any offer based on circular strategies must provide financial value, to the same or a higher extent than competitors, in order to be competitive. Also, an offer which provides financial value during the operations phase is likely to be more suitable for clients which retain ownership of the building in this period and thus can reap the financial benefits.

### 5.1.2 The perception of customer value is aligned with the conceptual framework

The initial assumption posed this study was that the customer value could be categorised into six themes: financial value, user value, environmental value, social value, competitive advantage and informational value. The findings of this study indicate that the type of factors prioritised are well aligned with the conceptual framework. Yet, the coding process revealed (i) more detailed descriptions of the factors associated with each value category, (ii) that specific categories seemed to be of minor relevance, and (iii) the existence of overlaps between categories.

In the case of user value, the coding process revealed more detailed aspects of the expected benefits identified in the literature. For example, while contribution to the well-being and organisational performance was highlighted in the literature (Azcarate-aguerre et al., 2018), quality of living or working standard was operationalised by interviewees in terms of good indoor-climate, attractive interior and noise-resistant environments. Whereas interviewees most commonly mentioned aesthetical value, a discrepancy between the factors mentioned by different primary stakeholders was also apparent, suggesting that there is not as clear prioritisation of benefits associated with the user's experience of the building. The literature proposes that the limited access to future property users in the construction phases and the long-life cycle of buildings makes it difficult to take end-user needs into account in the design- and construction process (Debacker & Manshoven, 2016). While one interviewee suggested that the end-user tend to be distant in the development process of rental apartments, another mentioned how reducing their lead times was crucial to be able to meet end-user demands for new office space. While such differences may depend on the characteristics of the end-users (e.g. a corporation or private individuals), another developer of rental housing further suggested that the ability to adjust to changing demand among tenants was a key priority of the organisation. Hence, the perception of the end-users role and their ability to influence the design- and construction of the buildings seem to differ between actors.

While environmental value is in-line with the values derived in the literature review, mitigation of resource depletion and reduction of noise from construction sites was not mentioned by the interviewees, indicating that such environmental issues are of a lower priority. While energy efficiency and reduced toxicity was an essential requirement for all primary stakeholders, increasing attention also seemed to be given to the $CO^2$ footprint of materials and the construction process, where resource efficiency strategies may support a lowering of the climate impact. When comparing with legal and policy trends on EU and national level, there are considerable overlaps. Indeed, Kylili & Fokaides (2017) suggests that the Energy Performance of Buildings Directive (EPBD) has greatly influenced the design- and construction process of buildings by putting enormous pressure on the industry. Also, recent policy developments on an EU level have focused on resource efficiency and climate neutrality in the building construction industry. At the same time, the results from the interviews indicate that national voluntary environmental certification schemes highly influence the type of environmental aspects considered by primary stakeholders. Thus, designing value propositions in line with the aspects of focus in environmental certification schemes might be a potential avenue for proactively identifying opportunities for creating superior customer value.

The results indicate how the social value category was less relevant to primary stakeholders with regards to their choice of products and suppliers, except for the product's impact on the security of the workplace. This category was also less apparent in previous literature in the field of construction and circular economy. However, considerable overlaps exist between the social value category and the user value category. Here, a distinction is made between user value and social value based on the group which experiences the benefits, with user value only referring to the value created for end-users, while social value refers more broadly to benefits for society. Demonstrated value, such as "pleasant and socially secure environments" or "aesthetical value" could, however, arguably also be defined as social value as it includes benefits created for a broader stakeholder group than the end-users of the building. Hence, the conceptual framework could benefit from further distinction of the different categories.

In the conceptual framework, benefits related to the competitive advantage of the customer was proposed as a value dimension. While a broad set of values were described in the literature (including improvement of stakeholder relations, innovation opportunities and increased productivity), the results from the interviews highlighted factors such as impact on brand reputation, positioning in market and attractiveness to investors. However, these factors were not only considered in relation to the image of the organisation but rather in relation to the image of proposed developments. Despite how improving competitive advantage was sometimes a driver for considering, e.g. implementation of circular strategies, improvement of corporate or project image can arguably be framed as an outcome of the delivery of other benefits to the customer. For example, increased environmental performance of materials. Hence, it is suggested that all gains associated with this category can be tied to other value categories, such as environmental- or user-value.

Finally, the results verify the conceptualisation of informational value as an enhancer of other value categories, as suggested by Schenkel et al. (2015). The potential of information to support additional value capture was mainly perceived in relation to financial value, including risk minimisation by supporting of long-term functioning of the building and environmental aspects, and environmental value, by supporting the selection of materials with a reduced environmental impact. However, the potential of information to improve EoL handling did not dominate the perception of its added value, which is in contrast with the literature on CBMs and material passports (Arup, 2016; Guldager Jensen et al., 2019; Minunno et al., 2018). This could be explained by the allocation of responsibility in the value chain and the long-time horizons of building, which has been found to inhibit the adoption of circular strategies which provide benefits mainly at EoL, as suggested by Adams et al. (2017), Kibert (2016) and Arup (2016).

The findings contributed to a new conceptualisation of the value categories (see Figure 5-1), where the successful delivery of financial value is considered the basis of any new value proposition, and the competitive advantage is an outcome of the delivery of either (i) financial value (ii) user value (iii) environmental value or (iv) social value.

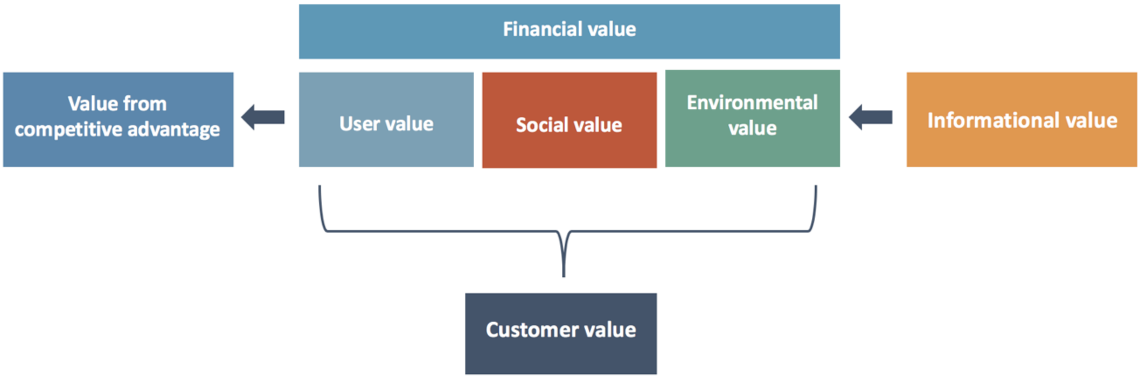


*Figure 5-1. Revised conceptualisation of value categories*

*Source: Developed by author*

## 5.2 The potential of circular strategies to deliver additional customer value

The benefits prioritised by key stakeholders have implications on the potential for capturing additional value by revising the value proposition of the case company following circular economy principles, as illustrated in section 4.2. The current value proposition of the case company is centred around the aspects of customisation and rationalisation through (i) high quality related to customisation and aesthetical values, (ii) cost management (i.e. budget control), (iii) reduced construction time (iii) predictability through customer assurance of the functioning of the façade elements. Thus, the current proposition focuses on the delivery of customer value in terms of financial risk minimization and user-value.

The results and the literature review indicate that additional value may be captured by embedding circular strategies in the value proposition. The opportunities associated with the proposed circular strategies suggest that implementation of such is perceived to capture additional benefits which can be related to the categories of user-value, financial value (reducing long-term costs and risk), and environmental value. Similarly, the literature review highlights several benefits which also relate to the categories of user-value, financial value and environmental value (for an overview, see section 2.2.1.). However, for design strategies, there seemed to be a discrepancy between the benefits identified in the literature review and the perceived benefits among interviewees. While the financial value such as long-term cost savings and retainment of asset value is both highlighted in the literature and by the interviewees, Surgenor et al. (2018) assert design strategies' potential for environmental value creation through reducing greenhouse gas emissions throughout the lifecycle. Also, the marketing opportunity associated with delivering increased user value through flexible spaces. This was further the case for the design for disassembly, which, according to the literature, may provide additional user value by reducing disruption caused by repurposing activities

(Surgenor et al. 2018). However, the interviewees only framed the benefits of design for disassembly in terms of environmental value. In contrast, the perceived opportunities identified by the interviewees of the lease- and service models in the operations phase is highly aligned with factors in the literature. This is also the case for business models which support proper handling at EoL, such as take-back system, where primarily environmental benefits are highlighted by both interviewees and previous literature. These findings suggest that a value proposition embedding circular design strategies may need to accurately communicate the associated benefits, as these may not be straightforward for the customer.

The results of this study have several implications on the feasibility of offerings based on circular strategies. First of all, the implementation of CBMs faces the challenge of split-incentives between actors in a fragmented value chain. The primary stakeholders were more inclined to identify opportunities with circular strategies when the benefits of such could be reaped under their ownership. For example, the perceived benefits of design for disassembly were limited, whereas several opportunities were identified with a design for flexibility. Indeed, the former was mainly considered to provide benefits at EoL while the latter was considered to provide both short- and long-term financial benefits. Split-incentives has also been identified as a significant barrier toward implementation of circular strategies in previous studies (ING, 2019; Kylili & Fokaides, 2017; Leising et al., 2018; Nußholz & Milios, 2017). Hence, this suggests that a circular value proposition may benefit from being tailored to the span of responsibility of the developer, investor or contractor. It further implies that separating customer segments based on short-term and long-term ownership might be beneficial to ensure a fit between the offering and the customer. Whereas circular strategies which create benefits in the early phases of the lifecycle (e.g. by reducing the environmental impact of construction) may be more prone to acceptability among actors which also operate at the beginning of the lifecycle, the opposite may be right for circular strategies which create more long-term benefits (e.g. by supporting longevity). This would imply that value proposition embedding circular design strategies may fit the business model of both short-term and long-term developers, investors and contractors, whereas circular use models focused on providing additional service may be more suitable to actors with long-term ownership.

Second of all, the long lifecycles of buildings make it difficult for actors at the beginning of the lifecycle to value potential benefits may occur at end-of-life even in cases where the ownership retained. This was, for example, the case for design strategies for disassembly, where some of the primary stakeholders pointed to the difficulty in knowing what the needs for ease of disassembly would look like in a long-term perspective. This is in-line with previous research, which suggests that the long-life cycles are a significant barrier for the realisation of circular strategies in construction, (see, e.g. Adams et al., 2017; Hart et al., 2019 or Kibert, 2003). Both the long-term perspective on the expected lifetime of buildings and the split-incentive between actors seem to further diminish the perceived added value of, e.g. leasing models of façade elements and take-back systems at EoL. This is illustrated by both a lack of perceived benefits and lack of customer acceptance of value proposition embedding these strategies, despite suggested financial benefits. This is in contradiction with the findings by Kyrö et al. (2019) who illustrated how users and clients were found to have a high acceptance of relocatable buildings provided through leasing services. However, the study by Kyrö et al. (2019) investigated three cases consisting of a hospital campus, care home and health-care centre. In this study, the interviewed primary stakeholders mainly provided residential properties, with a few exceptions where one developer and two contractors also worked within non-residential properties, e.g. commercial real estate. Hence, it might be that the properties developed for housing might find less need for adjusting space based on a fluctuating demand, as suggested by the lifespan estimated by some developers to between 50 to 100 years. Also, end-users were not interviewed in this study, thus, their perspective is not represented. This suggests that leasing models or take-back systems may be more suitability for buildings meeting a higher degree of fluctuating user-demands and designed for shorter or multiple use-phases. In such cases, the client's concerns linked to the ability of the focal company to execute such models long-term may be minimised due to a reduced time-horizon.

Thirdly, the external trends in the sector suggest the need for considering the implementation of strategies which seek to "narrow" resource loops in addition to "closing and slowing" accompanied by increased information provision concerning the environmental performance of the product offered. The increased focus of EU and national policy on the environmental impact of the early phases of the building process, including raw material sourcing, transports and material choices, is likely to influence the decisions of clients in the future. Especially if these are increasingly recognised in environmental certification schemes and legislative efforts, as the environmental issues prioritised by the primary stakeholders are aligned with the aspects accounted for in environmental certification systems. The increased focus on impacts in the early phases of the building process is illustrated by, e.g. the integration of aspects such as greenhouse gas emissions, resource efficiency, circular material cycles, and life cycle cost in the voluntary reporting framework Level(s) developed by the European Commission. Also, by initiatives on national levels, such as the requirement on a life cycle assessment on materials for public procurement of building and construction projects by the city of Copenhagen, and the planned introduction for obligatory climate declarations of the product and construction stage in for new developments the product and construction stage in Sweden. The requirements also stipulate improved information provision concerning the environmental performance of products and manufacturing processes. Hence, as several scholars have pointed out how circular strategies do not necessarily lead to resource efficiency or increased sustainability performance (see e.g. Pigosso, & Mcaloone, 2018), information provision to verify the environmental performance of the product offered, and integration of efforts to "narrow" resource loops, may both be considered vital to deliver environmental customer value.

## 5.3 Implementation of the re-designed value propositions

This study explored the opportunities for added value creation by embedding circular strategies into the value proposition of the case company. The value propositions which were deemed to have the highest potential for added value creation were the following: (i) longevity, (ii) circular inputs and (iii) recyclability. In the context of the case company and the interviewees of this study, the value proposition titled to "reusability" is deemed to face significant challenges in terms of achieving customer acceptance. This is likely to affect the viability of a business model embedding the circular strategies described in this model.

The following recommendations are made to the representatives of the case company representatives and similar organisations seeking to embark upon the implementation of circular strategies:

**Differentiate customer segments based on the type of property development and the actors' span of responsibility.** The results indicate how primary stakeholders tend to be more accepting of circular strategies from which they can reap the benefits off. Differentiating customer segments based on these factors might enable a better fit of the offer to the customer.

**Start with circular design strategies.** Circular design strategies, including design for adaptability, flexibility, disassembly or integration of reused or recycled inputs, are likely to require minor changes in the value creation and delivery and the value capture block of the existing business model of the case company. Circular design strategies also seemed to receive a higher degree of acceptance among the primary stakeholders of the company in comparison to circular use- or circular recovery strategies. Hence, circular design strategies may be attractive to primary stakeholders with a varying span of responsibility throughout the building lifecycle. The financial viability of circular design strategies is likely to be critical to reaching customer acceptance of the offering.

**Explore opportunities for creating added value through closer customer relationship.** The findings of this study indicate that "Circular Use Models", where increased service or maintenance is provided to customers to improve the longevity of the building, can create additional customer value by minimising risk. However, this is likely to be most attractive for the primary stakeholders which retain responsibility or ownership through a significant time of the building lifecycle, and where the additional service provided complements the activities of, e.g. service departments already in place. Potentially, components more prone to degradation (such as window frames) can be targeted. Benefits for the focal company include revenue diversification and increased customer loyalty through maintaining a close relationship with the primary stakeholder.

**Keep track of environmental performance.** The business analysis and the interviews reveal an increased focus on environmental issues beyond the energy efficiency in the operations phase in the building lifecycle. Several initiatives are also emerging to push the industry toward disclosing more information on the environmental impacts of sourcing, manufacturing and transportation of materials and building components. Having and disclosing such information is likely to be increasingly demanded by customers in the building construction industry. This may also increase the importance of environmental performance as a competitive factor. To obtain the highest reductions in environmental impacts, complementing strategies to slow and close resource loops with efforts to narrow resource loops (i.e. increase efficiency) should be considered.

**Assess the implications of the proposed value propositions on the other business model building blocks.** The scope of this study implies that implications of the re-defined value propositions on the other building blocks of the business model are not investigated. To embark upon the implementation process, further investigation and test of required changes in the value creation and delivery and the value capture building block of the business model to support the innovation will be necessary. For example, circular design models are likely to require changes in the value creation and delivery block of the business model, e.g. the adoption of new processes, alternative product design, and partnerships to ensure the design supports circular strategies in the operation- or EoL phase. Circular use models are likely to require new capabilities which support the delivery of e.g. additional service, while influencing the economic and revenue model, e.g. in terms of diversifying the revenue stream.

**Establish the purpose and explore partnerships for circular economy implementation.** The process of developing a sustainable business model should start by defining a clear sustainability purpose of the company (Bocken et al., 2018; Stubbs & Cocklin, 2008). Recognising the many barriers faced by single actors to contribute to a shift toward a circular economy, such as split incentives, there is a need for increased co-operation throughout the value chain. The current focus on the financial dimension of customer value may also inhibit the development of new solutions due to a focus on cost minimisation and risk reduction. Rohrbeck et al., (2013) suggests how CBMI between actors along the value chain provides an opportunity for co-creating business models and value networks which support the development of radical innovation. Working proactively with clients with similar ambitions or in projects with an increased focus on the total cost of operations may further provide additional room for testing and implementing circular business models.

## 5.4 Processes for value propositions design

Task one of this study was to explore how a process can be designed to help identify opportunities for adding value by the implementation of circular strategies. The process used in this study primarily built upon the process developed by Baldassarre et al. (2017), which combine insights from SBMI and user-driven innovation. The process covered three steps (see Table 5-1) and resulted in the development of four value propositions which embeds circular strategies, where three were deemed to have potential to reach customer acceptance and to deliver added customer value. In this section, a discussion concerning the functioning of the process is provided.

*Table 5-1. Overview of the process for value proposition re-design*

| | **Thinking** | **Talking** | **Testing** |
|---|---|---|---|
| **Objective** | Literature review and business analysis to identify circular strategies and inform stakeholder interaction. | Identify stakeholders and (i) the challenges and opportunities in the construction sector for added value creation and (ii) the perception of circular strategies. | Development and test of value propositions based on customer acceptance and sustainability potential. |
| **Activities** | • Literature review<br>• PESTEL analysis | • Semi-structured interviews<br>• Design and send-out of assessment questionnaire | • Development of value propositions<br>• Design and send-out of the assessment questionnaire<br>• Comparison of value propositions based on criteria |
| **Outcome** | Development of interview guidelines | Understanding of critical factors influencing customer value creation | Identification of value propositions with potential for added value creation. |

*Source: By author based on (Baldassarre et al. (2017).*

Whereas Baldassare et al. (2017) started the process by defining a sustainability problem, a different approach was taken in this study. Instead, it was initiated by a literature review and business analysis to identify key trends and circular strategies which informed the design of the interview guide and the assessment questionnaire used in the talking phase. Building upon design-thinking, defining the problem, was seen as a creative act. Hence, the interviews were used to further delineate the issues which customers face and assess the potential for added value creation by circular strategies (Vorbach et al. 2019). This was found suitable considering how the sustainability issues faced by the building construction industry and the focal company of this study are multifaceted, whereas the focus on a single issue might have limited the perspectives on the potential for added value creation.

Semi-structured interviews with primary and secondary stakeholders was the main method for stakeholder interaction. Broadening the interview sample to also include secondary stakeholders was found valuable as it contributed to a more holistic perspective of value creation in the industry and for different stakeholders operating at various stages of the building lifecycle. As the building construction industry is highly fragmented and the realisation of circular strategies often reacquires functioning collaboration throughout the value chain, attaining these perspectives is arguably important when developing new offerings for CE implementation. However, if the goal would be to identify conflicting values and opportunities for creating shared value between a broader set of stakeholders, the process would have benefitted from proactively involving a broader range of stakeholders, including non-industry actors and competitors, as suggested by Bocken et al. (2013).

A challenge in the *talking* phase was to attain the stakeholders' perceptive on the benefits and drawbacks of the different circular strategies proposed during the interviews. This was experienced to a higher degree with more radical ideas which would enable significant changes to the current business model of the case company (e.g. take-back systems or leasing models for façade elements), and to a lesser extent with less radical ideas, which are more in-line with the current business model of the case company (e.g. design changes of the façade elements). This might be due to the novelty of such solutions, which makes it difficult for stakeholders to evaluate perceived benefits and drawbacks. However, by comparing the respondent's perception of the benefits of circular strategies with the proposed benefits in the literature, this contributed to (i) insights into the alignment between these, (ii) identification of the need for additional communication of the benefits of an offer based on circular strategies (iii) and insights into the perceived barriers of implementation hindering customer acceptance. Hence, considering the novelty of circular strategies in the building construction industry, data triangulation was an essential step to distinguish between stakeholders' *perceived* benefits and disadvantages and *potential* benefits and disadvantages as identified in academic and grey literature.

Multiple factors influencing customer value for each of the value categories were identified from the interview data. An assessment questionnaire was used to verify the relevance of these factors and test alignment between actors. A drawback of this method of validation was the difficulty of attaining respondents. An alternative approach would be to use a co-creation session which involves the user in the development process and create alignment between actors (Vorbach et al., 2019). This might have reduced the numerous factors identified from the interviews. Similar, using a co-creation session could have mitigated issues related to lack of responses while allowing for more thorough feedback in the testing phase when assessing customer acceptance of the developed value propositions. However, the timing and geographical distance between stakeholders made such a process difficult to pursue in the context of this study.

The development of value proposition, in the *testing* phase, was based on the results from the *thinking* and *talking* phases of the process, in contrast to the processes used by Baldassare et al. (2017) which included a higher degree of active involvement and co-creation between stakeholders. Despite how co-creation allows for a higher degree of involvement of stakeholders in the development process, this would also require a higher degree of resources from stakeholders, which may not be feasible. Instead, primary stakeholders were involved at this stage through an assessment questionnaire developed with the purpose of providing an indication of customer acceptance which was not possible to attain through the interviews.

A drawback of the assessment questionnaire as a method for testing customer acceptance is its inability to assess the problem-solution fit. Hence, the potential for the value proposition to deliver its intended benefits could not be verified as in the process defined by Baldassare et al. (2017) and Ries (2011) were an MVP was developed. This is, however, difficult to overcome as verifying the benefits defined in the value proposition would require the implementation of the circular strategies, for which the benefits are realised at different lifecycle stages at the building value chain, and thus during a considerable long-time span. Despite this drawback, the approach used provided insights into how the stakeholders responded to the combination of circular strategies into a specific offer, which was difficult to assess through interviews. For example, whereas the interview data suggested that primary stakeholders seemed to associate limited benefits with design strategies to improve disassembly at EoL, the value proposition which embedded design for disassembly was considered a viable proposition among all respondents in the assessment questionnaire. This illustrates how the process of re-designing value propositions benefits from involving stakeholders at different stages of the process to test assumptions.

The comparison of value propositions using the criteria identified in the literature provided an assessment of its alignment with the SBM literature. However, specific criteria seem to have limited relevance for achieving the purpose of the comparison, which was to identify the sustainability potential of the value propositions. For example, Pádua et al. (2018) stipulate that value proposition should integrate multi-disciplinary knowledge and be based upon an assessment over time regarding opportunities and the value created and delivered, destroyed or missed. These criteria seem applicable not as a criterion for the value proposition per se, but rather as a guiding principle in the process of developing or re-designing value propositions (e.g. through multidisciplinary teams), which is also suggested by Geissdoerfer et al., (2016). Furthermore, the necessity of the criteria which stipulates that the value proposition should be based on radical innovation can be questioned. Arguably, implementing many of the circular strategies as outlined in this study would not require a radical product, process, or organizational innovation, i.e. innovation based on a high degree of novelty, which radically breaks with what existed previously (Teece, 2010). Instead, incremental innovation, i.e. an improvement of existing products, process or organizational methods, would be necessary (Souto, 2015). Still, the literature review indicates how the circular strategies identified in this study have the potential to deliver improved environmental, social and user value. Hence, it can be suggested that the criteria for radical innovation may not be necessary as a sustainable criterion for value propositions in CBMs. Following the suggestions made in this section, an updated version of the criteria for developing value propositions in CBMs is provided in Table 5-2 below.

*Table 5-2. Overview of criteria for sustainable value propositions in CBMs.*

| **Criteria** | | |
|---|---|---|
| 1. | The value proposition embeds circular strategies. | Geissdoerfer et al., 2018; Manninen et al., 2018; Nußholz, 2017 |
| 2. | The value proposition supports the proactive preservation of the embedded value of products and components at the highest level possible. | Nußholz, 2017; Uusitalo & Antikainen, 2018; Whalen, 2019 |
| 3. | The value proposition is based on an assessment of the value created and delivered, destroyed or missed and opportunities to be captured in the future. | Pádua et al. 2018; Bocken et al., 2013; Geissdoerfer, Bocken, & Hultink, 2016) |
| 4. | The value proposition includes of a lifecycle thinking approach meaning that the value proposition and identified opportunities address the beginning, middle and end of the lifecycle. | Manninen et al., 2018; Pádua et al., 2018 |
| 5. | The value proposition balances the needs from a triple-bottom-line perspective and ensures societal well-being. | Baldassarre et al., 2017; Boons & Lüdeke-Freund, 2013; Evans et al., 2017; Geissdoerfer et al., 2018; Pádua et al., 2018 |

| | |
|---|---|
| 6. The value proposition internalises externalities. | Baldassarre et al., 2017; Boons & Lüdeke-Freund, 2013; Evans et al., 2017; Geissdoerfer et al., 2018; Pádua et al., 2018 |
| 7. The value proposition adds extra value or benefits in comparison to market competition. | Lewandowski, 2016; Pádua et al., 2018 |

*Source: By author*

In summary, the employed process was found suitable for achieving the aim of identifying opportunities for superior customer value creation through implementation of circular strategies, where the outcome was the development, assessment and selection of three value propositions. In comparison with the approach developed by Bocken et al. (2013), the process goes beyond the identification of value creation opportunities and supports the formulation of value propositions. The process is also likely to require fewer resources when compared with the process for sustainable value proposition design put forward by Baldassare et al. (2017). However, the process identified by Baldassare et all (2017) offers a higher involvement of end-users in the development process and a strategy for assessing the problem-solution fit, which was not feasible in the context of this study.

## 5.5 Implications of methodological choices

### *Analytical approach*

This study sought to explore the opportunities to capture additional value through circular economy implementation. This thesis sought to fill in gaps in the poorly researched area of value proposition re-design in CBMs in the context of the building construction industry. Hence, a conceptual framework was developed based on previous research to develop categories, or themes, of importance to the primary stakeholders of the focal company. A similar approach has been adopted in previous research, e.g. by Schenkel et al. (2015) who investigated value creation for stakeholders in closed loops supply chain and divided value creation into the dimensions of economic, customer and environmental and social value creation. The conceptual framework of this study sought to narrow down the concept of customer value into more elaborated categories. In hindsight, having a more explicit focus on the jobs-to-be-done, pains and gains, and potential pain relievers and gain creators of primary stakeholders, as proposed in traditional management literature (Vorbach et al., 2019), might have provided a deeper understanding of primary stakeholder's needs and thus the potential for circular strategies to address such. However, the conceptual framework used in this study was found valuable in terms of creating an overview of factors which influenced value creation for primary stakeholders by allowing a differentiation based on outcome (e.g. environmental value) rather than customer experience (e.g. the positive and negative features to be attained or avoided). Future research might seek to combine the conceptual framework developed in this study, with a more in-depth analysis of the jobs, pains and gains, and potential pain relievers and gain creators of primary stakeholders, as this may widen the focus of customer value to include multiple dimensions (e.g. also focusing on environmental and social value), while still allowing for an in-depth analysis of customer's needs.

### *Interviews and assessment questionnaire*

The interview sample should be taken into consideration when interpreting the findings of this study. Both primary and secondary stakeholders were consulted, based on the ambition of going beyond the singular focus on value creation for the primary stakeholder apparent in traditional business management literature. While this contributed to broaden the understanding of opportunities and barriers associated with circular strategies and value creation from a sectoral perspective, the findings could have been strengthened by a more purposeful selection of secondary stakeholders based on the six stakeholder groups identified by Bocken et al. (2013) in sustainable business modelling. These include customers, investors and shareholders, employees, suppliers and partners, the environment and society. By proactively involving a broader range of stakeholders, including non-industry actors and competitors, this might have uncovered increased opportunities for creating shared value (Bocken et al., 2013) and it might also have uncovered group comparison of responses including potential conflicting values. The reliability of the findings could further have been strengthened by increasing the sample size and the representation of the different type of primary stakeholders (8 primary stakeholders were interviewed). More specifically, including primary stakeholders who represent different customer segments and inhibits different roles in the building value chain. For example, the suppliers of the focal company were not consulted in this study, and the reliability of the results could have been strengthened by including more investors and developers operating outside the rental housing market. Availability of these stakeholders represents a limitation of the presented findings, as these could have provided additional perspectives on the potential for added value creation by embedding circular strategies in the value proposition. The business analysis was conducted to counterbalance this deficit.

An assessment questionnaire was conducted to validate the results from the semi-structured interviews and test the developed value proposition. The questionnaire further offered a process of member-checking, as it served as an instrument to also determine the accuracy of the qualitative findings from the semi-structured interviews (Creswell, 2014). However, the assessment questionnaire was only directed at the primary stakeholders of this study as these were of primary interest for the unit of analysis, the value proposition. A shortcoming of the assessment questionnaire in terms of verifying the findings was the lack of responses from all the primary stakeholders interviewed in this study. Hence, this should be taken into consideration when interpreting the results.

# 6 Conclusion

This section will outline the main conclusions in regard to the research question and outline the practical and theoretical contribution of this study.

The research aimed to answer the following research question:

*RQ: How can a large manufacturing company in the building construction sector create superior customer value by re-defining its value proposition in line with circular economy principles?*

Findings show that financial value, more specifically reduced costs and risk minimisation, dominates the perception of value creation among primary stakeholders. This implies that delivering higher or equal financial value as conventional offers are critical for achieving customer acceptance of circular value propositions. The findings also indicate that charging a premium is largely omitted as an opportunity associated with circular strategies as end-users are reluctant to pay for public environmental benefits of sustainable construction. While financial value is considered a prerequisite for creating customer value, the findings of this study suggest that customer value can be categorised into six categories: financial value, user value, environmental value, social value, informational value, and value derived from competitive advantage. Whereas informational value is seen as an *enhancer* of other values, competitive advantage is seen as an outcome of the *delivery* of other value categories.

In this research, three suggestions for re-designed value propositions were developed, which have the potential to deliver enhanced customer value. These may be implemented separately or combined. Currently, the case company value propositions centres around customisation and rationalisation of the construction process and delivery of customer value in terms of reducing financial risk and delivering value for the end-user by high aesthetical quality.

The **first suggested value proposition** builds on principles of *longevity*. It seeks to slow resource loops by extending the useful life of the façade elements. It was found to provide additional value by minimising risk and reducing environmental impact. It was found to better fit customers with a long-term financial interest in the functioning of the building and hence more suitable for property owners with long-term ownership interested in simplifying maintenance and enabling long-term repurposing. Modification and durability need to be balanced, as durability seem to be of higher concern to most customers.

The **second suggested value proposition** is titled *circular inputs*. It seeks to slow resource loops through integrating reused inputs and components in the manufacturing of new façade elements. It was considered to be a viable option for all respondents, however, as the benefits were mainly framed in terms of environmental benefits of offsetting primary production, the need for also delivering equal product characteristics (quality and cost) in comparison with alternatives solution was emphasised.

The **third suggested value proposition**, *recyclability,* sought to close or slow resource loops through designing façade elements for reuse or recycling at EoL. The offering sought to provide mainly environmental benefits, which could be reaped at EoL. All respondents indicated a high level of acceptance of the offering, mainly motivated by external pressure to increase reuse practices. A drawback of the offering is that it does not allocate responsibility for reuse or recycling activities at EoL. Thus, it is important that the design of the building follows the technical specifications which allow for proper handling at EoL. The façade elements also need to be designed with future use and technical requirements in mind, as the risk of secondary elements being outdated quicker than virgin alternatives is a barrier to achieve reuse.

A potential value proposition that received less support by participants is an offer based on a leasing model or a deposit-system for façade elements. In this model, the focal company would retain ownership and thus be responsible for reusing the façade elements at EoL. Findings suggest that this value proposition would face significant difficulties in achieving customer acceptance, mainly due to the long-lasting and low-tech characteristics of the product. However, the offering may be viable for a customer who needs to address a more fluctuating demand for space, where buildings or components designed for several shorter use-phases may be a potential solution, as indicated by the findings of Kyrö et al., (2019).

Two key barriers that influence the feasibility of circular-based offers were identified. These include (i) *split-incentive* between actors and (ii) *the long lifecycles of buildings*. The *split-incentives* makes it crucial that different customers span of responsibility is taken into account when adopting circular strategies, as actors who do not retain ownership of the building after construction may experience a lack of incentive in investing in solutions which generate long-term benefits. The *long lifecycle of buildings* further makes it difficult to implement circular business models where the focal company seeks to retain ownership and e.g. lease façade elements.

Finally, whereas strategies to "narrow" resource loops were not included in the scope of this thesis, the findings suggest the need for accompanying circular strategies with strategies to narrow resource loops as the climate impact and resource efficiency of the early phases of construction is increasingly recognised in policy and environmental certification systems for buildings.

## 6.1 Contribution to practice and theory

This study sought to contribute to the emerging field of CBMI in the building construction industry, from a customer value perspective. Previous studies have found that customer acceptance of new value propositions is fundamental for succeeding with CBM. By building on the process for value proposition re-design developed by Baldassare et al. (2017) in the SBMI literature, this study exemplifies how the process can be adapted to the specific context of a manufacturing company in the building construction sector and support the development and initial testing of value propositions embedding circular strategies. Hence, this study provides practitioners and scholars with insights into how value propositions can be re-designed in a way that enables companies to capitalise on circular strategies.

In-line with the objective of this study, aspects to be considered for customer acceptance when implementing circular strategies are identified. First of all, the study reveals that circular strategies have the potential to deliver improved customer value, but that the value proposition needs to provide equal or similar financial value for the customer as the market competition. This is in-line with previous findings which emphasise how financial value is of high prioritisation for investors and developers (Azcarate-aguerre et al., 2018; Debacker & Manshoven, 2016), however, this study suggests that risk minimisation in addition to short term financial value is a critical driver of customer value as suggested by Schenkel et al. (2015) who investigated value creation in closed-loop supply chains. Secondly, this study contributes to the emerging research field of CBM in the building construction sector by establishing a higher degree of acceptance for circular design strategies to slow or close resource loops, when compared to circular strategies which necessitate alternative business models (e.g. leasing models of façade systems). Thirdly, the study identifies two key barriers which are inherent to the construction sector and need to be managed when implementing circular strategies; split-incentives and the long-lifecycles of buildings, as these affect the customer acceptance and thus the feasibility of circular economy implementation. This confirms findings from previous research which suggest that the long-lifecycle of buildings (Adams et al., 2017; Hart et al., 2019; Jones & Comfort, 2018; Kibert, 2003) and the split-incentive between actors (ING 2019; Kylili & Fokaides, 2017) constitute barriers to the adoption of strategies which improve the sustainability or circularity of buildings.

## 6.2 Suggestions for future research

Firstly, the dominant focus on financial value creation and the risk-averse characteristics of the building construction industry, in combination with split-incentives and the long lifecycles of building, are likely to constitute barriers for the implementation of circular strategies in the building construction sector, especially strategies embedded in *circular use* and *circular recovery* models. Emerging research on the topic of CBMI suggests that circular oriented innovation practices can be used to co-create best practices and guidance and mitigate complexity (Brown, 2019). Hence, to overcome these barriers, future research may investigate the potential of CBMI between value chain actors in the building construction industry to support the development of CBMs which more effectively distribute incentives for strategies which promote durability, reuse or recycling activities at EoL, in the early phases of the building lifecycle.

Secondly, future research may also investigate the potential for new financing models, which promotes the adoption of circular strategies in the building construction industry. The increased value of circular strategies tends to lie in the future, whereas financing occurs in the present, which creates a lack of short-term financial incentives for adopting circular strategies (ING, 2019; Kylili & Fokaides, 2017). Therefore, development and implementation of new valuation methods, which more adequately reflects long-term financial gains, e.g. improved residual value, adaptability or durability, might be an area suitable for further investigation.

Thirdly, future research may also seek to explore the potential for policy interventions to support the cost-effectiveness of circular strategies. For example, policy interventions which mitigate current challenges related to the competitiveness of reused materials, such as high cost, availability and perceived risks of failure, when compared with virgin materials.

Finally, the conceptual framework developed and revised in this study may benefit from further testing among a large variety of actors in the building construction industry. It could also be further merged with the value proposition canvas to create a tool for practitioners which supports value proposition re-design, acknowledges the variety of dimensions which contribute to creating customer value, and is aligned with the triple-bottom-line.

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# Appendix

## 6.3 Appendix A - Overview of interviewees

An overview of the interviewees is provided, separating primary and secondary stakeholders. The name of the interviewee, his/her position, and the company represented is excluded to preserve the confidentiality of the interviewees in this study.

| **Interviewee group** | **Organisation** | **Position** | **Country** |
|---|---|---|---|
| Primary stakeholder 1 | Developer: Rental housing | Manager of development | Sweden |
| Primary stakeholder 2 | Developer: Rental housing | Project manager | Sweden |
| Primary stakeholder 3 | Developer: Rental housing, private housing, office buildings | Project manager | Sweden |
| Primary stakeholder 4 | Developer: Rental housing | Architect | Denmark |
| Primary stakeholder 5 | Developer: Private housing and office buildings. | Chief communications officer | Denmark |
| Primary stakeholder 6 | Investor: Municipal Organisation | Sustainability manager | Sweden |
| Primary stakeholder 7 | Contractor | Sustainability manager | Sweden |
| Primary stakeholder 8 | Contractor | Managing director | Denmark |
| Secondary stakeholder 1 | Business Development Organisation | Senior investment manager | Sweden |
| Secondary stakeholder 2 | Demolition firm | Sustainability manager | Sweden |
| Secondary stakeholder 3 | Waste Handling and Recycling Firm | Business developer | Sweden |
| Secondary stakeholder 4 | Investment agency: Sustainable Cities & Circular Economy | Senior investment manager | Denmark |
| Secondary stakeholder 5 | Consultancy firm: Circular Economy | Senior consultant | Denmark |
| Secondary stakeholder 6 | Network organisation: sustainable urbanisation | Director | Denmark |
| Secondary stakeholder 7 | Building network | Managing director | Denmark |
| Secondary stakeholder 8 | Architectural firm | Architect | Denmark |

## 6.4 Appendix B - Sample interview guide

The interview guides were adapted during the interview process to fit the context of the interviewee (primary or secondary stakeholder) and to address new topics which emerged during interviews. The sample interview guide below includes all questions included in the interview guides, excluding probes.

1. How are sustainability concerns taken into considerations in your day-to-day operations?

2. Do your organisation work with CE today?
    a. If yes: To what extent and how? Examples? What are the key drivers?
    b. If no: What would be the key drivers for you as an organisation to engage in CE?

3. What are the qualities of importance when you think about the design, production and construction of façade elements?

4. What are the factors which decide a contractor or developers' competitiveness in tenders?

5. What are the challenges faced by developers, contractors or investors today with regards to development of new properties?

6. What pros and cons do you think the following strategies would bring for a developer, contractor or investor if employed?
    a. Circular design
        i. Design for disassembly to enable reuse of recycling of components.
        ii. Design for flexibility/adaptability to enable adjustments of space.
        iii. use of non-toxic and/or fully recyclable materials
        iv. use of reused and/or recycled materials
    **b.** Circular use
        i. Product-as-a-service: Extension of services (maintenance and repair of elements)
        ii. Product access-as-a-service: Lease of façade elements.
        iii. Material passports
    **c.** Circular recovery models
        i. Take back schemes of façade elements.

7. Could you rank which of these strategies would have highest potential for value creation for the developer, contractor or investor?

8. To implement these strategies, what are the other benefits which need to be provided?

9. What are performance indicators used in the design and construction process to follow up results?

10. What sustainability concerns is currently at focus in the construction sector? How are these taken into concerns in relation to other issues?

11. To what extent would you say that actors within the construction industry are starting to work with CE today?

## 6.5 Appendix C - PESTEL analysis

### 6.5.1 Political trends

#### *EU level*

There are several initiatives on an EU level which sets the strategical direction for the European construction industry.

**The roadmap to a resource efficient Europe** communicated by the European Commission in 2011 (COM(2011)571) sets out the vision for an EU economy which has developed with respect for resource constraints and within the limits of the planetary boundaries. Buildings represent one of the prioritised areas, where the strengthening of existing policies for energy efficiency and renewable energy is suggested together with policies for resource efficiency. The roadmap puts significant emphasis on achieving improvements in resource and energy use throughout the lifecycle of buildings, by the use of improved sustainable materials, the achievement of higher recycling rates of Construction and Demolition Waste (CDW) and improved design.

**The Strategy for the sustainable competitiveness of the construction sector and its enterprises** communicated by the European Commission in 2012 seeks to stimulate businesses in the construction sector and increase competition. The strategy outlines both short- and long-term measures which will boost resource efficiency and environmental performance, improve the human-capital basis, and create business opportunities and favourable investment conditions. These include: 1) *financing and digitalization* to promote energy efficiency measures in existing building stock but also to promote R&I more broadly in the sector; 2) *skills and competencies* to ensure that the workforce meet future demand for new competences associated with sustainable construction policy objectives; 3*) resource efficiency*, targeting recycling and valorisation of construction waste and low-emission construction recognizing the high resource- and energy consumption of the sector; 4) *regulatory framework*, emphasizing the need for reducing the administrative burden for companies and ensuring that the legal framework is predictable to support the strengthening of the internal construction market; and finally 5) *international competition* with efforts seeking to strengthen European firm's capabilities to participate in international markets (COM(2012)433). This includes measures such as promoting the uptake of Eurocodes, a series of technical standards for the structural design of the building (European Commission, n.d.-a), and increasing contractual agreements in non-EU countries (COM(2012)433).

The European Commission's Communication on **Resource efficiency opportunities in the building sector** seeks to promote a more efficient resource use and reduce the environmental impact of buildings throughout the lifecycle. The initiative highlights how decisions in design and choice of construction materials determine to a high extent the resource use in buildings. The initiative emphasises how a lack of reliable and comparable data, tools and methods to support benchmarking of the environmental performance of different solutions hinders the achievement of more resource-efficient buildings. The initiative sets out the plan for collaborating with member states on several issues, including how to stimulate the use of reused and recycled products. Some of the proposed areas for further collaboration include: How to divert CDW from landfilling and backfilling; integrating external environmental cost in the price of virgin materials; measures to ensure recycled materials meet quality and safety standards (e.g. through standardisation or certification); promoting the demand for recycled inputs in construction materials; and development of tools for assessment of buildings prior to demolition (COM(2014)445).

The built environment is one of the prioritised areas in the initiative **Closing the loop - European Action Plan for Circular Economy** (COM(2015)614) which presents the action plan for how EU shall realise the vision of a transition to a circular economy. For the built environment, increasing the reuse and recycling of CDW and stimulating design improvements which reduce the environmental impacts of buildings and supports life-extension through design for durability and recyclability of components are emphasised.

To support the implementation of CE strategies and improve the sustainability performance of buildings, the European Commission introduced the voluntary reporting framework Level(s) in 2017. The framework integrates existing standards to provide a common approach to assessing environmental performance in the built environment in the EU. It seeks to support lifecycle thinking as well as progress toward the sustainability issues prioritised on an EU levels which encompass the following strategic areas: 1) Greenhouse gas emissions throughout the building's lifecycle; 2) Resource efficiency and circular material life cycles; 3) efficient use of water resources; 4) healthy and comfortable spaces; 5) adaptation and resilience to climate change; 6) life cycle cost and value. Currently, the test period of the framework runs until the fall of 2019 (European Union, 2017)

To improve the handling of CDW streams on the national level, the European Commission introduced the EU Construction and Demolition Waste Protocol and Guidelines in 2018. The initiative consists of non-binding guidelines to provide the industry, government authorities, certification bodies and clients of recycled materials with support to improve the handling of the waste stream. Guidelines for waste audits providing best practice examples of how to assess waste streams prior to renovation or demolition of buildings and infrastructure to support reuse and recycling efforts was further published in 2018 (European Commission, 2018b).

## National level: Sweden

In the Swedish context, the deficit in the housing stock experienced in many municipalities sparked initiatives which seek to investigate how to modernise the regulatory framework for the building and construction sector.

For example, the Building Rules Modernizations committee was created in 2017 with the task of reviewing the current regulations in the building- and construction sector (in specific PBA, PBF, BBR and the regulations on the application of the EN Eurocodes which are described under "legal" factors) and suggest measures to stimulate increased competition on the market and overall construction (Dir. 2017:22.). The committee produced two interim reports on the topics of standardisation and resource-efficient use of building materials. In both areas, barriers and suggested measures were proposed (for an overview, see Table 0-1) (SOU 2017:106, n..; SOU 2018:51, n.d.). In terms of resource efficiency, the current voluntary system of construction product declarations in place in Sweden was found insufficient by both construction industry actors and government agencies on a national level as it is not used by all suppliers in the industry. A product declaration list is projected to have several benefits, including improved traceability of hazardous materials, reduced risks associated with the use and disposal of hazardous materials, enable more detailed procurement criteria for construction products, promoting recycling and reuse activities as well as supporting markets for reused and recycled materials, components and building products (SOU 2018:51)

*Table 0-1. Barriers and proposed measures: Standardisation and resource efficiency within the construction sector*

| **Topic: Standardisation of construction materials** | |
|---|---|
| **Barrier** | **Proposed measures** |
| Lack of functioning collaboration between stakeholders in the sector leading to (SOU 2017:106)<br>- Lack of knowledge of standardisation<br>- Deficient information, inadequate representation in standardisation committees<br>- Costs of standards. | Appointment of a national coordinator to support the Swedish Standards Institute (SIS), the building industry and the national board of Housing, Planning and Building in further cooperation regarding standardisation in construction (SOU 2017: 106). |
| | Establishment of a national government agency council on building standardisations is proposed to increase the efficiency of standardisation within construction (SOU 2017: 106). |
| | The government's co-finance of the Swedish Standards Institute (SIS) should take into consideration the need for strengthening the standardisation of building and construction (SOU 2017: 106). |
| **Topic: Resource efficiency of construction materials** | |
| **Barrier** | **Proposed measures** |
| Lack of information concerning the content of construction products which leads to (SOU: 2018:51) | The Swedish Government should work for inclusion of a requirement for lists of contents of construction products in the EU's Construction Products Regulation (SOU: 2018:51) |

| | |
|---|---|
| - Hindering of reuse and recycling efforts.<br>- Ignorance concerning the substances and materials used in construction with a potential adverse effect on human health and environment. | |
| Lack of economic incentives to reuse and recycle construction products (SOU: 2018:51) | Implementing a promotion package to support resource-efficient choices of building materials to drive developments and support knowledge dissemination of resource-efficient use of building materials. Include (SOU: 2018:51):<br>- Coordination efforts to increase demand for building products with high reuse and recycling potential.<br>- Subsidies to research- and innovation projects to accomplish zero-waste buildings<br>- Increased knowledge dissemination |

*Source: Author*

The target for reuse, recycling and material recovery of CDW in the EU Waste Framework Directive (2008/98/EC) is embedded into the environmental objectives system agreed upon by the Swedish parliament in 1991 which sets the overall aim for the Swedish Environmental Policy. It stipulates that a minimum of 70 per cent of non-hazardous CDW reuse, recycling and material recovery of CDW should be achieved by 2020. Currently, a lack of data concerning waste streams from the construction- and demolition industry makes it difficult to estimate goal fulfilment. Despite the lack of quality statistics, the EPA suggests that the general trend points toward difficulty in reaching the target on time (Swedish Environmental Protection Agency, 2018). To address this issue, efforts to improve the statistics has been suggested. To increase the reuse and recycling potential of materials and building components, a key focus has also been on reducing the amount of hazardous materials in use (Høibye & Sand, 2018). The government also appointed a delegation for circular economy in 2018, to accelerate the transition to a resource-efficient, circular and biobased economy (The Swedish Government Offices, 2018)t

The climate impact of buildings is also receiving increasing attention and there has been a growing political interest for policies which may reduce the climate impact of buildings. In 2017, the national board of Housing, Planning and Building was commissioned by the Swedish Government to investigate the conditions under which the sustainability of the building process could be improved, as well as how to increase the use of sustainable materials. They were also commissioned to propose a method for how to calculate and declare the climate impact of new buildings using a lifecycle perspective. In 2018, the agency proposed four measures (The National Board of Housing Planning and Building, 2018d).

- Development of guidelines concerning life cycle assessments of buildings.
- Introduction of climate declarations for buildings (described in more detail under "legal" factors").
- All government authorities, in their roles as property owners, developers and renters, should strive for a reduction of greenhouse gas emissions in the construction- and building sector.
- The procurement agency and the national board for housing, planning and building should be commissioned to develop criteria for public procurement to reduce

greenhouse gas emissions from buildings. These criteria should complement the procurement agencies voluntary criteria's that public procurer can use to put environmental demand during public procurement.

In addition to the proposed measures, the agency also highlights the potential for further investigation of instruments for reducing the climate impact of the building sector. These include cut-off points for greenhouse gas emissions from new buildings, bonus-malus for buildings as well as investment support to developers (The national board of Housing Planning and Building, 2018:5)

A focus on climate neutrality also seems to dominate the political agenda of the construction industry. In 2015, the initiative fossil-free Sweden was initiated by the Swedish Government with the purpose of accelerating the country's transition toward a fossil-free nation. The initiative seeks to provide a platform and space for dialogue and collaboration between industry actors, local governments and other actors seeking to take action to reduce fossil fuel use (Fossil Free Sweden & The Concrete Initiative, 2018). Following the government initiative, roadmaps for achieving climate neutrality by 2045 on a sectoral level has been developed by both the building- and construction industry and the concrete industry. The roadmap for the building- and construction industry was signed by 74 actors in 2018 and sets out five milestones for reaching the goal of carbon neutrality (Fossil Free Sweden, 2018a):

- 2020-2022: Actors in the building- and construction industry have mapped out their greenhouse gas emissions and adopted climate goals.
- 2025: Greenhouse gas emissions within the sector are decreasing.
- 2030: Greenhouse gas emissions have been lowered with 50 per cent compared to the 2015-level.
- 2040: Greenhouse gas emissions have been lowered with 75 per cent compared to the 2015-level.
- 2045: Zero net emissions.

It is estimated that current technology might support a reduction of the climate impact of the sector by 50 percent by 2030. Yet, to reach zero emissions, the roadmap emphasises the need for new technologies and commercialisation of innovations. To support this development, the key factors in reaching a climate-neutral building- and construction sector is summarised as: (1) *cooperation, leadership and knowledge;* (2) *regulations and policies* to drive investments and support the use of climate-neutral materials and processes; (3) *circular processes*; (4) *supply and efficient use of bio-based resources*; and (5) *public procurement.* Also, the need for the adoption of a lifecycle perspective in the built environment is advocated. The potential of circular strategies to reduce negative climate impact and contribute to cost reductions by minimising waste and increasing resource efficiency is further stressed (Fossil Free Sweden, 2018a).

The roadmap developed by the concrete industry states that that climate-neutral concrete shall be accessible on the market by 2030. On the short term, the target is to half the climate impact of concrete for buildings within five years from the publication of the roadmap. Key prioritises to ensure the goal is reached is described as (1) *an increased use of concrete with low climate impact;* (2) *continued development of the concrete mix;* (3) *use of alternative admixtures, optimisation of design;* (4) and *lower climate impact from transportation* (Fossil Free Sweden, 2018b).

On a local level, actors within the building- and construction industry have developed their roadmap for achieving a climate-neutral building- and construction industry in the city of

Malmö by 2030. Thus, reducing the timeline for goal fulfilment by fifteen years in comparison to the national strategy. The initiative emphasises the need for climate-neutral building materials; climate neutral management, operation and maintenance; and climate-neutral construction sites and transportation. Similar to the national roadmap for a climate-neutral building sector, circular economy and resource efficiency is emphasised. Specific strategies include selecting building components with regards to function, CO2 footprint and circular potential (LFM30, 2019).

### National level: Denmark

Climate neutrality is also on the political agenda in Denmark. On a national level, the government of Denmark announced their new climate- and air proposal in 2018, "Together for a greener future", which sets the target for achieving a climate-neutral society by 2050 (Copenhagen Capacity, 2019) This was followed by an announcement in June 2019 that the newly elected government in Denmark will raise the country's climate targets by promising a new political direction based on an ambitious climate manifesto (Farand, 2019).

On a local level, the city council of Copenhagen adopted the CPH 2025 climate plan in 2012 which sets out a roadmap for becoming the first climate-neutral capital in the world by 2025. The plan is based on four pillars, which encompass energy production, energy consumption, mobility and city administration initiatives. Concerning the construction industry, the strategy mainly focuses on how to increase energy efficiency by coordinating the design- and construction phases with the operation phase of the building. Emphasises is also put on the need for renovation of the existing building stock to improve energy efficiency (City of Copenhagen, 2016). Thus, the CPH 2025 is mainly focused on optimising the operational phase of buildings with regards to energy efficiency and lack a focus on the climate impact of the construction phase.

Initiatives to support the improvement of the sustainability performance of buildings has also been taken on a local level. An example is the development of environmental criteria for public procurement of building and construction projects. In 2016, the City Council of Copenhagen issued several environmental criteria called "Miljø I Byggeri og Anlæg 2016" which includes resource efficiency, recycling and reuse of material. Also, it stipulates that a life cycle assessment of different materials have to be conducted (City of Copenhagen, 2017). The department responsible for the tender then needs to choose the construction which shows the lowest negative environment impact (Alhola et al., 2017)

The target for reuse, recycling and material recovery of CDW as stipulated in the EU Waste Framework Directive (2008/98/EC) was exceeded with numbers indicating an 86 % recycling rate of CDW in 2012 (Deloitte, 2015). However, this number is expected to decrease as the Government introduces measures to separate substances of concern from the waste stream to ensure a high quality of recycling is achieved in the long-term (The Danish Government, 2013). A majority of the CDW consist of mineral waste, such as concrete and bricks, which is commonly used as aggregates for a variety of purposes. However, only a fraction of the waste is being recycled or reused for its original purpose (The Danish Government, 2013). This has caused up-cycling and the concept of Circular Economy to receive relatively high political attention in Denmark.

Sustainable construction was pointed out by the Danish Government as a Danish stronghold where circular economy offers the potential for further expansion (Ministry of Environment and Food & Ministry of Industry, Business and Financial Affairs, 2018). Yet, the Danish Government suggests that progress toward the implementation of CE strategies so far is characterised by two trends. The first being that public institutions are starting to work actively to promote CE in building and procurement activities. The second being that an increase in recycling of waste is starting to occur (Ministry of Environment and Food & Ministry of Industry, Business and Financial Affairs, 2018)

To accelerate the transition toward a circular economy, several initiatives have been initiative launched. For example, an advisory board for the circular economy was established in 2016 by the Danish Government which is compromised by firm leaders from Danish companies. The board adopted the objective of increasing resource productivity by 40 per cent from 2014 to 2030, while also increasing recycling rates from 58 to 80 per cent. The objective was supported by four industry associations including the Danish Construction Association (Ministry of Environment and Food & Ministry of Industry Business and Financial Affairs, 2018). A strategy for a Circular Economy was also produced by the Ministry of Environment and Food and Ministry of Industry, Business and Financial Affairs in 2018. The industry describes several initiatives to be launched to support a transition toward a circular economy, which is further likely to impact the construction industry. These are presented in Table 0-2 below (Ministry of Environment and Food & Ministry of Industry, Business and Financial Affairs, 2018).

*Table 0-2.Proposed measures: Strategy for Circular Economy (2018).*

| **Proposed measure** | **Purpose** |
|---|---|
| 1. Development of a voluntary sustainability class | The design of the sustainability class is not yet decided. The main purpose is to support the implementation of CE strategies in the building sector without compromising other aspects, such as competition, durability and safety. Seeks to overcome the following barriers:<br>- Limited traceability of materials which decreases the potential for reuse and recycling activities.<br>- Current lack of requirements for including the embedded energy of materials in building's energy calculation. |
| 2. Propagating selective demolition | Aims to increase the focus on reuse of construction materials in new buildings and overcome current barriers to reuse and recycling activities such as:<br>- Mixture of waste streams.<br>- Material value loss in connection with demolition. |
| 3. Supporting technological developments | Aims to support new solutions and optimise material flows by:<br>- Providing additional information concerning the type of materials found in existing products and building stocks, their location and the substances which they contain. |
| 4. Promote circular procurement of products and services | Aims to increase market demand of CE products and services. |
| 5. Increase focus on total cost of ownership in public procurement | Aims to overcome the primary focus on price at time of purchase rather than the total costs occurred over the lifetime. Strengthens the current requirement for total cost of ownership calculations in place for buildings exceeding a certain size. |
| 6. Harmonizing administration and rules for waste and recycled products both nationally and internationally | Aims to achieve a levelled playing field on the market for reuse and recycled materials. |

### 6.5.2 Economic trends

#### EU level

On an EU level, the construction sector plays an important role in the economy by its contribution to GDP, provider of employment (mainly in small- and micro enterprises), and consumer of intermediate products (COM(2012)433). Certain trends which may impact the economic performance of the sector are described below.

Debacker & Manshoven (2016) points to an increase in building vacancies due to an un-match between the building stock and the market demand which results in loss of real estate value. At the same time, the scholars also suggest that it is becoming increasingly common to demolish modern and post-modern buildings before they have reached their technical and functional service life of 50 to 75 years. The driving force of this development is the need for space for new construction which more effectively meets the requirement of the end-user. The financial implication of the current development is that the return on investment is becoming shorter (Debacker & Manshoven, 2016) with the perceived risk on investment based on a shorter time frame than the technical lifetime of the building (Guldager Jensen et al., 2019)

Material prices in the European construction market seem to be in a rising trend. In 2013, residential demand seemed to push up material prices in the EU (Kylili & Fokaides, 2017). Likewise, McKinsey Global Institute (2013) suggested that the average annual volatility of resource prices had nearly tripled and average resource prices had more than doubled between 2000 and 2013. For input materials such as copper and steel which are commonly used in construction, the price increased by 344 per cent and 167 respectively in nominal terms. In the future, factors such as increasing demand from emerging markets, logistical and skills challenges, incorporation of environmental costs and access to supply, is expected to continue to shape the price development of such input materials (McKinsey Global Institute & McKinsey Sustainability & Resource Productivity Practice, 2013). Deloitte (2018 ) also reports that a shortage of materials has resulted in an input cost inflation, which has put pressure on the margins in the European construction market. Kylili & Fokaides (2017) suggest that this development may push the industry toward adopting alternative production methods in the manufacturing process of building materials to cut production costs, which may potentially benefit the use of more sustainable construction materials.

#### National level: Sweden

In the Swedish context, the turnover of the construction sector increased by 42.3 per cent between 2010 and 2016. Investments in housing increased by 70 per cent between 2013 and 2017, after which the trend was broken in 2018 and total investments decreased by 1 per cent. The driving factor of the sudden decrease was the reduced production of tenant owner rights which fell with 30 per cent under 2018. On the other hand, increases in rental rights increased with 3 per cent, investments in premises by 8 per cent and investments in facilities by 5 per cent in 2018, which together provides a counterweight to the current trend (The Swedish Construction Federation, 2019).

Looking forward, the Swedish Construction Federation (2019) estimates that the total amount of building investments will decrease by 6 per cent between 2018 and 2020 due to a decline in the new production of housing developments. In specific, investment in housing is estimated to decrease by 11 per cent during 2019 and 8 per cent during 2020. At the same time, the investments in facilities and premises are set to increase during 2019 and 2020 (the Swedish Construction Federation, 2019). Following the expected decrease in building investments, employment within the building sector is estimated to decrease with two per cent during 2019 and 2020 (The Swedish Construction Federation, 2019).

Between 2010 and 2016, the industry experienced an increase in construction costs. This development was driven by an average cost increase of labour by 15.1 per cent and an increase in material prices by 13.1 per cent (European Construction Sector Observatory, 2018b). The rise in material prices is explained partly by increases in demand for input material outside the Swedish market (The National Board of Housing Planning and Building, 2018c).

Low labour-productivity growth in the construction sector is a global phenomenon (McKinsey Global Institute, 2017) which is also experienced in the Swedish market (The National Board of Housing Planning and Building, 2018c). The sector also faces limited competition, which has caused the Swedish Competition Agency to warn that construction costs may continue to increase with a potential hampering effect on construction projects (The Swedish Competition Authority, 2015). According to the findings in the report, driving factors of both limited competition and labour-productivity growth are (1) *ineffective planning- and construction processes*; (2) *complicated building regulations*; (3) *lack of developed land* and (4) *differences in local requirements on construction projects* (The Swedish Competition Authority, 2015).

With regards to domestic sales, the most sold construction products in 2016 were prefabricated wooden buildings, followed by windows, tiles, flagstones and bricks, and ready-mixed concrete. Between 2010 and 2016, prefabricated building or civil engineering components of concrete, cement or artificial stone increased by 216.18 per cent (European Construction Sector Observatory, 2018b) indicating an increasing interest for industrialised construction methods.

### National level: Denmark

The turnover in the construction industry increased by 34.9 per cent between 2010 and 2015 (European Construction Sector Observatory, 2018a). The Danish Construction Association (2019) estimates that residential construction will reach its peak in 2019, following a tripling of total building starts of dwellings since 2013. The number of dwellings is then expected to decrease in 2020. For non-residential construction, investments are expected to continue to grow between 4 to 5 per cent of the production value of new buildings during 2019 and 2020.

The Danish construction industry has also experienced an increase in construction costs, mainly driven by a 20 per cent increase in labour costs between 2010 and 2016. The level of employment increased with 14 per cent between 2010 and 2014, however, it is now expected to reach its height in 2019 with a potential decline in 2020. At the same time, construction companies have reported how limited access to labour have constrained production and access to skilled labour is likely to constitute a large challenge during the forthcoming years (European Construction Sector Observatory, 2018a).

Similar to Sweden and other countries on the European market, the labour-productivity growth is continuing to be weak (The Danish Construction Association, 2019). The construction market in Denmark also characterised by a low level of competition. In the case of production of housing, the market is mainly dominated by smaller businesses leaving international businesses with only a small part of the housing production. This is explained by a variety of factors. For example, the construction sector is described as highly with many actors involved in the construction process, which contributes to lowering the investments in the sector. The market is also often described as local rather than national, with local differences in regulations and enforcement of such as well as favouring treatment of local companies by the public sector. This further hinders competition on the market(The National Board of Housing Planning and Building, 2018c). In the case of the construction material industry, the level of competition varies highly depending on the actor's role in the value chain. For example, construction material produces generally faces lower levels of competition than businesses in operating in the execution phase of construction, such as contractors (The National Board of Housing Planning and Building, 2018c)

With regards to domestic sales, the most sold construction products have remained stable since 2010 and are dominated by windows, prefabricated building or civil engineering components, ready-mixed concrete and prefabricated wooden buildings (European Construction Sector Observatory, 2018a). When it comes to specific materials, the demand for concrete based on recycled aggregates is on the rise (Sørensen et al., 2019)

## 6.5.3 Social trends

### *EU and national level*

One factor expected to influence the construction industry is changes in demographics. The national populations in both Denmark and Sweden are expected to have increased by 2030 in comparison to current levels (Grunfelder et al., 2018). In Sweden, this growth is projected to be skewed mainly to larger urban areas. Up to 80 per cent of the population increase is expected to occur in the Southern areas of the country, while a majority of the population in municipalities in the North will decrease. In Denmark, the population growth will be somewhat more dispersed, although a similar trend with the population increase in urban areas and population decrease in rural areas is expected. While the population in the Nordic region as a whole is expected to increase, the population structure is also expected to see a shift toward higher ages with a similar age structure in both Sweden and Denmark. In specific, urban areas in both Denmark and Sweden are expected to have an old-age dependency ratio of between 16 to 30 per cent, with higher old-age dependency ratios in rural areas. This could put an increasing economic pressure on rural areas to cope with an ageing population. It also suggests that the pressure on cities to develop both housing and infrastructure for a growing population will continue to rise, while remote municipalities face the challenges of either influencing or adapting to a decline in population (Grunfelder et al., 2018). The need for housing in larger cities is further demonstrated by the city plans of both Stockholm and Copenhagen, where 100,000 new homes are to be built by 2030 in Stockholm (Stockholm stad, 2013) and 45,000 new homes are to be built by 2027 in Copenhagen (Københavns Kommune, 2015)

Høibye & Sand (2018) suggests that the construction sector in the Nordic will have to address increasing user demands on a higher degree of flexibility of space, healthy interiors and improved sustainability performance. User demand for healthy interiors is also experienced on a European level, together with an increasing awareness of both sustainability and circular economy in the construction industry landscape in general (Debacker & Manshoven, 2016). Sharing economy has gained popularity with scholars arguing that it may be particularly beneficial for activities with a high-emission intensity, such as housing (Kyrö et al., 2019). In a study by Kyrö et al (2019) on the potential for relocatable buildings to deliver circularity, they found that leasing and reusing buildings was not found problematic by the users, implying that the paradigm of ownership is shifting from owning to sharing. During the interviews conducted in this study, changing user needs and demand concerning the work environment and living arrangement were mentioned by some of the interviewees (primary stakeholder 1; primary stakeholder 2; primary stakeholder 3; primary stakeholder 5; secondary stakeholder 6). One of the interviewees suggested that they expected co-living to grow in importance, due to both increasing housing prices and changing requirements from users (secondary stakeholder

2). Another interviewee mentioned how co-working spaces are increasing in popularity. Both of these trends were considered likely to influence how buildings are designed and managed (primary stakeholder 1-3; primary stakeholder 5).

An increase in demand for voluntary environmental certifications of buildings has been noticeable in both Sweden and Denmark (DK-GBC, 2019; Fossil Free Sweden, 2018a). While specific requirements in different environmental certification systems may reflect the national prioritises and local circumstances, the common denominators between different systems have been defined as (i) *ensuring environmental production*, (ii) *encourage resource efficiency*, (iii) *reduce energy consumption* and (iii) *promote innovation and ambition* (Krizmane, Slihte, & Borodinecs, 2016)

The number of registered certifications in Sweden (including the environmental certifications systems CEEQUAL, LEED, BREEAM, Green Building, Nordic Ecolabel and Miljöbyggnad) have seen a rapid increase from under 100 to over 2500 in the period of 2009 to 2017 (Fossil Free Sweden, 2018a). The most commonly used certification system is Miljöbyggnad, which is designed according to the building conditions on the Swedish market. According to the Swedish Green Building Council, the growth in demand for environmentally certified buildings among end-users is due to a general increase in environmental consciousness among the population (ByggNorden, 2019). However, others have suggested that the driver behind the increase in environmentally certified buildings seem to mainly be a competitive advantage, where it is used as a strategy for differentiation on the market. For example, a study has shown that environmentally certified buildings may reduce operating and maintenance cost, strengthen the corporate image and increase property value (Szecsödy, 2016).

In 2012, a Danish version of the German DGNB system was launched with the ambition of creating a coherent and voluntary certification system which could drive development within the building sector (Mortensen, Kristiansen Rovsing, Kanstrup-Clausen, Ravn Zhou Jessen, & Jonsbak Rohde, n.d.). As of February 2018, 34 new developments had been certified according to the DGNB certification, whereas 12 had been certified according to LEED and 6 according to BREEAM (DK-GBC, 2019). The number of buildings certified under the Nordic Ecolabel has also increased significantly during the last two years, with the number of completed houses, apartments and facilities increasing from 1,780 to 4,120 (Ecolabelling Denmark, 2018)

### 6.5.4 Technological trends

As for most sectors, digitalisation is expected to have a significant impact on the construction industry (Circle Economy, 2015; Renz & Zafra, 2016) despite how the level of digitalization so far remains low in comparison with other sectors (The National Board of Housing Planning and Building, 2018c). The organization Circle Economy (2015) states that digitalization has the potential to deliver increased access to information throughout the value chain of the building which may support resource efficiency measures in the sector. An example of this is through Building Information Modelling (BIM), which has been described as one of the most promising innovations in the AEC (architectural, engineering and construction) industry (Azhar, 2011). In principle, BIM supports virtual construction of buildings and provides information concerning the functional and physical characteristics of the building and improves the efficiency of the construction process. The use of BIM is already relatively wide-spread in the construction industry (Guglielmo & Nitesh, 2017) although the adoption rate varies between countries in the EU (McCormick, 2016). The opportunities associated with the adoption of BIM is commonly denounced as increased quality, strengthening of preventative maintenance and thus reduction of failure costs, and increased of life-cycle thinking (Circle Economy, 2015; Zupancic et al., 2018).

Complementary to BIM, the concept of material passports (also referred to as product passports or circularity passports) is starting to gain traction amongst both scholars and politicians. Material passports are digital datasets with the purpose of storing and provision of information concerning the circular economy characteristics of building products, components and materials (BAMB, 2016). It has been suggested that existing solutions in this area tend to be limited to defined areas, such as providing information on e.g. health impacts of materials, and thus lack a more holistic perspective (Heinrich & Lang, 2019). However, initiatives such as the Horizon-2020 funded project Buildings-as-material-banks (BAMB), aim to develop electronic material passports which can meet the requirements concerning the information needed to support the slowing and closing of resource loops within the construction industry (BAMB, 2016).

With regards to the operational phase of a building in specific, there seem to be a rapid increase in the number of IoT devices in buildings (Debacker & Manshoven, 2016; Guglielmo & Nitesh, 2017). Debacker & Manshoven (2016) suggest that we since the 1980's have gone through a development of automated buildings, to smart buildings and finally arrived at the age of cognitive buildings. While smart buildings mainly supported analysis of energy consumption, cognitive buildings have the ability to provide insights, learn behaviour and deploy changes to building operations (IBM Global Business Services, 2016). With more companies specialised in innovative technologies and services entering the construction industry (Deloitte, 2018), the sector may be disrupted by innovation and digitization in the area of technology.

With regards to the construction phase, the adoption of alternative design, manufacturing- and construction techniques is expected to increase during the forthcoming years (Renz & Zafra, 2016). One example is 3D-printing, which could have a disruptive impact on the construction industry by enabling productivity gain, reduction in waste and a reduction of cost for the production of customized components (Deloitte, 2018; Renz & Zafra, 2016; The Ellen MacArthur Foundation, 2015). However, the technology is still in an early phase of development and significant barriers such as e.g. high costs makes it mostly applicably to low-volume and high-value components and products. Thus, when or whether the technology will reach economies of scale is still uncertain (Renz & Zafra, 2016).

Other design, manufacturing- and construction approaches which are becoming deployed in the construction industry on a more widespread basis are standardisation, modular design and prefabrication (Deloitte, 2018). Prefabrication describes the process of manufacturing the building structure in factory off-site and assembling it on the construction site (Minunno et al., 2018). While modular design refers to the design of building modules which are prefabricated-offsite, in specific referring to volumetric units which encompass the structural elements of a building (Lacey, Chen, Hao, & Bi, 2018). Thus, the concepts are closely interrelated, with modular building commonly understood as an advanced type of prefabrication process. All of these three approaches (standardisation, modular design and prefabrication) are gaining increasing momentum in the construction industry (Deloitte, 2018) due to associated benefits such as construction efficiency, reduced project delivery time, lower costs and safer working environments. However, the level of customer acceptance, and thus the application, of prefabrication and modular design depends highly the geographical context (Renz & Zafra, 2016). In both Sweden and Denmark, however, prefabricated components represents some of the most sold construction products (European Construction Sector Observatory, 2018a, 2018b). The use of prefabrication in construction also has a long history in Sweden. For example, prefabricated concrete elements was used in a large extent during the construction of housing in 1965 during the governments housing program "miljonprogrammet" (The National Board of Housing Planning and Building, 2002).

Advanced building and finishing materials represent an area where solutions emerging from the industry are numerous (Deloitte, 2018; Renz & Zafra, 2016). It has even been suggested how the increased sustainability of buildings will derive partly form the use of alternative, natural, unconventional and recycled building- and thermal insulation materials (Kylili & Fokaides, 2017). New solutions range from incremental innovations with advances on traditional materials to radical innovations with materials which exhibits entirely new functionality. These functionalities may include higher recyclability and reusability, reduced cost, faster construction process, higher energy efficiency and improved well-being (Renz & Zafra, 2016). However, despite the potential of advanced building materials, these often fail to achieve widespread acceptance due to several factors, including lack of track record and information, as well as high initial investments (Renz & Zafra, 2016).

One material in particular which has received a lot of attention in term of technological development is cementitious materials, potentially due to its widespread use in the construction industry combined with a high environmental impact in terms of $CO^2$emissions. The pledge of countries and cities to transition to a carbon neutrality society poses a challenge to the construction industry. Especially as less than 40 percent of the $CO^2$ emissions derives from the energy used in the production of cement, and more than 60 percent derives from the chemical breakdown of limestone, which lacks practical substitutes (Favier et al., 2018). On a concrete level, Favier, De Wolf, Scrivener, & Habert (2018) highlights the potential of reducing the $CO^2$ emissions by reducing the amount of cement used in the production of concrete. For example, the substitution of cement for other inputs is a strategy which is gaining ground for reducing the carbon footprint of the material. A review by Kylili & Fokaides (2017) showed how studies had indicated significant environmental benefits, such as a 25 percent reduction in energy consumption and 15 percent reduction in $CO^2$ equivalents, by the use of alternative input materials when compared to conventional concrete. Common alternative inputs include materials such as slag, silica fume or fly ash. The drawback of substitution of input materials is that it is most suitable in the case of non-reinforced structures rather than reinforced concrete, as it may lead to safety and durability concerns (Favier et al., 2018).

Other strategies for reducing the use of cement in concrete is granular optimisation and the use of admixtures. Recycled concrete can also be used as aggregated, however, the quality of secondary aggregates varies and the use of it often require additional cement to achieve the same strength as concrete based on virgin aggregates (Favier et al., 2018; Sørensen et al., 2019). This may reduce the environmental benefits from using secondary aggregates, as the main $CO^2$ emissions derive from the cement production. Despite this, progress in optimizing the processing of secondary aggregates is underway which may improve the suitability of secondary aggregates in production of virgin concrete (Sørensen et al., 2019). For example, a publication from The Danish Environmental Protection Agency (2018) reported on a project where the technical feasibility of producing recycled concrete with the use of 100 percent crushed concrete was demonstrated. Here, the transport distance became decisive for whether $CO^2$ savings could be achieved by the use of secondary aggregates which is in line with other research indicating that $CO^2$ equivalent emission savings are possible when concrete is recycled at site in close proximity to the areas where it will be used (Kylili & Fokaides, 2017).

On a structural level, main strategies for reducing the climate impact of concrete structures include optimizing the structure to use less concrete by elements. Reuse of elements in their original form has also been tested, although it is far from common practice (Favier et al., 2018;

Sørensen et al., 2019). The potential for reducing the embodied $CO^2$ is high, with the energy consumption deriving only from transportation. Limitations to achieving reuse at larger scale is availability of elements, need for materials to compensate for lack of connection between elements, and the risk of elements available today being outdated quicker than new alternatives. Thus, designing for flexibility will be important to enable an increase of reuse of elements in the future (Favier et al., 2018).

### 6.5.5 Environmental trends

The construction sector has a significant impact on the environment through large-scale use of raw materials, high energy use of raw materials, emission of greenhouse gases and particulates, transport related pollution and also the secondary impact caused by noise, dust, waste and contamination (Circle Economy, 2015; Stål & Jansson, 2017)

#### *National level: Sweden*

In Sweden, the National board of Housing, Planning and Building reported that the environmental impact from the housing- and building sector increased between 2015 and 2019. In specific, increases occurred for five of six environmental indicators including emissions of greenhouse gases, nitrogen oxides and particles, total energy use, and use of environmentally hazardous chemicals (The National Board of Housing Planning and Building, 2019). Altogether, the housing and building sector was responsible for between 10 to 40 percent of the total environmental impact measured by the indicators. Of all environmentally hazardous products used, 70 percent derived from imported building materials.

In relation to waste generation, primary building- and deconstruction waste represented 31 percent of total generated waste and 16 percent of total generated hazardous in Sweden in 2016, an increase of 0.9 million tonnes since 2014. Of the total waste generated, 50 percent was recycled through material recycling, reused as construction material or incinerated with energy recovery (The National Board of Housing Planning and Building, 2019).

The climate impact of the housing-and building sector in terms of total greenhouse gas emissions has been lowered the last 30 years, mainly due to improved energy efficiency in the use-phase. This development has been driven by energy requirements for new buildings, increased use of renewable energy for heating and developments in the Swedish energy system (The National Board of Housing Planning and Building, 2018d). In 1993, the greenhouse gas emissions derived from heating in the use phase of a building constituted 70 percent of the total climate impact while the production phase was limited to 30 percent. Currently, the building production phase (including manufacturing of building products and construction) and the use-phase is estimated by the National Board of Housing, Planning and Building to be on an equal level (The National Board of Housing Planning and Building, 2018d). This development has promoted a shift in the focus from solely energy efficiency to product and building production phases. Considering the relatively high climate impact derived from the production of building materials, primarily as cement and steel, in the production stages (Fossil Free Sweden, 2018a), the role of material and product choice in reducing the climate impact of buildings throughout its lifecycle is increasingly recognised (The National Board of Housing Planning and Building, 2018d).

#### *National level: Denmark*

Since 2010, the emissions of greenhouse gases (including carbon monoxide and dioxide, methane, nitrous oxides and PM) from the construction sector have increased with 4.1 percent. (Deloitte, 2014). Most government initiatives to reduce the greenhouse gas emissions so far seem focused on energy efficiency in the operational phase of buildings. For example, in the publication "together for a greener future" produced by the Danish Ministry of Energy, Utilities and Climate, several initiatives to promote increased energy efficiency in buildings is put forward while measures to combat the impacts occurring during the construction phase of a building is lacking (Energi- Forsynings- og Klimaministeriet, 2018)

In Denmark, about 87 % of the construction and demolition waste is recycled which is mainly due to a high use of crushed concrete and bricks as unbound filler (Deloitte, 2014). According to the European Construction Sector Observatory, (2018a), this is mainly the result of extensive policy efforts, including the possibility for actors to recycle C&D waste without a specific permit and a weight-based landfill tax. However, reuse and recycling of building components and lower-value materials, e.g. bricks, continues to be limited.

At the same time, the current development in Denmark is characterised by a strong ambition to improve the quality of recycling of materials and products from the construction sector, e.g. by focusing on up-cycling materials and products for direct reuse. This is expressed by the Danish Prevention Strategy published in 2015, where the construction sector represents one of five action areas (The Danish Government, 2015). The strategy further outlines an ambition to remove hazardous substances from building materials as well as to move into the direction of a shifting focus from *"energy optimisation to resource optimisation"* (The Danish Government, 2015: 30), suggesting that resource use will gain more attention in the future.

### 6.5.6 Legal trends

#### *EU level*

Legislation which refers solely to construction materials on an EU level considers the removal of technical barriers which may inhibit trading within the market (Regulation No 305/2011). This is mainly achieved through the establishment of harmonised technical specifications of the assessment of the performance of construction products and the use of a CE marking on construction materials, which is necessary to obtain in order to legally place the construction product on the market of the member states. Nevertheless, Kylili & Fokaides (2017) suggest that the evolution of construction materials in the EU is mainly determined by the requirements established by EU directives. In this respect, energy efficiency has received a high level of attention and continuous being an important issue (Herczeg et al., 2013). For example, the Energy performance of Buildings Directive (EPBD) (Directive 2010/31/EU, 2010) has greatly influenced the design- and construction process of buildings by putting an enormous pressure on the industry (Debacker & Manshoven, 2016; Kylili & Fokaides, 2017), e.g. by stipulating that all new buildings must be nearly zero-energy buildings (NZEB) by 2020 (European Commission, n.d.-b).

Despite how focus so far has been largely dominated by efforts to improve energy efficiency, Debacker & Manshoven (2016) suggest that the emergence of new policies which seeks to promote resource efficiency within the construction sector is a signal that the development of regulations moving forward will have an increased focus on materials. So far, the Waste Framework Directive (2008/98/ec) stipulates that a minimum of 70 percent of non-hazardous CDW by weight shall be prepared for reuse, recycled or material recovered by 2020. Construction- and demolition waste (CDW) has also been identified as a priority waste stream for increased reuse and recycling by the European Union, mainly due to its volume and the high residual value of certain components (European Commission, 2018a). In practice, the level of recycling and material recovery of CDW still varies greatly across member states (European Commission, 2018a). In specific, challenges related to identification, collection, separation and recovery of materials and components has been found to currently inhibiting the target to be met on an EU wide level (European Commission, 2018b)

### National level: Sweden

In Sweden, the planning of land and water areas, as well as construction, is regulated through the Planning and Building act (PBA) (2010:900) the Planning and Building Ordinance (PBF) (2011:338). The PBA places the main responsibility for planning of land, water and buildings on the municipalities. In addition, mandatory provisions and recommendations for construction works is specified in the National board of Housing, Planning and Building's building regulations (BBR) and the regulations on the application of the European construction standards (EN Eurocodes), which sets standards for the design of buildings and construction products. Altogether, PBA, PBF, BBR and the EN Eurocodes represents the minimal requirements that needs to be fulfilled by all construction works. The building sector is also affected by other regulations such as the Swedish Environmental Code and the Energy Declaration Act (2005:06:145) which stipulates that the energy declarations of buildings must be provided in connection with construction, sale or renting (The National Board of Housing Planning and Building, 2018b). In 2020, stricter energy requirements in the BBR are expected to enter into force as part of the integration of the NZEB in national legislation (The National Board of Housing Planning and Building, 2018a)

As an effort to improve the competition on the construction market, the possibility for local governments to impose additional technical requirements on buildings beyond the national plan- and building regulations has been strictly limited since 2015. This implies that local governments cannot impose their own technical requirements on developers when handling building permits, land allocations or land development agreements. However, they are free to do so in their role as developer or property owner (Sveriges Kommuner och Landsting, 2014).

The national legislation concerning public procurement in Sweden was changed in 2017, providing procurement officials with and increased opportunity, and in some cases obligation, to place increased environmental requirements on services and products. According to the national procurement strategy, public procurement should be environmentally responsible and promote innovation. Despite changes in legislation, the construction industry argues that low cost remains the most decisive factor in public procurement, and that public procurers lack the necessary knowledge to implement more stringent procurement criteria to reduce the negative environmental impacts of buildings (Fossil Free Sweden, 2018a). On the other hand, despite the opportunity of public procurement to promote e.g. the use reused building products, some actors in the government investigation on resource efficient use of building materials also pointed to the risk of not receiving any tenders due to increased requirements (SOU 2018:51)

Recognizing the environmental impact of the construction sector, there has been an increasing political interest to regulate the climate impact of buildings on a national level. In 2018, the national board of Housing, Planning and Building suggested the introduction of climate declarations (The national board of Housing Planning and Building, 2018:5), a proposal which was passed by the Swedish Government in June 2019 and is expected to be introduced the 1st of January 2022 (The Swedish Government Offices, 2019). The proposal outlines a minimum level of climate declaration for all new building, with certain exceptions, covering the product stage and the construction process stage (including raw material sourcing in the product stage, transport in the product phase, manufacturing in the product phase, transport and building- and installation). The building components for which the declaration will be mandatory for, according to the proposal, include the building shell (roof, floor, walls, windows and doors), the building framework, the garage and the basement. The initiative is estimated to promote a shift among developers toward processes, materials and products which reduce the negative climate impact of the product and construction process stage (The national board of Housing Planning and Building, 2018:5)

### National level: Denmark

According to a publication by the organization Copenhagen Capacity, Denmark has one of the strictest building regulations in the world (Mortensen et al., n.d.). The construction of new buildings, both private and commercial is regulated in the Building Regulations 2018 (BR18). Regulation is primarily based on functional requirements (EASME, 2017). The Eurocodes has also been implemented in the national standards on building constructions (Dansk standard, n.d.). The main responsibility for planning activities is placed on the municipalities (EASME, 2017)

Similar to Sweden, regulatory efforts have been taken to stimulate increased competition on the construction market. In specific, significant changes in the building permit process was made in the BR18 to stimulate competition. This include the introduction of a certification system which in practice removes the responsibility of municipalities to control that the technical requirements of a building are fulfilled. Instead, the developer will have to involve certified counsellors in the construction process. The certified consultant will be responsible for documenting or verifying compliance with fire and construction requirements, and it is the client's responsibility to document that the other technical requirements in the building regulations are observed (The National Board of Housing Planning and Building, 2016). The expected results of this legislative change in the building permit process is improved competitiveness of standardised construction processes, by the reduction differences in requirements between municipalities and increased predictability of the building permit process (The National Board of Housing Planning and Building, 2018c).

Reducing energy consumption in new buildings has highly prioritised by the Danish government for several years. Mot energy requirements are on the building as a whole, however, detailed requirements also exist in relation to the building envelope and installations (The Danish Knowledge Centre for Energy Savings in Buildings, 2018). In 2008, the Danish government agreed in 2008 on a plan for reducing energy consumption of buildings by 25 percent in 2010, 25 percent in 2015 and 25 percent by 2020. In 2010, a tightening of the energy regulation by 25 percent was combined with the introduction of a voluntary energy class. The introduction of a voluntary energy class served the purpose of supporting the industry in the development of products aligned with future legislative changes. In 2015, the voluntary energy class introduced in 2010 became final and binding under the Danish Building Regulation 2015. A new voluntary energy class was introduced, called the "building class 2020", equivalent to the level of nearly-zero energy buildings (NZEB) outlined in the Energy performance of Buildings Directive (EPBD) (Directive 2010/31/EU, 2010). Although the building class 2020 was planned to become the minimum requirement 2020 (Engelund Thomsen et al., 2016), the Building Regulations 2018 (BR18) stipulates that it will remain voluntary also after 2020. Mot energy requirements are on the building as a whole, however, detailed requirements also exist in relation to the building envelope and installations (The Danish Knowledge Centre for Energy Savings in Buildings, 2018)