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Faculty of Business Economics

Master of Management

Master's thesis

Circular business model design in the Belgian construction industry

Kasper Jans

Thesis presented in fulfillment of the requirements for the degree of Master of Management, specialization Strategy and Innovation Management

SUPERVISOR :
Prof. dr. Jean-Pierre SEGERS

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Executive Summary

Research Purpose

The construction industry is known for high energy consumption, carbon emissions, and relatively low efficiencies. The construction industry contributes to the greater share of energy consumption and other natural resources, significantly affecting the environment, economy, and society. To undergo significant transformation, the industry urgently needs to adapt its current business model into circular models, fostering the principles of cradle to cradle.

This research's objective lies in gaining a deeper understanding of the difficulties arising when implementing circular business models in the Belgian built environment. Further it explores how organisations in the environment can prepare themselves to make smooth transitions towards a circular built environment with the greater goal of fulfilling industry-specific Sustainable Development Goals (SDGs). Furthermore, it explores how several firms within the built environment make contributions towards sustainability in a circular context and how they take steps towards complete circular business models.

Methodology

This qualitative research consists of 6 different semi-structured interviews to collect insightful primary data to answer key points in this thesis. To answer each research question specifically, the transcribed data was coded and divided into clusters showcasing topic-relevant information. The researcher considered the position of the interviewees within the industry, the firm's role within the industry, and the firm size to represent the built environment as accurately as possible. Secondly, the researcher included a business model expert to acquire a secondary viewpoint on circular business models. The diversity of interviewees enabled the researcher to gain a viewpoint from different perspectives, enriching the depth of the findings. The duration of the interviews ranged from 25-40 minutes, all of which were carried out in an online environment.

Findings/Results

After the completion of the interviews and data analysis, important findings have been highlighted and discussed in this dissertation. The findings illustrate the awareness Belgian construction firms have of the pollutive industry characteristics. And therefore contribute to carbon dioxide neutrality. The industry stakeholders focus on the fulfilment of industry-specific Sustainable Development Goals such as SDG 12, "Responsible consumption and production," SDG 13, "Climate action," and SDG 17, "Partnership for the goals,." These were perceived as important drivers of sustainability within the Belgian construction industry. Several incentives were taken to contribute to these SDGs.

The first incentive to achieve this is vertically integrating several innovations and technologies within their processes. These ranged from the design methodology of architects to the implementation of secondary raw materials, using lifecycle assessment tools among stakeholders, and preparing for carbon-capturing technologies installation within production facilities. Unfortunately, reaching complete circularity within the industry has been indicated to be a practice for pioneering organizations. Complete CO2 neutrality cannot be consistently executed to this day. The findings highlight the importance of stakeholder engagement and indicate that all key players have to make contributions to facilitate circularity. Starting with the importance of the architect's ability to design projects in a sustainable manner, having to pay attention to sustainable material selection and technologies. Subsequently, collaborations between suppliers and contractors need to be characterized by sustainability. It has been highlighted that contractors utilize dedicated software tracking the environmental impact of the materials. The supplier's willingness to share insights about the material origin and footprint, therefore, is crucial to stimulate circularity in the environment. Additionally, embracing an internal organizational culture that aligns employee roles with sustainable goals is crucial. It has been indicated that employee diversity within organizations positively impacts an organization's sustainable and circular progression.

Within the findings it has been demonstrated that the success of circular business models depends on consumer demand for sustainable practices. Currently, organizations are not demonstrating the economic and environmental benefits of circular construction clearly enough to trigger consumer investments in often expensive solutions. Here, governmental support can help the industry reach better value propositions by providing scaling-up subsidies. Unfortunately, governmental support has proven to be inconsistent and biased, even though it is crucial to push the industry toward circularity. Upscaling options for promising organizations are often not subsidized since the government prioritizes investing in experimenting startups. All these findings determine the successful integration of circular business models within the Belgian construction industry and, therefore, need to be considered by all industry stakeholders to foster a sustainable and circular future built environment.

This research has been executed since the Belgian construction industry has difficulty in reaching circular business model transitions. In order to reach the 2030 agenda, the industry has to find ways to fulfil industry-specific Sustainable Development Goals. This ultimately fosters our environment and the environment of future generations. This research helps industry stakeholders understand the current enablers and barriers for circular transitions within the Belgian built environment. The findings indicate that even though the built environment is moving in the right direction, numerous difficulties need to be addressed and resolved.

Critical Recommendations and Considerations

This research underscores several significant challenges in implementing circular business models within the Belgian construction industry, which have notable implications for future research and practical applications. The research has identified the lack of governmental support and effective legislation as a barrier to implementing circular business models in the Belgian built environment. The absence of strict policies and subsidies hinders the construction industry from adapting to circular innovation.

Future research could explore the policy and regulatory frameworks needed to incentivize and support the transition towards circularity. To successfully transition to an organizational culture, managers should lead by example, demonstrating a vision towards sustainability and transmitting this vision to all levels of the organization. This can potentially be achieved by training employees, including circular and sustainable goals in the KPIs, and by the creation of sustainable ambassador programs. These programs reward employees for their free willingness to contribute to the sustainable vision. Furthermore, the research highlights the importance of understanding consumer perceptions of the clients. As managers, investing in market research to acquire broader insights into the client's necessity and demands is recommended. Additionally, enhancing consumer awareness of the benefits of sustainable construction practices can help managers influence clients' perspectives.

This conducted research contains a few limitations that should be considered when drawing conclusions. The researcher interviewed several organizations within the construction industry, but most interviewed organizations are located within the same province (Limburg) of Belgium. Therefore, this research represents only a fraction of the entire Belgian built environment. In future research, it is therefore important to include stakeholders in different provinces to represent the environment accurately. Subsequently, the research involved a limited number of interviews. This small sample size may not accurately represent the diverse perspectives within the industry, potentially limiting the generalizability of the findings. Additionally, insights about governmental support and regulations are discussed, but this research does not include representatives from the Belgian government; this limits the perspective of the study regarding the role and impact of governmental policies and support. Future research could explore the policy and regulatory frameworks needed to incentivize and support the transition towards circularity. The study highlights the dependency of circular business models on consumer demand and willingness to invest in sustainable solutions. The researcher of this dissertation recommends future research in exploring the factors influencing consumer necessity and demand for sustainable practices within the construction field.

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1. Problem Statement

The construction industry plays a fundamental role in facilitating economic growth, societal progress, and urban development (Global Construction Perspectives and Oxford Economics, 2021). More specifically, the construction industry stands as a cornerstone of modern civilization, forming the landscape and influencing the functionalities of societies worldwide. The industry's nature encompasses the design, development, and execution of structures, which range in several construction activities. The construction industry shapes the physical environment and contributes significantly to job creation, economic prosperity, and technological innovation (Hollander et al., 2020).

Due to its constructive nature, the industry is known for high energy consumption and carbon emissions, and compared to other industries, relatively low efficiencies. It has been analysed that the construction industry contributes to the greater share of energy consumption and other natural resources, significantly affecting the environment, economy, and society. In 2010, the construction industry was responsible for 32% of the global energy consumption, produced 19% of the global energy-related greenhouse gas emissions, and produced close to one-third of the global carbon emission (Darko et al. 2017). Since then, these statistics only have augmented. Thus making the sector energy-intensive and pollutive (Wang et al., 2022). This character of inefficiencies and pollution forms a significant threat to society.

Since the introduction of the Sustainable Development Goals (SDG’s), industries have been going through a process of change trying to implement sustainable-oriented innovations. These sustainable innovations are pillars for advancements in technology, materials science, and project management methodologies, positively reshaping practices and capabilities of the construction industry, driving efficiency, safety, and most importantly, sustainability (Kärnä et al., 2020). Due to the major evolution towards sustainability, a competitive market is continuously reshaping itself in the construction industry where new trends and technologies are being developed and evolved continuously.

The industry is known for its complicated design, where at its heart lies a network of stakeholders, including architects, engineers, contractors, subcontractors, suppliers, and regulatory authorities all having their own interests and requirements (Shivakumar, Sheng, & Weber, 1991). To initiate, regulatory obligations and the fulfilment of green building certificates are necessary to allow initiation of construction processes and simultaneously are crucial for the fulfilment of changing client preferences shifting towards efficiency and sustainability. In addition, convincing suppliers and subcontractors to adapt to sustainable and technological construction processes can be challenging. Therefore, the complicated design of the industry requires impeccable management to strategize implementation and enhance the readiness of all stakeholders towards emerging trends and technologies, transforming the industry into an innovative, sustainable and circular construction environment.

To undergo significant transformation, the industry needs to adapt its current business models into circular models where resource waste is reduced and where businesses operate with a vision of cradle to cradle to increase resource efficiency (Jørgensen & Pedersen, 2018). However, the industry is currently moving towards circular construction at a slow pace (Heesbeen & Hoces, 2020). While the application of circular economy thinking in construction is in its infancy, it has been largely limited to waste minimization and recycling (Adams et al., 2017). These previous findings indicate a need for further research into how organizations in the construction industry can strategize their transition into a circular business and what challenges and long-term advantages this transition offers.

Therefore, this research deeply analyses the current state of the Belgian built environment in relation to the Sustainable Development Goals, trend and technology integration within the environment and circular business model design. This approach provides insights into how Belgian construction firms reach industry-specific Sustainable Development Goals by strategizing towards circular business models. To execute this study, this dissertation is structured as follows. The first part is a Literature Review, followed by Research Methodology and the third part is a broad discussion with findings and a conclusion including the findings of this study.

2. Literature review

2.1. Introduction

The construction industry is known for playing an impactful role in forming economies and societies worldwide. In Belgium, the built environment significantly contributes to the Gross Domestic Product (GDP) and realizes urban development. Unfortunately, the industry is characterized by high energy consumption and the massive impact it has on the environment. The industry is known for high global contributions towards carbon emissions (Wang et al., 2022). According to Van Haver (2024) the construction industry was responsible for 35% of waste generation and 36% of the carbon dioxide emissions in the European Union (EU). Therefore, The construction industry has a significant impact on sustainability, and adopting Sustainable Development Goals is crucial. The fulfilment of industry-specific SDGs can potentially be reached by adopting circular business models and reshaping the relationship between economic activities with sustainability. (Jørgensen & Pedersen, 2018)

Circular business models in the construction industry facilitate a transformative approach of a business model, integrating the principles of circular economy. (Geissdoerfer et al., 2018). Despite the potential of these models, organizations have difficulties in adopting their entire activities towards circularity in the Belgian construction sector, since various barriers hinder the widespread implementation.

This research delves into the challenges the Belgian built environment faces for implementing circular business models. The research explores how Belgian firms can transition towards a circular business model and highlights current barriers and enablers for this transition. This research is motivated by the global push towards sustainability and circularity, demonstrated in the Sustainable Development Goals. The literature review within this research portrays the composition of the Belgian built environment, highlighting its economic relevance and complicated ecosystem. Further, the literature highlights the importance of sustainability and the fulfilment of the 2030 agenda containing the Sustainable Development Goals in relation to the construction industry. To illustrate current sustainable-oriented innovation within the industry, the literature review provides an overview of the current implemented technologies and trends within the environment. These innovations are implemented to foster a sustainable and/or circular strategy within the industry, and therefore, circular business models are being discussed. Previous research and literature have discussed circular business models within other countries and regions, but currently, little has been explored about circular business models within the Belgian construction industry.

The findings of this research highlight insights from Belgian construction firms and business model experts in relation to sustainable and circular industry adaption. There are several barriers and enablers, hindering or facilitating circular business model adaption within the industry, these will be covered within this dissertation. Furthermore, this dissertation will highlight the current preparations made by Belgian construction stakeholders to reach a circular built environment. Throughout this thesis, the terms "built environment" and "construction industry" are used interchangeably. Additionally, the terms "industry stakeholders" and "industry key players" are used interchangeably.

2.2 The construction ecosystem

2.2.1 Economic relevance and composition of the construction industry

When looking at the Belgian construction industry, It is measured that the contribution to the Gross Domestic Product is significant and rises moderately and consistently. To give a specific indication, the GDP from construction in Belgium increased from 4644 EUR Million in the third quarter of 2023 to 5565 EUR Million in the fourth quarter of 2023. Currently, In total, the construction industry's GDP in 2023 in Belgium was 20 830 EUR Million. Looking at the Belgian total GDP figure in 2023, which was 602 330 USD million, or approximately 530 000 EUR million, The contribution of the construction industry towards the total GDP in Belgium accounted for 3.93% in 2023. In comparison with sectors such as the pharmaceutical and chemical sectors in Belgium, this contribution seems relatively low. When zooming out and looking at the construction industry on the European level, we see a tremendous shift. Here, the GDP contribution is around 9%, which is tremendously larger than the contribution of the Belgian construction industry in its respective market. (Trading Economics, n.d.)

To further indicate the economic relevance of the construction industry we will take a deeper look at the influence of construction activities on GDP growth. A previous study conducted on the construction industry in Nigeria researched the causal relationship between the growth of GDP and the growth of the construction sector, here results indicated that growth of the construction sector preceded growth in the entire national economy (with one year of lag). This "lead -lag" relation is existent due to time of the construction process. Effects of this lead-lag relationship between gross domestic product and construction output prove that the construction industry has been closely related to national economies. Therefore, more construction activity will raise GDP through a multiplier effect, causing higher demand for construction activities. Therefore it is important to understand that construction demand is not autonomous and depends on several external influences such as the level of GDP. (Oladinrin et al, 2012)

Besides creating significant contributions to economic growth in terms of GDP, the construction industry stands for significant job creation opportunities. More specifically, in the EU, the direct workforce in construction is measured to be around 18 Million employees active in several roles such as on-site construction work, project management, engineering, architecture, and skilled trades (Haupt & Pillay, 2016). Indirectly, the construction industry stimulates job creation in related sectors such as the manufacturing of construction materials, transportation, and professional services (Kim & Go, 2022). The construction sector also absorbs surplus labour, particularly in rural areas, offering employment and income opportunities (Ni et al., 2022). Furthermore, the construction industry acts as a bridge for disadvantaged groups to access employment opportunities, promoting social inclusion and economic empowerment (Loosemore, 2015).

When analysing the construction firm composition, its visible that 99.9% of the European construction sector is composed of micro, small and medium-sized enterprises. In the European Union (EU), micro-enterprises account for 94.1% of all enterprises. Considerable growth has been seen when comparing this to the situation in 2016, where construction SMEs accounted for 88% of total employment and 80% of the total value added of the construction sector in the EU-28. Therefore, the construction industry typically consists of small firms with under 20 employees. these small firms are responsible for most output within the industry. (European Builders Confederation, n.d.).

2.2.2 The construction ecosystem and key players

The construction industry consist of many key players or stakeholders, contributing to several aspects of the construction process. To succeed these players need to cooperate consistently and communicate daily, therefore it is important to identify and define these stakeholders and determine their roles and responsibilities in the built environment. First of all, the owners or clients are initiating the construction projects and are providing the financial investment necessary for project execution. Further we have consultants, playing a vital role in the early stages of a construction project. They conduct pre-feasibility studies, provide technical expertise in plant design, and offer project management and supervision services. They help owners evaluate the viability of the project, identify potential challenges, and explore alternative solutions. Another key player is the main contractor, responsible for overseeing the construction of the designed plant. They manage subcontractors, coordinate project activities, and ensure that work is completed on time and within budget. Thus, what is contracting? It is a relationship under which the contractor does a specified type of work for the client for a specified price. The contractor is an agent (or agency) performing a specified task based on a contract. When a series of contracting occurs, then subsequent contractors are known as 'subcontractors' to the main contractor (Shivakumar, Sheng, & Weber, 1991). Steered by the main contractor, we have subcontractors (appointed by Owner/Client and Main Contractor), hired to perform specific tasks assigned by the main contractor. Sub-contracting is most feasible in construction, as the production processes are often separated, and the final product depends on separate specialized labour providers. Therefore, the activities can be divided into various independent domains which can be carried out independently. Subcontracting is an inter-firm contractual relationship under which the taker of the contract (subcontractor) does specified types of work according to specifications of the order from the contract provider, this often is the main contractor. Examples of subcontracting types are site preparation, excavation, concrete, flooring, painting, carpentry, electricity, plumbing, and more, but also service providers such as security and food service (Shivakumar, Sheng, & Weber, 1991).

Additionally, a seamless collaboration among suppliers, architects, and engineers is imperative for project success. Suppliers play a critical role in providing materials and equipment necessary for project completion. They are essential partners for both contractors and subcontractors, ensuring in-time delivery of quality materials to the construction site. On the other hand, the architect's responsibility lies in the layout and structure of buildings and infrastructure projects. Working closely with structural engineers, architects make critical decisions regarding building stability and material selection, ensuring structural integrity and aesthetic appeal (Roos et al., 2010). Meanwhile, engineers play a crucial role in the construction process by providing expertise in various disciplines, such as civil, structural, mechanical, and electrical engineering. they are involved in many stages of construction projects, ranging from designing the project to the execution. Engineers collaborate with architects, contractors, and other stakeholders to ensure projects are completed efficiently and meet quality standards. (Ghoddousi & Hosseini,2012). Together these players form the business side of the environment.

Regulatory authorities enforce building codes, zoning regulations, and safety standards. Regulatory authorities responsible for approving structural plans play a tremendous role in making sure that construction projects meet safety and quality standards before commencement. Compliance with regulatory documents and approval processes is of major importance to guarantee the structural integrity and safety of buildings and the environment (Wong et al., 2023; Yakovleva & Kurochkina, 2019). Furthermore, regulatory frameworks in construction aim to address environmental concerns and promote sustainable practices. Environmental planning policies and land conservation principles guide construction operations to minimize negative environmental impacts and promote sustainable development in construction projects (Maund et al., 2018; Abaikyzy et al., 2020). Lastly, also educational institutions play a role in the construction industry. Collaboration between universities and construction firms has been recognized as essential for driving innovation and fostering growth within the built environment (Al-Gasim et al., 2021). By engaging in partnerships with the construction industry, universities contribute to the development of the industry and regional growth strategies (Etzkowitz, 2017).

All these key players together form the construction meso environment, and the actions taken by these parties have significant impacts on the macro environment, “the society” and “the environment”. The industry influences the quality of life and provides the necessary environment for human activities (Stan, 2021). Furthermore, the built environment has broader implications for a country's productivity, competitiveness, living standards, and ecological sustainability (Rose & Manley, 2011).

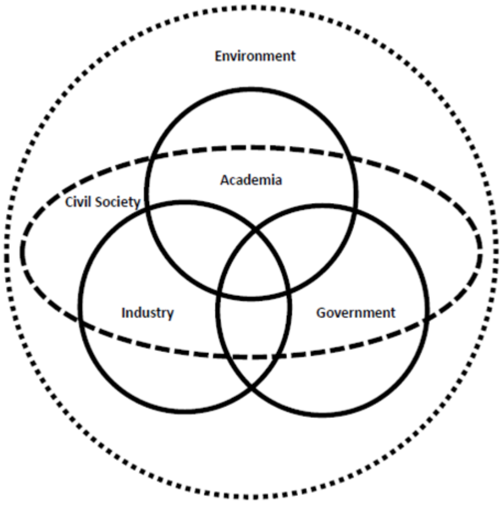

Figure 1: Quintuple helix model built environment (Carayannis et al., 2012)

2.3 Sustainability

Originally, the sustainability concept originated from the forestry field, in this context it meant that society should never harvest more than what the forests could naturally regenerate in terms of growth (Kuhlman & Farrington, 2010). When speaking about sustainability, most people think about waste generation. In theory, sustainability is much more than this. In fact, as we define sustainability, we can say that it comes down to meeting the necessary requirements of the present without limiting the ability of future generations to meet their own necessity (Vos, 2007). What makes this definition so explicit is that it highlights the multi-generational equity aspect of sustainability, stating that our ancestors, the current generation and future generations continuously have to contribute to harvest from the sustainability concept. An extension to this definition is that sustainability involves preventing the depletion of natural and physical resources to ensure that these are available for society in the long term (Machado, 2024). Here, the focus specifically lies on depleting resources, which is key to ensuring the fulfilment of future needs. Another source states that next to these principles of sustainability, it is of major importance that natural resources are being protected and are equally accessible to create opportunities for each and every individual (Miceli et al., 2021). As we merge these definitions together, sustainability comes down to the following: "Having equal resource distribution to meet the needs of the present without jeopardizing the capacity of future generations to fulfil their own requirements as individuals equally" (Brundtland, 1987).

It's known that the construction industry copes with continuous demands for resources and is responsible for relatively high pollution. Therefore, sustainability is quickly becoming a dominant concern in this industry. There is yet no consensus on the definition of sustainable construction. However, the common interpretation of sustainability within the construction industry is the delivery of buildings using less virgin material and energy and producing less pollution and waste (Zimmermann et al., 2005; Szokolay, 2004). Beside playing roles in protecting the environment, sustainable construction practices secure the earth for future generations (Mashwama et al., 2019).

The industry's role in achieving Sustainable Development Goals is of major importance, requiring the integration of social, economic, and environmental considerations into project delivery processes (Fei et al., 2021). Being aware of the benefits sustainable construction practices offer is fundamental to thriving and implementing sustainable practices (Okoye et al., 2021). The construction sector has the potential to influence the realization of sustainable development goals by adopting sustainable practices ("The Sustainable Development Goals, Organizational Learning and Efficient Resource Management in Construction", 2020).

2.4 Triple bottom Line

Elkington, (1997) introduced the idea of "the triple bottom line (TBL)" in 1998, resulting from the paradigm of sustainable development seeking for a balance between three dimensions: the economic, social and environmental. Next to the traditional economic measures typically used in an organization, the triple bottom helix adds social and environmental measures of performance. Environmental performance refers to the amount of resources used by the firm in its operational activities and the "by-products" created by its activities. On the other hand, social performance refers to the impact a firm has on the communities. When orienting the three pillars of TBL towards sustainability in the construction industry, we arrive at the following: sustainable environmental practices that contain the building, management, and upkeep of estates with efficient use of natural resources and a minimized impact on the environment. Further, social sustainability covers social cohesion, safe and healthy environments. Lastly, economic sustainability lies focus on building cost-effectively while functionally meeting requirements, keeping operating costs low, extending the service life of the estate through the Total Maintenance Scheme, and enforcing tenancy control for the best utilization of existing stock. To ensure sustainable practices within construction, understanding the theoretical design of TBL is crucial for reaching sustainability through the fulfilment of industry-specified Sustainable Development Goals (SDGs).

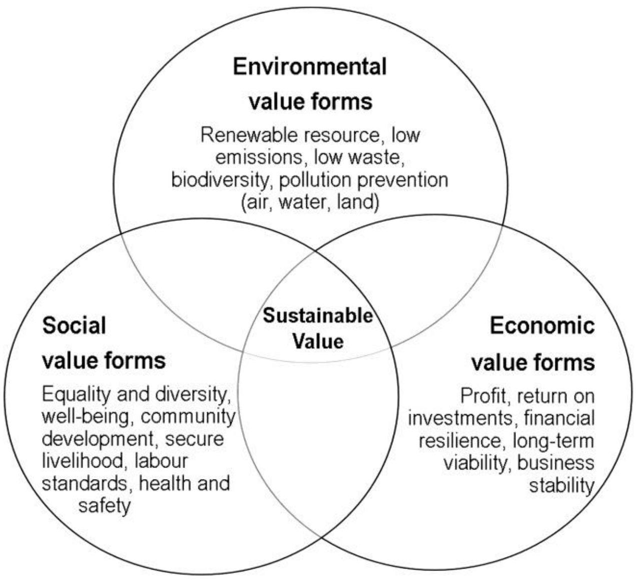

Figure 2: Three spheres of sustainability (Evans et al., 2017)

2.5 The Sustainable Development Goals

To meet the principle of sustainability, a process of change is needed (Weingaertner & Moberg, 2011). Therefore, the concept of sustainable development was first mentioned in the document "Our Common Future" (Brundtland, 1987). To reach societal change, the United Nations initially came up with the Millennium Development Goals (MDGs), at that time, these goals outlined universally accepted objectives for addressing severe poverty, hunger, diseases, lack of education and other priorities in severe need of development (UNDP, 2015). Unfortunately, the MDGs did not succeed in completely fulfilling the prioritized objectives during the active period from 2000 till 2015. The MDGs failed due to a lack of financial resources provided by the agreeing 189 UN members. Furthermore, the methodology for analysing potential advancements was missing. Lastly, continuous advancements of the MDGs during international discussions were scarce (Leal Filho, 2020). Since the failure of the MDGs, continuous advancements have been made towards the sustainable development concept. A breakthrough happened at the 2012 Rio+20 Conference on Sustainable Development, a significant milestone was reached with the initiation of a process to develop Sustainable Development Goals (SDGs).

Figure 3: Sustainable Development Goals (United Nations, 2015)

The conference outcome document, 'The Future We Want,' marked the convergence of sustainability principles with global development agendas. This led to the establishment of an intergovernmental "Open Working Group" tasked with formulating a comprehensive set of 17 SDGs that balance environmental, social, and economic dimensions" (Rio+20, 2012). To achieve a sustainable society, sustainable development should be perceived as a process to change the world and be implemented in society as the new lens for addressing global challenges (Pizzi et al., 2020). These 17 goals together formed the Sustainable Development Goals (SDGs), which exist to change the world. In September 2015, the 2030 agenda containing the Sustainable Development Goals was unanimously signed by all United Nations members, and the agenda was launched on the first of January 2016 (Rosa et al., 2019). Today, The SDGs provide the construction industry with a viewpoint through which global needs and desires can be translated into business solutions and applications. The construction industry has a significant impact on sustainability, the adoption of Sustainable Development Goals, therefore, is crucial. To reach a set of SDG's such as SDG 11 "sustainable cities and communities", the industry needs to adapt and undergo the process of change where sustainable-oriented innovation is needed to shift from a high energy and resource consuming industry with the generation of waste, towards a built environment protecting life and health, its inhabitants 'psychological and social welfare, sustaining aesthetics and the protection of cultural values (Holm, 2003). In addition, other goals such as SDG9 "industry innovation and infrastructure" and SDG12 "responsible consumption and production" are heavily influenced by the character of the construction industry. The fulfilment of these goals highly impacts the realization of many other goals. Demonstrating this, construction and demolition activities generate large volumes of waste, requiring the adoption of new technologies and trends for reducing waste generation and maximizing resource re-usage to lower negative impact on the environment included in SDG3, SDG7, SDG13-16. (Gálvez-Martos et al., 2018) (Fei et al., 2021)

2.6 Sustainable-oriented innovation

The previously discussed process of change is made possible by innovations. Therefore, sustainability-oriented innovation offers the means to achieve sustainable development within an industry. This is by fostering creativity and ingenuity in developing solutions that contribute to sustainability. To determine what sustainability-oriented innovation means, we look at the six continuously recurring aspects in the different definitions of sustainable innovation. (Lubberink et al., 2017). The first aspect is that sustainable innovations can appear in different forms, such as products, processes, services, or business models. Secondly, sustainable innovations are market-oriented, meaning they satisfy needs and are competitive in the market. Further, sustainable innovations exist to lower environmental negative impacts, preferably having no negative environmental impact. Lubberink (2017) described the fourth aspect of innovation as follows: *"The full life-cycle of the innovation should be considered when assessing the sustainability effect of an innovation"*. Following this, sustainable innovations can be driven by economic or ecological motivations and can set new sustainability standards for firms. As an organization in the construction industry, sticking to these aspects of sustainable-oriented innovations facilitates a pathway towards a process of change, aiming to create value across three dimensions, seeking to balance environmental conservation with social equity and economic prosperity, recognizing that sustainable development requires simultaneous progress in all three areas. (Lubberink et al., 2017)

2.6.1 Sustainability-oriented innovation in the Construction Industry

Charter and Clark, 2007 state that "*Sustainable innovation is driven by challenges such as increasing energy consumption, climate change, dependency on fossil fuels, pollution and water shortages*". The motivations to address these challenges can be driven by social or environmental motivators, but also as economic motivations since companies can benefit from potential competitive advantages by responding to these challenges.

In the specific context the construction environment, sustainable development is considered for various reasons. While many think that there is a tremendously high cost related to the development of a sustainable environment, the potential benefits and motivators are multifaceted. Therefore, the key reasons for considerations towards innovation of sustainable practices should be discussed. Firstly, innovation within construction towards sustainable practices often offers a competitive advantage by developing environmentally friendly products, services, and processes. By doing this, they enhance their market position by having a unique offering that attracts environmentally conscious clients and fulfils current and future governmental norms. (Behnam & Cagliano, 2016). Linked to this, competitive, sustainable innovations and developments help to mitigate risks associated with environmental degradation, climate change, and social issues. This by developing new and sustainable practices adapting to the constantly changing market conditions, requirements and stakeholder expectations. (Opoku et al., 2015). These stakeholder engagements can be positively influenced by demonstrating the commitment towards sustainable innovation and social and environmental responsibilities, potentially enhancing trust and engagement by addressing their concerns and thereby strengthening long-term partnerships. (Opoku et al., 2015). Another key point highlighting the significance of innovation practices is regulatory compliance. Moving towards sustainable practices helps the construction industry to comply with environmental regulations and standards; often, organizations feel the urge to proactively address environmental concerns through innovation to avoid potential fines, penalties, and, even worse, reputational risks. (Ramanathan et al., 2017). Further, it's known that sustainable innovation potentially leads to resource efficiency and cost savings; this is by developing solutions that reduce resource consumption, minimize production waste and optimize energy usage during processes. (Costa, 2021). All these key benefits of integrating sustainable innovation lead to the long-term viability of the business practices and ensure a quality set of future-proof operations, anticipation of market trends and value creation for society and the environment. (Behnam & Cagliano, 2016).

2.7 Innovative technologies and trends leading to sustainable built environments

2.7.1 Construction 4.0

Construction historically relied heavily on craft-based processes and has been linked with poor performance and quality. According to Wang and Guo (2022), "The slow rate of innovation is significant due to the industry's negative economic (e.g., low-profit margins, budget overruns, and significant project delays), social (e.g., high accident rate and poor working conditions), and environmental (e.g., high water, material, and energy consumption and waste generation) impacts" (p. 2). Therefore, the concept of industry 4.0 in construction plays a tremendous role in reshaping the way the built environment operates. This fourth industrial revolution in construction, represents the integration of advanced digital technologies into the construction industry to enhance efficiency, productivity, and safety. In Industry 4.0, the first fundamental driver is the use of cyber-physical systems (CPS); these are technologies enabling the combination of physical and virtual objects to create a world where intelligent objects communicate with each other (Griffor et al., 2017). An example of this are smart sensors in buildings that can communicate with each other.

Industry 4.0 combines this CPS with the second driver, digital ecosystems. These are digital environments where companies and stakeholders are sharing information and practices on a mutual platform, to gain insights and gain long-term advantages of various kinds (Gartner, 2017); in combination, these drivers are the fundaments of industry 4.0, forming a new paradigm for the development of environmental assets. Construction 4.0 emerged from industry 4.0, since the concept started to spread towards the construction industry. Construction 4.0 can be seen as an umbrella, housing several digital applications which have emerged from the roots of Industry 4.0. These applications are Building Information Modelling (BIM), unmanned aerial systems, cloud-based project management, Augmented Reality and Virtual Reality, Artificial Intelligence, Cybersecurity, Big Data and analytics, Blockchain, laser scanning, but also Robotics and Automation, Internet of Things, wearable sensors and much more (Forcael et al., 2020). Integrating these in the construction sector significantly strengthened the sustainable building environment (Beddiar et al, 2019).

Previous studies indicated the significance of these construction 4.0 technologies in relation to the triple bottom helix sustainability framework. Key technologies of construction 4.0 supporting sustainable development have been analysed. The following figure shows what technologies influence the development of sustainability. Here, it is clearly visible that Building Information Modelling is linked to supporting sustainable development on a consistent basis. This finding is declarable since BIM is completely integrated into all phases of construction projects, as it has the capacity to present data from other technologies digitally. (Begić & Galić, 2021; Ellegaard & Wallin, 2015). In addition, C4.0 concepts such as 3D printing, machine learning, digital twin, internet of things, and virtual reality were relatively consistently integrated to support sustainable development in construction.

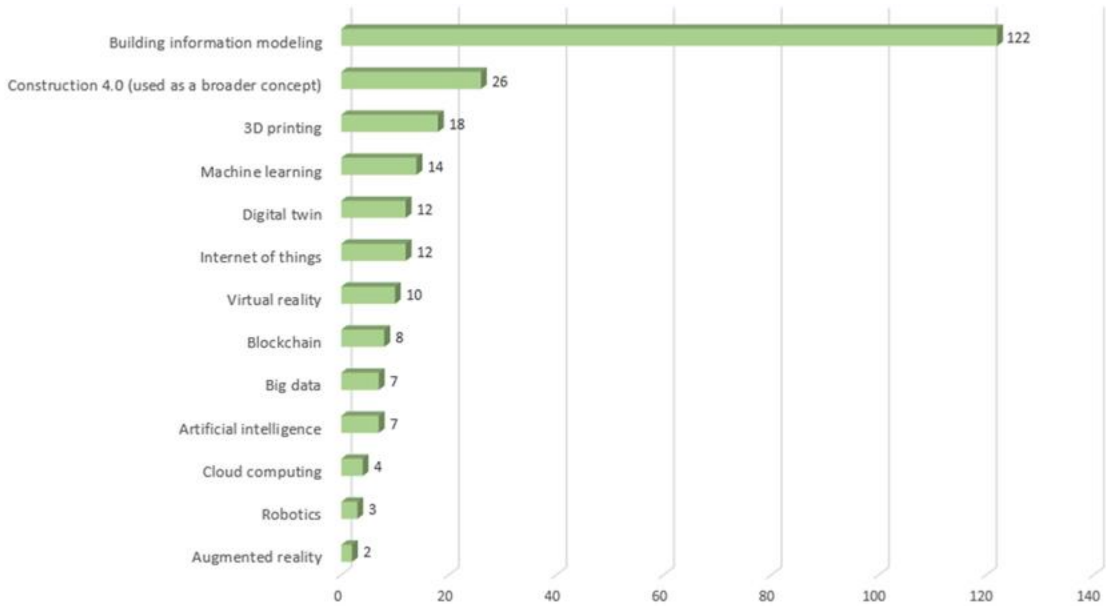

Figure 4: Technologies linked with C4.0 and sustainable development (Wang et al, 2022).

2.7.2 Emerging (technology) trends in the built environment

Building Information Modelling (BIM) is a revolutionary development that is quickly reshaping the construction industry. Next to functionalities as a product (technology), BIM is also considered as a tool for optimizing processes. The technology component of BIM supports project stakeholders in visualizing a simulation of a building to identify issues related to the design or construction process. The process component of the system provides collaboration features and encourages the integration of all key players within a project (Forcael et al., 2020). From a technology perspective, BIM is considered to be a 3D model that links informative connections to specific operations such as project planning, design, and construction (Azhar et al., 2012). The differentiating aspect of BIM compared to previously used technology such as 3D CAD is the ability to store all project-related information in a collection of smart objects (CRC Construction Innovation, 2007). From a process perspective, Building Information Modelling (BIM) enables streamlined collaboration and integration among all project stakeholders. This promotes transparency and accountability by ensuring that all project information is accessible and up-to-date for everyone involved, further helping to minimize misunderstandings and conflicts, leading to smoother project execution and delivery. The process aspect of BIM encourages the adoption of standardized workflows and best practices, which can improve project efficiency and quality. By establishing clear roles and responsibilities, BIM helps to streamline project management processes and minimize delays or errors (Azhar et al., 2012). Furthermore, BIM stands at the centre of construction 4.0 since most information acquired from other technologies used by the stakeholders is constantly integrated in the BIM platform to ensure smooth collaboration amongst all parties resulting into more flawless construction advancement.

Virtual Reality (VR) technology has revolutionized the construction industry by offering immersive experiences simulating real environments. In construction, VR provides a solution by allowing project visualization so stakeholders can experience projects before they physically exist. Since the first integrations of VR technologies, they have become integral across various departments within the construction industry, serving as essential tools for worker training, safety management, quality control and visualization. When looking at worker training, construction often falls short in effectively conveying the reality of work procedures and associated risks. Therefore, VR-based training is being used to enhance workers' abilities in specific construction tasks (Peters et al., 2016). For instance, platforms are being explicitly developed to train workers to install electrical systems (Le et al., 2015; Zhao & Lucas, 2015). Besides training, VR also supports safety management in construction. VR simulations can run various scenarios, providing users with simulated scenarios of potential threats. Implementing VR in safety management programs has proven to reduce accident rates and improve understanding of safety implications in designs (Bhoir & Esmaeili, 2015; Sacks et al., 2015). Furthermore, VR technologies streamline defect and quality management processes. Applications such as defect reporting using VR-based mobile and digital workbench technologies (Dong, Maher, & Daruwala, 2006) and automatic quality and defect management models (Gordon et al., 2003). VR facilitates proactive defect management frameworks, enhancing overall construction quality (Wong et al., 2014).

Augmented Reality (AR), on the other hand, overlays digital information and objects onto the real world's environment; in construction, this technology has capabilities to assist in scheduling and project progress tracking. AR enhances scheduling and progress tracking by providing visual representations of planned versus actual progress, Allowing project managers to monitor construction activities in real time and make informed decisions to ensure adherence to project timelines. Studies by Meža et al. (2015), Wang et al. (2013), Golparvar et al. (2009), Omar & Nehdi (2016), Zhou et al. (2008), and Turkan et al. (2012) have touched on the effectiveness of AR in this aspect. Also, AR technologies contribute to time and cost management in construction by providing accurate project monitoring, reducing defects and rework, and optimizing resource utilization. They help project managers identify inefficiencies, streamline workflows, and make data-driven decisions to minimize project delays and cost overruns.

Artificial Intelligence and Machine Learning are shifting the construction industry landscape, leveraging data availability to introduce innovative applications. One significant area where these technologies are making strides is in generative design has taken its first steps in the architectural field and has generally been applied in open-problem scenarios characterized by large design spaces. In this context, the term "Generative Design" refers to a series of tools, that implement artificial intelligence methods and algorithms applied to solve design problems (Buonamici et al., 2020). Generative design explores several design possibilities to identify optimal project layouts. For instance, an Autodesk team in Toronto utilized generative design to plan their new office building, considering parameters such as adjacency preference, work style, productivity, and daylight. Risk management in construction projects also benefits from artificial intelligence and machine learning. These algorithms have analyzing capabilities, scanning project data to reveal risks and make predictions of project outcomes, enabling construction companies to mitigate risks proactively and enhance project performance. (PMO Partners, 2023)

Additionally, Artificial Intelligence and Machine Learning contribute to improving schedule management by analysing project schedules and historical data to identify potential delays and optimize scheduling for increased efficiency and timely project completion. Artificial Intelligence and Machine Learning applications extend to subcontractor management, where Machine Learning algorithms analyse subcontractor performance data to predict the likelihood of delays or issues. This allows construction companies to make accurate decisions when selecting subcontractors, ultimately optimizing project outcomes. Moreover, Artificial Intelligence and Machine Learning automate construction site environment monitoring by analysing sensor data and real-time information, thereby detecting potential hazards and anomalies to prevent accidents and enhance safety compliance. Safety remains paramount in the construction industry, and Artificial Intelligence and Machine Learning play a pivotal role in enhancing safety measures. Machine Learning algorithms analyse historical safety data to identify patterns indicative of potential safety risks, empowering construction companies to implement preventive measures and improve overall safety on construction sites. (Pandey, 2023)

Blockchain technology's primary applications lie in the realm of smart contracts, which play a crucial role in tracking project progress and managing financial transactions. By leveraging blockchain-based smart contracts, construction stakeholders can precisely identify responsible parties in case of delays or disputes, thereby enhancing accountability and transparency throughout project lifecycles (Mahmudnia et al., 2022; Yang et al., 2020) When considering the design process, blockchain facilitates the seamless tracking of transactions, such as advance payments to vendors and equipment deliveries. Through unchangeable records stored on the blockchain, delays in payment or delivery can be simply traced back to their sources, whether it be the vendor or other involved parties. This not only streamlines the resolution of disputes but also establishes clear responsibility, mitigating potential conflicts (Yang et al., 2020) Furthermore, blockchain-based frameworks offer robust solutions to financial challenges encountered in construction projects, particularly concerning payment delays and disputes. These frameworks leverage blockchain's decentralized nature and cryptographic protocols to create secure and transparent payment systems. By the decentralization of payment processes and ensuring transaction immutability, blockchain frameworks provide an equal playing field for all parties involved, thus eliminating the need for mutual trust while safeguarding the interests of stakeholders (Das et al., 2020) In addition to addressing financial issues, blockchain fosters collaboration and transparency among construction stakeholders. By granting equal rights to share ideas and reducing bureaucratic hurdles through decentralized documentation processes, blockchain promotes a culture of cooperation and trust within construction projects. Through transparent and immutable documentation stored on the blockchain, participants gain access to real-time project status updates, fostering a collaborative environment fostering efficient decision-making and conflict resolution (Mahmudnia et al., 2022; Yang et al., 2020).

As concerns about environmental degradation, resource depletion, and climate change intensify, the need for sustainable building practices becomes more important. Green building certification systems have emerged as powerful tools to address these challenges, offering frameworks designed to evaluate the environmental performance of buildings throughout their lifecycle. These systems encompass a wide range of criteria, considering energy consumption, indoor environmental quality, materials and resources usage, and the building’s operational management (Anderson et al., 2002). By setting sustainability standards and benchmarks, they guide building professionals, developers, and policymakers seeking to minimize the environmental footprint of construction projects. Next to the primary goal of sustainability, these certification frameworks serve to achieve increased energy efficiency. More specifically, reduced energy consumption during off-peak hours, efficient water usage, and improved waste management lead to decreased operational expenses. Simultaneously, the building's market worth rises as a result of its certified environmentally sustainable attributes. Furthermore, the certification evaluates indoor air quality and thermal comfort. In this regard, green certification strives to enhance the quality of life and productivity of building occupants, thereby indirectly but significantly influencing financial and social aspects (Lee & Guerin, 2010).

Leadership in Energy and Environmental Design (LEED) is an example of such a green building certification program. This green building certification program developed by the U.S. Green Building Council (USGBC) provides a framework for designing, constructing, and operating environmentally sustainable buildings. It offers a set of rating systems for various building types, including new construction, existing buildings, commercial interiors, and neighbourhood developments. LEED certification evaluates a building's performance across categories ranging from energy efficiency and water conservation to materials selection and sustainable site development (U.S. Green Building Council, n.d.). LEED is a point-based system, where different green features of a building earn different points based on environmental. Based on the total credit score, the building receives a LEED rating level, ranging from Certified and Silver to Gold and Platinum (Uğur & Leblebici, 2018). The LEED certification process encourages building excellence and promotes sustainability in construction projects worldwide. LEED certification serves as a globally recognized standard for sustainable building practices, promoting environmental stewardship, resource efficiency, and occupant health and well-being (U.S. Green Building Council, n.d.). Since certified building is becoming common practice, the application of renewable energy techniques in construction is increasingly prioritized and integrated into building design and development processes.

Furthermore, Integrating renewable energy technologies into building design has become a key strategy to enhance energy efficiency and operational cost reduction. Renewable energy integration includes solar energy, wind energy, geothermal energy, and biomass, as well as low-embedded energy, daylighting and green roofing. Renewable energy mainly originates from solar energy manipulations. Solar energy enables the existence of hydropower, wind energy, and biomass. Thus, converting solar energy into a useful form of energy is more feasible using different energy systems and devices. The intensity and spectrum of solar irradiation influence the performance of any solar system. The technological non-complexity and local applicability make solar energy a first choice for renewable energy applications in buildings. Solar energy is commonly used for the production of electrical and thermal energy. Electrical energy can be directly used for cooling, heating, and other building electrical requirements. Additionally, thermal energy can be directly used for hot water and heating. Technologies such as solar thermal absorption cooling systems enable cooling in building areas with high cooling demands. On the other hand, the placement of solar absorbers for hot water production is the most effective way to produce hot water in buildings. Solar energy for cooling and heating in building projects can be integrated as an active or passive system. (Khan & Al-Ghamdi, 2021) The passive solution is generally related to the design stage, which consists of various techniques to store, collect, distribute, and control solar energy (Khan et al., 2020).

The most emerging technique is Passive solar building design. This is a sustainable technique focusing on conserving energy as much as possible. More specifically, this technique involves harnessing the sun's energy for heating, cooling, and daylighting without additional cost, thereby reducing reliance on other energy sources and enhancing indoor comfort. These design principles are adaptable to various architectural styles and can be incorporated into existing buildings to achieve low to net zero energy usage (Aksamija, 2015). In integrating passive solar building designs, attention is particularly paid to the sun to minimize heating and cooling needs. These designs seem to have a complex nature, but in reality, since the integration is relatively possible in any kind of building environment, grounded knowledge of solar geometry, window technology, and local climate is sufficient for the integration of these advanced technologies (Aksamija, 2015). In general, the natural processes used in passive solar energy are thermal energy flows associated with radiation, conduction, and natural convection. More specifically, when sunlight reaches the building, solar radiation gets absorbed, reflected, or even transmitted by the selection of the specific material. Furthermore, the heat generated by the sun generates predictable air movements within carefully designed spaces. These responses to solar heat are used in combination with design elements and material selection that can provide heating and cooling capabilities in a building (Chel & Kaushik, 2017). The advantage of these systems is that there is no need for mechanical structures to trigger them, therefore being tremendously energy-efficient (Perlova et al., 2015). On the other hand, active systems rely on external mechanical equipment to generate solar energy for buildings. Photovoltaic panels, air–water collectors, and other efficient collectors are examples of such solar systems (Khan et al., 2021). Solar heating systems are common active systems where solar energy is collected and stored in storage tanks placed inside or near the building. This energy is then pumped to the building using external electrical energy. Hot water is the fluid typically used in these systems for thermal energy transportation. Similarly, absorption cooling using solar energy is another example of an active solar system(Khan et al., 2021).

Besides renewable solar energy integration, installing wind turbine systems for energy generation in buildings is getting more popular, especially in well-developed European countries. Developing countries, on the other hand, practice for small-scale wind turbine installations (Yuan et al., 2013). Wind energy can be used for both thermal and electrical energy generation. In general, wind turbines are deployed to convert the kinetic energy of wind to electricity for the generation of electrical energy. Secondly, wind turbines can also be used to convert mechanical energy to other energy forms, such as pumping, wood cutting, and thermal energy generation. However, wind energy is limited due to the fluctuation in the intensity of wind throughout the year. The storage of collected wind energy is therefore essential for its successful implementation. In general, this energy can be stored as chemical energy (hydrogen), electrochemical energy (batteries), and kinetic energy (flywheel). Small-size wind turbines are currently being researched for integration into the built environment, with a particular interest in their decentralized power generation ability. These turbines are preferred to be installed on top of buildings in urban areas (Balduzzi et al., 2012). Unfortunately, accurately predicting wind turbine energy output in urban areas is challenging due to complicated wind profiles caused by high-rise buildings. While some general principles exist, such as installing turbines on buildings taller than nearby structures, various factors hinder precise prediction and implementation. These include difficulties integrating turbines into architectural designs for optimal output, turbulent airflow caused by urban obstacles impacting turbine efficiency, risks to flying animals from turbine blade ends, and potential disturbances from low-frequency noise, potentially affecting nearby residents or workers. Thus, further comprehensive testing and consideration of these factors are essential before the implementation in urban environments.

Further, In the construction industry, geothermal energy is commonly used for space cooling and heating using heat pump technology. This specific technology uses the earth's warmth as a heat source during wintertime and employs heat sinks (thermal reservoirs collecting heat) in the summer to remove heat for cooling purposes. This emerging technology is currently being integrated into new buildings in developed and developing countries. The technology has the capacity to save 30 to 70% of the required energy for space heating and cooling in buildings (Yuan et al., 2013). Geothermal systems are often widely used with solar energy for a sustainable building energy design. For instance, combining solar photovoltaics with a geothermal system can fulfil both the electrical and thermal energy needs of a building.

Another emerging application of sustainable design in the construction industry is the implementation of Biomass as an insulation product. Several forms of biomass insulation are deployed depending on the degree of insulation needed and intended application. In general, bio-based building materials perform equally to regular insulation materials, often carrying out several functions simultaneously (Jones & Brischke, 2017). Examples of Biomass integration in buildings are straw bales and wood-based concrete blocks used in the building for wall filling and insulation purposes (Meng et al., 2018).

Additionally, energy consumed during the production process of a building contributes from 15% to 20% of the energy used by the total active life-time of a building over a 50-year period (Architecture 2030, 2010). Utilizing materials with low embodied energy for construction purposes is being considered more often. Embodied energy encompasses the total energy consumed throughout the production processes of a building, from resource acquisition to product delivery (Antypa et al., 2022). Therefore, construction industry clients must consciously discuss embodied material selection with engineers and project managers to select materials with low embodied energy, thus reducing the amount of fossil-fuel energy used during production. The use of low-embodied energy materials in buildings can considerably lower the usage of energy and minimize impacts on the construction environment (Chel & Kaushik, 2017).

Economies of daylighting in buildings, on the other hand, are concepts where various techniques are used for natural lighting in buildings, limiting artificial lighting and thus limiting energy consumption during daytime. In addition, the inclusion of daylighting in construction offers improved life-cycle cost, increased user productivity, reduced emissions, and reduced operating costs. Also, sufficient daylighting increases user comfort and satisfaction, leading to improved performance. Further contributing to the Sustainable Development Goals of well-being and generating a productivity advantage for businesses. (Sandanasamy et al., 2013)

Lastly, the introduction of green buildings and specifically green roofs in construction offers a promising solution to several emerging issues faced by cities. These issues originate from the decline of grasslands, which has triggered shifts in hydrological patterns within river basins, leading to tremendous consequences such as increased flooding in urban areas (USEPA, 2001), soil erosion (Doyle, Harbor, & Rich, 2000), and heightened levels of pollutants in runoff (Mansell, 2003).

Additionally, urban development has been linked to the diminishing natural replenishment of groundwater (Slonecker & Tilley, 2004). Moreover, with the emergence of climate change, cities are experiencing heavy rainfall frequently, awakening the need for more efficient rainwater management systems (USEPA, 2001). Green roofs implementation into buildings offers a multifaceted approach to addressing these challenges. Green roofs act as carbon sinks, which absorb carbon dioxide and lower the urban heat island effect. Furthermore, they excel at retaining rainwater, having capabilities of reducing stormwater runoff and supporting pressure on drainage systems. Additionally, green roofs provide high insulative levels, contributing to noise reduction within buildings, enhancing thermal insulation properties, and consequently reducing heating and cooling costs. Moreover, the presence of green roofs offers psychological and aesthetic benefits to urban dwellers while fostering biodiversity (Ying et al., 2022).

2.8 Circular business model innovation in construction

2.8.1 What is a business model

To integrate emerging technologies and trends, construction firms need to strategize implementation. The main goal of strategizing is to ensure the long-term companies' competitiveness. This can be achieved by sketching an image of the businesses realized or desired strategy using a business model (Casadesus-Masanell & Ricart 2010). Important to understand is that business modelling in its singularity is not a complete guide to achieving a strong corporate strategy; their successes and failures depend on how the model interacts with other industry players in the environment (Casadesus-Masanell & Ricart 2011). The arising question now is, what is a business model then?

The first time the term "business model" was written in an academic article dating from 1957 (Bellman et al., 1957). Here the word business model was used once and referred to a representation of the real world through a model. Later the business model concept emerged in context of e-businesses where many definitions of business models originate from (e.g. Timmers 1998, Afuah & Tucci 2001, Amit & Zott 2001). Resulting from this, the concept of business models has been applied to several business branches and definitions therefore emerged from several fields such as strategy, technology and entrepreneurship (Chesbrough & Rosenbloom 2002, Morris et al. 2005, Shafer et al. 2005). Despite the fact that the term "business model" has roots in many economic branches, it tends to cover issues in value creation and value capturing in multiple branches (Pekuri, 2015). Osterwalder (2004) defined a business model as follows;

'A conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money. It is a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams'.

Later, Osterwalder and Pigneur (2009) constructed and defined the Business Model Canvas (a tool for constructing business models) to structure a business model further and, therefore, created nine building blocks: value proposition, partners, activities, resources, customer relationships, channels, customer segments, cost structure, and revenue streams. Today, the Business Model Canvas is still widely used by professionals to design, illustrate, and revolutionize the strategy of a business.

2.8.2 Business model innovation in construction

Emerging technology trends within Construction 4.0 offer opportunities for innovative business models (BMs) based on improved methods and techniques, providing an augmentation in effectiveness and efficiency in the built environment. Unfortunately, integrating these emerging (technology) trends in the built environment often appears challenging. Variables such as training employees, change management, implementation costs and technology complexity are barriers for smooth integrations. Business model innovation, therefore, is paramount for effectively integrating new innovations into the industry. Business model innovation represents novel, nontrivial design changes to the nine key elements of a firms business model architecture (Foss & Saebi, 2017). Important is that these design changes are steered by management, playing a significant role in designing the business model innovation architecture. These design changes are often evolutionary and go beyond slight adaptions to the company's environment. Managerial challenges arise in making these adoptions, since business model design can be highly complex. Here it is crucial for managers to perfectly understand the current business model of their firm to change them at the right time in the future. (Linder & Cantrell 2000, Johnson et al. 2008).

Transforming an original model to integrate new technologies can tremendously shift the nine building blocks of the business model, resulting in potential changes in cost structures, revenue streams, value propositions, activities and resources, partnerships, distribution channels and even customer relationships (Osterwalder and Pigneur, 2010). Successfully adapting business models within the industry leverages the integration capabilities of technological advancements and new industry trends. These successful integrations often lead to attracting new customers (Johnson et al., 2008), increasing customer loyalty due to augmentation in value offerings (Enkel and Mezger, 2013) or simply reducing customer costs (Mitchell and Coles, 2004).

2.8.3 Circular economy

Kriza, 2016 Defined circular economy as an economic system aimed to eliminate waste by ensuring that resources remain in a perpetual loop. When looking at a perfect circular economy, it suggests that environmental sustainability can be embraced by transforming products and processes to the extent that the relationship between economic growth and ecological systems are compatible with each other (Braungart & McDonough, 2002). Furthermore, circular economy has been identified as a sustainable development initiative representing a new way of doing economy, managing systems and creating value with realigned products, services and processes (Korhonen et al., 2018:Murray et al., 2015, p.373). The circular economy is driven by the cradle-to-cradle principle (C2C), laying focus on closed loops of material flows and novel energy-efficient product designs (McDonough and Braungart, 2002; Stahel, 1994). Following the C2C principle, production design needs to closely imitate nature’s system where waste is non-existent. Thus to eliminate the waste concept, understanding that waste does not exist in the C2C theory is crucial for designing new products and processes. (Braungart & McDonough, 2002, p. 90). Scaling up the C2C principle towards a circular economy, Industries and supply chains aim to eliminate waste ensuring that resources are kept in a repeating loop, lowering or eliminating the need for virgin materials within a chain or economy (Kriza, 2016:Nasir et al., 2017). The transformation from a typical linear economy towards a closed circular economy design ensuring repetitive resource reusage, prevents waste generation and earths depletion (Jørgensen & Pedersen, 2018:Carra & Magdani, 2016). Therefore, it is key that the resources remain in a complete or a high state of the original resource value to embrace the circular economy design (Braungart & McDonough, 2002); these circular practices, reducing emissions and environmental footprints, have been capturing interest from waste generating industries such as the construction industry. The built environment already contributes towards the fulfilment of the Sustainable Development Goals with the integration of many revolutionary technologies and trends but is challenged by governance, regulations and most importantly, business model innovation, serving a significant role in the transition towards a circular economy design were principles of C2C can be executed (Carra and Magdani, 2016).

2.8.4 Circular Business Models in the built environment

To create a world, taking into consideration sustainability, we need business models operating within the planet´s limits and are being mindful of their impact on the three pillars of TBL. (Lenssen & Smith, 2019). These sustainable business models integrate sustainable goals and principles into the building blocks of a business. Circular business models are a subcategory of sustainable business models; they are often described as an extension of sustainable models that reflect sustainable practices in the value proposition, value creation, and value capturing. Geissdoerfer et al. (2018a, 2018b). Circular business models have the primary goal of assisting organisations in creating value by using resources throughout multiple cycles, reducing waste or, in the best case, avoiding waste completely by only using renewable resources (Lüdeke-Freund et al., 2019). Nußholz, (2017, p. 12) described circular business models as "the way a business creates, delivers and captures value at every chain in the system with and within closed material loops". Achieving the implementation of these business models requires incentives from many key players within the built environment, ranging from designers, suppliers and contractors to additional end-of-life companies. Therefore, collaboration throughout the ecosystem is crucial for successful circular business model implementation. (Carra & Magdani, 2016). The focus of the research, identifying the barriers and enablers for circular business models within the Belgian construction industry, is therefore driven based on the interactions between the key players within the built environment.

3. Methodological Framework

3.1 Research Context

Since currently little is known about circular business models in the Belgian built environment, the researchers of this study decided to execute exploratory research. The usefulness of this research type lies in identifying potential research questions and hypotheses to be further investigated in future studies.

It is common that exploratory research is used in social science to gain insights in behaviour or other phenomena (Swedberg, 2020). Methods such as interviews, case studies, and observations are common enablers for accomplishing these insights. Specifically in this research, the decision was made to collect qualitative data by conducting expert interviews on 1. experts in sustainability and/or circularity within the Belgian built environment and 2. a certified expert in business model design trained by Pigneur and Osterwalder. Using these interviews, this study generates a deeper understanding of the opinions, behaviours and experiences of the interviewees. During this study, the researcher investigated the perspectives, experiences, knowledge and future visions of interviewees active in the Belgian built environment. Collecting data by conducting semi-structured interviews was essential in this study to gather detailed information and insights. Therefore, the recommended approach for this study is a qualitative approach since it provides the most efficient and effective way for the researcher to examine the range of subjects and to identify and structure occurring patterns.

3.2 Research Questions

This research's objective lies in gaining a deeper understanding in the difficulties arising when implementing a circular business model design in the Belgian built environment. Further, it will explore how firms in the environment can prepare themselves to make smooth transitions towards a circular built environment with the greater goal of fulfilling industry-specific Sustainable Development Goals (SDGs). It will explore how several firms within the built environment make contributions towards sustainability in a circular context and how they take steps towards a complete circular business. Additionally this research investigates methods to accelerate the implementation of circular business models and tries to find reasoning for circular implementations within Belgian construction firms. These objectives will be fulfilled by the following research questions.

1. **What are the barriers and enablers for implementing circular business models within the Belgian construction industry?**
   This question delves into the examination of various obstacles and facilitators taking part in the integration of circular business models within the Belgian construction industry. By looking for diverse profiles during the interviews, we aim to gather deep and accurate insights into the barriers and enablers for circular business model implementation.

2. **How do circular business models facilitate the transition to a sustainable built environment?**
   This question aims to explore the mechanisms through which circular business models contribute to the progression towards a sustainable built environment. What are potential Sustainable Development Goals construction firms take into consideration to create circular value through the business model?

3. **How do Belgian construction firms prepare for a transition towards a circular business model.**
   The research dives into exploring initiatives firms take to transit towards circularity within their business models. We seek to find answers how construction firms try to diversify themselves and how they prepare themselves for a unique circular value creation.

3.3 Methodology approach

This research utilizes semi-structured interviews to collect insightful data to answer key points in this thesis. These have been conducted to visualize current efforts construction firms take within the built environment to contribute towards a circular economy and thus the creation of circular business models. The interviews facilitate the answering of the three previously discussed research questions. These interviewees have been selected carefully, considering the interviewee's position within the construction industry, the firm's role within the industry and the firm size. Secondly, the inclusion of a business model expert has been selected to gather specialist insights. This has been done to link his theoretical and practical insights with the practices of the interviewees originating from the built environment. The interviews have been conducted via online meetings and phone conversations. The researcher reached the respondents via mail, including an introduction about the study and the interview questions. Taking the interviewees' field diversity into consideration, the researcher decided to design two separate interviews with slightly different interview questions. This has been done to optimally execute interview conduction and ease understanding among different interviewed experts. In total, there were six respondents generating the source of data collected in this research.

Candidate function	Candidate ID	Sex	Duration
Business Model Design Expert	C1	male	36 min
Sustainability Manager	C2	male	39 min
CEO	C3	male	27 min
Architect	C4	male	29 min
Industrial Engineer	C5	male	40 min
Sustainability Manager	C6	male	25 min

Table 3.1: List of interviewees.

3.4 Data Collection

The researcher opted to collect the interviewee's data utilizing digital communication. This has been done to ease the strict agendas of the reached interviewees since many of them have strict agendas due to their important roles within their organizations. Preferences, therefore, lay into interviewing all respondents using online meetings with active camera usage, stimulating better interaction and non-verbal communication.

Since the aim of this study is to gather deep and broad insights into a specific industry, it has been decided to interview in a semi-structured fashion to openly approach each interview without surpassing the research barriers. Thus, the respondents were allowed to share their insights, experiences and perspectives, as long as they would benefit the researchers questions. All interviews were initiated with a few warmup questions, gathering insight into the role of the interviewee and secondly to test their knowledge of key principles discussed further in the interview. Afterwards, the researcher shifted towards asking the main interview questions designed to answer the research questions. To ease interviewing, a list of interview questions was delivered to the respondents, giving them the opportunity to read the questions and potentially even prepare for the interview.

3.5 Data analysis

To accurately process the collected data, the researcher asked permission to record the interviews. This is done to further accurately transcribe the dialogues and generate truthful information provided from the viewpoint of the respondent. When analysing these transcripts, it is crucial to recognize the experts' information and to avoid interference with subjective opinions coming from the researcher's perspective.

To support this analysis and find a structure for the different themes and the general outline of the findings, the researchers utilized the concept of thematic coding in this study. This thematic coding is applied to identify and link information acquired from the interviews, identifying passages of text linked by common themes (Garbe et al., 2020). When looking at coding itself, it provides means of purposefully managing locating, sifting, sorting, and querying data. This data is designed to facilitate analysis. Coding is a necessary step in nearly all qualitative analysis approaches, but several forms, approaches and purposes of coding exist and can vary enormously. (Bazeley, 2013, p. 125) In this study, each interview has been transcribed and carefully reviewed. Afterwards, familiarities with the data have been developed into recurring themes. In this study, the themes are categorized into main themes and subcategories. To allocate the gathered information to the correct theme, the researcher conducted several steps to execute data analysis.

To establish this, the researcher read all transcripts and highlighted general information applicable to supporting the answering of one or more research questions. Subsequently, the researcher applied coding principles to shorten the information into relevant subject-specific keywords and short phrases. Lastly, the researcher matched the relevant information corresponding to the research questions and constructed a coding tree table, which is presented below.

Phase 1	Phase 2	Phase 3
RQ1: barriers and enablers for implementing circular business models in the Belgian built environment	Vertical integration of sustainable practices in business models Problem-solving approach: scarcity and stakeholder engagement	Initiatives towards CO2 neutrality Importance of embedding sustainability within organizational culture Strategies for material lifecycle management and reuse Need for a scarcity-driven business model Stakeholder engagement and resistance
RQ2: circular business models facilitation in the transition towards sustainable development	Governmental support and regulations Market dynamics and consumer behaviour	Regulations, Policy initiatives subsidies and shortcomings Consumer value perception and demand Subsidy impact on business practices Market competitiveness
RQ3: Belgian construction firm preparation for circular business model transition	Sustainable oriented partnerships and procurement Technological advancements and innovation	Sustainable oriented partnerships Procurement of people, product and processes Carbon capture and reduction strategies Integration of secondary raw materials Adoption towards circularity

Table 3.2: Coding tree

4. Findings

The findings of this dissertation, discussing circular business model design within the construction industry, are projected within the following sections. This study provides insights in how businesses operating within the built environment can enhance their business model towards a circular design, considering elements of the Sustainable Development Goals. This is achieved through analysing the existing literature and through expert interviews. The findings of this study demonstrate the current state of circular business model design within the Belgian construction industry.

To answer the main research question and sub-questions of this study, the researcher decided to analyse different themes the interviewees touched upon. Therefore, the findings section is divided into several components highlighting insights about relevant subjects related to the main research question and the sub-questions (table 3.2).

The captured findings highlight the barriers and enablers for implementing circular business models in the Belgian built environment. Initiatives towards CO2 neutralities, in combination with the embedment of sustainability within the organizational culture, are being discussed as enablers for circular business models within the industry. Simultaneously, lifecycle management strategies positively influence the transfer towards circularity in the industry. Additionally, industry insights concerning the barriers to circular business model implementation are highlighted. These range from stakeholders' resistance to circular adaption to a potential lack of a scarcity-driven business model. Moreover, the limitations of governmental support and subsidies are discussed.

In addition, the findings illustrate the current dynamics of market forces and consumer behaviour. This section explores the impact of these dynamics on the transition towards circular business models. Furthermore, the findings discuss the importance of partnerships in the supply chain and indicate incentives taken by organizations to reach sustainable procurement. Furthermore, the findings highlight how circular business models facilitate a transition towards sustainability. This is illustrated by the variety of circular initiatives taken by industry stakeholders. These initiatives not only target specific Sustainable Development Goals (SDGs), indicating the importance of circularity but also contribute to the other 17 SDGs. Technological advancements and innovations, such as carbon capture technologies and advanced construction methods, are also discussed as critical components for achieving circularity. Lastly, organizations need to prepare for a circular transition to ensure a sustainable built environment. Therefore, the findings highlight what current initiatives are taken within the built environment to stimulate the transition towards circular business models.

4.1 Vertical integration of sustainable practices in business models

To be able to integrate circular business models within the Belgian construction industry, sustainable practices need to be integrated vertically within the current business models. (Hina et al., 2023). Our interviewees indicated that within the built environment, there are several elements contributing to the establishment of sustainable and circular business models within the industry. They also indicated that these practices have to be integrated vertically meaning that all stakeholders within the organization and preferably partners such as suppliers and contractors need to be willing to integrate sustainable practices. This to strictly contribute to a circular business model design.

"It all starts with designing sustainable, if the architect willingness to design sustainable is not there then it gets hard to follow up the construction process with parties that are actually willing to participate in these practices, right?" (C2)

In addition, C2 and C3 mentioned that the Sustainable Development Goal "partnership for the goals" is of major importance, implying that vertical integration of sustainable practices within business models can only be achieved when all stakeholders participate.

4.1.1 Initiatives towards CO2 neutrality

Based on the answers of our respondents, the researcher analysed that several respondents explicitly indicated that the industry is responsible for a tremendous amount of carbon dioxide emissions. These emissions characterize the built environment as one of the most pollutive industries in the world. In relation to this, C2 and C3 supported this statement.

"One of the things that plays a major role today is everything related to footprint data and CO2 issues, which are very prominent, especially in the context of certain goals towards becoming climate neutral." (C2)

"Cement is very important here because you see 86% of the emissions of CO2 originate from it."(C2)

"The construction industry accounts for 40% of global CO2 emissions worldwide. Therefore, sustainability is a very, very important topic in the construction industry in Belgium, but also around the world." (C3)

These statements demonstrate that the industry is conscious regarding this sustainability issue. To overcome this issue, Belgian construction firms utilize several techniques and innovations to lower their carbon dioxide footprint. This can be validated when analysing the initiatives taken by the interviewed organizations, varying from initiatives in design and material selection to the execution of building procedures. When looking at the sustainability manager (C2), he claimed that his organization is contributing to lowering carbon dioxide emissions by tracking the origin of materials and labelling the raw materials with a sustainability score. His organization integrates sustainable KPIs, analysing the material selection and level of emissions of these materials, especially for concrete and asphalt suppliers. In addition the CEO (C3) mentioned initiatives for CO2 neutrality, having processes from material selection towards a sustainable end product.

"…So here is the KPI. The percentage of secondary raw materials used is therefore reflected in both the concrete and in our products. So ultimately, this is already logged and tracked by us."(C2)

"We start from waste products or natural sources, then we convert them into high-quality chemicals, and then we turn them into a product that solves the problem again. So we solve the problem by starting from waste, which would normally end up in landfills, be incinerated, and then end up in our atmosphere. So we reuse that."(C3)

Here, the interviewee specifically indicated that they prevent emissions by simply using waste materials that would normally already end up being a waste product and consequently become a major polluter. Secondly, it is clear that this organization takes into consideration the life cycle of materials, referring to a circular business model design. Also (C6) referred to concrete factories adapting their production with carbon capture, lowering the CO2 emissions immensely.

"Yes, cement production is one of the major contributors to CO2 emissions in construction. I know that cement factories are currently in the process of adapting their production with carbon capture, and from 2028, the first factories in Belgium, for example, will be implementing this. Reduced CO2 emissions will mean that the share of cement in emissions will decrease even further."(C6)

Additionally, the interviewed architect (C4) also made contributions towards a CO2-neutral environment. Their contributions aligned with a quote from the sustainability manager (C2), stating that it all starts with the design of an architect and the materials used in a project".

"It all starts with designing sustainable, if the architect willingness to design sustainable is not there then it gets hard to follow up the construction process with parties that are actually willing to participate in these practices, right?"(C2)

Aligning with this statement, the architect (C4) mentioned that he is responsible for an energy-efficient design, by integrating passive design principles such as mechanical heating and cooling systems.

"…We surely do! It starts with us right, if we don't design it right, it simply is not there. We try to integrate sustainable design into the projects as much as possible, I don't know if you are familiar with passive building designs? because we commonly include it!"(C4)

Unfortunately, the industry is currently not capable of consistently integrating full life cycle circular business practices in the entire built environment chain; the interviewed sustainability manager mentioned that to this day, complete CO2 neutrality for the Belgian built environment is hard to achieve.

"…Its still challenging, but there are only a few happy few, so to speak, who are already further along with that. Especially when we look at the construction sector. It's not the intention, as they often say, 'oh, we break something down and we put all that rubble in the foundations and we're being circular.' No, it needs to be high-quality, maximally high-quality reusage. So, that requires some know-how."(C6)

Based on these arguments, it becomes clear that the built environment is conscious of the tremendous amount of pollution the industry generates. It is also remarkable that many respondents have their contribution towards a CO2-neutral environment, showing that the sector is willing to contribute towards lowering its footprint by integrating several processes and techniques within the daily practices of the organization. Unfortunately, this CO2 neutrality cannot be completely executed to this day. There are current initiatives, but businesses with complete circular lifecycles are scarce, and some materials today simply cannot be produced while being completely CO2-neutral.

4.1.2 Importance of embedding sustainability within organizational culture

Research has shown that the embedment of sustainability within the organizational culture is crucial for organizations to properly implement sustainable practices. It is important that the employees' roles and responsibilities are aligned with the culture to make sustainable contributions as an organization successfully. (Haugh & Talwar, 2010) In relation to this, the interviewer analyzed incentives for creating this organizational culture among the interviewees.

"If you're not committed to sustainability, you're not the right fit for us. Everyone here is driven to push boundaries and make a difference." (C3)

"…Our organizational culture revolves entirely around sustainability. It's not just a part of what we do; it's the essence of our existence. From our hiring practices to our daily operations, everything aligns with our commitment to sustainability." (C3)

Since the organization of this interviewee strives for sustainable excellence, it is of major importance for the organization to have a culture moving in the same direction, embracing the principles of sustainability. The sustainability manager’s organization (C2) specifically focuses on the mindset of their employees, also referring to creating this sustainable organizational culture.

"I think organizational culture is essential for achieving sustainability within a company. It's not just about implementing policies and procedures, but also about fostering a mindset and way of working that embraces sustainability as a core value."(C2)

The researcher can draw conclusions here that embedding sustainability within the organizational culture is of major importance for Belgian construction firms. There are strong arguments implying that incorporating sustainability within the mindset of employees is a right fit for the organization. Looking at it from a business model perspective, the way of working needs to align with sustainability to create a core value for the business. This sheds light on the importance of having the right employees to establish a sustainable business model.

4.1.3 Strategies for material lifecycle management and reuse

One of the challenges to arriving at a circular business model within the construction industry undoubtedly is strategizing material lifecycle management and reuse. The potential benefits of managing these lifecycles in construction businesses range from lower material usage and a stronger value proposition towards contributing to the Sustainable Development Goals. More specifically, interviewed organizations focused on responsible consumption and production, industry innovation and infrastructure, and clean energy in relation to lifecycle management.

“Energy conservation. Climate change mitigation, and avoiding waste generation of course,” (C3)

"Twelve. Responsible consumption and production, that's where the circular story is. And also along with the piece of Climate Action in thirteen. So if you want to pick two, those are very present, but it can only work if you SDG 17, partnership." (C2)

The interviewees mentioned several initiatives taken to strategize for managing their material lifecycle. These strategies ranged from simple initiatives to complete material lifecycles including reusage of “waste” material. In relation to the previous quote of the sustainability manager (C2), partnership for his organization is the main strategy to reach successful material lifecycle management. Often, large organizations involve collaboration with suppliers and manufacturers to ensure the effective management and reuse of materials.

“So, imagine a scenario where there's a specific infrastructure where end-of-life materials are recycled, partly reintegrated as foundations for new projects, or prioritized for granulate production in the appropriate format. This essentially is the core principle of what we aim to achieve.”(C2)

“For instance, we have ongoing investigations into reusing insulation and repurposing specific components. let's say, parts that could give a building a second life. However, this process faces challenges because we're no longer dealing with standardized volumes. These are unique pieces, often custom-designed for specific openings or sealing purposes. It's crucial to focus on this aspect. It's one of the strategic focal points aiming towards a sort of standardization, which would facilitate and promote reuse more effectively.” (C2)

On the other hand, the interviewed CEO based his material life cycle strategy on using waste, starting his product from scratch, and having the ability to recycle his product again after usage; this adds tremendous value to the product and aligns way further with a complete material life-cycle then most initiatives taken by other industry players. This is an example of a complete material life-cycle contributing to a strong value proposition of a circular business model. The interviewee (C3) stated that, currently circularity is scarce within the built environment, giving his organization a competitive edge.

"The success we've had, on the one hand, is also due to the fact that very little innovation and effort are being put into circularity in the construction industry. As a result, we've achieved tremendous success in the short term because so little has been done in this area. We're one of the game changers that are actively pursuing circular practices, which is why we're receiving a lot of attention and have been able to be highly successful in the short term." (C3)

"Similar but not quite the same; they contribute to circularity, but they're not exactly similar. We've been heavily involved, but there are companies like, for instance, Orbex, or Van der Zanden in Limburg, who are also heavily engaged in this area" (C3)

The researcher analysed this scarcity and concluded that key players within the Belgian construction industry mention various ways they can strategize, but only a few organizations are actually implementing complete material life cycle strategies. Many are still researching or developing their strategy for future material life cycle implementation. This points out a rather slow strategy implementation with loads of additional progress needed before the word "circularity" can be awarded to organizations claiming to be circular, including material life cycle management.

4.2 Problem-solving approach: Scarcity and stakeholder engagement

This section examines how scarcity challenges and stakeholders' engagement influence the adoption of circular business practices. It explores the necessity-driven aspects of circular innovation, the role of scarcity in driving business model acceptance, and the crucial part played by stakeholders in supporting or resisting these changes. An understanding of these dynamics helps firms navigate the complexities of implementing sustainable practices in a traditionally resource-intensive industry.

4.2.1 Need for a scarcity-driven business model

According to our interviewed business model expert, organizational success within the built environment depends on several factors. The expert mentioned that successful circular business models depend on the acceptance of innovations. Firstly, this acceptance is based on the value your business provides, considering consumers' current struggles in solving their problems. Secondly, something the business model canvas has little to no influence on is scarcity and necessity. Scarcity is closely related to necessity or desirability. Scarcity is often a desired belief that rare things should be worth more, and therefore, the assimilation of value perception is heightened (Seta, 1992). The expert provided the researcher with valuable insight into why this is also the case for business circular models within the construction industry.

The interviewee (C1), highlighted that new innovations only get traction when two things are fulfilled. Firstly, your new innovation needs to solve a problem and provide value to customers. To do this the innovation a business applies needs to be unique and special. The interviewee mentioned that circular business models can only attain traction when there actually is a scarcity problem. A shortage of materials and resources forces people to adapt out of necessity towards a new innovation or process. This statement underscores the importance of practical necessity in driving the adoption of new business models, especially in resource-constrained environments.

"We should not forget that, a lot of innovations get acceptance mainly because of two reasons, One is that they are closely linked to the current experience people have in solving a specific problem, and secondly is out of scarcity and necessity." (C1)

"Ten years ago, there were already thinking about building a complete building. With a blockchain linked to it, so that you knew for every piece of material that was in it, that it was in the blockchain. Whether that's a screw, a lighting device, a sanitary pipe, a brick, and that afterwards you could dismantle it and know these are the components. But this is something that was too far away from where society was at that moment." (C1)

"Today, there are more circular business models in the construction industry for the simple reason of scarcity and inflation." (C1)

Validating the current scarcity problem within the built environment, the CEO (C3) stated the consumers buying power is dropping significantly due to geopolitical issues, making materials and resources more expensive.

"But the main cause is the high interest rates and the general decline in consumer purchasing power due to expensive raw materials, which are also caused by geopolitical issues."(C3)

These statements enforce that innovation adoption is driven by practical necessity and problem-solving capability. This necessity is specifically displayed in resource-constrained environments. In these environments, the scarcity of materials and resources impacts the acceptance of new business models. Innovations closely linked to current problem-solving experiences have higher acceptance odds, indicating the importance of relevance. Additionally, the timing of innovations plays a crucial role, since it has to align with societal readiness.

4.2.2 Stakeholder engagement and resistance

The built environment is characterized by its complicated design and its network of key players, all fulfilling important roles within the environment. These key players are stakeholders needing to adapt themselves towards sustainable practices to succeed in the creation of circular business models within the construction industry. During the researcher's interview procedure, it became clear that these stakeholders imply a significant force in the adoption of a circular business model design. Our interviewees discussed various stakeholders having an impact on engagement and resistance towards circular business models. On an individual level, it was common for organisations to take into account Sustainable Development Goals and try to integrate them into their KPIs. Furthermore, when looking towards collaboration among the industry stakeholders, it was mentioned that Belgian construction firms utilize software analysing the environmental effects of used materials. Based on the sustainability of the materials, organisations decide whether to work with certain suppliers or not. This software also is capable of tracking all materials used within a project, making it easier to determine what materials can later be reused for new projects.

"For example, concrete here has a footprint of 119 kilograms of CO2 per cubic meter. So, each material has its own footprint, and that's increasingly being used today. I don't know if you've heard of this, but there's also the MKI value, Environmental Cost Indicators, which mainly comes from the Netherlands. They effectively assign values to materials and their environmental impact. Belgium is adopting part of that system from Europe." (C2)

"You might have also heard of Totem, you have to load your materials into it and based on your materials, certain EPDs (Environmental Product Declarations) have to be loaded. And in those EPDs, if you look into them, you see the environmental impact of the materials. That's the point, so that's the European data for having those insights. So, that will be the future for a transparent and consistent way of presenting things. You can't just say, "My material is like this," but it has to be substantiated, and that's the foundation, of course. The circular story."(C2)

To answer the demands for more sustainable materials, suppliers have already started transforming factories to new carbon-capturing factories. These will lower carbon dioxide emissions tremendously and contribute to the upcoming demand for sustainable resources within the supply chain.

"I know that cement factories are currently in the process of adapting their production with carbon capture, and from 2028, the first factories in Belgium, for example, will be implementing this. Reduced CO2 emissions will mean that the share of cement in emissions will decrease even further."(C6)

Unfortunately, despite these initiatives, one of our interviewees mentioned that it depends on the willingness of the client to make a budget for innovative solutions.

"And that happens with us through certain types of clients who allocate a specific budget for innovation or for pushing forward certain initiatives where you can effectively experiment with or test out a number of things to be more circular."(C5)

The researcher can interpret this in two ways: it seems that the client is not always willing to pay for circular construction, but it can also be seen as a flaw in the value proposition of the organization, not recognizing that it can be competitive by providing unique sustainable solutions while maintaining similar pricing as competitors.

Analysing this entire section, the researcher identified several incentives towards sustainability and circularity. Industry players tend to integrate Sustainable Development Goals in their operations, utilizing MKIs and material analysing software in their processes. Also, large investments are being made to optimize sustainable resource production. However complete circular business models are still scarce. Lastly, there is hesitancy among the project clients, who are reluctant to allocate budgets for innovative solutions. However, this reluctance to allocate budgets for innovative solutions highlights potential flaws in the organization's value proposition.

4.3 Governmental support and regulations

The research has identified the lack of governmental support and effective legislation as a barrier to implementing circular business models in the Belgian built environment. The absence of strict policies and subsidies hinders the construction industry from adapting to circular innovation. According to our interviews, the researcher discussed the governmental actions in the section below, containing a mixture of current policy initiatives, subsidies and shortcomings causing potential barriers towards a circular business model in construction.

4.3.1 Regulations, Policy initiatives, subsidies, and shortcomings

Governmental institutions imply several sustainable rules and methods that organizations have to take into consideration. New buildings in Flanders, for example, need to fulfil Energy presentation indoor climate requirements (EPB), demanding different energy saving levels depending on the type of building (Vlaanderen.be, n.d.). The common usage of EPB has been directly stated by two of our interviewees, the architect (C4) and the industrial engineer (C5) both indicated that their organization had to take EPB into account.

"…we constantly take energy-efficient construction into account, it has simply become an obligation, think of EPB certifications that new houses must have before they can even be sold"(C4)

"EPB today is a standard requirement, we can no longer look away from energy efficiency, but our company's DNA has been working on this for a long time" (C5)

This EPB standard is already normalized and is a standard all construction participants must follow. Additionally, the government implies initiatives to engage enterprises towards sustainable and circular practices, one of which is corporate social responsibility (CSR). CSR is based on a range of tools, triggering improvement of social, environmental, and economic considerations in the overall management of organizations (Belgium.be, n.d.). The usage of CSR has been validated by the sustainability manager (C2) stating the following.

"…because every company must now begin following this new reporting form of CSR where they have to filter out material themes within their organization. And I am firmly convinced that many things will emerge towards circularity, also as a material theme, when you look ahead..."(C2)

Additionally, the researcher analyzed two more indications of governmental initiatives; one interviewee indicated that “Build wise” (previously named “WTCB”) is a Belgian certifying organism standing for the allowance of implementation of new products within the built environment. Secondly, the interviewee indicated that Flanders has an agency for innovation and entrepreneurship named “LAIO”, supporting sustainable initiatives financially. The interviewee mentioned that both of these institutions have a good foundation but are limited. These limitations are indicated in the statements below.

“…a very big problem, is that there should actually be independent oversight in Belgium, but they are sponsored by very large construction conglomerates that have a very strong foothold in Belgium, with a very strong economic footprint in Belgium. This often means that they can exert pressure on those certification organisms, making it harder for some alternative, economic, sustainable products to be certified and harder for them to enter those databases. It's actually something everyone knows, but it's never really talked about.”(C3)

“…but the impacts they make are actually being less closely monitored afterwards. So, they should actually tighten up on that, I think, or have better follow-up, or better support with the next subsidy towards scaling up and such, that would be better, I believe.” (C3)

Supporting these statements, the sustainability manager (C2) shared his insights in relation to the shortcomings of governmental subsidies. He also experienced that only small-scale projects received governmental support to explore initiatives. Hence, large-scale projects are ignored more often since these often require much more funding.

“Yes, subsidies do exist today. And indeed, the Flemish or Belgian government do support principles, but these are of course mostly small-scale projects that are initiated for startups to explore certain initiatives.”(C2)

Additionally, one of the interviewees provided the researcher with insights concerning innovation-driven migration of organisations. These organisations relocate to countries, allocating higher budgets to sustainable innovations, giving the companies faster growth and development capabilities.

“So you see a lot of those big, promising technologies moving abroad because there is simply not enough space on one hand. And on the other hand, so many regulations are imposed, and also the wage costs are so high, the tax burden is so high, that it is much more interesting to go to neighbouring countries, which for example have budgets for northeastern France, of 70 billion euros per year, to attract the manufacturing industry from Belgium to neighbouring countries. And where you can actually build a factory from scratch, from airport to finished factory, in 12 months, while it takes up to 2 years in Belgium.”(C6)

The researcher analysed this section and came to the following findings: the government takes the initiative to imply rules and guidelines, but based on the insights of our interviewees, the execution of these is not at an optimal level. The governmental initiatives lack consistency in the follow up of subsidies for innovation projects and have considerable bias in determining decision-making authorities. Lastly, being competitive in Belgium is hard since businesses are limited by high wage costs, taxes and relatively low innovation budgets, resulting in innovation migration.

4.4 Market dynamics and consumer behaviour

Within this section of the findings, the researcher explores market dynamics and consumer behaviour within the built environment. This section examines how demand for sustainable and circular practices is driven by the value perception of consumers. Secondly, it explores government subsidies' role in shaping business practices and market dynamics. Lastly, this section demonstrates the influence that regulations, pricing, and innovation are having on competitiveness in the Belgian built environment.

4.4.1 Consumer value perception and demand

In this section the researcher discusses how the demand towards sustainable and circular practices is determined by the value perception of the consumer. The value perception a consumer has of a product depends on several aspects. Some of these aspects can be directly linked with product features, while others are determined by scarcity and necessity (section 4.2.1). The interviewed business model expert (C1) shared his experiences on this and stated the following.

"Yes! I think if you look at it from a business model design perspective, the better you understand your customer. The better the value will be that you will design. And if your customer and his environment require something that falls under the definition of sustainability, you will design it and you will deliver it with your business model and hence make you more competitive." (C1)

The interviewee points out a relation between the design of a business model and understanding the customer and, more importantly, the environment he is coping with. The quote highlights that when there is such a requirement under the definition of sustainability, only then should a business incorporate this sustainable desire in the business model, and only then can competitiveness be pursued. In relation to the construction industry, The sustainability manager (C2) indirectly strengthened this statement by saying the following.

"…the type of clients who allocate a certain budget for innovation or prioritize initiatives, where you can effectively experiment or test out a number of things to be more circular. And indeed, to demonstrate that it effectively meets the specifications. Now, there may need to be other standards to convince them into this direction…" (C2)

In other words, the environment of the consumer needs to shift towards different standards, potentially imposed by the environment. This activates the consumer into adapting to innovative solutions provided by organizations that are simultaneously looking for experiments in circular building. The researcher interprets these imposed standards as obligations from the government, forcing the consumer to change his necessity, and thus changing his value perception of certain innovations embracing circularity or sustainability in the built environment.

4.4.2 Subsidy impact on business practices

Focusing specifically on governmental subsidies, three of the interviewees shared broad insights about the current state of the subsidies and their impact on business practices. In the previous section (4.3.1), subsidies and shortcomings have been discussed. Therefore this section will focus on the impact of these on business practices. The CEO (C3), made statements to advocate higher subsidies for businesses and also consumers opting for sustainable and circular building options. The interviewee pointed out that increasing subsidies for sustainable practices compared to non-sustainable practices will significantly change market dynamics.

"Higher subsidization for the consumer who builds or renovates, or for the business or industry that is building. Giving a higher governmental subsidy to sustainable products f than to non-sustainable products."(C3)

This statement specifically shows perspective on how subsidies are currently employed; the interviewee suggests further change and requests governmental action to enhance competitiveness and innovation within the industry. The interviewee points out the existence of subsidy initiatives such as "LAIO", supporting organizations positively impacting the Flemish economy, but indicates that there is a lack of consistent support when these organizations scale up to larger operations.

"Thanks to the Flemish government agency LAIO, sustainable and innovative initiatives are very well supported. A number of subsidy programs, which LAIO determines can have a positive impact on the new Flemish economic fabric, are heavily subsidized."(C3)

"If your technology has been developed and you want to start producing it on a large scale, then you have a big problem in Belgium with obtaining permits... It is a very bureaucratic process that takes far too long and for which the government has created far too many positions."(C3)

Additionally, both sustainability managers (C2, C6) support the statement of the limitation towards growth, the focus of these subsidies is primarily on small-scale projects and startups that are exploring innovative initiatives. Both interviewees added that subsidies are given when significant risks exist, or uncertainties need to be mitigated.

"Yes, subsidies exist today. Indeed, the Flemish or Belgian government does support principles, but these are naturally small-scale projects. They are started indeed for what are startups to explore certain initiatives."(C2)

"That is actually the subsidy is usually only granted at the moment when there are risks and there are certain uncertainties before clarifying it." (C6)

Together, these statements touch upon an enormous problem within the Belgian built environment. Organizations contributing to positively impacting the economy with sustainable and circular practices are being limited in their growth once they are scaling up. These organizations are then forced to move their business practices and operations to countries that heavily support sustainable and circular operations.

"For example, northeastern France has budgets of 70 billion euros per year to attract the manufacturing industry from Belgium and other neighbouring countries to northeastern France"(C3)

This statement receives support from the sustainability manager (C6) stating that broader supportive measures can be found in neighbouring countries.

"In the Netherlands, machines that operate on electricity instead of fossil fuels are subsidized. Now in Belgium, this is not so, or less" (C6)

Based on this the researcher discusses business practices caused by governmental subsidies within the Belgian construction industry. Subsidies, in general, are being targeted towards small-scale projects and startups exploring innovative initiatives. This enables startups to invest more easily and explore new innovations within the Belgian-built environment. Starting with strong local support, these organizations can encounter subsidy issues when scaling up to larger operations. These are caused by existing bureaucratic challenges, such as slow permitting processes and discouraging sustainable growth within the industry. For businesses, this can mean relocating to countries that offer better subsidies for sustainable and circular operations. Geographical mobility, therefore, needs to be considered by the organization.

4.4.3 Market competitiveness

In this section, the researcher explored potential enablers and barriers to the market competitiveness of Belgian construction firms, focusing their business models on sustainable and circular practices. The researcher analysed that regulations have a massive impact on the competitiveness of an innovative business. In the section below, these relationships are highlighted. Starting with the business model expert (C1) mentioned that sustainability can be considered a market competitive factor but is far more complex than most of us think.

"If sustainability needs to be innovation, it might improve your competitiveness. So what? Sounds like a simple question, but it's actually a very complex." (C1)

Additionally, the expert (C1) stated there is a potential complexity when operating a sustainable business on a global scale, indicating that different regions often carry various levels and degrees of regulations. This diversity can potentially affect a company's competitiveness.

"If you're working on a global scale, it might even damage your competitiveness if others don't have to follow those rules." (C1)

The researcher compared this to answering of the other interviewees and found out that this indeed recurs in their answers. Section 4.4.2 already touched upon this slightly as interviewees indicated that other neighbouring countries have advantageous regulations and subsidies compared to Belgium.

"In the Netherlands, machines that operate on electricity instead of fossil fuels are subsidized. Now in Belgium, this is not so, or less" (C6)

"For example, northeastern France has budgets of 70 billion euros per year to attract the manufacturing industry from Belgium and other neighbouring countries to northeastern France"(C3)

Conclusions can be drawn that governmental support and regulations are a competitive barrier for Belgian businesses contributing to sustainability and circularity in comparison to certain neighbouring countries. Further, the researcher noticed an interesting remark that the business model expert (C1) added to the discussion.

"The reason for failure is that they were not thinking practically enough and bringing their innovation closely to what people at that moment understood."(C1)

In the context of the discussion with the expert, this remark states that in order to be competitive, as an innovative business within construction, This correlates with the concepts discussed by Pigneur and Osterwalder (2009) in their seminal work 'Business Model Generation,' where they point out the importance of aligning value creation closely with consumer needs. Part of value creation is pricing since consumers often see lower prices as augmented value received from a product or service. This is touched upon by nearly all of our interviewees, referring to a price-driven environment within the Belgian built environment.

"Everything revolves around cost price. In Belgium, unfortunately, the deciding factor for which products they will choose is still the cost price." (C2)

"The construction industry and also many others are strongly price driven." (C3)

"That is a very, very difficult challenge that many companies simply do not attempt. Because it is so complex to achieve, and so capital intensive." (C4)

"Finally, they must be economically just as interesting and thus as price-competitive as the current traditional products." (C6)

These statements indicate the relevance of competitive pricing within the industry, aligning with Porter's Competitive Strategy framework. Which highlights cost leadership as a key component of gaining competitive advantage. Porter (1980) explains the following: achieving a low-cost position enables a company to compete more effectively by offering lower prices while maintaining profitability. Therefore, pricing can be considered as a competitive factor differentiating businesses within the sustainable built environment. Additionally, differentiation is also a factor that contributes to market competitiveness (Porter, 1980). The interviewees also indicated this by demonstrating the unique sustainable innovations executed by their organizations.

"Our business model is vertical integration. We start with waste products or natural resources, then convert them into high-quality chemicals, and then into a product that solves the problem again."(C3)

"We make the best insulation material in the world from waste. We make the best-performing adhesives in the world from waste and natural resources." (C3)

The CEO's (C3) organization differentiates itself by integrating circular practices vertically within all of its processes. The entire process he incorporates throughout his organization is unique in a way that he is one of the few organizations within the built environment embracing a complete circular process.

"I think I have something in my presentation about that. This is an example of our lifecycle analysis we made visually, which is also the basis for looking at circularity." (C2)

Here, the sustainability manager (C2) demonstrates how the organisation incorporates a circular lifecycle analysis that is implemented by the organisation, potentially contributing to market competitiveness. Additionally, the business model expert provided the researcher with a blockchain innovation used by a company that made a unique contribution to sustainability and potentially also the competitiveness of the business.

"Ten years ago, there were already thinking about building a complete building. With a blockchain linked to it, so that you knew for every piece of material that was in it, that it was in the blockchain. Whether that's a screw, a lighting device, a sanitary pipe, a brick and that afterwards you could dismantle it and know these are the components."(C1)

Based on these insights, the researcher highlighted the critical enablers and barriers towards market competitiveness based on the insights gathered from the interviewees. The analysis indicates that governmental regulations and subsidies play a role in forming competitive environments. Belgian businesses encounter a competitive barrier compared to other neighbouring nations due to less favourable initiatives and regulations for sustainable initiatives. Additionally, the industry is known for its competitive pricing, forcing sustainable organizations to operate price-driven. Lastly, organizations need to differentiate their competitiveness through innovation to stand out in the market and create additional value for their customers.

4.5 Sustainable oriented partnerships and procurement

In the sections below, the researcher discusses how firms within the Belgian built environment prepare themselves for a transition towards circularity. The initiatives concerning sustainable oriented partnerships and procurement of people, products and processes taken by the interviewed organizations are discussed.

4.5.1 Sustainable oriented partnerships

The researcher identified statements among the interviewees indicating the importance of partnering with sustainable-oriented suppliers and contractors in the environment. These partnerships are crucial for organizations in the transition towards circular business models. The significance of these partnerships was indicated by one of the sustainability managers (C2) and also by the industrial engineer (C5). The sustainability manager (C2) indicated the importance of having suppliers aligned with the organization's sustainability objectives. The manager stated that they select suppliers carefully depending on a lifecycle analysis of their materials. This is done to determine how sustainable the supplier’s materials and processes are. This demonstrates early initiatives in the direction of circularity.

"This is a little bit of a benchmark for us. We start with a lifecycle analysis of the material we are going to use. We look at where our resources come from and their transportation to our production sites. The entire lifecycle of the resources is analysed to ensure that every phase adheres to our sustainability criteria” (C2)

On the other hand, the researcher was provided insights in how construction firms determine partnerships with contractors. The industrial engineer mentioned that his organization selects contractors based on the criteria of a project. In many cases, standards and policies are required, which need to be answered. The contractor plays a tremendous role here, and partnerships sometimes depend on specific certificates obtained by the contractor. Examples of these sustainable certificates are BREEAM, LEED, HQE, and DGNB (Encon, n.d.). The interviewee stated the following:

“We select our partners based on how they answer sustainable requirements, often those we know, having experience and certain certifications are contacted first” (C5)

Based on these indications, the researcher could draw conclusions that a determining factor for partnerships within the construction environment is based on the incentives suppliers and contractors embrace towards sustainability. In some instances, the lifecycle journey is taken into account, and construction firms narrowly do background checks on the partner’s practices. Within contracting, partnerships are often only considered when certain certificates are obtained by the external party.

4.5.2 Procurement of People, products and processes.

This section further zooms in on how firms within the Belgian built environment prepare for circular transition. Based on the interviewee's statements, the researcher analysed three components the procurement focuses on. These are people, products, and processes. These three are known as a common framework within general management and quality management (Liker, 2004). In this section, statements enforcing each procurement component are demonstrated.

Starting with people, the interviewees supported statements stating that successful circular adaption starts with hiring and training people with the right background and, most importantly, the desired vision towards circularity. The CEO (C3) demonstrated how his hiring process and talent acquisition is executed.

"In addition, we hire the right people from all over the world. We have a petroleum engineer from Nigeria and a chemical engineer from Iran, and we employ people of various nationalities. These are truly talented individuals that we source purely for their talent."(C3)

"It doesn't matter where they are from, and they are then guided to come work in Belgium. I arrange for a single permit, ensure they have housing, support them, and handle their contracts, purely to have the talent in our company and also to foster the intended ambition."(C3)

Besides hiring talented profiles, the CEO’s enterprise has a diversity of backgrounds within the organization. Often, diversity positively impacts organizational idea generation and problem-solving, providing a competitive edge in comparison to non-diverse organizations (Dixon-Fyle et al., 2020).

The researcher also analyzed the procurement of products. The sustainability manager (C2) indicated efforts the organization takes to acquire resources whereby the supplier engages in sustainable practices or which originate from sources considered to be unusable. The manager mentioned that material selection is based on the environmental impact.

"For example, this concrete has 119 kilos of CO2 per cubic meter. So every material has its own footprint, and that is being used more and more today."(C2)

In addition, his organization collaborates with suppliers to provide resource-specific information. This information is uploaded to the software (in this case, “Totem”) and contains the environmental impact of the resources. By doing this the organization can track the footprint of suppliers resources and base their decisions on the provided Environmental Product Declarations (EPD) values.

"You need to upload your materials into that, and based on your materials, certain EPDs must be loaded. And in those EPDs, if you look into them, you can see the environmental impact of the materials in points. So that is the European standard for having those insights."(C2)

On the other hand, when looking at the CEO's organization (C3), the researcher analysed that they obtain their materials from natural sources or even waste products. The interviewee stated the following:

"*We start from waste products or natural sources, then convert them into high-quality chemicals, and then turn them into a product that solves the problem again."(C3)*

Looking at our final procurement component, "processes", our researcher refers to "How are Belgian construction firms managing their processes to ease the transition towards a circular business model design"? Our interviewees discussed strategies incorporated within their organisation in relation to process procurement, easing the circular transition. The sustainability manager (C6) indicates that they focus on the maximal usage of secondary raw materials. These materials have already been used in previous construction processes and are being re-used in new projects to maintain a longer lifecycle of the resource.

"Of course, this is also connected to other issues that are coming into focus, such as maximizing the use of secondary raw materials, which your questions are now addressing. This forms an essential part of our activities."(C6)

The other sustainability manager (C2) indicated that their organisation participates in similar re-usage of materials; the interviewee indicated that they have dedicated recycling centres responsible for purifying and sorting secondary materials.

"We have our own recycling centres which nowadays primarily serve for processing. This has become increasingly prominent because it's an important aspect of the entire process, ensuring that the raw materials are sufficiently purified or sorted."(C2)

"it gets recycled and is then partly used as a foundation in new constructions or primarily turned back into aggregates in the proper format that can be used for production."(C2)

These statements indicate the implementation of processes to enable the reuse of secondary materials. This prolongs the life-cycle of resources throughout several projects, maintaining as much value as possible from the original material. This demonstrates that firms within the industry participate in a transition towards a circular business model by adapting their processes to reuse and recycling of secondary materials.

The previous statements have been examined by the researcher and indicate how Belgian construction firms prepare for a circular transition through the procurement of people, products, and processes. Starting with people, organizations hire individuals with industry-specific expertise and a sustainable mindset. Additionally, some organizations focus on diversity to generate better ideas and enable better problem-solving. Additionally, software programs are implemented to analyse the environmental impact of materials. Furthermore, common findings show that firms maximize the usage of secondary raw materials. This prolongs resource life cycles and contributes to circularity. Lastly, the researcher concluded that recycling centres contribute to raw materials purification and material sorting. These processes contribute to the reuse of materials in new constructions, maintaining their value across several projects.

4.6 Technological advancements and innovation

The researcher will discuss the technological advancements and innovations used within the built environment in this final section of the findings. The researcher will discuss the Carbon dioxide reduction strategies implemented by the interviewed firms and point out innovations used to reach carbon neutrality. Furthermore, the researcher shares his findings on how organizations integrate secondary raw materials by incorporating software and principles within the organizations.

1.6.1 Carbon capture and reduction strategies

In the previous section, 4.1.1, the interviewees validated the significance of carbon dioxide emissions within the industry. Therefore, key industry players contribute to reducing high amounts of carbon emissions by implementing strategies and technologies within their organizations. The researcher gathered insights from the interviewees and identified the following carbon capturing initiatives:

"I know that the cement factory is currently busy adjusting their production to include carbon capture. From 2028, the first factories in Belgium, for example, will have lower CO2 emissions, making the share of cement even lower."(C2)

This statement refers to the technology responsible for capturing CO2 emissions at its source before being released into the atmosphere. This CO2 can be stored and potentially reused in other industry-related processes. (International Energy Agency, n.d.) Besides this specific carbon capture technology, the Belgian construction industry contributes to reducing carbon emissions in several indirect ways. Think about reusing materials to avoid extra CO2 emissions, or recycling used materials for new purposes. These two will be discussed in the remaining sections.

1.6.2 Integration of secondary raw materials

When analyzing how the local industry integrates secondary raw materials, the researcher arrived at the following. These statements indicate efforts towards the integration of secondary raw material employment into the processes of the interviewed organizations. Both sustainability managers provided the researcher with the organization's specific actions to integrate secondary raw materials within the construction process.

"Of course, this is also connected to other issues that are coming into focus, such as maximizing the use of secondary raw materials, which your questions are now addressing. This forms an essential part of our activities."(C6)

“it gets recycled and is then partly used as a foundation in new constructions or primarily turned back into aggregates in the proper format that can be used for production."(C2)

“So, imagine a scenario where there's a specific infrastructure where end-of-life materials are recycled, partly reintegrated as foundations for new projects, or prioritized for granulate production in the appropriate format. This essentially is the core principle of what we aim to achieve.”(C2)

Here, the managers indicate that including secondary raw materials has become a significant activity within the organisation's process. Recycled materials are given a second life, this to be reemployed within a certain format to be used for production. Important here is that these products are being recycled since without reformation of any kind, the integration of these materials within new projects gets difficult. Additionally, the researcher analysed that organisations carry out efforts towards employing reused materials, but complete secondary material usage within the industry is scarce. This requires optimized circular activities, which, in the current state of the industry, not many possess. This has been highlighted by the CEO (C3).

“Similar but not quite the same; they contribute to circularity, but they're not exactly similar. We've been heavily involved, but there are companies like, for instance, Orbex, or Van der Zanden in Limburg, who are also heavily engaged in this area” (C3)

Lastly, the industry is investigating new methods to potentially increase the usage of these secondary raw materials. This indicates that the industry is aware of the advantages secondary raw materials can offer and also demonstrates that the current state is far from the desired direction the industry plans to move towards.

“For instance, we have ongoing investigations into reusing insulation, repurposing specific components. let's say, parts that could give a building a second life. However, this process faces challenges because we're no longer dealing with standardized volumes. These are unique pieces, often custom-designed for specific openings or sealing purposes. It's crucial to focus on this aspect. It's one of the strategic focal points aiming towards a sort of standardization, which would facilitate and promote reuse more effectively.” (C2)

Based on these findings, the researcher concludes that the industry is occupied with integrating secondary raw materials within construction processes. Currently, the secondary raw materials are based on the extent to which circular processes are developed. Lastly, the industry is aware of the current state of secondary raw material usage and investigates solutions for more customized employment of these materials.

1.6.3 Adoption towards circularity

In this final section, the researcher discusses the current initiatives taken towards circularity by the interviewed organizations. Here, only specific quotes that directly refer to the contribution towards circularity are being highlighted and discussed. In other words, the current state of circularity within the organizations is demonstrated in this section. Looking at the sustainability managers' insights (C2), the researcher analysed that they employ a circular process where recycling is utilized to integrate secondary raw materials within the construction process.

"We have our own recycling centres which nowadays primarily serve for processing. This has become increasingly prominent because it's an important aspect of the entire process, ensuring that the raw materials are sufficiently purified or sorted."(C2)

Additionally, the circular lifecycle within construction starts with smart designing. This also is taken into account within his organisation (C2). Ensuring collaborations with sustainable oriented architects is crucial for circular construction practices. In addition, the organisation pays close attention to the origin of materials, this by closely monitoring suppliers sustainable practices.

"It all starts with designing sustainable, if the architect willingness to design sustainable is not there then it gets hard to follow up the construction process with parties that are actually willing to participate in these practices, right?" (C2)

"This is a little bit of a benchmark for us. We start with a lifecycle analysis of the material we are going to use. We look at where our resources come from and their transportation to our production sites. The entire lifecycle of the resources is analysed to ensure that every phase adheres to our sustainability criteria" (C2)

Not only does the sustainability managers organization (C2) contribute significantly to circularity, but The CEO's firm (C3) bases its entire existence on the principles of circularity. They achieve this by starting from secondary raw materials and transforming these into high-quality products. They integrate circularity vertically within the organization, ensuring that all practices are characterized as circular. This is made possible by ensuring the organization only hires high-quality employees, with a sustainable/circular vision.

"*We start from waste products or natural sources, then convert them into high-quality chemicals, and then turn them into a product that solves the problem again."(C3)*

"In addition, we hire the right people from all over the world. We have a petroleum engineer from Nigeria and a chemical engineer from Iran, and we employ people of various nationalities. These are truly talented individuals that we source purely for their talent."(C3)

"It doesn't matter where they are from, and they are then guided to come work in Belgium. I arrange for a single permit, ensure they have housing, support them, and handle their contracts, purely to have the talent in our company and also to foster the intended ambition."(C3)

"If they don't have a sustainable mindset, they don't belong here…" (C3)

The researcher determined that these efforts are directly contributing towards the principles of a circular business model design. Of course, within the findings, many quotes indicated efforts towards sustainability and potential circularity, but to a less visible extent. Therefore, the researcher decided to demonstrate the most significant contributions. The findings of this section demonstrate that firms within the Belgian construction industry prepare for a circular shift by focusing on the design stage, where it is important that stakeholders have a similar circular mindset. Secondly, organizations contribute towards circularity by assuring that resources originate from trustworthy suppliers, characterized by sustainable practices. Lastly, secondary raw materials should be employed within all possible processes of production and construction.

5.0 Discussion

The main goal of this research is to identify the barriers and enablers faced by the Belgian construction industry when implementing circular business models. In this section, the researcher aims to discuss the factors influencing the transition to circular business models. Previous research indicates that the construction industry accounts for 35% of waste generation and 36% of the carbon dioxide emissions within Europe. (Van Haver, 2024). Because of this, sustainable and circular approaches have reached a high level of relevancy. Even though the industry places considerable focus on circularity, a complete transition towards a circular built environment has yet to be made. The factors that influence or block this transition range tremendously, and therefore, a discussion is necessary to understand how a complicated environment interacts with the transition towards circularity.

5.1 What are the barriers and enablers for implementing circular business models within the Belgian construction industry?

Based on the findings of this research, it has been analysed that there are several barriers and enablers influencing the integration of circular business models within the Belgian construction industry. The findings illustrate that the Belgian construction firms are aware of the industry's highly pollutive character and, therefore, contribute to carbon dioxide neutrality. This is partially achieved by integrating several innovations and technologies within their processes. These ranged from the design methodology of architects to the implementation of secondary raw materials within construction processes and preparation for carbon-capturing technologies installation within production facilities. Unfortunately, reaching complete circularity within the industry has been indicated to be a practice for only the happy few organizations. Complete CO2 neutrality cannot be consistently executed to this day.

Successful circularity within construction firms is closely related to how sustainable practices are vertically integrated within the current business models (Hina et al., 2023). This vertical integration depends on the fulfilment of sustainable practices by stakeholders within their respective organizations and on how industry key players such as suppliers, contractors, and architects are willing to integrate sustainable practices in their processes. When analysing the importance of sustainability in the organizational culture, we arrive at the following. Haugh and Talwar (2010) state that vertical integration depends on the degree to which employees within an organization align their responsibilities and roles with the sustainable culture of the organization. The findings highlight that having a correct and streamlined mindset among the employees towards sustainability enables the creation of a strong core value for the business. This aligns with Murray et al. (2015), who identified that the circular economy is a sustainable development initiative representing a new way of creating value with realigned products, services, and processes.

Secondly, the findings highlight the importance of stakeholder engagement and indicate that all key players have to make contributions to facilitate circularity. Firstly, the importance lies with the architect's ability to design projects in a sustainable manner, paying attention to sustainable material selection and technologies. Subsequently, collaborations between suppliers and contractors need to be characterized by a sustainable character. It has been highlighted that contractors utilize dedicated software tracking the environmental impact of the materials. Therefore, the willingness to share insights about the material origin and footprint is crucial to stimulate circularity in the environment. A final addition to the importance of stakeholder engagement lies in the willingness of clients to invest in circular solutions. Interviewed organizations indicated that in order to truly operate at a circular level, clients need to be willing to let organizations experiment with their capital, to implement circular practices within projects. According to the findings, this willingness potentially depends on the need(s) the client possesses. It has been highlighted in the findings that innovation only gets traction when an organization provides value to fulfil customers' needs. Seta (1992) indicates that these needs are subsequently proven to be based on the principles of scarcity. It could be the case that the willingness of clients/customers nowadays is not high enough to convince them to invest tremendously in something they don't necessarily desire. Unfortunately, many organizations have difficulties funding these circular activities since the construction industry is known for its price-driven character with immense low-profit margins (Killingsworth & Mehany, 2018).

In addition to this, the findings highlighted the importance of governmental support and regulations. Within the Belgian built environment, the government implies various regulations, initiatives, and subsidies to enhance the adaptation of sustainable and circular practices within the construction industry. The interviewed organizations indicated that the government's initiatives exist but lack follow-up investments and are biased in determining decision-making authorities. The findings highlight existing incentives but most are targeted towards small startups, experimenting with new innovations. Therefore, scaling up in the Belgian built environment is nearly non-existent, resulting in the relocation of organizations with promising circular technologies and innovations to countries investing tremendously in scaling up innovative operations. Besides these barriers, it is incredibly hard for Belgian construction firms to be competitive since businesses are limited by high wage costs and taxes compared to neighbouring countries.

5.2 How do circular business models facilitate the transition to a sustainable built environment?

According to Benachio et al. (2020), Circular business models within the industry are key in steering a transition towards a sustainable built environment. Circular business models are a redesigned version of traditional business models, helping construction firms reduce their environmental footprint by integrating principles of reuse, recycling, and resource efficiency (Lüdeke-Freund et al., 2019). By doing this, circular business models assist organisations in achieving several SDGs within the 2030 agenda. According to Benachio et al. (2020), Circular business models within the industry are key in steering a transition towards a sustainable built environment. The findings indicate that organisations within construction are aware of the 17 Sustainable Development Goals and take industry-specific goals into consideration within their operations. Goals such as SDG 12, "Responsible consumption and production," SDG 13, "Climate action," and SDG 17, "Partnership for the goals," were perceived as important drivers of sustainability within the Belgian construction industry. Partnership, in particular, is emphasized as a major influencing factor since the vertical integration of sustainable practices depends on stakeholders' willingness to adapt. The findings highlighted the importance of having all stakeholders, including suppliers and contractors, aligned and committed to sustainable goals.

Adopting circular economy practices within the construction industry is characterized by reusing resources, reducing waste, and promoting the fulfilment of sustainability (Zulkieflimasnyah et al., 2021). Organizations within the industry indicated their contributions towards a sustainable environment, by using secondary raw materials in new projects and recycling waste products into valuable resources, which later are utilized in new projects. This is executed by incorporating recycling centres within the organizations. These centres process used materials and purify them in order to be reintegrated into new construction projects. The execution of this practice reduces material production with new resources, resulting in less overall carbon emissions.

The integration of sustainable KPIs that assess material selection and emissions data supports the industry's sustainability contributions. The findings highlighted the implementation of material lifecycle analysis. Lifecycle analyses are implemented to ensure close monitoring of the material extraction, processing, implementation, and usage. Supporting this, the findings indicated widespread integrations of lifecycle assessment software within firms, analysing the environmental impact of materials. The interviewees specifically indicated that the software TOTEM (Tool to Optimize the Total Environmental Impact of Materials) plays a significant role in advancing sustainability within the construction industry. The integration of this software tool in the built environment forces stakeholders such as suppliers to label their products with EPD (environmental product declarations), leading to increased awareness and activity concerning sustainability. Labelling materials within a construction project inform organizations about the environmental characteristics of materials till the end of their life, fostering options for later circular practices (Carra & Magdani, 2016).

Furthermore, governmental support and regulations are essential for circular business model advancement in the construction industry (Zhu et al., 2019). Promoting public-private partnerships is crucial for driving circular innovation in the industry since these collaborations unite resources, expertise, and investment. Unfortunately, the findings illustrate a shortcoming of scaling-up support from the government, resulting in the migration of promising organizations and a built environment losing out on promising advancements toward sustainability. On the other hand, the findings indirectly hint that stronger governmental support and regulations could result in an innovation-driven built environment that executes sustainable practices. This aligns with Müller and Wagner (2020), who indicate that governments lack incentives, support, regulations, and actions to assist in the implementation of circular business models within the Norwegian built environment.

5.3 How do Belgian construction firms prepare for a transition towards a circular business model.

Belgian construction firms are integrating several approaches to prepare themselves for a transition towards circular business models. A crucial part of preparing for circular business models is the preparation for vertically integrating sustainable practices within the organization. The interviewees indicated that starting from the design stage, architects play a significant role in incorporating sustainable materials within construction projects. The architect's willingness to use sustainable materials is crucial for laying a sustainable-oriented foundation for the other stages of the construction process. Therefore, paying attention to the embedment of sustainability within the organizational culture is crucial. The findings highlight that organizations focus on hiring individuals with a strong vision toward sustainable and/or circular practices. Some firms even demonstrate the hiring of individuals originating from different backgrounds, believing that diversity helps idea generation for circular progression within organizations. Aligning with Alshemmari and Al Monawer (2024) indicating that workplace diversity positively impacts innovation. Diverse perspectives, experiences, and backgrounds contribute to more innovative and creative solutions within organizations.

The alignment of stakeholders' roles and responsibilities with the organizational sustainable goals generates a strong core value for preparing for circular business models. Therefore, the researcher concluded that sustainable-oriented partnerships and procurement are fundamental to reaching circular business models. To arrive at strong partnerships, characterizing circularity, firms select suppliers employing sustainable practices. Previous research delves deeper into these findings, stating that circular-oriented innovation depends on selecting known and trusted partners to engage in phased collaborations for incremental innovation and building collaborative portfolios for more systemic changes (Brown et al., 2020, pp. 9-11). Additionally, the findings indicated that suppliers should be willing to share insights about the environmental characteristics of their supplied materials and resources. This helps firms prepare for complete material life cycles, which contribute to a circular business model design. Furthermore, the interviewed companies indicated they are determined to work together with contractors who can present specific certifications supporting sustainable and circular building.

Moreover, the findings highlight that technological advancements play a significant role in the transition to circular business models in the industry. Organizations indicated a widespread implementation of lifecycle assessment tools, enabling firms to analyse the environmental impact of several operations. Even though technologies such as carbon capture are being implemented in production facilities, helping the industry reduce the overall carbon footprint, interviewees indicated that the industry is still at the first stages of complete circular processes. Current technological advancements are still being investigated. Only a few organizations already succeeded in implementing complete circularity within their business processes.

Within the findings, it has been demonstrated that the success of circular business models depends on consumer demand for sustainable practices. Currently, organizations are not demonstrating the economic and environmental benefits of circular construction clearly enough to trigger consumer incentives to invest in often expensive circular solutions. Here, governmental support can help the industry reach better value propositions by providing the currently missing scaling-up subsidies. This potentially can lead to economies of scale, resulting in more competitive circular solutions and the enhancement of innovation in the industry. The findings indicate that the built environment should focus more on understanding consumer value perception to reach a market environment that is willing to foster sustainability.

6. Conclusion

The discussion demonstrates the barriers and enablers influencing the transition towards circular business models within the built environment. This transition is influenced by several factors, ranging from technological innovation and stakeholder engagement to market dynamics and regulatory support.

First and foremost, vertical integration of sustainable practices within business models is a crucial driver for circularity. It has been demonstrated that this integration depends on stakeholders' efforts towards sustainable and circular practices. Additionally, embracing an organizational culture that aligns employee roles with sustainable goals is crucial. Subsequently, it has been indicated that employee diversity within organizations positively impacts an organization's sustainable and circular progression.

Furthermore, industry stakeholder engagement is essential to successfully implement circular business models. Stakeholders should foster sustainable practices during their collaborations within the entire construction process. It has been indicated that the material selection phase and design phase are crucial to guarantee this. Therefore, architects and suppliers play an initiating role in driving the environment towards sustainability and circularity. These collaborations can be assisted by lifecycle assessment tools, aiming to openly communicate about the selection of sustainable materials and resources. In addition, collaborating with specific contractors often depends on the contractor's acquired certifications.

Looking at the transition from a technological perspective, it has been demonstrated that firms take initiatives in producing secondary raw materials by implementing recycling centres. Material lifecycle analysis are made by the organization to measure the sustainable footprints of materials within the construction process. Additionally, carbon capture technologies will be integrated into production facilities to address the pollutive character of cement and concrete production. Unfortunately, the interviewed organizations indicated that they are still researching many technologies and innovations. Only a few pioneers are carrying out complete circular solutions within the Belgian built environment.

Lastly, governmental support has proven to be inconsistent and biased. Upscaling options for promising organizations are often not subsidized, since the government prioritizes investing in experimenting startups. The industry is known for its low profit margins, and the client's willingness to invest heavily in circular solutions is not guaranteed since investment depends on their value perception of sustainable and circular innovations. The researcher concludes that while certain organizations within the industry have progressed significantly in integrating sustainable and circular practices, the industry is still in the early stages of achieving complete circularity. Nevertheless, all organizations contributed to reducing pollutive activities and moved in a positive trend towards a more sustainable and circular future.

6.1 Theoretical implications

The findings of this Master's dissertation highlight the barriers and enablers of a transition towards circular business models. These findings include significant theoretical implications that need to be discussed. The research demonstrates that the construction industry is still in the developing phases of reaching complete circularity. This aligns with previous studies, indicating the initial phases of the technological adoption of sustainable practices. This study enlarges the existing literature by providing empirical evidence specified in the Belgian context. The study showcases how local innovations and technologies initiate a path towards circularity. The study indicates the current state of technology and innovation within the Belgian built environment, enriching the practicalities of the circular economy theories within the boundaries of the Belgian construction industry.

Secondly, this research underscores the significant role of consumer demand for sustainable practices. It, therefore, contributes by demonstrating that the economic and environmental benefits of circular construction need to be more clearly communicated to consumers, potentially triggering investment. Furthermore, the findings emphasize the importance of stakeholder engagement in the material selection and design phases. Underscoring the initiating role of architects and suppliers in sustainable construction processes. This contributes to a deeper understanding of stakeholder dynamics in circular business models.

Additionally, this study contributes to existing theories on the role of government in sustainability transitions by indicating inconsistent and biased governmental support, which is slowing down the transition towards circular business models. This research indicates the need for more targeted and stable policy frameworks to support scaling up promising innovations. Additionally, this research provides specific examples of how current policies and regulations fail to support the transition to circular business models.

Lastly, the research demonstrates that including sustainability within the organizational culture is crucial for the implementation of circular business models. Organizations with a strong commitment to sustainability at all levels are more likely to achieve circularity, aligning with theoretical frameworks that indicate the importance of a sustainable organizational culture (Haugh & Talwar, 2010).

6.2 Managerial implications

The conclusion of this study indicates that certain actions from a managerial viewpoint can be taken within the construction industry. First and foremost, the study demonstrated how important lifecycle management tools are in reducing the industry's environmental impact. For managers, investing in these technologies and pushing towards standardization in the industry can help organizations reach sustainable and circular goals. Additionally, this study indicates that many technologies are still in the early implementation stages, which can indicate that there is a need for a structured approach to scaling these operations up. Doing smaller-scale tests can potentially help managers refine the implemented technologies to lower the risks of upscaling. Here, managers can invest time and effort in collaborating with educational institutions and possibly other industry experts to reach new development opportunities.

Furthermore, the research highlights the importance of understanding consumer perceptions of the clients. As managers, investing in market research to acquire broader insights into the client's necessity and demands is recommended. Additionally, enhancing consumer awareness of the benefits of sustainable construction practices can help managers influence clients' perspectives.

This study demonstrates the importance of embedding sustainability within organizational culture. To successfully transition to an organizational culture, managers should lead by example, demonstrating a vision towards sustainability and transmitting this vision to all levels of the organization. This can potentially be achieved by training employees, including circular and sustainable goals into the KPIs, but also by the creation of sustainable ambassador programs. These programs reward employees for their free willingness to contribute to the sustainable vision. These ambassadors carry out the desired organizational vision and can influence the organizational and environmental mindset.

Lastly, achieving strong partnerships among the industry stakeholders is of major importance. Managers should aim for consistent stakeholder meetings and work towards collaborative platforms, aligning all stakeholders with sustainable construction processes.

6.3 Limitations and Future Research

This conducted research contains a few limitations that should be considered when drawing conclusions. The researcher interviewed several organizations within the construction industry, but most interviewed organizations are located within the same province (Limburg) of Belgium. Therefore, this research represents only a fraction of the entire Belgian built environment. In future research, it therefore is important to include stakeholders in different provinces to accurately represent the environment. Subsequently, the research involved a limited number of interviews. This small sample size may not accurately represent the diverse perspectives within the industry, potentially limiting the generalizability of the findings.

While this research demonstrated the Sustainable Development Goals (SDGs) the industry is currently focusing on, it has its limitations in precisely addressing what specific innovations and technologies are being executed to reach the industry-relevant SDGs.

Additionally, insights about governmental support and regulations are discussed, but this research does not include representatives from the Belgian government; this limits the perspective of the study regarding the role and impact of governmental policies and support. Furthermore, the research indicates inconsistent and sometimes biased governmental support as a barrier to circular economy initiatives. Future research could explore the policy and regulatory frameworks needed to incentivize and support the transition towards circularity.

The study highlights the dependency of circular business models on consumer demand and willingness to invest in sustainable solutions. The researcher of this dissertation recommends future research in exploring the factors influencing consumer necessity and demand for sustainable practices within the construction field.

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Addendum 1: Interview Questionnaires

Circular business model design in the Belgian construction industry

Main Research Question: How can we potentially overcome the current barriers of implementing circular business models in the Belgian built environment?
Sub question 1: How do circular business models facilitate the transition to a sustainable built environment?
Sub question 2: How do Belgian construction firms prepare for a transition towards a circular business model, what are potential barriers?

Interview Questionnaire:(construction businesses)

A- <u>Warm-up question:</u>

1. What is your position within your organization?

2. Are you familiar with the concepts of sustainability, Sustainable Development Goals, circularity and business models?

B- <u>Main interview questions</u>

1. Following your opinion, do you believe that the players in the Belgian construction industry contribute in generating sustainable value? Why/why not?

2. What role(s) does your organization play in reaching sustainable development goals in the environment? Can you Elaborate?

3. How important do you believe it is to have sustainable related innovation in the built environment?

4. What is the main sustainable development goal (SDG) for your company ?

5. Are there currently (sustainable/circular) innovation(s) being developed/implemented in your organization to create value for customers or other stakeholders? If so, what factors do you believe contributed to its success?

6. To what extend do you believe that circular economy is important for the future of the Belgian built environment?

7. Have you experienced successful circular solutions/methods withing this sector? What factors do you believe made contributions to its success?

8. What do you believe is the biggest barrier related to transition to a circular economy in the built environment? What enables this?

9. What do you see as important factors to successfully implementing circular business models in the Belgian built environment?

   a. Are there any incentives you believe could be implemented to stimulate a transition to circular economy?

Circular business model design in the Belgian construction industry

Main Research Question: How can we potentially overcome the current barriers of implementing circular business models in the Belgian built environment?
Sub question 1: How do circular business models facilitate the transition to a sustainable built environment?
Sub question 2: How do Belgian construction firms prepare for a transition towards a circular business model, what are potential barriers?

Interview Questions: (Business modelling specialist)

A- <u>Warm-up question:</u>

1. How did you become expert in business modelling?
2. Are you familiar with the concepts of sustainability, Sustainable Development Goals, circularity?

B- <u>Main interview questions</u>

1. In your view, what level of significance does sustainable-related innovation hold in shaping business models within the built environment? How does the integration of sustainable innovations impact the overall viability and competitiveness of business models?
2. To what extent do you perceive the concept of a circular economy as pivotal for shaping the future landscape of the Belgian built environment? How does this perspective influence strategic business modelling decisions?
3. Based on your experience, have you encountered successful circular solutions or methods within the construction sector? Could you identify the critical factors contributing to their success from a business modelling perspective?
4. In your opinion, what constitutes the most significant barrier hindering the transition to a circular economy within the built environment? How does this barrier impact the formulation and implementation of innovative business models?
5. From your expertise, what are the key factors crucial for the successful implementation of circular business models within the Belgian built environment? Additionally, do you envision any incentives that could effectively drive and accelerate the transition towards a circular economy?